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Compartmentalized electric vehicle (EV) having attached compartments with separate power systems

Abstract

Methods and systems for power transfer and routing in a compartmentalized electric vehicle (EV) having detachable compartments, and for handing off a load from one EV to another EV for delivering the load to a destination are described herein. Each detachable compartment in the compartmentalized EV may have a separate power supply, motor, set of wheels, and/or autonomous operation features. The detachable compartments may attach to each other, such that each of the detachable compartments combine to form a compartmentalized EV that travels to a particular location.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims priority to and the benefit of the filing date of (1) provisional U.S. Patent Application No. 63/355,894 entitled

“Compartmentalized Electric Vehicle (EV) Having Attached Compartments with Separate Power Systems,” filed on Jun. 27, 2022; and (2) provisional U.S. Patent Application No. 63/356,782 entitled “Compartmentalized Electric Vehicle (EV) Having Attached Compartments with Separate Power Systems,” filed on Jun. 29, 2022. The entire contents of each of which is hereby expressly incorporated herein by reference.

FIELD

(1) The present disclosure generally relates to electric vehicles (EVs), and more specifically, a compartmentalized EV having detachable compartments and a delivery hand off method when an EV delivering a load is running out of power.

BACKGROUND

(2) Vehicles are typically powered using electricity, gasoline, and/or a hybrid of the two. When a vehicle is running low on power and does not have enough range to reach the nearest fueling and/or charging station, the vehicle may need emergency services, such as a tow truck to assist the vehicle in reaching the nearest fueling and/or charging station.

(3) Furthermore, manually operated vehicles may deliver loads, such as packages, from shipping locations to recipient locations. In some scenarios, manually operated vehicles deliver several loads in the same trip when each load is going to the same location or geographic area. The manually operated vehicles may travel from one centrally located transportation hub to another transportation hub. Then additional vehicles may obtain the loads from the centrally located transportation hub and drop them off at the recipient locations.

(4) When a vehicle delivering a load runs out of power on the route to the recipient location, the load may be not be delivered on time or may not be delivered to the recipient location at all. Conventional vehicles and techniques may have additional inefficiencies, inadequacies, ineffectiveness, and/or other drawbacks as well.

BRIEF SUMMARY

(5) The present embodiments may be related to, inter alia, electric vehicles and/or autonomous or semi-autonomous vehicle operation, including driverless operation of fully autonomous vehicles. The embodiments described herein may relate particularly to various aspects of communication between autonomous operation features, components, and software. Specific systems and methods are summarized below. The methods and systems summarized below may include additional, less, or alternate actions, including those discussed elsewhere herein.

(6) In one aspect, a compartmentalized electric vehicle (EV) may have a plurality of attached compartments each configured to operate separately from other compartments. The EV may include: a plurality of detachable compartments. Each detachable compartment may include: (i) a power supply; (ii) a motor; (iii) a set of wheels; and/or (iv) one or more autonomous operation features. The plurality of detachable compartments may be attached to each other to travel to a same location. The compartmentalized EV may include additional, less, or alternate actions and functionality, including that discussed elsewhere herein.

(7) For instance, a first compartment of the plurality of compartments may be configured to receive power from a second compartment of the plurality of compartments to charge the power supply in the first compartment. The compartmentalized EV may travel to an intermediate destination. Two or more of the plurality of detachable compartments may be configured to detach from the compartmentalized EV, and travel to different final destinations.

(8) In some scenarios, a first detachable compartment may include (i) a first load to be delivered to a first final destination, and (ii) a second detachable compartment may include a second load to be delivered to a second final destination.

(9) Each of the plurality of detachable compartments may further include a magnet attached to an external surface of the compartment. The plurality of detachable compartments may be attached to each other via magnetic attraction from the magnets.

(10) In some embodiments, each compartment may be configured to detach from the compartmentalized EV by de-energizing the magnet attached to the external surface of the compartment. In other embodiments, each compartment may be configured to detach from the compartmentalized EV by accelerating by more than a threshold acceleration in a direction opposite a direction of attachment to the compartmentalized EV

(11) In some embodiments, each detachable compartment may further include: (i) one or more processors and/or associated transceivers; and/or (ii) a non-transitory computer-readable medium storing instructions thereon.

(12) Also in some embodiments, the instructions, when executed by the one or more processors, may cause the one or more processors to: (i) determine an amount of charge remaining for powering the compartment; (ii) obtain indications of amounts of charge remaining for powering other compartments in the EV; and/or (iii) transfer at least some of the charge remaining for powering the compartment to another compartment based upon the amount of charge remaining for powering the other compartment or the amount of charge remaining for powering the compartment.

(13) In some embodiments, the instructions may cause the one or more processors to transfer at least some of the charge remaining for powering the compartment to the other compartment in response to determining at least one of: (i) the amount of charge remaining for powering the compartment is above a first threshold charge level; and/or (ii) the amount of charge remaining for powering the other compartment is below a second threshold charge level.

(14) In further embodiments, the instructions may cause the one or more processors to transfer at least some of the charge remaining for powering the compartment to the other compartment such that each compartment may have a same amount of charge remaining.

(15) Methods or computer-readable media storing instructions for implementing all or part of the system described above may also be provided in some aspects. Systems for implementing such methods may include one or more of the following: a special-purpose assessment computing device, a mobile computing device (mobile device), a personal electronic device, an on-board computer, a remote server, one or more sensors, one or more communication modules (and/or transceivers) configured to communicate wirelessly via radio links, radio frequency links, and/or wireless communication channels, and/or one or more program memories coupled to one or more processors of the mobile computing device, personal electronic device, on-board computer, or remote server. Such program memories may store instructions to cause the one or more processors to implement part or all of the methods. Additional or alternative features described herein below may be included in some aspects.

(16) In another aspect, a computer-implemented method in a compartmentalized electric vehicle (EV) for delivering loads to a plurality of final destinations may be provided. The method may be implemented via one or more local or remote processors, servers, sensors, transceivers, memory units, and/or other electric or electronic components. In one instance, the method may include: (1) causing a compartmentalized EV, by one or more processors in the compartmentalized EV having a plurality of detachable compartments, each detachable compartment including a power supply, a motor, a set of wheels, and one or more autonomous operation features, to travel to an intermediate destination within a threshold range of a plurality of final destinations; and/or (2) in response to arriving at the intermediate destination, causing at least one of the plurality of detachable compartments, by one or more processors in the detachable compartment, to detach from the compartmentalized EV and to deliver a first load in the detachable compartment to a first final destination of the plurality of final destinations. The method may include additional, less, or alternate actions and functionality, including that discussed elsewhere herein.

(17) For instance, at least some of the charge remaining for powering the first detachable compartment may transferred to the second detachable compartment in response to determining at least one of: (i) the amount of charge remaining for powering the first detachable compartment is above a first threshold charge level; and/or (ii) the amount of charge remaining for powering the

second detachable compartment is below a second threshold charge level. At least some of the charge remaining for powering the first detachable compartment may also be transferred to the second detachable compartment such that each compartment has a same amount of charge remaining.

(18) Each of the plurality of detachable compartments may further include a magnet attached to an external surface of the compartment. The plurality of detachable compartments may be attached to each other via magnetic attraction from the magnets. Each compartment may be configured to detach from the compartmentalized EV by de-energizing the magnet attached to the external surface of the compartment.

(19) In some embodiments, the method may further include causing the compartmentalized EV to deliver a second load to a second final destination of the plurality of final destinations.

(20) Also in some embodiments, causing the compartmentalized EV to travel to the intermediate destination may include: (i) obtaining an indication of a route for traveling from a starting location to the intermediate destination; and/or (ii) sending control signals to the compartmentalized EV to cause the compartmentalized EV to travel along the route to the intermediate destination.

(21) In further embodiments, causing the detachable compartment to detach from the compartmentalized EV and to deliver the first load may include: (i) obtaining an indication of a route for traveling from the intermediate destination to the first final destination; (ii) detaching from the compartmentalized EV in response to arriving at the intermediate destination; and/or (iii) sending control signals to the detachable compartment to cause the detachable compartment to travel along the route to the first final destination.

(22) In some embodiments, the method may further include in a first detachable compartment: (i) determining an amount of charge remaining for powering the first detachable compartment; (ii) obtaining indications of amounts of charge remaining for powering other detachable compartments in the compartmentalized EV; and/or (iii) transferring at least some of the charge remaining for powering the first detachable compartment to a second detachable compartment based upon (a) the amount of charge remaining for powering the second detachable compartment, or (b) the amount of charge remaining for powering the first detachable compartment.

(23) In yet another aspect, a computer-implemented method for handing off a load when an electric vehicle (EV) delivering the load is running out of power may be provided. The method may be implemented via one or more local or remote processors, servers, sensors, transceivers, memory units, and/or other electric or electronic components. In one instance, the method may include: (1) receiving, by one or more processors (and/or associated transceivers) in a first EV having one or more autonomous operation features, an indication from a second EV that the second EV has less than a threshold amount of charge remaining, and an indication of a destination for delivering a load in the second EV; (2) determining, by the one or more processors, a meeting location for handing off the load in the second EV; (3) causing, by the one or more processors, the first EV to travel to the meeting location; and/or (4) in response to obtaining the load from the second EV, causing, by the one or more processors, the first EV to travel to the destination for delivering the load. The method may include additional, less, or alternate actions and functionality, including that discussed elsewhere herein.

(24) For instance, the indication that the second EV has less than the threshold amount of charge remaining may be received via a vehicle-to-vehicle (V2V) communication. The meeting location may be a current location of the second EV or a location along a route to the destination.

(25) In some embodiments, the method may further include: transmitting, by the one or more processors (and/or associated transceivers), a response message to the second EV indicating that the first EV will pick up the load from the meeting location and deliver the load to the destination. The response message may be transmitted in response to determining that the first EV is within a threshold distance of the meeting location.

(26) In further embodiments, determining the meeting location may include: (i) receiving, by the

one or more processors (and/or associated transceivers), an indication of a route for the second EV to travel to the destination; (ii) determining, by the one or more processors, a waypoint along the route which is closest to a location of the first EV; and/or (iii) transmitting, by the one or more processors (and/or associated transceivers), a request for the determined waypoint to be the meeting location. In some embodiments, the method may further include receiving, by the one or more processors (and/or associated transceivers) from the second EV, an indication accepting the request for the determined waypoint to be the meeting location in response to the second EV determining that the second EV will reach the determined waypoint without running out of power.
(27) Also in some embodiments, causing the first EV to travel to the meeting location may include: (i) obtaining, by the one or more processors, an indication of a route from a current location of the first EV to the meeting location; and/or (ii) sending, by the one or more processors, control signals to cause the first EV to travel along the route to the meeting location.
(28) In some embodiments, causing the first EV to travel to the destination may include: (i) obtaining, by the one or more processors, an indication of a route from the meeting location to the destination; and/or (ii) sending, by the one or more processors, control signals to cause the first EV to travel along the route to the destination.
(29) In further embodiments, the method may further include sending, by the one or more processors, control signals to cause a door to the first EV or trunk of the first EV to open for receiving the load.
(30) Systems or computer-readable media storing instructions for implementing all or part of the system described above may also be provided in some aspects. Systems for implementing such methods may include one or more of the following: a special-purpose assessment computing device, a mobile computing device, a personal electronic device, an on-board computer, a remote server, one or more sensors, one or more communication modules configured to communicate wirelessly via radio links, radio frequency links, and/or wireless communication channels, and/or one or more program memories coupled to one or more processors of the mobile computing device, personal electronic device, on-board computer, or remote server. Such program memories may store instructions to cause the one or more processors to implement part or all of the method described above. Additional or alternative features described herein below may be included in some aspects.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) 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.
(2) 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.
(3) FIG. **1**A illustrates an exemplary compartmentalized EV having detachable compartments;
(4) FIG. **1**B illustrates a block diagram of an exemplary EV communication system, showing EV compartments and a remote server device;
(5) FIG. **2** illustrates a block diagram of an exemplary on-board computer or mobile device;

(6) FIG. **3** illustrates an exemplary transfer of power between the detachable compartments;
(7) FIG. **4** illustrates a schematic diagram of an exemplary compartmentalized EV on a route to an intermediate destination where each compartment detaches from the EV and travels to a different final destination to deliver a respective load;
(8) FIGS. **5**A-**5**C illustrate an example delivery hand off procedure where a first EV delivering a load is running out of power, and a second EV picks up the load from the first EV and transports the load to its destination;
(9) FIG. **6** illustrates a flow diagram of an exemplary power transfer method for transferring power between compartments of an EV;
(10) FIG. **7** illustrates another flow diagram of an exemplary delivery method for delivering loads in detachable compartments of a compartmentalized EV to different final destinations;
(11) FIG. **8** illustrates yet another flow diagram of an exemplary delivery hand off method for handing off a load when an EV delivering the load is running out of power;
(12) FIG. **9** illustrates an exemplary swarm of unmanned aerial vehicles (UAVs) or drones including a mothership drone coupled to other drones; and
(13) FIG. **10** illustrates a flow diagram of an exemplary power transfer method for transferring power between drones within a swarm.
(14) While the systems and methods disclosed herein is susceptible of being embodied in many different forms, it is shown in the drawings and will be described herein in detail specific exemplary embodiments thereof, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the systems and methods disclosed herein and is not intended to limit the systems and methods disclosed herein to the specific embodiments illustrated. In this respect, before explaining at least one embodiment consistent with the present systems and methods disclosed herein in detail, it is to be understood that the systems and methods disclosed herein is not limited in its application to the details of construction and to the arrangements of components set forth above and below, illustrated in the drawings, or as described in the examples. Methods and apparatuses consistent with the systems and methods disclosed herein are capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract included below, are for the purposes of description and should not be regarded as limiting.
DETAILED DESCRIPTION
(15) The systems and methods disclosed herein generally relate to, inter alia, various aspects of electric vehicles (e.g., cars, trucks, motorcycles, etc.) and utilizing fuel and/or battery power within an electric vehicle to power components within the electric vehicle, such as the motor, engine (or other means of movement or propulsion), steering control, brakes, vehicle sensors, lighting, heating system, cooling system, in-vehicle infotainment system, windshield wipers, etc. The electric vehicles described herein may include fully electric vehicles powered solely by a battery or hybrid vehicles powered by a combination of a battery and fuel, such as gasoline.
(16) The systems and methods disclosed herein also generally relate to various aspects of communication between autonomous operation features, components, and software. 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). Fully or partially autonomous operation features may perform specific functions to control or assist in controlling some aspect of vehicle operation, or such features may manage or control other autonomous operation features. For example, a vehicle operating system may control numerous subsystems that each fully or partially control aspects of

vehicle operation. The electric vehicles described herein may be fully autonomous, partially autonomous, manually operated, or any suitable combination of these.
(17) Autonomous operation features utilize data not available to a human operator, respond to conditions in the vehicle operating environment faster than human operators, and do not suffer fatigue or distraction. Thus, the autonomous operation features may also significantly affect various risks associated with operating a vehicle.
(18) In certain embodiments, the electric vehicles may be boats, planes, or unmanned aerial vehicles (such as drones), and the systems and methods may relate to utilizing fuel and/or battery power within the electric vehicle to power components within the electric vehicle, such as the motor, engine (or other means of movement or propulsion), rotors, propellers, wings, or other means of movement or propulsion, such as ground, water, and/or air travel.
(19) Exemplary Compartmentalized Electric Vehicle
(20) FIG. **1**A illustrates an exemplary compartmentalized EV **100** having detachable compartments **110-140** where each detachable compartment **110-140** may be configured to operate separately from the other detachable compartments **110-140**. Each detachable compartment **110-140** may include a power supply **102-142**, such as a battery which supplies power to the electrical components within the detachable compartment **110-140**, such as a motor **104-134**, on-board computer **106-136**, engine, steering control, brakes, vehicle sensors, lighting, heating system, cooling system, windshield wipers, etc.
(21) Each battery **102-132** may be electrically coupled to the components within the detachable compartment **110-140**, for example via a wired connection. Each battery **102-132** may include a charge level sensor to detect the amount of charge remaining in the battery **102-132**. Each detachable compartment **110-140** may also include a separate set of wheels **108-138** and/or autonomous operation features for the respective on-board computer **106-146** to autonomously operate the detachable compartment **110-140**. Accordingly, each detachable compartment **110-140** may be configured to operate as a stand-alone EV, such that each detachable compartment **110-140** can travel to different final destinations to drop respective loads off at the final destinations.
(22) Each of the detachable compartments **110-140** within the compartmentalized EV **100** may be attached to each other, such that they may all travel to the same location. In this manner, the compartments **110-140** may conserve energy and transfer power between each other to prevent any one compartment from draining its battery while they are attached. The compartments **110-140** may share power amongst the respective batteries **102-132** when for example, one compartment **110** is performing most of the control (e.g., the steering, braking, throttling, etc.) and the others **120-140** are being carried along by being attached to the compartment **110**.
(23) The detachable compartments **110-140** may also detach from the compartmentalized EV **100** so that a particular detachable compartment **110-140** may travel to a separate location from the compartmentalized EV **100**. For example, the compartmentalized EV **100** may travel to an intermediate destination which may be a centralized location proximate to several final destinations for the detachable compartments **110-140** to separately deliver their respective loads. Upon arriving at the intermediate destination, the detachable compartments **110-140** may detach from the compartmentalized EV **100** and travel to their respective final destinations.
(24) More specifically, each detachable compartment **110-140** may include one or more attachment mechanisms, such as magnets **152-174** attached to external surface(s) of the detachable compartment **110-140**. In some implementations, a detachable compartment **120** may include a first magnet **154** attached to the front of the detachable compartment **120** and a second magnet **162** attached to the back of the detachable compartment **120**. The first and second magnets **154**, **162** may have the opposite polarity so that a magnet **162** attached to the back of one detachable compartment **120** is attracted to a magnet **164** attached to the front of another detachable compartment **130**, thereby causing the two compartments **120**, **130** to attach via magnetic attraction.

(25) In other implementations, each detachable compartment **110-140** may be layered with a magnetic coating or may include magnetic materials to attach to the other detachable compartments **110-140**. The magnets **152-174** may be permanent magnets or electromagnets. In embodiments where the magnets **152-174** are electromagnets, the on-board computer **106** within a detachable compartment **110** may send a control signal to energize the magnet **152** for the detachable compartment **110**. To detach from the other compartments **120-140**, the on-board computer **106** may stop sending an electric signal to the magnet **152** to de-energize the magnet **152**. Then the magnet **152** may no longer attach to the magnet **154** for the compartment **120**.
(26) In other implementations, such as when the magnets **152-174** are permanent magnets, a compartment **110-140** may accelerate by more than a threshold acceleration in a direction opposite the direction of attachment to the compartmentalized EV **100** to detach from the compartmentalized EV **100**. The threshold acceleration may correspond to a force which is greater than the force of magnetic attraction of the magnets to separate the compartment **110-140** from the other compartments **110-140**. For example, the compartment **140** may be attached in the front to the compartment **130**. To detach from the compartment **130**, the compartment **140** may accelerate backwards away from the front-facing attachment by more than the threshold acceleration.
(27) To monitor the compartmentalized EV **100**, each detachable compartment **110-140** may include one or more sensors installed within the compartment **110-140** and/or personal electronic devices that may communicate with the respective on-board computer **106-136** in the compartment **110-140**. The sensor data may be processed using the on-board computer **106-136** or a mobile device (e.g., a smart phone, a tablet computer, a special purpose computing device, smart watch, wearable electronics, smart glasses, augmented reality (AR) glasses, virtual reality (VR) headset, etc.) to determine when the detachable compartment **110-140** is in operation and information regarding the detachable compartment **110-140**.
(28) One or more on-board computers **106-136** may be permanently or removably installed in each detachable compartment **110-140**. Each on-board computer **106-136** may interface with the one or more sensors within the detachable compartment **110-140** (e.g., a digital camera, a LIDAR sensor, an ultrasonic sensor, an infrared sensor, an ignition sensor, an odometer, a system clock, a speedometer, a tachometer, an accelerometer, a gyroscope, a compass, a geolocation unit, radar unit, etc.), which sensors may also be incorporated within or connected to the on-board computer **106-136**.
(29) Each detachable compartment **110-140** may further include a communication component to transmit information to and receive information from external sources, including the other compartments **110-140**, other vehicles, infrastructure, etc. In some embodiments, a mobile device in each compartment **110-140** may supplement the functions performed by the on-board computer **106-136** described herein by, for example, sending or receiving information to and from other compartments **110-140** or other vehicles via a network, such as over one or more radio frequency links or wireless communication channels. In other embodiments, the on-board computer **106-136** may perform all of the functions of the mobile device described herein, in which case no mobile device may be present in the detachable compartments **110-140**. Additionally, the mobile device and on-board computer **106-136** in each compartment **110-140** may communicate with one another directly over a communication link.
(30) Each mobile device may be either a general-use personal computer, cellular phone, smart phone, tablet computer, smart watch, wearable electronics, or a dedicated vehicle monitoring or control device. Each on-board computer **106-136** 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, each on-board computer **106-136** may be installed by the manufacturer of the compartmentalized EV **100** or as an aftermarket modification or addition to the compartmentalized EV **100**. In some embodiments or under certain conditions, each mobile device or on-board computer **106-136** may function as thin-client devices that outsource some or most of

the processing to a server.
(31) The sensors **120** may be removably or fixedly installed within each detachable compartment **110-140** and may be disposed in various arrangements to provide information to the detachable compartment **110-140** for operation. Among the sensors may be included one or more of a GPS unit, a radar unit, a LIDAR unit, an ultrasonic sensor, an infrared sensor, an inductance sensor, a camera, an accelerometer, a tachometer, a speedometer, an outdoor temperature sensor for sensing the temperature outside of the detachable compartment **110-140**, and/or an in-cabin temperature sensor for sensing the temperature within the detachable compartment **110-140**.
(32) Some of the sensors (e.g., radar, LIDAR, or camera units) may actively or passively scan the vehicle environment for obstacles (e.g., other vehicles, buildings, pedestrians, etc.), roadways, lane markings, signs, or signals. Other sensors (e.g., GPS, accelerometer, or tachometer units) may provide data for determining the location or movement of the detachable compartment **110-140**. Still other sensors may be directed to the interior of the detachable compartment **110-140**, such as cameras, microphones, pressure sensors, thermometers, or similar sensors to monitor the vehicle operator and/or passengers within the detachable compartment **110-140**. Information generated or received by the sensors may be communicated to the on-board computer **106-136** or the mobile device within the respective detachable compartment **110-140** for use in vehicle operation.
(33) In addition to receiving information from the sensors, the on-board computer **106-136** in a particular detachable compartment **110-140** may directly or indirectly control the operation of the detachable compartment **110-140** according to various autonomous operation features. The autonomous operation features may include software applications or modules implemented by the on-board computer **106-136** to generate and implement control commands to control the steering, braking, or throttle of the detachable compartment **110-140**. To facilitate such control, the on-board computer **106-136** may be communicatively connected to control components of the detachable compartment **110-140** by various electrical or electromechanical control components (not shown). When a control command is generated by the on-board computer **106-136**, it may thus be communicated to the control components of the detachable compartment **110-140** to effect a control action. In embodiments involving fully autonomous vehicles, the detachable compartment **110-140** 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.
(34) FIG. **1**B illustrates a block diagram of an exemplary EV communication system **180** on which the exemplary methods described herein may be implemented. In one aspect, system **180** may include a network **182**, N number of vehicles and/or vehicle compartments **110-120** and respective mobile computing devices **184**.**1-184**.N, one or several personal electronic devices (not shown), and/or a remote server device **186**. The vehicle compartments **110-120** may include compartments within a compartmentalized EV **100** or within multiple EVs. Some of the vehicle compartments **110-120** may have autonomous operation features while others may not have autonomous operation features.
(35) Each of vehicles and/or vehicle compartments **110-120** may be configured for wireless inter-vehicle communication, such as vehicle-to-vehicle (V2V) wireless communication and/or data transmission via the communication component, directly via the mobile computing devices **184**.**1-184**.N, or otherwise.
(36) Although system **180** is shown in FIG. **1**B as including one network **180**, two mobile computing devices **184**.**1** and **184**.N, two vehicle compartments **110** and **120**, and/or one remote server device **186**, various embodiments of system **180** may include any suitable number of networks **180**, mobile computing devices **184**.**1-184**.N, vehicles and/or vehicle compartments **110-120**, and/or remote server devices **186**.
(37) In one aspect, each of mobile computing devices **184**.**1** and **184**.N may be configured to

communicate with one another directly via peer-to-peer (P2P) wireless communication and/or data transfer. In other aspects, each of mobile computing devices **184.1** and **184**.N may be configured to communicate indirectly with one another and/or any suitable device via communications over network **180**, such as remote computing device, for example. In still other aspects, each of mobile computing devices **184.1** and **184**.N may be configured to communicate directly and/or indirectly with other suitable devices, which may include synchronous or asynchronous communication.

(38) Each of mobile computing devices **184.1** and **184**.N and/or personal electronic devices may be configured to send data to and/or receive data from one another and/or via network **180** using one or more suitable communication protocols, which may be the same communication protocols or different communication protocols. For example, mobile computing devices **184.1** and **184**.N may be configured to communicate with one another via a direct radio link, which may utilize, for example, a Wi-Fi direct protocol, an ad-hoc cellular communication protocol, etc.

(39) Mobile computing devices **184.1** and **184**.N and/or personal electronic devices may also be configured to communicate with vehicles and/or vehicle compartments **110-120**, respectively, utilizing a BLUETOOTH communication protocol (radio link not shown). In some embodiments, this may include communication between a mobile computing device **184.1** and a vehicle controller. In other embodiments, it may involve communication between a mobile computing device **184**.N and a vehicle telephony, entertainment, navigation, or information system (not shown) of the vehicle and/or vehicle compartment **120** that provides functionality other than autonomous (or semi-autonomous) vehicle control. Thus, vehicles and/or vehicle compartments without autonomous operation features may nonetheless be connected to mobile computing devices in order to facilitate communication, information presentation, or similar non-control operations (e.g., navigation display, hands-free telephony, or music selection and presentation).

(40) To provide additional examples, mobile computing devices **184.1** and **184**.N and/or personal electronic devices may be configured to communicate with one another via radio links by each communicating with network **180** utilizing a cellular communication protocol. As an additional example, mobile computing devices **184.1** and/or **184**.N may be configured to communicate with the remote server device **186** via radio links. Similarly, one or more vehicle controllers may be configured to communicate directly to the network **180** or indirectly through mobile computing device **184.1**. Vehicle controllers may also communicate with other vehicle controllers and/or mobile computing devices **184**.N directly or indirectly through mobile computing device **184.1** via local radio links.

(41) As discussed elsewhere herein, network **180** may be implemented as a wireless telephony network (e.g., GSM, CDMA, LTE, etc.), a Wi-Fi network (e.g., via one or more IEEE 802.11 Standards), a WiMAX network, a Bluetooth network, etc.

(42) The remote server device **186** may facilitate communication between the vehicles and/or vehicle compartments **110-120**. For example, a vehicle compartment **110** may transmit a request to the remote server device **186** for the amount of charge remaining in the batteries **112-132** of the other compartments within a compartmentalized EV **100**. The remote server device **186** may receive responses to the requests and forward the responses to the vehicle compartment **110**. In other implementations, the vehicle compartments **110-120** communicate directly with each other.

(43) In some embodiments, the remote server device **186** may generate a route from a starting location for a compartmentalized EV **100** to an intermediate destination at a centralized location proximate to several final destinations for delivering loads in the respective compartments of the EV **100**. The remote server device **186** may also determine the intermediate destination by identifying a location within a threshold radius of each of the final destinations. Additionally, the remote server device **186** may generate routes from the intermediate destination to each of the final destinations. Then the remote server device **186** may provide the generated routes to the intermediate destination and/or the final destinations to the compartmentalized EV **100** and/or the particular compartments **110-140** delivering loads to the final destinations.

(44) Also in some embodiments, the remote server device **186** may obtain location information for EVs and may determine a meeting location for the EVs, for example during a delivery hand off, described in more detail below.
(45) Additionally, the mobile computing devices **184.1** and **184**.N may be configured to execute one or more algorithms, programs, applications, etc., to (i) determine a geographic location of each respective mobile computing device (and thus their associated vehicle); (ii) to generate, measure, monitor, and/or collect one or more sensor metrics as telematics data; (iii) to broadcast the geographic data and/or telematics data via their respective radio links; (iv) to receive the geographic data and/or telematics data via their respective radio links; (v) to determine whether an alert should be generated based upon the telematics data and/or the geographic location data, to generate the one or more alerts; and/or (vi) to broadcast one or more alert notifications. Such functionality may, in some embodiments be controlled in whole or part by a Data Application operating on the mobile computing devices **184**. Such Data Application may communicate between the mobile computing devices **184** and one or more remote server devices **186** to facilitate centralized data collection and/or processing.
(46) In some embodiments, the Data Application may facilitate control of a vehicle and/or vehicle compartment **110-120** by a user, such as by selecting vehicle destinations and/or routes along which the vehicle and/or vehicle compartment **110-120** will travel. The Data Application may further be used to establish restrictions on vehicle use or store user preferences for vehicle use, such as in a user profile. In further embodiments, the Data Application may monitor vehicle operation or sensor data in real-time to make recommendations or for other purposes as described herein. The Data Application may further facilitate monitoring and/or assessment of the vehicle and/or vehicle compartment **110-120**, such as by evaluating operating data to determine the condition of the vehicle or components thereof (e.g., sensors, autonomous operation features, etc.).
(47) FIG. **2** illustrates a block diagram of an exemplary mobile device **184** or an exemplary on-board computer **106-136** consistent with the compartmentalized EV **100** and the system **180**. The mobile device **184** or on-board computer **106-136** 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, a controller **204**. In some embodiments, the mobile device **184** or on-board computer **106-136** may be integrated into a single device, or either the mobile device **184** or on-board computer **106-136** may perform the functions of both. The on-board computer **106-136** (or mobile device **184**) interfaces with the sensors **221** and/or personal electronic devices to receive information regarding the respective compartment **110-140** and its environment, which information is used by the autonomous operation features to operate the respective compartment **110-140**.
(48) 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** includes 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 **106-136**.
(49) 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 compartment **110-140**.
(50) 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.
(51) 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. Another of the plurality of applications **230** may be a power transferring application **234** that may be implemented as a series of machine-readable instructions for transferring power from the battery **102** to charge another battery **112-132** in another compartment **120-140**. Still another application of the plurality of applications **230** may include a delivery hand off application **236** that may be implemented as a series of machine-readable instructions for receiving a load from another EV and delivering the load to a destination.
(52) 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. One of the plurality of software routines **240** may be a routing routine **242** to route the compartmentalized EV **100** to an intermediate destination. Another of the plurality of software routines **240** may be a detachment routine **244** to detach a particular compartment **140** from the compartmentalized EV **100**. 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, 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.
(53) Similarly, one of the plurality of software routines **240** may be a monitoring and reporting routine **248** that transmits information regarding autonomous vehicle operation to the server **186** via the network **130**. Yet another of the plurality of software routines **240** may be a route separate routine **250** for routing the compartments **110-140** to different final destinations. Any of the plurality of software applications **230** may be designed to operate independently of the software applications **230** or in conjunction with the software applications **230**.
(54) In addition to connections to the sensors **221** that are external to the mobile device **184** or the on-board computer **106-136**, the mobile device **184** or the on-board computer **106-136** may include additional sensors **218**, such as the GPS unit **206** or the accelerometer **224**, which may provide information regarding the particular compartment **110-140** for operation and other purposes. Such sensors **218** may further include one or more sensors of a sensor array **225**, which may include, for example, one or more cameras, accelerometers, gyroscopes, magnetometers, barometers, thermometers, proximity sensors, light sensors, Hall Effect sensors, etc. The one or more sensors of the sensor array **225** may be positioned to determine telematics data regarding the speed, force, heading, and/or direction associated with movements of the particular compartment **110-140**.
(55) Furthermore, the communication unit **220** may communicate with other compartments, autonomous vehicles, infrastructure, or other external sources of information to transmit and receive information relating to vehicle operation. The communication unit **220** may communicate with the external sources via the network **180** 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. 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, or other output from the controller **204** to one or more external sensors within the compartments **110-140**, mobile devices **186**, on-board computers **106-136**, or servers **186**.

(56) The mobile device **184** or the on-board computer **106-136** 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 touch pad, 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.

(57) Exemplary Power Transfer

(58) FIG. **3** illustrates an example transfer of power between the detachable compartments **110-140** within the compartmentalized EV **100**. As mentioned above, the compartments **110-140** may share power amongst the respective batteries **102-132** when for example, one compartment **110** is performing most of the control (e.g., the steering, braking, throttling, etc.) and the others **120-140** are being carried along by being attached to the compartment **110**. Accordingly, the compartments **110-140** may prevent any one compartment from draining its battery while they are attached.

(59) To transfer power amongst each other, the compartments **110-140** may transmit requests for the amount of charge remaining in the batteries **102-132** in each respective compartment **110-140**. For example, the on-board computers **106-136** in the compartments **110-140** may transmit V2V communications to each other requesting charge statuses from the other compartments **110-140** and receiving responses to the requests.

(60) In some implementations, one compartment **110** may act as a primary compartment **110** and may receive the charge statuses from each of the other compartments. Then the primary compartment **110** may identify compartments in which to transfer power based upon the amount of charge remaining in another compartment **120-140** and/or the amount of charge remaining in the primary compartment **110**. For example, the primary compartment **110** may identify compartments **110-140** having more than a first threshold charge level (e.g., 50% battery power remaining) and compartments **110-140** having less than a second threshold charge level (e.g., 20% battery power remaining). The primary compartment **110** may transmit instructions to the compartments **110-140** having more than the first threshold charge level to transfer power to the compartments **110-140** having less than the second threshold charge level.

(61) In other implementations, the primary compartment **110** may aggregate the total amount of charge remaining across the compartments **110-140** and divide the total amount of charge by the number of compartments **110-140** to determine the average amount of charge remaining. Then the primary compartment **110** may transmit instructions to the compartments **110-140** to transfer power between the compartments **110-140** until each of the compartments **110-140** has the average amount of charge remaining, so that each of the compartments **110-140** has the same amount of charge remaining.

(62) In yet other implementations, one compartment does not act as a primary compartment. Instead, each compartment **110-140** receives charge statuses from adjacent compartments directly connected to the compartment. For example, compartment **120** receives charge statuses from compartment **110** and compartment **130**. Then a particular compartment **120** may determine whether any of the adjacent compartments has less power remaining than the second threshold charge level. If the compartment **120** has more power remaining than the first threshold charge level and an adjacent compartment **130** has less power remaining than the second threshold charge level, the compartment **120** transfers power to the adjacent compartment **130** for example, until the adjacent compartment has more power remaining than the second threshold charge level. In another example, the compartment **120** transfers power to the adjacent compartment **130** until both compartments have the same amount of charge remaining. In some implementations, multiple

compartments **120**, **140** may transfer power to the same compartment **130** reducing the amount of power that each compartment **120**, **140** transfers.
(63) In any event, to transfer power from a first compartment **110** to a second compartment **120**, the first compartment **110** transmits a communication signal **302** via a radio link (e.g., a near field communication (NFC) link) to the second compartment **120** to inductively charge the second compartment **120**. The first compartment **110** includes an antenna having a transmit coil and the second compartment **120** includes an antenna having a receive coil. The transmit and receive coils may induce a magnetic field to transfer power from the first compartment to the second compartment **120**. Each compartment **110-140** may transmit communication signals **302-310** via radio links, such as NFC links to inductively charge adjacent compartments. To transfer power to a nonadjacent compartment **140**, a compartment **110** may transfer power to an adjacent compartment **120** which continues to transfer the power to adjacent compartments until the nonadjacent compartment **140** receives the power.
(64) Exemplary Compartmentalized EV Routing
(65) In some embodiments, some or all of the compartments **110-140** include a load to deliver to a different destination. The compartments **110-140** may attach to each other when each of the compartments **110-140** is traveling to the same geographic area (e.g., the same city, the same neighborhood, the same suburb, the same town, etc.) but different destinations within the geographic area. This may save power for the compartments **110-140** by spreading the power out across each of the compartments **110-140** in the compartmentalized EV **100**. Additionally, each compartment **110-140** may not have to control steering, braking, and/or throttling. Instead, one compartment **110-140** may perform most of the control while pulling the other attached compartments **110-140** along or the other attached compartments may provide minimal power to their respective wheels.
(66) FIG. **4** illustrates a schematic diagram of an exemplary compartmentalized EV **100** on a route from a starting location **402** to an intermediate destination **404**. The compartmentalized EV **100** includes four compartments **110-140**, where three of the four compartments may carry loads to different final destinations **406-410**. However, this is merely one example embodiment for ease of illustration only. The compartmentalized EV **100** may include any suitable number of compartments carrying any suitable number of loads to any suitable number of final destinations.
(67) In some implementations, an on-board computer **106-136** in one of the compartments may transmit a request to the remote server device **186** for navigation directions from the starting location **402** to the final destinations **406-410**. The on-board computer **106-136** may also transmit a request for the remote server device **186** to identify an intermediate destination **404** which is equidistant to each of the final destinations **406-410** or within a threshold radius of each of the final destinations **406-410**. The remote server device **186** may communicate with a map and/or navigation server to identify the intermediate destination **402**. The remote server device **186** may also generate a first set of navigation directions for traversing along a first route from the starting location **402** to the intermediate destination **404**. Additionally, the remote server device **186** may generate second sets of navigation directions for traveling along respective second routes from the intermediate destination **404** to each of the final destinations **406-410**. Then the remote server device **186** may transmit each of the first and second sets of navigation directions to the on-board computer **106-136**.
(68) In some implementations, the on-board computer **106-136** may use the first set of navigation directions to cause the compartmentalized EV **100** to travel to the intermediate destination **404**. For example, the on-board computer **106-136** may send control signals to the compartmentalized EV **100**, and more specifically, the steering, braking, and throttling components within the compartmentalized EV **100** to cause the EV **100** to travel along the first route to the intermediate destination **404**.
(69) The on-board computer **106** may also forward the second sets of navigation directions to on-

board computers **116-136** in the respective compartments **120-140**, so that the on-board computers **116-136** may cause the respective compartments **120-140** to travel along the respective second routes to the respective final destinations **406-410**. For example, the on-board computer **106** may forward a set of navigation directions for traveling to a first final destination to a first on-board computer **116**. The on-board computer **106** may forward another set of navigation directions for traveling to a second final destination **408** to a second on-board computer **126**. The on-board computer **106** may also forward a set of navigation directions for traveling to a third final destination **410** to a third on-board computer **136**.
(70) Upon arriving at the intermediate destination **404**, the compartments **120-140** may detach from the compartmentalized EV **100** in the manner described above. For example, the compartments **120-140** may de-energize their respective magnets or may accelerate by more than a threshold acceleration in a direction opposite the direction of attachment to the compartmentalized EV **100**.
(71) Then a first compartment **120** may travel with a first load to a first final destination **406**. For example, the on-board computer **116** may send control signals to the first compartment **120**, and more specifically, the steering, braking, and throttling components within the first compartment **120** to cause the first compartment **120** to travel along a route to the first final destination **406**.
(72) A second compartment **130** may travel with a second load to a second final destination **408**. For example, the on-board computer **126** may send control signals to the second compartment **130**, and more specifically, the steering, braking, and throttling components within the second compartment **130** to cause the second compartment **130** to travel along a route to the second final destination **408**.
(73) A third compartment **140** may travel with a third load to a third final destination **410**. For example, the on-board computer **136** may send control signals to the third compartment **140**, and more specifically, the steering, braking, and throttling components within the third compartment **140** to cause the third compartment **140** to travel along a route to the third final destination **410**.
(74) Exemplary Delivery Hand Off Procedure
(75) In some scenarios, an EV delivering a load to a destination or recipient location may run low on power. The amount of charge remaining for the EV may be too low for the EV to reach the destination or a charging station without running out of power. In these scenarios, the EV may request emergency services, such as towing services or a temporary charge. The EV may also broadcast a notification to other EVs in the geographic area requesting another EV to pick up the load from the EV and transport the load the rest of the way to the destination. For example, the EV may broadcast the notification when the EV determines that the load will not be delivered on time if the EV waits for emergency services to arrive and temporarily charge the EV.
(76) The EV may be fully autonomous, partially autonomous, manually operated, or any suitable combination of these. Additionally, the other EVs receiving the broadcast notification may be fully autonomous, partially autonomous, manually operated, or any suitable combination of these.
(77) FIG. **5**A illustrates an example scenario **500** where an EV **502** delivering a load **510** is running out of power (also referred to herein as a “low charge EV”). For example, the amount of charge remaining in the low charge EV **502** may be below a threshold amount of charge to reach the destination and/or a charging station. The low charge EV **502** may be a compartmentalized EV having detachable compartments. In other implementations, the low charge EV **502** is not a compartmentalized EV.
(78) In any event, the low charge EV **502** may broadcast a notification **512** to EVs within a threshold radius of the low charge EV **502**. For example, the low charge EV **502** may broadcast the notification **512** via a V2V communication, where EVs within communication range of the low charge EV **502** may receive the notification **512**. In other implementations, the low charge EV **502** may transmit the notification **512** to the remote server device **186**. The notification **512** may include an indication of the current location of the low charge EV **502**. The remote server device **186** may also receive location information from other EVs and may forward the notification **512** to

a subset of the EVs having current locations within a threshold radius of the low charge EV **502**.
(79) The notification may also include an indication that the low charge EV **502** has less than a threshold amount of charge remaining, an indication of the route for the low charge EV **502** to travel to the destination, and/or an indication of the destination.
(80) Another EV **504** having an amount of charge remaining which is above the threshold amount of charge (also referred to herein as a “high charge EV”) may receive the notification **512** and may determine a meeting location for the low charge EV **502** to hand off the load **510** to the high charge EV **504**. In some embodiments, the high charge EV **504** may determine the meeting location as the current location of the low charge EV **502**. In other embodiments, the high charge EV **504** may determine the meeting location as a location along the route for the low charge EV **502** to travel to the destination. For example, the high charge EV **504** may determine the meeting location as a waypoint along the low charge EV's **502** route which is closest to the current location of the high charge EV **504** when the low charge EV **502** can reach the waypoint without running out of power. More generally, the high charge EV **504** may determine the meeting location based upon any suitable combination of the current location of the low charge EV **502**, waypoints along the route for the low charge EV **502** to travel to the destination, the current location of the high charge EV **504**, and/or the amount of charge remaining in the low charge EV **502**.
(81) Then the high charge EV **504** may transmit a response message **514** to the low charge EV **502** indicating that the high charge EV **504** will pick up the load **510** from the meeting location and/or deliver the load to the destination. In some implementations, the high charge EV **504** may transmit the response message **514** in response to identifying a meeting location which is within a threshold distance of the current location of the high charge EV **504**.
(82) In other implementations, the remote server device **186** may determine the meeting location based upon any suitable combination of the current location of the low charge EV **502**, waypoints along the route for the low charge EV **502** to travel to the destination, the current location of the high charge EV **504**, and/or the amount of charge remaining in the low charge EV **502**. The remote server device **186** may then transmit a first request to the high charge EV **504** to pick up the load **510** at the meeting location and may transmit a second request to the low charge EV **502** to drop off the load **510** at the meeting location.
(83) In any event, the low charge EV **502** may receive the response message **514** and may transmit an indication to the high charge EV **504** accepting the request to drop off the load **510** at the meeting location. In some implementations, the low charge EV **502** may determine that the meeting location is acceptable in response to determining that the low charge EV **502** will reach the meeting location without running out of power based upon the amount of charge remaining in the low charge EV **502**. In other scenarios, the low charge EV **502** may reject the request and may request a new meeting location and/or may provide a different meeting location. The high charge EV **504** may then accept the different meeting location or may provide yet another proposed meeting location.
(84) In response to agreeing to a meeting location, the low and high charge EVs **502**, **504** may travel to the meeting location. When the low and high charge EVs **502**, **504** are fully autonomous, the on-board computers in the respective EVs **502**, **504** may obtain routes (e.g., from the remote server device **186**) for traveling from their respective current locations to the meeting location. Then the on-board computers may send control signals to the respective EVs **502**, **504**, and more specifically, the steering, braking, and throttling components within the respective EVs **502**, **504** to cause the respective EVs **502**, **504** to travel to the meeting location.
(85) FIG. 5B illustrates an example scenario **530** where the low and high charge EVs **502**, **504** reach the meeting location. Upon reaching the meeting location, the low charge EV **502** may hand off or deliver the load **510** to the high charge EV **504**. In some implementations, such as when the low charge EV **502** is a fully autonomous vehicle, an on-board computer at the low charge EV **502** may send control signals to a back door or trunk of the low charge EV to cause the back door or

trunk to open for transferring the load **510**. The high charge EV **504** may also position itself so that back door or trunk of the high charge EV **504** is adjacent to the back door or trunk of the low charge EV **502**. An on-board computer at the high charge EV **504** may send control signals to the back door or trunk of the high charge EV to cause the back door or trunk to open for receiving the load **510**.

(86) Also in some implementations, the low charge EV **502** may include a robotic arm for picking up the load **510** in the low charge EV **502** and dropping off the load **510** into the high charge EV **504** via the back door or trunk. In other implementations, the low charge EV **502** may automatically slide out a flat surface that extends from the back door or trunk of the low charge EV **502** to the back door or trunk of the high charge EV **504**. The low charge EV **502** may include an electrically controlled mechanism for sliding out and/or retracting the flat surface from the back door or trunk of the low charge EV **502**. Then the robotic arm may push the load **510** across the flat surface until the load **510** reaches the back door or trunk of the high charge EV **502**.

(87) The low charge EV **502** may then provide control signals to the flat surface to retract the flat surface back into the low charge EV **502**. The low and high charge EVs **502**, **504** may also send control signals to close the back doors or trunks of the respective EVs **502**, **504**. In other implementations, a human operator may transfer the load **510** from the low charge EV **502** to the high charge EV **504**.

(88) FIG. **5**C illustrates an example scenario **560** after the load **510** has been transferred from the low charge EV **502** to the high charge EV **504**. In this scenario **560**, the high charge EV **504** may obtain a route (e.g., from the remote server device **186**) for traveling from the meeting location to the destination location for the load **510**. Then the on-board computer for the high charge EV **504** may send control signals to the high charge EV **504**, and more specifically, the steering, braking, and throttling components within the high charge EV **504** to cause the high charge EV **504** to travel to the destination location. Upon reaching the destination location, the high charge EV **504** may deliver the load **510** to the recipient. The low charge EV **502** may pull over to the side of the road and wait for emergency services to arrive to tow the low charge EV **502** or provide a temporary charge to the low charge EV **502**.

(89) While the example scenario illustrated in FIGS. **5**A-**5**C includes a delivery hand off procedure between two EVs **502**, **504**, this is merely one example embodiment for ease of illustration only. The delivery hand off procedure may include any suitable number of EVs for transporting a load to a destination. For example, a first EV may transport a load for a first portion of a route, and may transfer the load to a second EV which may transport the load for a second portion of the route. The second EV may then transfer the load to a third EV which may transport the load for a third portion of the route. The third EV may then transfer the load to an nth EV which may transport the load for an nth portion of the route and may arrive at the destination.

(90) Exemplary Power Transfer Method

(91) FIG. **6** illustrates a flow diagram of an exemplary power transfer method **600** for transferring power between compartments of an EV **100**. In some embodiments, the power transfer method **600** may be implemented on the on-board computer **106-136** within a compartment **110-140** of the EV **100**.

(92) The power transfer method **600** may include determining the amount of charge remaining for powering a detachable compartment **120** of the EV **100** (block **602**). Then the on-board computer **116** may obtain indication(s) of amount(s) of charge remaining for powering other compartment(s) **110**, **130** in the EV **100** (block **604**). The on-board computer **116** may then transfer at least some charge remaining for powering the detachable compartment **120** to another compartment **110** based upon the amount of charge remaining for powering the compartment **120** and/or the amount of charge remaining for powering the other compartment **110** (block **606**). Although the method **600** is described with reference to the on-board computer **116** for simplicity, the described method may be easily modified for implementation by other systems or devices, including the mobile device **184**.

(93) At block **602**, the on-board computer **116** may determine the amount of charge remaining for powering the detachable compartment **120** which houses the on-board computer **116** for example, by receiving an indication of the amount of charge remaining from a charge level sensor in the battery **112**. The indication may be a battery percentage or an energy metric. The on-board computer **116** may receive continuous or periodic (e.g., every second, every minute, etc.) updates from the charge level sensor indicating the current amount of charge remaining in the battery **112**.
(94) At block **604**, the on-board computer **116** may obtain indication(s) of amount(s) of charge remaining for powering other compartment(s) **110**, **130** in the EV **100**. The on-board computer **116** may obtain indications from other compartments **110**, **130** which are adjacent to the compartment **120** which houses the on-board computer **116**.
(95) At block **606**, the on-board computer **116** transfers power to another compartment **110**. To transfer power from a first compartment **120** to a second compartment **110**, the first compartment **120** may transmits a communication signal via a radio link (e.g., a near field communication (NFC) link) to the second compartment **110** to inductively charge the second compartment **110**. The first compartment **120** may include an antenna having a transmit coil and the second compartment **110** may include an antenna having a receive coil. The transmit and receive coils may induce a magnetic field to transfer power from the first compartment to the second compartment **120**. To transfer power to a nonadjacent compartment **140**, a compartment **120** may transfer power to an adjacent compartment **130** which continues to transfer the power to adjacent compartments until the nonadjacent compartment **140** receives the power.
(96) The on-board computer **116** may transfer power to another compartment **110** in response to determining that the amount of charge remaining in the compartment **120** which houses the on-board computer **112** exceeds a first threshold charge level (e.g., 50% battery power remaining) and/or in response to determining that the amount of charge remaining in another compartment **110** is less than a second threshold charge level (e.g., 20% battery power remaining). Then the on-board computer **116** may transfer power to the other compartment **110** until the other compartment **110** has more power remaining than the second threshold charge level. In another example, the compartment **120** may transfer power to the other compartment **110** until both compartments have the same amount of charge remaining. In yet another example, the compartment **120** may transfer power to adjacent compartments **110**, **130** until the compartment **120** and the adjacent compartments **110**, **130** each have the same amount of charge remaining. The method **600** may include additional, less, or alternate actions, including those discussed elsewhere herein.
(97) Exemplary Delivery Method
(98) FIG. **7** illustrates a flow diagram of an exemplary delivery method **700** for delivering loads in detachable compartments **110-140** of a compartmentalized EV **100** to different final destinations **406-410**. In some embodiments, the delivery method **700** may be implemented on the on-board computer **106-136** within a compartment **110-140** of the EV **100**. The compartmentalized EV **100** and/or each of the compartments **110-140** may be operating in a fully autonomous mode of operation without any control decisions being made by a vehicle operator, excluding navigation decisions such as selection of a destination or route.
(99) In some embodiments, the compartmentalized EV **100** and/or each of the compartments **110-140** may be operating with only passengers who are physically or legally unable to operate the vehicles in a manual or semi-autonomous mode of operation (e.g., children, persons suffering acute illness, intoxicated or otherwise impaired persons, etc.). In other embodiments, the compartmentalized EV **100** and/or each of the compartments **110-140** may be operated manually by a driver or may be operating in a semi-autonomous mode with some control decisions being made by a vehicle operators and others being made autonomously, such as adaptive cruise control.
(100) The delivery method **700** may include causing a compartmentalized EV **100** to travel to an intermediate destination **404** (block **702**). In response to determining that the compartmentalized EV **100** has arrived at the intermediate destination **404** (block **704**), the on-board computer **106-136**

within a compartment **110-140** may cause at least one compartment **120** to detach from the compartmentalized EV **100** and deliver a first load to a first final destination **406** (block **706**). Although the method **700** is described with reference to the on-board computer **106-136** for simplicity, the described method may be easily modified for implementation by other systems or devices, including the mobile device **184**.

(101) At block **702**, the on-board computer **106-136** may cause the compartmentalized EV **100** to travel to an intermediate destination **404**. In some implementations, the on-board computer **106-136** in one of the compartments **110-140** may transmit a request to the remote server device **186** for navigation directions from the starting location **402** to the final destinations **406-410**. The on-board computer **106-136** may also transmit a request for the remote server device **186** to identify an intermediate destination **404** which is equidistant to each of the final destinations **406-410** or within a threshold radius of each of the final destinations **406-410**.

(102) The remote server device **186** may communicate with a map and/or navigation server to identify the intermediate destination **402**. The remote server device **186** may also generate a first set of navigation directions for traversing along a first route from the starting location **402** to the intermediate destination **404**. Additionally, the remote server device **186** may generate second sets of navigation directions for traveling along respective second routes from the intermediate destination **404** to each of the final destinations **406-410**. Then the remote server device **186** may transmit each of the first and second sets of navigation directions to the on-board computer **106-136**.

(103) In some implementations, the on-board computer **106-136** may use the first set of navigation directions to cause the compartmentalized EV **100** to travel to the intermediate destination **404**. For example, the on-board computer **106-136** may send control signals to the compartmentalized EV **100**, and more specifically, the steering, braking, and throttling components within the compartmentalized EV **100** to cause the EV **100** to travel along the first route to the intermediate destination **404**.

(104) At block **704**, the on-board computer **106-136** may determine that the compartmentalized EV **100** has arrived at the intermediate destination **404**. Then at block **706**, the on-board computer **106-136** may cause at least one compartment **120** to detach from the compartmentalized EV **100** and deliver a first load to a first final destination **406**. In some implementations, the on-board computer **106** may be in a first compartment **110** and may transmit instructions to an on-board computer **136** in a second compartment **140** to detach from the compartmentalized EV **100**. In other implementations, the on-board computer **116** may detach the compartment **120** which houses the on-board computer **116** from the compartmentalized EV **100**. For example, the on-board computer **116** may de-energize a magnets used to attach the compartment **120** to another compartment **110** or may cause the compartment **120** to accelerate by more than a threshold acceleration in a direction opposite the direction of attachment to the compartmentalized EV **100**.

(105) Then the on-board computer **116** may send control signals to the first compartment **120**, and more specifically, the steering, braking, and throttling components within the first compartment **120** to cause the first compartment **120** to travel along a route to the first final destination **406**.

(106) In some implementations, the on-board computer **106-116** may also cause the compartmentalized EV **100** to deliver a second load to a second final destination. For example, the on-board computer **106-116** may send control signals to the compartmentalized EV **100** and/or at least one of the remaining compartments in the compartmentalized EV **100**, and more specifically, the steering, braking, and throttling components within the compartmentalized EV **100** to cause the compartmentalized EV **100** to travel along a route to the second final destination. The method **700** may include additional, less, or alternate actions, including those discussed elsewhere herein.

(107) Exemplary Delivery Hand Off Method

(108) FIG. **8** illustrates a flow diagram of an exemplary delivery hand off method **800** for handing off a load **510** when a second EV **502** delivering the load **510** is running out of power. In some

embodiments, the delivery method **800** may be implemented on the on-board computer of the first EV **504** receiving the load. The first EV **502** and/or the second EV **504** may be operating in a fully autonomous mode of operation without any control decisions being made by a vehicle operator, excluding navigation decisions such as selection of a destination or route.

(109) In some embodiments, the first EV **502** and/or the second EV **504** may be operating with only passengers who are physically or legally unable to operate the vehicles in a manual or semi-autonomous mode of operation (e.g., children, persons suffering acute illness, intoxicated or otherwise impaired persons, etc.). In other embodiments, the first EV **502** and/or the second EV **504** may be operated manually by a driver or may be operating in a semi-autonomous mode with some control decisions being made by a vehicle operators and others being made autonomously, such as adaptive cruise control.

(110) The delivery hand off method **800** may include receiving, at a first EV **504**, an indication from a second EV **502** that the second EV **502** has less than a threshold amount of charge remaining and/or an indication of a destination for delivering a load **510** in the second EV **502** (block **802**). The on-board computer of the first EV **504** may determine a meeting location for handing off the load **510** in the second EV **502** (block **804**). The on-board computer of the first EV **504** may cause the first EV **504** to travel to the meeting location (block **806**). In response to receiving the load **510** (block **808**), the on-board computer of the first EV **504** may cause the first EV **504** to travel to the destination for delivering the load **510** (block **810**). Although the method **800** is described with reference to the on-board computer for simplicity, the described method may be easily modified for implementation by other systems or devices, including the mobile device **184**.

(111) At block **802**, the first EV **504** receives an indication from the second EV **502** that the second EV **502** has less than a threshold amount of charge remaining and/or an indication of a destination for delivering a load **510** in the second EV **502**. In some implementations, the second EV **502** may broadcast a notification **512** to EVs within a threshold radius of the second EV **502**. For example, the second EV **502** may broadcast the notification **512** via a V2V communication, where EVs within communication range of the second EV **502** may receive the notification **512**. In other implementations, the second EV **502** may transmit the notification **512** to the remote server device **186**. The notification **512** may include an indication of the current location of the second EV **502**. The remote server device **186** may also receive location information from other EVs and may forward the notification **512** to a subset of the EVs having current locations within a threshold radius of the second EV **502**.

(112) The notification may also include an indication that the second EV **502** has less a threshold amount of charge remaining, an indication of the route for the second EV **502** to travel to the destination, and/or an indication of the destination.

(113) At block **804**, the first EV **504** may determine a meeting location for handing off the load **510** in the second EV **502**. The first EV **504** may determine the meeting location based upon any suitable combination of the current location of the second EV **502**, waypoints along the route for the second EV **502** to travel to the destination, the current location of the first EV **504**, and/or the amount of charge remaining in the second EV **502**.

(114) In some implementations, the first EV **504** may transmit a response message **514** to the second EV **502** indicating that the first EV **504** will pick up the load **510** from the meeting location and/or deliver the load **510** to the destination.

(115) In other implementations, the remote server device **186** may determine the meeting location based upon any suitable combination of the current location of the second EV **502**, waypoints along the route for the second EV **502** to travel to the destination, the current location of the first EV **504**, and/or the amount of charge remaining in the second EV **502**. The remote server device **186** may then transmit a first request to the first EV **504** to pick up the load **510** at the meeting location and may transmit a second request to the second EV **502** to drop off the load **510** at the meeting

location.
(116) In any event, the second EV **502** may receive the response message **514** and may transmit an indication to the first EV **504** accepting the request to drop off the load **510** at the meeting location. In some implementations, the second EV **502** may determine that the meeting location is acceptable in response to determining that the second EV **502** will reach the meeting location without running out of power based upon the amount of charge remaining in the second EV **502**.
(117) At block **806**, the first EV **504** may travel to the meeting location. For example, the on-board computer in the first EV **504** may obtain a route (e.g., from the remote server device **186**) for traveling from its current locations to the meeting location. Then the on-board computer may send control signals to the first EV **504**, and more specifically, the steering, braking, and throttling components within the first EV **504** to cause the first EV **504** to travel to the meeting location.
(118) At block **808**, the first EV **504** may receive the load **510** from the second EV **502**. In some implementations, such as when the second EV **502** is a fully autonomous vehicle, an on-board computer at the second EV **502** may send control signals to a back door or trunk of the second EV to cause the back door or trunk to open for transferring the load **510**. The first EV **504** may also position itself so that back door or trunk of the first EV **504** is adjacent to the back door or trunk of the second EV **502**. An on-board computer at the first EV **504** may send control signals to the back door or trunk of the first EV **504** to cause the back door or trunk to open for receiving the load **510**. Also in some implementations, the second EV **502** may include a robotic arm for picking up the load **510** in the second EV **502** and dropping off the load **510** into the first EV **504** via the back door or trunk. In other implementations, a human operator may transfer the load **510** from the second EV **502** to the first EV **504**.
(119) At block **810**, the first EV **504** may travel to the destination for delivering the load **510**. In some implementations, the first EV **504** may obtain a route (e.g., from the remote server device **186**) for traveling from the meeting location to the destination location for the load **510**. Then the on-board computer for the first EV **504** may send control signals to the first EV **504**, and more specifically, the steering, braking, and throttling components within the first EV **504** to cause the first EV **504** to travel to the destination location. Upon reaching the destination location, the first EV **504** may deliver the load **510** to the recipient. The method **800** may include additional, less, or alternate actions, including those discussed elsewhere herein.
(120) Exemplary Drone Swarm
(121) FIG. **9** illustrates an exemplary drone swarm **900** including several drones **902-904*n***. For example, the drones **902-904*n*** may travel together in a swarm **900** to deliver loads to the same geographic area (e.g., the same city, the same neighborhood, the same suburb, the same town, etc.) but different destinations within the geographic area. This may save power for the drones **902-904*n*** by spreading the power out across each of the drones **902-904*n*** in the swarm **900**. Additionally, each drone **902-904*n*** may not have to control propulsion. Instead, one drone **902** may perform most of the control while carrying the other attached drones **904*a*-904*n*** along.
(122) Each drone **902-904*n*** may include a processor, a memory, a sensor array, a communication unit, a cargo bay (e.g., for storing loads to be delivered to various destinations), and/or a power supply such as a battery. The communication unit may be configured to support any suitable number and/or type of communication protocols to facilitate communications between the drone **902-904*n*** and other drones **902-904*n*** in the swarm and/or the remote server device **186**.
(123) In some implementations, the drones **902-904*n*** may navigate autonomously or with minimal assistance from one or more persons. For example, the swarm **900** may receive instructions (e.g., from the remote server device **186**) to travel along a first route to an intermediate destination, and for each individual drone **902-904*n*** or a subset of the drones **902-904*n*** to travel along second routes to different final destinations. The drones **902-904*n*** in the swarm **900** may navigate autonomously to the intermediate destination **902-904*n*** and/or the respective final destinations.
(124) In some implementations, the drones **902-904*n*** may include a hierarchy in which at least one

of the drones **902** acts as a “mothership” drone to exert control over the other drones **904***a*-**904***n*. The mothership drone **902** may carry the other drones **904***a*-**904***n* to an intermediate destination and the other drones **904***a*-**904***n* may detach from the mothership drone and/or exit the cargo bay of the mothership drone **902** and travel to different final destinations to deliver respective loads. In some implementations, the mothership drone **902** may also travel to a final destination to deliver a load stored in the cargo bay of the mothership drone **902**.

(125) Each of the drones **904***a*-**904***n* may attach to the mothership drone **902** for example, via magnets on an external surface of the mothership drone **902** and on external surfaces of each of the other drones **904***a*-**904***n*. In other implementations, the mothership drone **902** may be layered with a magnetic coating or may include magnetic materials to attach to the other drones **904***a*-**904***n* which may also be layered with a magnetic coating or may include magnetic materials.

(126) The magnets may be permanent magnets or electromagnets. In embodiments where the magnets are electromagnets, the processor within a drone **902**-**904***n* may send a control signal to energize the magnet for the drone **902**-**904***n*. To detach from another drone **902**-**904***n* such as the mothership drone **902**, the processor may stop sending an electric signal to the magnet to de-energize the magnet. Then the magnet may no longer attach to the magnet for the mothership drone **902**.

(127) In other implementations, such as when the magnets are permanent magnets, a drone **904***a*-**904***n* may accelerate by more than a threshold acceleration in a direction opposite the direction of attachment to the mothership drone **902** to detach from the swarm **900**. The threshold acceleration may correspond to a force which is greater than the force of magnetic attraction of the magnets to separate the drone **904***a*-**904***n* from the mothership drone **902**. For example, the bottom of the drone **904***a*-**904***n* may be attached at the bottom to an external surface of the mothership drone **902**. To detach from the mothership drone **902**, the drone **904***a*-**904***n* may accelerate upwards away from the attachment by more than the threshold acceleration.

(128) In yet other implementations, the drones **904***a*-**904***n* may be stored in the cargo bay of the mothership drone **902** without using magnets to attach to the mothership drone **902**. In still other implementations, the drones **904***a*-**904***n* may not use magnets to attach to the mothership drone **902** or be stored within the cargo bay of the mothership drone **902**. Instead, the drones **902**-**904***n* may fly within a threshold distance of each other, and/or may be communicatively coupled to each other and within range to transfer power amongst each other.

(129) Similar to the compartmentalized EV **100**, the drones **902**-**904***n* within the swarm may share power amongst the respective batteries when for example, one drone **902** is performing most of the control (e.g., the mothership drone **902**) and the others **904***a*-**904***n* are being carried along by being attached to the mothership drone **902** and/or being stored in the cargo bay of the mothership drone **902**. Accordingly, the drones **902**-**904***n* may prevent any one drone **902**-**904***n* from draining its battery while they are attached.

(130) To transfer power amongst each other, the drones **902**-**904***n* may transmit requests for the amount of charge remaining in the batteries in each respective drone **902**-**904***n*. For example, the processor in each drone **902**-**904***n* may transmit communications to each other requesting charge statuses from the other drones **902**-**904***n* and receive responses to the requests.

(131) In some implementations, one drone **902** may act as a primary drone **902** and may receive the charge statuses from each of the other drones **904***a*-**904***n*. Then the primary drone **902** may identify drones in which to transfer power based upon the amount of charge remaining in another drone **904***a*-**904***n* and/or the amount of charge remaining in the primary drone **902**. For example, the primary drone **902** may identify drones **902**-**904***n* having more than a first threshold charge level (e.g., 50% battery power remaining) and drones **902**-**904***n* having less than a second threshold charge level (e.g., 20% battery power remaining). The primary drone **902** may transmit instructions to the drones **902**-**904***n* having more than the first threshold charge level to transfer power to the drones **902**-**904***n* having less than the second threshold charge level.

(132) In other implementations, the primary drone **902** may aggregate the total amount of charge remaining across the drones **902-904***n* and divide the total amount of charge by the number of drones **902-904***n* to determine the average amount of charge remaining. Then the primary drone **902** may transmit instructions to the drones **902-904***n* to transfer power between the drones **902-904***n* until each of the drones **902-904***n* has the average amount of charge remaining, so that each of the drones **902-904***n* has the same amount of charge remaining.
(133) In yet other implementations, one drone **902** does not act as a primary drone. Instead, each drone **902-904***n* receives charge statuses from the other drones **902-904***n*. Then a particular drone **902** may determine whether any of the other drones **904***a***-904***n* has less power remaining than the second threshold charge level. If the drone **902** has more power remaining than the first threshold charge level and another drone **904***a***-904***n* has less power remaining than the second threshold charge level, the drone **902** transfers power to the other drone **904***a***-904***n* for example, until the other drone **904***a***-904***n* has more power remaining than the second threshold charge level. In another example, the drone **902** transfers power to the other drones **904***a***-904***n* until both drones have the same amount of charge remaining. In some implementations, multiple drones **902**, **904***a* may transfer power to the same drone **904***b* reducing the amount of power that each drone **902**, **904***a* transfers.
(134) In any event, to transfer power from a first drone **902** to a second drone **904***a*, the first drone **902** transmits a communication signal **912***a* via a radio link (e.g., a near field communication (NFC) link) to the second drone **904***a* to inductively charge the second drone **904***a*. The first drone **902** includes an antenna having a transmit coil and the second drone **904***a* includes an antenna having a receive coil. The transmit and receive coils may induce a magnetic field to transfer power from the first drone **902** to the second drone **904***a*. Each drone **902-904***n* may transmit communication signals **912***a***-926***b* via radio links, such as NFC links to inductively charge other drones **902-904***n* in the swarm **900**.
(135) While the swarm **900** includes one mothership drone **902** and four other drones **904***a***-904***n*, this is merely one exemplary embodiment for ease of illustration only. A swarm **900** may include any suitable number of mothership drones **902** or may not include any mothership drones **902** and/or may include any suitable number of other drones **904***a***-904***n*.
(136) Exemplary Drone Power Transfer Method
(137) FIG. **10** illustrates a flow diagram of an exemplary drone power transfer method **1000** for transferring power between drones **902-904***n* within a swarm **900**. In some embodiments, the power transfer method **1000** may be implemented by the processor within a drone **902-904***n* of the swarm **900**.
(138) The drone power transfer method **1000** may include determining the amount of charge remaining for powering a drone **902** of the swarm **900** (block **1002**). Then the processor in the drone **902** may obtain indication(s) of amount(s) of charge remaining for powering other drones **904***a***-904***n* in the swarm **900** (block **1004**). The processor may then transfer at least some charge remaining for powering the drone **902** to another drone **904***a***-904***n* based upon the amount of charge remaining for powering the drone **902** and/or the amount of charge remaining for powering the other drone **904***a***-904***n* (block **1006**).
(139) At block **1002**, the processor may determine the amount of charge remaining for powering the drone **902** which houses the processor for example, by receiving an indication of the amount of charge remaining from a charge level sensor in the battery. The indication may be a battery percentage or an energy metric. The processor may receive continuous or periodic (e.g., every second, every minute, etc.) updates from the charge level sensor indicating the current amount of charge remaining in the battery.
(140) At block **1004**, the processor may obtain indication(s) of amount(s) of charge remaining for powering other drones **904***a***-904***n* in the swarm **900**.
(141) At block **1006**, the processor transfers power to another drone **904***a***-904***n*. To transfer power

from a first drone **902** to a second drone **904***a*, the first drone **902** may transmits a communication signal via a radio link (e.g., a near field communication (NFC) link) to the second drone **904***a* to inductively charge the second drone **904***a*.

(142) The processor may transfer power to another drone **904***a*-**904***n* in response to determining that the amount of charge remaining in the drone **902** which houses the processor exceeds a first threshold charge level (e.g., 50% battery power remaining) and/or in response to determining that the amount of charge remaining in another drone **904***a*-**904***n* is less than a second threshold charge level (e.g., 20% battery power remaining). Then the processor may transfer power to the other drone **904***a*-**904***n* until the other drone **904***a*-**904***n* has more power remaining than the second threshold charge level. In another example, the drone **902** may transfer power to the other drone **904***a*-**904***n* until both drones have the same amount of charge remaining. The method **1000** may include additional, less, or alternate actions, including those discussed elsewhere herein.

(143) Other Matters

(144) 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.

(145) 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).

(146) 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.

(147) 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 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 module that operates to perform certain operations as described herein.

(148) In various embodiments, a module may be implemented mechanically or electronically. Accordingly, the term "module" 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 modules are temporarily configured (e.g., programmed), each of the modules need not be configured or instantiated at any one instance in time. For example, where the modules comprise a general-purpose processor configured using software, the general-purpose processor may be configured as respective different modules at different times. Software may accordingly configure a processor, for example, to constitute a particular module at one instance of time and to constitute a different module at a different instance of time.

(149) Modules can provide information to, and receive information from, other modules. Accordingly, the described modules may be regarded as being communicatively coupled. Where multiple of such modules exist contemporaneously, communications may be achieved through signal transmission (e.g., over appropriate circuits and buses) that connect the modules. In embodiments in which multiple modules are configured or instantiated at different times, communications between such modules may be achieved, for example, through the storage and retrieval of information in memory structures to which the multiple modules have access. For example, one module may perform an operation and store the output of that operation in a memory device to which it is communicatively coupled. A further module may then, at a later time, access the memory device to retrieve and process the stored output. Modules may also initiate communications with input or output devices, and can operate on a resource (e.g., a collection of information).

(150) 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. Moreover, the systems and methods described herein are directed to an improvement to computer functionality and improve the functioning of conventional computers.

(151) Similarly, the methods or routines described herein may be at least partially processor-implemented. For example, at least some of the operations of a method may be performed by one or more processors or processor-implemented modules. 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.

(152) 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 one or more processors or processor-implemented modules may be located in a single geographic location (e.g., within a home environment, an office environment, or a server farm). In other example embodiments, the one or more processors or processor-implemented modules may be distributed across a number of geographic locations.

(153) 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. 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.

(154) 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. 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. This description, and the claims that follow, should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

(155) 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. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

(156) 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.

(157) 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.

(158) While the preferred embodiments of the invention have been described, it should be understood that the invention is not so limited and modifications may be made without departing from the invention. The scope of the invention is defined by the appended claims, and all devices that come within the meaning of the claims, either literally or by equivalence, are intended to be embraced therein. It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting, and that it be understood that it is the following claims, including all equivalents, that are intended to define the spirit and scope of this invention.

Claims

1. A compartmentalized electric vehicle (EV) having a plurality of attached compartments each configured to operate separately from other compartments, the EV comprising: a plurality of detachable compartments, each detachable compartment including: a power supply; a motor; a magnet attached to an external surface of the detachable compartment; an on-board computing device configured to transmit a control signal to energize the magnet; a set of wheels; and one or more autonomous operation features, wherein the plurality of detachable compartments are attached to each other via magnetic attraction from the magnets to travel to a same location, wherein the on-board computing device stops sending the control signal to de-energize the magnet attached to the external surface of the detachable compartment to detach from the compartmentalized EV, and wherein the on-board computing device is configured to determine an amount of charge remaining for powering the detachable compartment, and transfer at least some of the charge remaining for powering the detachable compartment to another detachable compartment in response to determining the amount of charge remaining for powering the detachable compartment is above a first threshold charge level, and the amount of charge remaining for powering the other detachable compartment is below a second threshold charge level.
2. The compartmentalized EV of claim 1, wherein the on-board computing device is configured to transfer at least some of the charge remaining for powering the detachable compartment to the other detachable compartment such that each detachable compartment has a same amount of charge remaining.
3. The compartmentalized EV of claim 1, wherein the compartmentalized EV travels to an intermediate destination, and two or more of the plurality of detachable compartments are configured to detach from the compartmentalized EV, and travel to different final destinations.
4. The compartmentalized EV of claim 3, wherein a first detachable compartment includes a first load to be delivered to a first final destination and a second detachable compartment includes a second load to be delivered to a second final destination.
5. The compartmentalized EV of claim 1, wherein each compartment is further configured to detach from the compartmentalized EV by accelerating by more than a threshold acceleration in a direction opposite a direction of attachment to the compartmentalized EV.
6. A computer-implemented method in a compartmentalized electric vehicle (EV) for delivering loads to a plurality of final destinations, the method comprising: causing a compartmentalized EV, by one or more processors in the compartmentalized EV having a plurality of detachable compartments, each detachable compartment including a power supply, a motor, a magnet attached to an external surface of the detachable compartment, a set of wheels, and one or more autonomous operation features, to travel to an intermediate destination within a threshold range of a plurality of final destinations, wherein the plurality of detachable compartments are attached to each other via magnetic attraction from the magnets; determining an amount of charge remaining for powering a first detachable compartment; transferring at least some of the charge remaining for powering the first detachable compartment to a second detachable compartment in response to determining the amount of charge remaining for powering the first detachable compartment is above a first threshold charge level, and the amount of charge remaining for powering the second detachable compartment is below a second threshold charge level; and in response to arriving at the intermediate destination, causing at least one of the plurality of detachable compartments, by one or more processors in the detachable compartment, to detach from the compartmentalized EV by stopping a control signal from being sent to the magnet to de-energize the magnet attached to the external surface of the detachable compartment and to deliver a first load in the detachable compartment to a first final destination of the plurality of final destinations.
7. The computer-implemented method of claim 6, further comprising: causing the compartmentalized EV to deliver a second load to a second final destination of the plurality of final destinations.

8. The computer-implemented method of claim 6, wherein causing the compartmentalized EV to travel to the intermediate destination includes: obtaining an indication of a route for traveling from a starting location to the intermediate destination; and sending control signals to the compartmentalized EV to cause the compartmentalized EV to travel along the route to the intermediate destination.

9. The computer-implemented method of claim 6, wherein causing the detachable compartment to detach from the compartmentalized EV and to deliver the first load includes: obtaining an indication of a route for traveling from the intermediate destination to the first final destination; detaching from the compartmentalized EV in response to arriving at the intermediate destination; and sending control signals to the detachable compartment to cause the detachable compartment to travel along the route to the first final destination.

10. The computer-implemented method of claim 6, wherein at least some of the charge remaining for powering the first detachable compartment is transferred to the second detachable compartment such that each compartment has a same amount of charge remaining.