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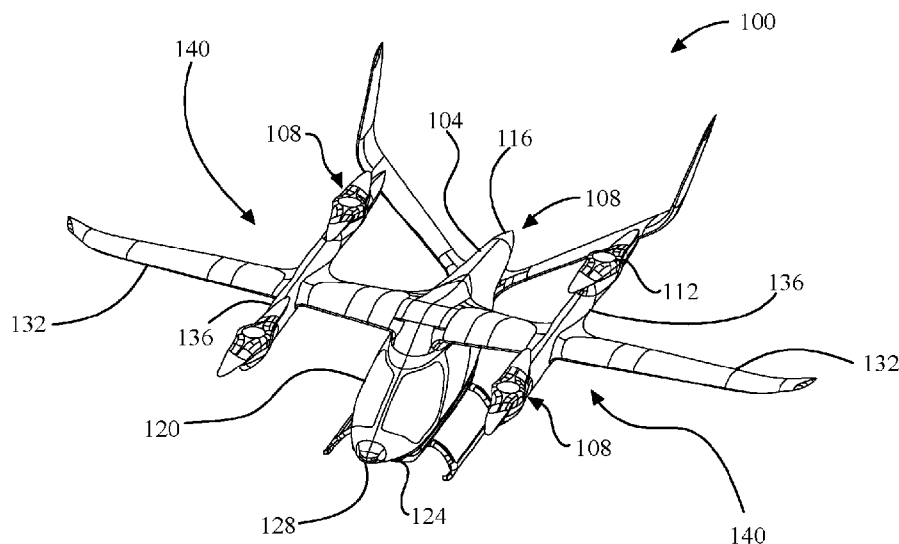


FIG. 1

(57) Abstract: A hybrid electric vertical takeoff and landing (VTOL) aircraft. The hybrid electric VTOL aircraft generally includes a fuselage, a pair of wings, a pair of booms, a plurality of flight components and a power system. The wings are connected to the fuselage and extend generally laterally therefrom with each wing on either side of the fuselage. Each boom is connected to a respective one of the wings and extends generally longitudinally and parallel to the fuselage. The plurality of flight components is configured to provide thrust to the hybrid electric VTOL aircraft. The power system is configured to power the plurality of flight components and includes at least a fuel tank and a generator, and at least a battery. The at least a fuel tank is mounted to at least one of the booms. The at least a battery is configured to power the plurality of flight components.



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HYBRID ELECTRIC VERTICAL TAKEOFF AND LANDING AIRCRAFT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority of U.S. Nonprovisional Application Serial No. 17/733,487, filed on April 29, 2022, and entitled “HYBRID ELECTRIC VERTICAL TAKEOFF
5 AND LANDING AIRCRAFT,” U.S. Nonprovisional Application Serial No. 17/733,686, filed on April 29, 2022, and entitled “FUEL POD FOR HYBRID ELECTRIC AIRCRAFT,” U.S. Nonprovisional Application Serial No. 17/734,014, filed on April 30, 2022, and entitled “HYBRID PROPULSION SYSTEMS FOR AN ELECTRIC AIRCRAFT,” and U.S. Nonprovisional Application Serial No. 18/116,141, filed on March 1, 2023, and entitled
10 “HYBRID PROPULSION SYSTEMS FOR AN ELECTRIC AIRCRAFT,” which are each incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to the field of hybrid electric aircraft. In particular, the present invention is directed to hybrid electric vertical takeoff and landing
15 (VTOL) aircraft.

BACKGROUND

Hybrid electric aircraft utilize at least two sources of energy to power the aircraft. However, optimally utilizing and distributing the power from these sources of energy can be a complex task and involve challenges.

SUMMARY OF THE DISCLOSURE

In an aspect, a hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising: a fuselage; a pair of wings connected to the fuselage and extending generally laterally therefrom, wherein each wing is on either side of the fuselage; a
25 pair of booms with each boom connected to a respective one of the wings, wherein each boom extends generally longitudinally and parallel to the fuselage; a plurality of flight components configured to provide thrust to the hybrid electric VTOL aircraft; and a power system configured to power the plurality of flight components, wherein the power system comprises: at least a fuel tank and a generator, wherein the at least a fuel tank is mounted to at least one of the booms; and
30 at least a battery configured to power the plurality of flight components.

In another aspect, a hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising: a fuselage; a pair of wings connected to the fuselage and extending generally laterally therefrom, wherein each wing is on either side of the fuselage; a pair of booms with each boom connected to a respective one of the wings, wherein each boom
5 extends generally longitudinally and parallel to the fuselage; a plurality of flight components configured to provide thrust to the hybrid electric VTOL aircraft, wherein a flight component of the plurality of flight components comprises a propulsor; a power system configured to power the plurality of flight components, wherein the power system comprises: at least a fuel tank and a generator, wherein the at least a fuel tank is mounted to one boom of the pair of booms; and at
10 least a battery configured to power the plurality of flight components; and a flight controller configured to command the plurality of flight components into a flight mode, wherein the flight mode comprises at least a regenerative drag operation.

In another aspect, a fuel pod for a hybrid electric aircraft, the fuel pod comprising: a housing; a fuel tank contained within the housing, wherein the fuel tank is configured to hold a
15 fuel therein; a generator contained within the housing and connected to the fuel tank, wherein the generator is configured to power at least one of a plurality of flight components of a hybrid electric aircraft; and a connection mechanism at the housing, wherein the connection mechanism is configured to removably attach the fuel pod to the hybrid electric aircraft, and wherein the connection mechanism comprises: an electrical interface configured to electrically link to at least
20 one of the plurality of flight components of the hybrid electric aircraft; and a communication interface configured to communicatively link to a flight controller communicatively connected to the hybrid electric aircraft.

In another aspect, a fuel pod for a hybrid electric aircraft, the fuel pod comprising: a housing; a fuel tank contained within the housing, wherein the fuel tank is configured to hold a
25 fuel therein; a generator contained within the housing and connected to the fuel tank, wherein the generator is configured to power at least one of a plurality of flight components of a hybrid electric aircraft; and a connection mechanism at the housing, wherein the connection mechanism is configured to removably attach the fuel pod to the hybrid electric aircraft, and wherein the connection mechanism comprises: a mechanical interface comprising a keyed locking
30 mechanism configured to selectively lock the housing to the hybrid electric aircraft; an electrical interface configured to electrically link to at least one of the plurality of flight components of the

hybrid electric aircraft; and a communication interface configured to communicatively link to a flight controller communicatively connected to the hybrid electric aircraft.

In another aspect, a hybrid propulsion system for an electric aircraft, the system comprising: an electric aircraft, the electric aircraft comprising: a fuselage, the fuselage comprising an energy source, wherein the energy source is configured to store electric power; at least a laterally extending element, wherein: the at least a laterally extending element is attached to the fuselage; and the at least a laterally extending element extends laterally from the fuselage; and at least a propulsor, wherein the at least a propulsor is electrically connected to the energy source; and at least a power unit pod, wherein the at least a power unit pod is attached to the at least a laterally extending element, the at least a power unit pod comprising: an auxiliary power unit, the auxiliary power unit configured to generate electric power; and a fuel tank, wherein the fuel tank is in fluid communication with the auxiliary power unit; and a power output line, the power output line electrically connected to the

In another aspect, a hybrid propulsion system for an electric aircraft, the system comprising: an electric aircraft, the electric aircraft comprising: a fuselage, the fuselage comprising an energy source, wherein the energy source is configured to store electric power; at least laterally extending element, wherein: the at least laterally extending element is attached to the fuselage; and the at least laterally extending element extends laterally from the fuselage; and at least a propulsor, wherein the at least propulsor is electrically connected to the energy source; and at least a power unit pod, wherein the at least power unit pod is attached to the at least a laterally extending element, the at least power unit pod comprising: an auxiliary power unit, the auxiliary power unit configured to generate electric power; a fuel tank, wherein the fuel tank is in fluid communication with the auxiliary power unit and includes a fuel pump for transferring fuel from the fuel tank to the auxiliary power unit; a local controller communicatively connected to the auxiliary power unit, the fuel tank and a flight controller onboard the electric aircraft, wherein the local controller is configured to: transmit a control signal to at least the fuel pump of the fuel tank to control operation of the fuel pump; a power supply electrically connected to the auxiliary power unit, the local controller and the fuel tank, wherein the power supply is configured to convert source power from the auxiliary power unit to load power and provide the load power to the local controller and the fuel tank including the fuel pump; and a power output

line, the power output line electrically connected to the energy source of the electric aircraft for recharging the energy source.

In another aspect, a hybrid propulsion system for an electric aircraft, the system comprising: an electric aircraft, the electric aircraft comprising: a fuselage; at least laterally
5 extending element, wherein: the at least laterally extending element is attached to the fuselage; and the at least laterally extending element extends laterally from the fuselage; an energy source, wherein the energy source is configured to store electric power; at least a propulsor, wherein the at least propulsor is electrically connected to the energy source; and a fuel tank; and at least a
10 power unit pod, wherein the at least power unit pod is attached to the at least laterally extending element, the at least power unit pod comprising: an auxiliary power unit in fluid communication with the fuel tank, the auxiliary power unit configured to generate electric power; a local controller communicatively connected to the auxiliary power unit, the fuel tank and a flight controller onboard the electric aircraft; a power supply electrically connected to the auxiliary
15 power unit, the local controller and the fuel tank, wherein the power supply is configured to convert source power from the auxiliary power unit to load power and provide the load power to the local controller; and a power output line electrically connected to the at least a propulsor for powering the at least a propulsor.

The details of one or more variations of the subject matter described herein are set forth in the accompanying drawings and the description below. Other features and advantages of the
20 subject matter described herein will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

For the purpose of illustrating the invention, the drawings show aspects of one or more embodiments of the invention. However, it should be understood that the present invention is not
25 limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

FIG. 1 is a diagrammatic representation of an exemplary embodiment of a hybrid electric vertical takeoff and landing (VTOL) aircraft;

FIG. 2 is a block diagram of an exemplary embodiment of a hybrid electric VTOL aircraft;

30 FIG. 3 is a block diagram of an exemplary embodiment of a power system for a hybrid electric VTOL aircraft;

FIG. 4 is a block diagram of another exemplary embodiment of a power system for a hybrid electric VTOL aircraft;

FIG. 5 is a block diagram of yet another exemplary embodiment of a power system for a hybrid electric VTOL aircraft;

5 FIG. 6 is a block diagram of an exemplary embodiment of a flight controller;

FIG. 7 is a block diagram of an exemplary embodiment of a machine-learning module;

FIG. 8 is a diagram of an exemplary embodiment of a fuel pod for a hybrid electric aircraft;

FIG. 9 is a depiction of an exemplary power unit pod system;

10 FIG. 10 is a depiction of an exemplary assembly of a laterally extending element and power unit pod system;

FIG. 11 is a profile view of an exemplary electric aircraft with an exemplary power unit pod system;

15 FIG. 12 is a box diagram of an exemplary power distribution system for a hybrid electric aircraft;

FIG. 13 is a depiction of an exemplary power distribution system; and

FIG. 14 is a block diagram of a computing system that can be used to implement any one or more of the methodologies disclosed herein and any one or more portions thereof.

20 The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations, and fragmentary views. In certain instances, details that are not necessary for an understanding of the embodiments or that render other details difficult to perceive may have been omitted. Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

25 Referring now to FIG. 1, an exemplary embodiment of a hybrid electric vertical takeoff and landing (VTOL) aircraft is illustrated. As used in this disclosure, an “aircraft” is any vehicle that may fly by gaining support from the air. As a non-limiting example, aircraft may include airplanes, helicopters, commercial, personal and/or recreational aircrafts, instrument flight aircrafts, drones, electric aircrafts, hybrid electric aircrafts, electric aerial vehicles, 30 airliners, rotorcrafts, vertical takeoff and landing aircrafts, jets, airships, blimps, gliders, paramotors, quad-copters, unmanned aerial vehicles (UAVs) and the like. As used in this

disclosure, an “electric aircraft” is an electrically powered aircraft such as one powered by one or more electric motors or the like. Electrically powered (or electric) aircraft may be an electric vertical takeoff and landing (eVTOL) aircraft. In some embodiments, aircraft may include a hybrid electric aircraft, for example and without limitation, an aircraft that may be powered by two or more energy sources. Aircraft may be capable of rotor-based cruising flight, rotor-based takeoff, rotor-based landing, fixed-wing cruising flight, airplane-style takeoff, airplane-style landing, and/or any combination thereof. Aircraft may include one or more manned and/or unmanned aircrafts. Aircraft may include one or more all-electric short takeoff and landing (eSTOL) aircrafts. For example, and without limitation, eSTOL aircrafts may accelerate the plane to a flight speed on takeoff and decelerate the plane after landing. In an embodiment, and without limitation, aircraft may be configured with an electric propulsion assembly. Including one or more propulsion and/or flight components.

Still referring to FIG. 1, as used in this disclosure, a “vertical take-off and landing (VTOL) aircraft” is one that can hover, take off, and land vertically. An “electric vertical takeoff and landing aircraft” or “eVTOL aircraft”, as used in this disclosure, is an electrically powered VTOL aircraft. In order to optimize the power and energy necessary to propel the aircraft, eVTOL may be capable of rotor-based cruising flight, rotor-based takeoff, rotor-based landing, fixed-wing cruising flight, airplane-style takeoff, airplane style landing, and/or any combination thereof. Rotor-based flight, as described herein, is where the aircraft generates lift and propulsion by way of one or more powered rotors or blades coupled with an engine, such as a “quad copter,” multi-rotor helicopter, or other vehicle that maintains its lift primarily using downward thrusting propulsors. “Fixed-wing flight”, as described herein, is where the aircraft is capable of flight using wings and/or foils that generate lift caused by the aircraft’s forward airspeed and the shape of the wings and/or foils, such as airplane-style flight.

Still referring to FIG. 1, in an embodiment, aircraft 100 is a hybrid electric aircraft and is powered by a hybrid electric power system. A hybrid-electric vehicle (HEV) or aircraft may be a type of hybrid vehicle or aircraft that combines an internal combustion engine (ICE) system with an electric propulsion system. As used in the present disclosure, a “hybrid electric vehicle” or “hybrid electric aircraft” is any vehicle or aircraft that combines a minimum of two sources of energy for propulsion. For example, and without limitation, the two sources can be either gasoline or diesel fuel combined with a battery. In some hybrid vehicles or aircrafts, both of

these power systems may propel vehicle or aircraft separately or together. As used in this disclosure, “a hybrid electric VTOL aircraft” is an aircraft that combines hybrid electric and VTOL features. In some embodiments, aircraft 100 may include a hybrid electric aircraft. In some embodiments, aircraft 100 may include a hybrid electric VTOL aircraft.

5 Still referring to FIG. 1, hybrid electric VTOL aircraft 100, in some embodiments, may include a fuselage 104, flight component 108 (or plurality of flight components 108), a pilot control 120, a flight controller 124, a sensor (or aircraft sensor) 128 (or a plurality of sensors (or aircraft sensors) 128), a pair of wings 132, a pair of booms 136 and a power system 140. In one embodiment, flight components 108 may include at least a lift component 112 (or a plurality of
10 lift components 112) and at least a pusher component 116 (or a plurality of pusher components 116). Hybrid electric VTOL aircraft is also described further below with reference to at least FIG. 2 and power system is also described further below with reference to at least FIG. 2 and FIG. 3.

Still referring to FIG. 1, as used in this disclosure a “fuselage” is the main body of an
15 aircraft, or in other words, the entirety of the aircraft except for the cockpit, nose, wings, empennage, nacelles, any and all control surfaces, and generally contains an aircraft’s payload. Fuselage 104 may include structural elements that physically support a shape and structure of an aircraft. Structural elements may take a plurality of forms, alone or in combination with other types. Structural elements may vary depending on a construction type of aircraft such as without
20 limitation a fuselage 104. Fuselage 104 may comprise a truss structure. A truss structure may be used with a lightweight aircraft and comprises welded steel tube trusses. A “truss,” as used in this disclosure, is an assembly of beams that create a rigid structure, often in combinations of triangles to create three-dimensional shapes. A truss structure may alternatively comprise wood construction in place of steel tubes, or a combination thereof. In embodiments, structural
25 elements may comprise steel tubes and/or wood beams. In an embodiment, and without limitation, structural elements may include an aircraft skin. Aircraft skin may be layered over the body shape constructed by trusses. Aircraft skin may comprise a plurality of materials such as plywood sheets, aluminum, fiberglass, and/or carbon fiber.

Still referring to FIG. 1, it should be noted that an illustrative embodiment is presented
30 only, and this disclosure in no way limits the form or construction method of any of the aircrafts as disclosed herein. In embodiments, fuselage 104 may be configurable based on the needs of the

aircraft per specific mission or objective. The general arrangement of components, structural elements, and hardware associated with storing and/or moving a payload and/or fuel pods or tanks may be added or removed from fuselage 104 as needed, whether it is stowed manually, automatically, or removed by personnel altogether. Fuselage 104 may be configurable for a plurality of storage and loading options. Bulkheads and dividers may be installed and uninstalled as needed, as well as longitudinal dividers where necessary. Bulkheads and dividers may be installed using integrated slots and hooks, tabs, boss and channel, or hardware like bolts, nuts, screws, nails, clips, pins, and/or dowels, to name a few. Fuselage 104 may also be configurable to accept certain specific cargo containers and/or fuel pods or tanks, or a receptacle that can, in turn, accept certain cargo containers and/or fuel pods or tanks.

Still referring to FIG. 1, hybrid electric VTOL aircraft 100 may include a plurality of laterally extending elements attached to fuselage 104. As used in this disclosure a “laterally extending element” is an element that projects essentially horizontally from fuselage, including an outrigger, a spar, and/or a fixed wing that extends from fuselage. Wings 132 may be structures which include airfoils configured to create a pressure differential resulting in lift. Wings 132 may generally be disposed on the left and right sides of the aircraft symmetrically, at a point between nose and empennage. Wings 132 may comprise a plurality of geometries in planform view, swept wing, tapered, variable wing, triangular, oblong, elliptical, square, among others. A wing’s cross section geometry may comprise an airfoil. An “airfoil” as used in this disclosure is a shape specifically designed such that a fluid flowing above and below it exert differing levels of pressure against the top and bottom surface. In embodiments, the bottom surface of an aircraft can be configured to generate a greater pressure than does the top, resulting in lift. Laterally extending element or wings may comprise differing and/or similar cross-sectional geometries over its cord length or the length from wing tip to where wing meets the aircraft’s body. One or more wings may be symmetrical about the aircraft’s longitudinal plane, which comprises the longitudinal or roll axis reaching down the center of the aircraft through the nose and empennage, and the plane’s yaw axis. Laterally extending element or wings may comprise control surfaces configured to be commanded by a pilot or pilots to change a wing’s geometry and therefore its interaction with a fluid medium, like air. Control surfaces may comprise flaps, ailerons, tabs, spoilers, and slats, among others. The control surfaces may dispose on the wings in a plurality of locations and arrangements and in embodiments may be

disposed at the leading and trailing edges of the wings, and may be configured to deflect up, down, forward, aft, or a combination thereof. An aircraft, including a dual-mode aircraft may comprise a combination of control surfaces to perform maneuvers while flying or on ground. In some embodiments, winglets may be provided at terminal ends of the wings which can provide improved aerodynamic efficiency and stability in certain flight situations. In some embodiments, the wings may be foldable to provide a compact aircraft profile, for example, for storage, parking and/or in certain flight modes.

Continuing to refer to FIG. 1, hybrid electric VTOL aircraft 100 may include plurality of flight components 108. As used in this disclosure a “flight component” is a component that promotes flight and guidance of an aircraft. Flight component 108 may include power sources, control links to one or more elements, fuses, and/or mechanical couplings used to drive and/or control any other flight component. Flight component 108 may include a motor that operates to move one or more flight control components, to drive one or more propulsors, or the like. A motor may be driven by direct current (DC) electric power and may include, without limitation, brushless DC electric motors, switched reluctance motors, induction motors, or any combination thereof. A motor may also include electronic speed controllers or other components for regulating motor speed, rotation direction, and/or dynamic braking. Flight component 108 may include an energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery), a turbine, an engine, and the like. An energy source may also include a battery cell, or a plurality of battery cells connected in series into a module and each module connected in series or in parallel with other modules. Configuration of an energy source containing connected modules may be designed to meet an energy or power requirement and may be designed to fit within a designated footprint in an aircraft. An energy source may also include one or more fuel tanks.

With continued reference to FIG. 1, in an embodiment, flight component 108 may be mechanically coupled to an aircraft. As used herein, a person of ordinary skill in the art would understand “mechanically coupled” to mean that at least a portion of a device, component, or circuit is connected to at least a portion of the aircraft via a mechanical coupling. Said mechanical coupling can include, for example, rigid coupling, such as beam coupling, bellows

coupling, bushed pin coupling, constant velocity, split-muff coupling, diaphragm coupling, disc coupling, donut coupling, elastic coupling, flexible coupling, fluid coupling, gear coupling, grid coupling, hirth joints, hydrodynamic coupling, jaw coupling, magnetic coupling, Oldham coupling, sleeve coupling, tapered shaft lock, twin spring coupling, rag joint coupling, universal joints, or any combination thereof. In an embodiment, mechanical coupling may be used to connect the ends of adjacent parts and/or objects of an electric aircraft. Further, in an embodiment, mechanical coupling may be used to join two pieces of rotating electric aircraft components.

Still referring to FIG. 1, in an embodiment, plurality of flight components 108 of aircraft 100 may include at least a lift component 112 and at least a pusher component 116. Flight component 108 may include a propulsor, a propeller, a motor, rotor, a rotating element, electrical energy source, battery, and the like, among others. Each flight component may be configured to generate lift and flight of hybrid electric aircraft. In some embodiments, flight component 108 may include one or more lift components 112, one or more pusher components 116, one or more battery packs including one or more batteries or cells, and one or more electric motors. Flight component 108 may include a propulsor. As used in this disclosure a “propulsor component” or “propulsor” is a component and/or device used to propel a craft by exerting force on a fluid medium, which may include a gaseous medium such as air or a liquid medium such as water. In an embodiment, when a propulsor twists and pulls air behind it, it may, at the same time, push an aircraft forward with an amount of force and/or thrust. More air pulled behind an aircraft results in greater thrust with which the aircraft is pushed forward. Propulsor component may include any device or component that consumes electrical power on demand to propel an aircraft in a direction or other vehicle while on ground or in-flight.

Still referring to FIG. 1, in some embodiments, lift component 112 may include a propulsor, a propeller, a blade, a motor, a rotor, a rotating element, an aileron, a rudder, arrangements thereof, combinations thereof, and the like. Each lift component 112, when a plurality is present, of plurality of flight components 108 may be configured to produce, in an embodiment, substantially upward and/or vertical thrust such that aircraft moves upward.

Continuing to refer to FIG. 1, as used in this disclosure a “lift component” is a component and/or device used to propel a craft upward by exerting downward force on a fluid medium, which may include a gaseous medium such as air or a liquid medium such as water. Lift

component 112 may include any device or component that consumes electrical power on demand to propel an aircraft in a direction or other vehicle while on ground or in-flight. For example, and without limitation, lift component 112 may include a rotor, propeller, propulsor, paddle wheel and the like thereof, which may produce torque along a longitudinal axis and/or a vertical axis. In an embodiment, lift component 112 includes a plurality of blades. As used in this disclosure a “blade” is a propeller that converts rotary motion from an engine or other power source into a swirling slipstream. In an embodiment, blade may convert rotary motion to push the propeller forwards or backwards. In an embodiment lift component 112 may include a rotating power-driven hub, to which are attached several radial airfoil-section blades such that the whole assembly rotates about a longitudinal axis. Blades may be configured at an angle of attack. In an embodiment, and without limitation, angle of attack may include a fixed angle of attack. As used in this disclosure a “fixed angle of attack” is fixed angle between a chord line of a blade and relative wind. As used in this disclosure a “fixed angle” is an angle that is secured and/or unmovable from the attachment point. In an embodiment, and without limitation, angle of attack may include a variable angle of attack. As used in this disclosure a “variable angle of attack” is a variable and/or moveable angle between a chord line of a blade and relative wind. As used in this disclosure a “variable angle” is an angle that is moveable from an attachment point. In an embodiment, angle of attack be configured to produce a fixed pitch angle. As used in this disclosure a “fixed pitch angle” is a fixed angle between a cord line of a blade and the rotational velocity direction. In an embodiment fixed angle of attack may be manually variable to a few set positions to adjust one or more lifts of the aircraft prior to flight. In an embodiment, blades for an aircraft are designed to be fixed to their hub at an angle similar to the thread on a screw makes an angle to the shaft; this angle may be referred to as a pitch or pitch angle which will determine a speed of forward movement as the blade rotates.

With continued reference to FIG. 1, in an embodiment, lift component 112 may be configured to produce a lift. As used in this disclosure a “lift” is a perpendicular force to the oncoming flow direction of fluid surrounding the surface. For example, and without limitation relative air speed may be horizontal to the aircraft, wherein lift force may be a force exerted in a vertical direction, directing the aircraft upwards. In an embodiment, and without limitation, lift component 112 may produce lift as a function of applying a torque to lift component. As used in this disclosure a “torque” is a measure of force that causes an object to rotate about an axis in a

direction. For example, and without limitation, torque may rotate an aileron and/or rudder to generate a force that may adjust and/or affect altitude, airspeed velocity, groundspeed velocity, direction during flight, and/or thrust. For example, one or more flight components 108 such as a power source(s) may apply a torque on lift component 112 to produce lift.

5 In an embodiment, and still referring to FIG. 1, a plurality of lift components 112 of plurality of flight components 108 may be arranged in a quad copter orientation. As used in this disclosure a “quad copter orientation” is at least a lift component oriented in a geometric shape and/or pattern, wherein each of the lift components is located along a vertex of the geometric shape. For example, and without limitation, a square quad copter orientation may have four lift
10 propulsor components oriented in the geometric shape of a square, wherein each of the four lift propulsor components are located along the four vertices of the square shape. As a further non-limiting example, a hexagonal quad copter orientation may have six lift components oriented in the geometric shape of a hexagon, wherein each of the six lift components are located along the six vertices of the hexagon shape. In an embodiment, and without limitation, quad copter
15 orientation may include a first set of lift components and a second set of lift components, wherein the first set of lift components and the second set of lift components may include two lift components each, wherein the first set of lift components and a second set of lift components are distinct from one another. For example, and without limitation, the first set of lift components may include two lift components that rotate in a clockwise direction, wherein the second set of
20 lift propulsor components may include two lift components that rotate in a counterclockwise direction. In an embodiment, and without limitation, the first set of lift components may be oriented along a line oriented 45° from the longitudinal axis of aircraft 100. In another embodiment, and without limitation, the second set of lift components may be oriented along a line oriented 135° from the longitudinal axis, wherein the first set of lift components line and the
25 second set of lift components are perpendicular to each other. Any aircrafts, including electric and eVTOL aircrafts, as disclosed in any of these applications may efficaciously be utilized with any of the embodiments as disclosed herein, as needed or desired. Any flight controllers as disclosed in any of these applications may efficaciously be utilized with any of the embodiments as disclosed herein, as needed or desired.

30 Still referring to FIG. 1, pusher component 116 may include a propulsor, a propeller, a blade, a motor, a rotor, a rotating element, an aileron, a rudder, arrangements thereof,

combinations thereof, and the like. Each pusher component 116, when a plurality is present, of the plurality of flight components 108 may be configured to produce, in an embodiment, substantially forward and/or horizontal thrust such that the aircraft moves forward.

Still referring to FIG. 1, as used in this disclosure a “pusher component” is a component that pushes and/or thrusts an aircraft through a medium. As a non-limiting example, pusher component 116 may include a pusher propeller, a paddle wheel, a pusher motor, a pusher propulsor, and the like. Additionally, or alternatively, pusher flight component may include a plurality of pusher flight components. Pusher component 116 may be configured to produce a forward thrust. As a non-limiting example, forward thrust may include a force to force aircraft in a horizontal direction along the longitudinal axis. As a further non-limiting example, pusher component 116 may twist and/or rotate to pull air behind it and, at the same time, push aircraft 100 forward with an equal amount of force. In an embodiment, and without limitation, the more air forced behind aircraft, the greater the thrust force with which the aircraft is pushed horizontally will be. In another embodiment, and without limitation, forward thrust may force aircraft 100 through the medium of relative air. Additionally or alternatively, plurality of flight components 108 may include one or more puller components. As used in this disclosure a “puller component” is a component that pulls and/or tows an aircraft through a medium. As a non-limiting example, puller component may include a flight component such as a puller propeller, a puller motor, a tractor propeller, a puller propulsor, and the like. Additionally, or alternatively, puller component may include a plurality of puller flight components.

Still referring to FIG. 1, in an embodiment, aircraft 100 may include a pilot control 120. As used in this disclosure, a “pilot control” is a mechanism or means which allows a pilot to monitor and control operation of aircraft such as its flight components (for example, and without limitation, pusher component, lift component and other components such as propulsion components). For example, and without limitation, pilot control 120 may include a collective, inceptor, foot brake, steering and/or control wheel, control stick, pedals, throttle levers, and the like. Pilot control 120 may be configured to translate a pilot’s desired torque for each flight component of the plurality of flight components, such as and without limitation, pusher component 116 and lift component 112. Pilot control 120 may be configured to control, via inputs and /or signals such as from a pilot, the pitch, roll, and yaw of the aircraft. Pilot control may be available onboard aircraft or remotely located from it, as needed or desired.

Still referring to FIG. 1, as used in this disclosure a “collective control” or “collective” is a mechanical control of an aircraft that allows a pilot to adjust and/or control the pitch angle of plurality of flight components 108. For example and without limitation, collective control may alter and/or adjust the pitch angle of all of the main rotor blades collectively. For example, and without limitation pilot control 120 may include a yoke control. As used in this disclosure a “yoke control” is a mechanical control of an aircraft to control the pitch and/or roll. For example and without limitation, yoke control may alter and/or adjust the roll angle of aircraft 100 as a function of controlling and/or maneuvering ailerons. In an embodiment, pilot control 120 may include one or more foot-brakes, control sticks, pedals, throttle levels, and the like thereof. In another embodiment, and without limitation, pilot control 120 may be configured to control a principal axis of the aircraft. As used in this disclosure a “principal axis” is an axis in a body representing one three dimensional orientations. For example, and without limitation, principal axis or more yaw, pitch, and/or roll axis. Principal axis may include a yaw axis. As used in this disclosure a “yaw axis” is an axis that is directed towards the bottom of aircraft, perpendicular to the wings. For example, and without limitation, a positive yawing motion may include adjusting and/or shifting nose of aircraft 100 to the right. Principal axis may include a pitch axis. As used in this disclosure a “pitch axis” is an axis that is directed towards the right laterally extending wing of aircraft. For example, and without limitation, a positive pitching motion may include adjusting and/or shifting nose of aircraft 100 upwards. Principal axis may include a roll axis. As used in this disclosure a “roll axis” is an axis that is directed longitudinally towards nose of aircraft, parallel to fuselage. For example, and without limitation, a positive rolling motion may include lifting the left and lowering the right wing concurrently. Pilot control 120 may be configured to modify a variable pitch angle. For example, and without limitation, pilot control 120 may adjust one or more angles of attack of a propulsor or propeller.

Still referring to FIG. 1, aircraft 100 may include one or more sensor(s) (or aircraft sensor(s)) 128. Sensor(s) 128 may include any sensor or noise monitoring circuit described in this disclosure. Sensor(s) are also described further below with reference to at least FIG. 2. Sensor 128, in some embodiments, may be communicatively connected or coupled to flight controller 124. Sensor may be a device, module, and/or subsystem, utilizing any hardware, software, and/or any combination thereof to sense a characteristic and/or changes thereof, in an instant environment, for instance without limitation a pilot control 120, which the sensor is

proximal to or otherwise in a sensed communication with, and transmit information associated with the characteristic, for instance without limitation digitized data. Sensor 128 may be mechanically and/or communicatively coupled or connected to aircraft 100, including, for instance, to at least a pilot control 120. Sensor 128 may be configured to sense a characteristic associated with at least a pilot control 120. An environmental sensor may include without limitation one or more sensors used to detect ambient temperature, barometric pressure, and/or air velocity. Sensor 128 may include without limitation gyroscopes, accelerometers, inertial measurement unit (IMU), and/or magnetic sensors, one or more humidity sensors, one or more oxygen sensors, or the like. Additionally or alternatively, sensor 128 may include at least a geospatial sensor. Sensor 128 may be located inside aircraft, and/or be included in and/or attached to at least a portion of aircraft. Sensor may include one or more proximity sensors, displacement sensors, vibration sensors, and the like thereof. Sensor may be used to monitor the status of aircraft 100 for both critical and non-critical functions. Sensor may be incorporated into vehicle or aircraft or be remote.

Still referring to FIG. 1, non-limiting examples of sensor 128 may include an inertial measurement unit (IMU), an accelerometer, a gyroscope, a proximity sensor, a pressure sensor, a light sensor, a pitot tube, an air speed sensor, a position sensor, a speed sensor, a switch, a thermometer, a strain gauge, an acoustic sensor, and an electrical sensor. In some cases, sensor 128 may sense a characteristic as an analog measurement, for instance, yielding a continuously variable electrical potential indicative of the sensed characteristic. In these cases, sensor 128 may additionally comprise an analog to digital converter (ADC) as well as any additionally circuitry, such as without limitation a Wheatstone bridge, an amplifier, a filter, and the like. For instance, in some cases, sensor 128 may comprise a strain gage configured to determine loading of one or more aircraft components, for instance landing gear. Strain gage may be included within a circuit comprising a Wheatstone bridge, an amplified, and a bandpass filter to provide an analog strain measurement signal having a high signal to noise ratio, which characterizes strain on a landing gear member. An ADC may then digitize analog signal produces a digital signal that can then be transmitted other systems within aircraft 100, for instance without limitation a computing system, a pilot display, and a memory component. Alternatively or additionally, sensor 128 may sense a characteristic of a pilot control 120 digitally. For instance in some embodiments, sensor 128 may sense a characteristic through a digital means or digitize a sensed signal natively. In

some cases, for example, sensor 128 may include a rotational encoder and be configured to sense a rotational position of a pilot control; in this case, the rotational encoder digitally may sense rotational “clicks” by any known method, such as without limitation magnetically, optically, and the like. Sensor 128 may include any of the sensors as disclosed in the present disclosure. Sensor
5 128 may include a plurality of sensors or a sensor suite. Any of these sensors may be located at any suitable position in or on aircraft 100. As noted above, further embodiments of sensor(s) 128 are also described further below with reference to at least FIG. 2.

Still referring to FIG. 1, hybrid electric VTOL aircraft 100 may include at least a controller or computing device such as flight controller 124. Flight controller 124 may include
10 any computing device as described in this disclosure, including without limitation a microcontroller, microprocessor, digital signal processor (DSP) and/or system on a chip (SoC) as described in this disclosure. Computing device may include, be included in, and/or communicate with a mobile device such as a mobile telephone or smartphone. Computing device may include a single computing device operating independently, or may include two or more computing
15 device operating in concert, in parallel, sequentially or the like; two or more computing devices may be included together in a single computing device or in two or more computing devices. Computing device may interface or communicate with one or more additional devices as described below in further detail via a network interface device. Network interface device may be utilized for connecting computing device to one or more of a variety of networks, and one or
20 more devices. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network,
25 a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (e.g., data, software etc.) may be communicated to and/or from a computer and/or a computing device. Computing
30 device may include but is not limited to, for example, a computing device or cluster of computing devices in a first location and a second computing device or cluster of computing

devices in a second location. Computing device may include one or more computing devices dedicated to data storage, security, distribution of traffic for load balancing, and the like.

Computing device may distribute one or more computing tasks as described below across a plurality of computing devices of computing device, which may operate in parallel, in series, redundantly, or in any other manner used for distribution of tasks or memory between computing devices. Computing device may be implemented using a “shared nothing” architecture in which data is cached at the worker, in an embodiment, this may enable scalability of system and/or computing device.

Continuing to refer to FIG. 1, controller (or computing device) such as flight controller 124 may be designed and/or configured to perform any method, method step, or sequence of method steps in any embodiment described in this disclosure, in any order and with any degree of repetition. For instance, controller (or computing device) may be configured to perform a single step or sequence repeatedly until a desired or commanded outcome is achieved; repetition of a step or a sequence of steps may be performed iteratively and/or recursively using outputs of previous repetitions as inputs to subsequent repetitions, aggregating inputs and/or outputs of repetitions to produce an aggregate result, reduction or decrement of one or more variables such as global variables, and/or division of a larger processing task into a set of iteratively addressed smaller processing tasks. Computing device may perform any step or sequence of steps as described in this disclosure in parallel, such as simultaneously and/or substantially simultaneously performing a step two or more times using two or more parallel threads, processor cores, or the like; division of tasks between parallel threads and/or processes may be performed according to any protocol suitable for division of tasks between iterations. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which steps, sequences of steps, processing tasks, and/or data may be subdivided, shared, or otherwise dealt with using iteration, recursion, and/or parallel processing.

With continued reference to FIG. 1, in some embodiments, hybrid electric VTOL aircraft 100 may include, or may be coupled to or communicatively connected to, flight controller 124 which is described further with reference to at least FIG. 2 and FIG. 3. As used in this disclosure a “flight controller” is a computing device of a plurality of computing devices dedicated to data storage, security, distribution of traffic for load balancing, and flight instruction. In embodiments, flight controller may be installed in an aircraft, may control the aircraft remotely,

and/or may include an element installed in the aircraft and a remote element in communication therewith. Flight controller 124, in an embodiment, is located within fuselage 104 of aircraft. In accordance with some embodiments, flight controller may be configured to select a flight mode of aircraft such as to operate a vertical lift flight (upwards or downwards, takeoff, landing, climb or descent), a fixed wing flight (forward or backwards), a transition between a vertical lift flight and a fixed wing flight, and a combination of a vertical lift flight and a fixed wing flight. In other embodiments, flight mode may be selected by a pilot, user or the like.

Still referring to FIG. 1, in an embodiment, and without limitation, flight controller 124 may be configured to operate a fixed-wing flight capability. A “fixed-wing flight capability” can be a method of flight (or flight mode) wherein the plurality of laterally extending elements or wings generate lift. For example, and without limitation, fixed-wing flight capability may generate lift as a function of an airspeed of aircraft 100 and one or more airfoil shapes of the laterally extending elements. As a further non-limiting example, flight controller 124 may operate the fixed-wing flight capability as a function of reducing applied torque on lift (propulsor) component 112. In an embodiment, and without limitation, an amount of lift generation may be related to an amount of forward thrust generated to increase airspeed velocity, wherein the amount of lift generation may be directly proportional to the amount of forward thrust produced. Additionally or alternatively, flight controller may include an inertia compensator. As used in this disclosure an “inertia compensator” is one or more computing devices, electrical components, logic circuits, processors, and the like there of that are configured to compensate for inertia in one or more lift (propulsor) components present in aircraft 100.

In an embodiment, and still referring to FIG. 1, flight controller 124 may be configured to perform a reverse thrust command. As used in this disclosure a “reverse thrust command” is a command to perform a thrust that forces a medium towards the relative air opposing aircraft 100. In another embodiment, flight controller may be configured to perform a regenerative drag operation. As used in this disclosure a “regenerative drag operation” is an operating condition of an aircraft, wherein the aircraft has a negative thrust and/or is reducing in airspeed velocity. For example, and without limitation, regenerative drag operation may include a positive propeller speed and a negative propeller thrust.

Continuing to refer to FIG. 1, in an embodiment, flight controller 124 may be configured to perform a corrective action as a function of a failure event. As used in this disclosure a

“corrective action” is an action conducted by the plurality of flight components to correct and/or alter a movement of an aircraft. For example, and without limitation, a corrective action may include an action to reduce a yaw torque generated by a failure event. As used in this disclosure a “failure event” is a failure of a flight component of the plurality of flight components. For example, and without limitation, a failure event may denote a rotation degradation of a rotor, a reduced torque of a rotor, and the like thereof.

With continued reference to FIG. 1, flight controller 124 may include one or more computing devices. Computing device may include any computing device as described in this disclosure. Flight controller 124 may be onboard aircraft 100 and/or flight controller 124 may be remote from aircraft 100, as long as, in some embodiments, flight controller 124 is communicatively connected to aircraft 100. As used in this disclosure, “remote” is a spatial separation between two or more elements, systems, components or devices. Stated differently, two elements may be remote from one another if they are physically spaced apart. In an embodiment, flight controller 124 may include a proportional-integral-derivative (PID) controller.

Still referring to FIG. 1, in some embodiments, hybrid electric VTO aircraft 100 may include one or more booms, a plurality of booms or a pair of booms 136. Booms 136 may extend generally parallel to fuselage 104 on either side of fuselage 104. A respective one of booms 136 may be connected to a respective one of wings 132. Booms 136 may extend generally perpendicularly to wings 132 or they may have a different angular orientation with respect to wings, as needed or desired. Booms 136 may be configured to contain or be attachable to ancillary items such as fuel tanks, fuel pods, cargo, payload, and the like, among others. Booms 136 may provide a supporting and/or loading structure for ancillary items and/or aircraft. Booms 136 may be fabricated from substantially the same material as fuselage 104 and/or wings 132, as needed or desired. Booms 136 may include one or more internal or external latching mechanisms to facilitate attachment to ancillary items.

Still referring to FIG. 1, in some embodiments, hybrid electric VTOL aircraft 100 includes a power system 140. As also discussed further with reference to at least FIG. 2 and FIG. 3, power system 140 is configured to generate electrical energy to power various flight components of aircraft. Power system 140 is a hybrid electric power system generating electrical power from at least two energy sources such as a battery system and a fuel system. Embodiments

of various power system configurations are discussed further with reference to at least FIG. 2, FIG. 3, FIG. 4 and FIG. 5.

Referring now to FIG. 2, an exemplary embodiment of a hybrid electric VTOL aircraft 200 is illustrated. Hybrid electric VTOL aircraft 200 can be the same, substantially the same or similar to the hybrid electric VTOL aircraft 100 of FIG. 1 or any of the other such aircrafts disclosed in the entirety of the present disclosure. For purposes of readability, the same reference numerals as FIG. 1 may be used to refer to like elements in FIG. 2.

Still referring to FIG. 2, as used in this disclosure, “communicatively connected” means connected by way of a connection, attachment or linkage between two or more relata which allows for reception and/or transmittance of information therebetween. For example, and without limitation, this connection may be wired or wireless, direct or indirect, and between two or more components, circuits, devices, systems, and the like, which allows for reception and/or transmittance of data and/or signal(s) therebetween. Data and/or signals therebetween may include, without limitation, electrical, electromagnetic, magnetic, video, audio, radio and microwave data and/or signals, combinations thereof, and the like, among others. A communicative connection may be achieved, for example and without limitation, through wired or wireless electronic, digital or analog, communication, either directly or by way of one or more intervening devices or components. Further, communicative connection may include electrically coupling or connecting at least an output of one device, component, or circuit to at least an input of another device, component, or circuit. For example, and without limitation, via a bus or other facility for intercommunication between elements of a computing device. Communicative connecting may also include indirect connections via, for example and without limitation, wireless connection, radio communication, low power wide area network, optical communication, magnetic, capacitive, or optical coupling, and the like. In some instances, the terminology “communicatively coupled” may be used in place of communicatively connected in this disclosure.

Still referring to FIG. 2, in some embodiments, a hybrid electric VTOL aircraft 200 is provided. In some embodiments, hybrid electric VTOL aircraft 200 includes a fuselage (e.g. fuselage 104 of FIG. 1), a pair of wings (e.g. wings 132 of FIG. 1), a pair of booms (e.g. booms 136 of FIG. 1), a plurality of flight components 108 and a power system 140. Pair of wings is connected to fuselage and extends generally laterally therefrom with each wing on either side of

fuselage. Each boom of pair of booms is connected (or attached) to a respective one of the wings wherein each boom extending generally longitudinally and parallel to fuselage. Plurality of flight components 108 are configured to provide thrust to hybrid electric VTOL aircraft 200. Power system 140 includes a battery system 224 and a fuel system 204. Power system 140 is configured to power plurality of flight components 108. Fuel system 204 includes a pair of fuel pods 208 with each fuel pod containing a fuel tank 212 and a generator 216. Each fuel pod 208 is mounted to a respective one of booms (e.g. booms 136 of FIG. 1).

Still referring to FIG. 2, fuel system may further include a turbine 236 and/or an engine 240. Turbine 236 and/or engine 240 may be integrated into generator 216 or be separate from generator 216. Battery system 224 may include one or more battery packs 228. Each battery pack 232 may include one or more batteries 232. Hybrid electric VTOL aircraft 200 may further include or be communicatively connected to one or more sensors 128. Sensors 128 may include any of the sensors as disclosed in the present disclosure. Hybrid electric VTOL aircraft 200 may further include or be communicatively connected to flight controller 124. Flight controller 124 may include any of the flight controllers as disclosed in the present disclosure and described with reference to at least FIG. 1 and FIG. 6. Sensor(s) 128 may be communicatively connected to flight controller 124. Flight component(s) 108 may include one or more lift components 112, pusher components 116, electric motors 220, among other components. Power system 140 is configured to provide electrical energy and/or electrical flow (e.g. current) to plurality of flight components 108 such as electric motor 220 which in turn may power one or more lift components 112 and/or pusher components 116 to propel aircraft 200.

Continuing to refer to FIG. 2, fuel system 204 may be further configured to charge or recharge at least a battery 232 of battery system 224. As used in this disclosure, “charging” or “recharging” refers to a process of increasing energy stored within an energy source. In some cases, an energy source may include at least a battery and charging may include providing an electrical flow or current to at least a battery. As used in this disclosure, an “electrical flow” or “current” is a flow of charged particles (e.g. electrons) or an electric current flowing within a material or structure which is capable of conducting it. Current may be measured in amperes or the like. As used in this disclosure, a “battery pack” is a set of any number of identical (or non-identical) batteries or individual battery cells. These may be configured in a series, parallel or a mixture of both configuration to deliver a desired electrical flow, current, voltage, capacity, or

power density, as needed or desired. A battery may include, without limitation, one or more cells, in which chemical energy is converted into electricity (or electrical energy) and used as a source of energy or power. Power system 140, fuel system 204, battery system 224 and/or aircraft 200 may efficaciously include one or more components such as open-close contactors to provide an electrical connection between systems and aircraft components.

With continued reference to FIG. 2, each fuel pod 208 may be mounted, attached or mechanically connected to an outer lower surface of a respective one of pair of booms (e.g. booms 136 of FIG. 1). Each fuel pod 208 may be mounted, attached or mechanically connected to a latching mechanism on an outer surface of a respective one of booms (e.g. booms 136 of FIG. 1). Certain embodiments of a latching mechanism are described further below in connection with at least FIG. 3. In modified embodiments, fuel pods 208 may be mounted, attached or mechanically connected to other structures of aircraft such as, without limitation, fuselage, wings, and the like, among others. Each fuel tank 212 may contain a hydrocarbon fuel or a petroleum-based fuel which may be in a liquid or gaseous form and which may be compressed or pressurized. As used in this disclosure, a “pod” is a container or housing. Pod may be a detachable and/or self-contained unit. As used in this disclosure, a “fuel” is a material that is burned or undergoes combustion to produce power. Fuel may include, without limitation, a hydrocarbon fuel, a petroleum-based fuel, a gaseous fuel, a liquid fuel, a solid fuel, natural gas, oil, coal, gasoline, diesel, ethanol, hydrogen, or the like, among others. A “fuel pod”, as used in this disclosure, is a pod with at least a fuel therein or a pod designed to hold at least a fuel therein. For the purposes of this disclosure, a “fuel tank” is a container designed to hold fuel or a container with fuel therein.

Still referring to FIG. 2, generator 216 may be configured to convert mechanical energy to electrical energy. Generator 216 may include a turbine generator. Generator 216 may include an engine such as an internal combustion engine (ICE). Generator 216 may include a gas turbine or a diesel turbine. In an embodiment, generator 216 may be connected to at least one electric motor 220 of plurality of flight components 108 to provide electrical flow thereto. Plurality of flight components 108 may include at least one lift component 112. plurality of flight components 108 may include at least one pusher component 116. Plurality of flight components 108 may include at least a propulsor, a blade and/or a blade arrangement.

Still referring to FIG. 2, as used in this disclosure, a “generator” is a device that converts mechanical energy to electrical energy. For example, a generator may convert motive power (mechanical energy or kinetic energy) into electrical power for use in an external circuit such as an electric motor. Sources of mechanical energy may include, without limitation, steam turbines, gas turbines, water turbines, internal combustion engines, wind turbines, and the like, among others. As used in this disclosure, a “turbine” is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator. As used in this disclosure, a “turbine generator” is an electric generator driven by a steam, gas or hydraulic turbine. As used in this disclosure, an “engine” is a machine that converts one or more forms of energy into mechanical energy. For example, and without limitation, an engine may convert energy from a source of heat, such as the burning or combustion of a fuel, into mechanical energy, force or motion. As used in this disclosure, an “internal combustion engine” or “ICE” is an engine in which the burning of a fuel occurs in a confined space called a combustion chamber.

Still referring to FIG. 2, power system 140 may be further configured to allow selection between battery system 224 and fuel system 204 for powering plurality of flight components 108. Hybrid electric VTOL aircraft may further include flight controller 124 which may be configured to select at least one of battery system 224 and fuel system 204 for powering at least one of plurality of flight components 108. Selection of at least one of battery system 224 and fuel system 204 by flight controller 124 may be based on a machine-learning model. Training of machine-learning model may be based on battery system state of charge (SOC) data and flight mode (e.g. takeoff, landing, climb, descent, transitions therebetween) data to output an optimum profile for utilizing battery system 224 and/or fuel system 204 for powering aircraft and/or recharging batteries. Machine-learning model may be based on any of the machine-learning features as disclosed in the present disclosure and described below with reference to at least FIG. 7.

Still referring to FIG. 2, fuel system 204 and battery system 224 may operate in series to drive and power plurality of flight components 108. In a modified embodiment, these systems may operate in a parallel configuration or even a series-parallel configuration. Thus, embodiments disclosed herein encompass tandem and/or independent operation of fuel system 204 and battery system 224 of hybrid power systems disclosed herein.

Continuing to refer to FIG. 2, battery system 224 may include at least a battery pack 228. Battery system 224 (and/or battery pack(s) 228) may be mounted in fuselage of aircraft. Battery system 224 (and/or battery pack(s) 228) may be mounted in a bay at a lower portion of fuselage. In modified embodiment, battery system may be mounted at other aircraft structures such as ,
5 and without limitation, wings, booms, and the like, among others. Moreover, portions of battery system 224 may be mounted at different locations withing aircraft. As used in this disclosure, a “bay” is a partly enclosed area, inside or outside, a structure. For example, and without limitation, a bay may be an area inside an aircraft’s fuselage for placement of a fuel pod and/or a battery pack.

10 With continued reference to FIG. 2, in some embodiments, hybrid electric VTOL aircraft 200 may be configured for flight without fuel system 204 (or a portion thereof). Advantageously, such an adaptable aircraft may provide enhanced versatility based on, for example, travel distance to a particular destination. Such aircraft and/or fuel system features as also discussed further below with reference to at least FIG. 3.

15 Still referring to FIG. 2, hybrid electric VTOL aircraft 200 may further include at least a sensor 128. Sensor 128 may be communicatively connected to flight controller 124. Sensor 128 may include a battery sensor such as a sensor configured to detect a state of charge (SOC) of battery system 224, battery pack 228 and/or battery 232. Sensor 128 may include a sensor configured to detect a flight mode (e.g. takeoff, landing, climb, ascent, descent, transitions
20 therebetween, and the like) of hybrid electric VTOL aircraft 200. Hybridization performance of power system 140 may be optimized by use of sensor(s) 128.

With continued reference to FIG. 2, as used in this disclosure, an “energy source” is a source (or supplier) of energy (or power) to power one or more components. Energy source may include fuel system 204 and power system 140 and any of their elements such as, and without
25 limitation, battery pack(s), battery(ies), fuel pod(s), fuel tank(s), generator(s), turbine(s), engine(s), and the like. As used in this disclosure, a “battery pack” is a set of any number of identical (or non-identical) batteries or individual battery cells. These may be configured in a series, parallel or a mixture of both configuration to deliver a desired electrical flow, current, voltage, capacity, or power density, as needed or desired. A battery may include, without
30 limitation, one or more cells, in which chemical energy is converted into electricity (or electrical energy) and used as a source of energy or power. For example, and without limitation, energy

source may be configured provide energy to an aircraft power source that in turn that drives and/or controls any other aircraft component such as other flight components. An energy source may include, for example, an electrical energy source, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g., a capacitor, an inductor, and/or a battery). An electrical energy source may also include a battery cell, a battery pack, or a plurality of battery cells connected in series into a module and each module connected in series or in parallel with other modules. Configuration of an energy source containing connected modules may be designed to meet an energy or power requirement and may be designed to fit within a designated footprint in an aircraft.

In an embodiment, and still referring to FIG. 2, an energy source may be used to provide a steady supply of electrical flow or power to a load over the course of a flight by a vehicle or other aircraft. For example, an energy source may be capable of providing sufficient power for “cruising” and other relatively low-energy phases of flight. An energy source may also be capable of providing electrical power for some higher-power phases of flight as well, particularly when the energy source is at a high state of charge (SOC), as may be the case for instance during takeoff. In an embodiment, an energy source may be capable of providing sufficient electrical power for auxiliary loads including without limitation, lighting, navigation, communications, de-icing, steering or other systems requiring power or energy. Further, an energy source may be capable of providing sufficient power for controlled descent and landing protocols, including, without limitation, hovering descent or runway landing. As used herein an energy source may have high power density where electrical power an energy source can usefully produce per unit of volume and/or mass is relatively high. “Electrical power,” as used in this disclosure, is defined as a rate of electrical energy per unit time. An energy source may include a device for which power that may be produced per unit of volume and/or mass has been optimized, at the expense of the maximal total specific energy density or power capacity, during design. Non-limiting examples of items that may be used as at least an energy source may include batteries used for starting applications including Lithium ion (Li-ion) batteries which may include NCA, NMC, Lithium iron phosphate (LiFePO₄) and Lithium Manganese Oxide (LMO) batteries, which may be mixed with another cathode chemistry to provide more specific power if the application requires Li metal batteries, which have a lithium metal anode that provides high power on

demand, Li ion batteries that have a silicon or titanite anode, energy source may be used, in an embodiment, to provide electrical power to an aircraft or drone, such as an hybrid electric aircraft, during moments requiring high rates of power output, including without limitation takeoff, landing, thermal de-icing and situations requiring greater power output for reasons of stability, such as high turbulence situations. A battery may include, without limitation a battery using nickel based chemistries such as nickel cadmium or nickel metal hydride, a battery using lithium ion battery chemistries such as a nickel cobalt aluminum (NCA), nickel manganese cobalt (NMC), lithium iron phosphate (LiFePO₄), lithium cobalt oxide (LCO), and/or lithium manganese oxide (LMO), a battery using lithium polymer technology, lead-based batteries such as without limitation lead acid batteries, metal-air batteries, or any other suitable battery. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various devices or components that may be used as an energy source.

Still referring to FIG. 2, an energy source may include a plurality of energy sources, referred to herein as a module of energy sources. A module may include batteries (and/or generators) connected in parallel or in series or a plurality of modules connected either in series or in parallel designed to deliver both the power and energy requirements of the application. Connecting batteries (and/or generators) in series may increase the voltage of at least an energy source which may provide more power on demand. High voltage batteries may require cell matching when high peak load is needed. As more cells are connected in strings, there may exist the possibility of one cell failing which may increase resistance in the module and reduce an overall power output as a voltage of the module may decrease as a result of that failing cell. Connecting batteries (and/or generators) in parallel may increase total current capacity by decreasing total resistance, and it also may increase overall amp-hour capacity. Overall energy and power outputs of at least an energy source may be based on individual battery cell performance or an extrapolation based on measurement of at least an electrical parameter. In an embodiment where an energy source includes a plurality of battery cells, overall power output capacity may be dependent on electrical parameters of each individual cell. If one cell experiences high self-discharge during demand, power drawn from at least an energy source may be decreased to avoid damage to the weakest cell. An energy source may further include, without limitation, wiring, conduit, housing, cooling system, battery management system and fuel

management system. Persons skilled in the art will be aware, after reviewing the entirety of this disclosure, of many different components of an energy source.

Still referring to FIG. 2, as used in this disclosure a “power source” is a source that powers, drives and/or controls any flight component and/or other aircraft component. For example, and without limitation power source may include motor(s) or electric motor(s) 220 that operates to move one or more lift components 112 and/or one or more pusher components 116, to drive one or more blades, or the like thereof. Motor(s) 220 may be driven by direct current (DC) electric power and may include, without limitation, brushless DC electric motors, switched reluctance motors, induction motors, or any combination thereof. Motor(s) 220 may also include electronic speed controllers or other components for regulating motor speed, rotation direction, and/or dynamic braking. A “motor” as used in this disclosure is any machine that converts non-mechanical energy into mechanical energy. An “electric motor” as used in this disclosure is any machine that converts electrical energy into mechanical energy.

Still referring to FIG. 2, in an embodiment, aircraft 200 may further include one or more sensors 128. Sensor(s) 128 may be configured to transmit, directly or indirectly, flight data and system data to flight controller 124 and/or other computing device. Sensor(s) 128 may be communicatively connected to flight controller 124 and/or another computing device. In an embodiment sensor 128 may include a battery sensor. In an embodiment, sensor(s) 128 may be included in or be a part of flight controller 124. Sensor(s) 128 may include any of the sensors as disclosed in the entirety of the present disclosure.

With continued reference to FIG. 2, in some embodiments, sensor 128 may be mechanically connected to aircraft 200. As used herein, a person of ordinary skill in the art would understand “mechanically connected” to mean that at least a portion of a device, component, or circuit is connected to at least a portion of the aircraft via a mechanical connection. Said mechanical connection may be established, for example and without limitation, by mechanical fasteners such as bolts, rivets, screws, nails, bolt-nut combinations, pegs, dowels, pins, rods, locks, latches, clamps, combinations thereof, and the like, among others. Said mechanical connection may include, for example and without limitation, rigid coupling, such as beam coupling, bellows coupling, bushed pin coupling, constant velocity, split-muff coupling, diaphragm coupling, disc coupling, donut coupling, elastic coupling, flexible coupling, fluid coupling, gear coupling, grid coupling, hirth joints, hydrodynamic coupling, jaw coupling,

magnetic coupling, Oldham coupling, sleeve coupling, tapered shaft lock, twin spring coupling, rag joint coupling, adhesive coupling, universal joints, or any combination thereof. In an embodiment, mechanical connection may be used to connect the ends of adjacent parts and/or objects of an electric aircraft. Further, in an embodiment, mechanical connection may be used to join two pieces of rotating aircraft components. In some instances, the terminology “mechanically coupled” may be used in place of mechanically connected in this disclosure.

Still referring to FIG. 2, sensor(s) 128 may include any of the sensors as disclosed in the entirety of the present disclosure including those described with reference to at least FIG. 1. As used in this disclosure, a “sensor” is a device that is configured to detect a phenomenon and transmit information related to the detection of the phenomenon. For example, in some cases a sensor may transduce a detected phenomenon, such as without limitation, voltage, current, resistance, capacitance, impedance, distance, speed, velocity, angular velocity, rotational velocity, acceleration, direction, force, torque, temperature, pressure, humidity, precipitation, density, and the like, into a sensed signal. Sensor may include one or more sensors which may be the same, similar or different. Sensor may include a plurality of sensors which may be the same, similar or different. Sensor may include one or more sensor suites with sensors in each sensor suite being the same, similar or different.

Still referring to FIG. 2, sensor 128 may include any sensor or noise monitoring circuit described in this disclosure. Sensor 128, in some embodiments, may be communicatively connected or coupled to flight controller 124. Sensor may be a device, module, and/or subsystem, utilizing any hardware, software, and/or any combination thereof to sense a characteristic and/or changes thereof, in an instant environment, for example and without limitation, which the sensor may be proximal to or otherwise in a sensed communication with, and transmit information associated with the characteristic, for instance without limitation digitized data. Sensor 128 may be mechanically and/or communicatively coupled to aircraft 200. Sensor 128 may be configured to sense a characteristic associated with, for example and without limitation, a battery, a flight component and/or a pilot control of aircraft. An environmental sensor may include without limitation one or more sensors used to detect ambient temperature, barometric pressure, and/or air velocity. Sensor 128 may include without limitation gyroscopes, accelerometers, inertial measurement unit (IMU), and/or magnetic sensors, one or more humidity sensors, one or more oxygen sensors, or the like. Additionally or alternatively, sensor 128 may

include at least a geospatial sensor. Sensor 128 may be located inside aircraft, and/or be included in and/or attached to at least a portion of aircraft. Sensor may include one or more proximity sensors, displacement sensors, vibration sensors, and the like thereof. Sensor may be used to monitor the status of aircraft 200 for both critical and non-critical functions. Sensor may be
5 incorporated into vehicle or aircraft or, in some cases, be remote.

Continuing to refer to FIG. 2, non-limiting examples of sensor 128 may include an inertial measurement unit (IMU), an accelerometer, a gyroscope, a proximity sensor, a pressure sensor, a light sensor, a pitot tube, an air speed sensor, a wind sensor, a position sensor, a speed sensor, a switch, a thermometer, a strain gauge, an acoustic sensor, an electrical sensor, a current
10 sensor, a voltage sensor, a capacitance sensor, a resistance sensor, an impedance sensor, a thermal sensor, a humidity sensor, an angle sensor, a velocity sensor, an acceleration sensor, an optical sensor, a magnetic sensor, an electromagnetic sensor, and the like, among others. In some cases, sensor 128 may sense a characteristic as an analog measurement, for instance, yielding a continuously variable electrical potential indicative of the sensed characteristic. In these cases,
15 sensor 128 may additionally comprise an analog to digital converter (ADC) as well as any additionally circuitry, such as without limitation a Wheatstone bridge, an amplifier, a filter, and the like. For instance, in some cases, sensor 128 may comprise a strain gage configured to determine loading of one or more aircraft components, for example and without limitation, landing gear. Strain gage may be included within a circuit comprising a Wheatstone bridge, an
20 amplified, and a bandpass filter to provide an analog strain measurement signal having a high signal to noise ratio, which characterizes strain on a landing gear member. An ADC may then digitize analog signal produces a digital signal that can then be transmitted other systems within aircraft 200, for instance without limitation a computing system, a pilot display, and a memory component. Alternatively or additionally, sensor 128 may sense a characteristic of a pilot control
25 digitally. For instance in some embodiments, sensor 128 may sense a characteristic through a digital means or digitize a sensed signal natively. In some cases, for example, sensor 128 may include a rotational encoder and be configured to sense a rotational position of a pilot control or the like; in this case, the rotational encoder digitally may sense rotational “clicks” by any known method, such as without limitation magnetically, optically, and the like. Sensor 228 may include
30 any of the sensors as disclosed in the present disclosure. Sensor 128 may include a plurality of sensors. Any of these sensors may be located at any suitable position in or on aircraft 200.

With continued reference to FIG. 2, sensor 128 may include any device configured to measure and/or detect information related to electric aircraft 200. In a non-limiting embodiment, first sensor may include airspeed sensors, GPS sensors, altimeters, pitot tubes, pitot-static tubes, sensors and/or systems, external air density sensors (e.g. to facilitate in the calculation of stall speed and/or wind speed), pressure sensors, torque sensors, angle sensors (e.g., angle of attack, flight path angle), wind speed sensors, and the like, among others.

Referring now to FIG. 3, an exemplary embodiment of a power system 300 for a hybrid electric VTOL aircraft is illustrated. Hybrid electric VTOL aircraft can be the same, substantially the same or similar to any of the aircrafts as disclosed in the entirety of the present disclosure. For purposes of readability, the same reference numerals as FIG. 1 and FIG. 2 may be used to refer to like elements in FIG. 3. Power system 300 can be the same, substantially the same or similar to power system 140 of FIG. 1 and FIG. 2. Power system 300 may include one or more sensors which may include any of the sensors as disclosed in the entirety of the present disclosure. Power system 300 may include a computing device or controller which may include any of the computing devices and/or controllers as disclosed in the entirety of the present disclosure. Computing device may be communicatively connected to sensor(s) and/or any other components of power system 300 for purposes of controlling operation of power system 300 and its associated aircraft.

Still referring to FIG. 3, in some embodiments, fuel pod 208 includes and/or is integrated with a latching mechanism 304 which enables removable or detachable attachment to or mating with aircraft. Aircraft (e.g. aircraft 100 of FIG. 1 and aircraft 200 of FIG. 2) may have a compatible mating latching mechanism to facilitate such removable attachment. Advantageously, this adds a new dimension of versatility as, depending on the payload, flight conditions, and/or destination of the aircraft, fuel system 204 may be selectively utilized. A mating latching mechanism may be provided at any suitable location on aircraft such as, and without limitations, internal or external to booms, wings and fuselage of aircraft. As used in this disclosure, a “latching mechanism” is any mechanism or device that allows for removable or detachable connection between two elements. Latching mechanism may include latches, fasteners, clamps, locks, clips, actuators, bolts, screws, bolt-nut combinations, connectors which may be manually, electronically, magnetically and/or remotely operable to detachably connect, attach or fasten elements. Compatible and/or mating latching mechanism and elements may be provided on both

fuel pod and aircraft. For the purposes of this disclosure, “removably attached” means attached to an object such that it may be removed without damaging the object.

Referring now to FIG. 4, another exemplary embodiment of a power system 400 for a hybrid electric VTOL aircraft is illustrated. Hybrid electric VTOL aircraft can be the same, substantially the same or similar to any of the aircrafts as disclosed in the entirety of the present disclosure. For purposes of readability, the same reference numerals as FIG. 1 may be used to refer to like elements in FIG. 4. Power system 400 may include one or more sensors which may include any of the sensors as disclosed in the entirety of the present disclosure. Power system 400 may include a computing device or controller which may include any of the computing devices and/or controllers as disclosed in the entirety of the present disclosure. Computing device may be communicatively connected to sensor(s) and/or any other components of power system 400 for purposes of controlling operation of power system 400 and its associated aircraft.

Still referring to FIG. 4, power system 400 may include a battery system 424 and a fuel system. Battery system 424 may be housed in a fuselage 104 of hybrid electric VTOL aircraft. In a non-limiting example, battery system 424 may include three battery packs 428. In modified embodiments, the number of battery packs (and batteries therein) may be efficaciously changed, as needed or desired, depending on factors such as flight plan, flight destination, payload, and the like, among others. Battery system 424 and/or battery packs 428 may be housed in one or more bays in fuselage 104.

Continuing to refer to FIG. 4, power system 400 may include a fuel system with a first fuel pod 408a and a second fuel pod 408b. Fuel pod 408a may be attached to first boom 136a of aircraft. Fuel pod 408b may be attached to second boom 136b of aircraft. First fuel pod 408a may contain a first fuel tank 412a and a generator 416a. Second fuel pod 408b may contain a second fuel tank 412b and a second generator 416b. A latching mechanism may be provided to attach fuel pods to booms of aircraft. Fuel pods may be removably or detachably attached to booms of aircraft. This attachment may involve a “bolt-on” configuration. Hard mounting points may also be utilized for the attachment of fuel pods. Fuel pods may also be referred to as “drop tanks” and/or auxiliary power units (APUs). In a non-limiting example, fuel pods 408a, 408b may each have a power capacity in the range from about 60 kW to about 85 kW.

Referring now to FIG. 5, yet another exemplary embodiment of a power system 500 for a hybrid electric VTOL aircraft is illustrated. Hybrid electric VTOL aircraft can be the same,

substantially the same or similar to any of the aircrafts as disclosed in the entirety of the present disclosure. For purposes of readability, the same reference numerals as FIG. 1 may be used to refer to like elements in FIG. 5. Power system 500 may include one or more sensors which may include any of the sensors as disclosed in the entirety of the present disclosure. Power system

5 500 may include a computing device or controller which may include any of the computing devices and/or controllers as disclosed in the entirety of the present disclosure. Computing device may be communicatively connected to sensor(s) and/or any other components of power system 400 for purposes of controlling operation of power system 500 and its associated aircraft.

Still referring to FIG. 5, power system 500 may include a battery system 524 and a fuel

10 system 504. Battery system 524 may be housed in a fuselage 104 of hybrid electric VTOL aircraft. In a non-limiting example, battery system 524 may include two battery packs 528. In modified embodiments, the number of battery packs (and batteries therein) may be efficaciously changed, as needed or desired, depending on factors such as flight plan, flight destination, payload, and the like, among others. Battery system 524 and/or battery packs 528 may be housed

15 in one or more bays in fuselage 104.

Continuing to refer to FIG. 5, power system 500 may include a fuel system with a first fuel pod 508a, a second fuel pod 508b, a third fuel pod 508c and a generator 516. Fuel pods 508a, 508b, 508c may be housed in one or more bays in fuselage 104. First fuel pod 508a may contain a first fuel tank 512a. Second fuel pod 508b may contain a second fuel tank 512b. Third

20 fuel pod 508c may contain a third fuel tank 512c. A latching mechanism may be provided to attach fuel pods to fuselage of aircraft. Fuel pods may be removably or detachably attached to fuselage of aircraft. This attachment may involve a “bolt-on” configuration. Hard mounting points may also be utilized for the attachment of fuel pods. Fuel pods may also be referred to as “drop tanks” and/or auxiliary power units (APUs). Generator 516 may be provided in fuselage

25 104 of aircraft. Generator may be spaced from fuel pods. In an embodiment, generator 516 may be fixedly attached to fuselage 104 and may be integral to aircraft. In a modified embodiment, generator 516 may be removably or detachably attached to aircraft. In a non-limiting example, fuel system 504 may have a power capacity in the range from about 250 kW to about 500 kW.

Now referring to FIG. 6, an exemplary embodiment 600 of a flight controller 604 is

30 illustrated. (Flight controller 124 of FIG. 1 and FIG. 2 may be the same as or similar to flight controller 604.) As used in this disclosure a “flight controller” is a computing device of a

plurality of computing devices dedicated to data storage, security, distribution of traffic for load balancing, and flight instruction. Flight controller 604 may include and/or communicate with any computing device as described in this disclosure, including without limitation a microcontroller, microprocessor, digital signal processor (DSP) and/or system on a chip (SoC) as described in this disclosure. Further, flight controller 604 may include a single computing device operating independently, or may include two or more computing device operating in concert, in parallel, sequentially or the like; two or more computing devices may be included together in a single computing device or in two or more computing devices. In embodiments, flight controller 604 may be installed in an aircraft, may control the aircraft remotely, and/or may include an element installed in the aircraft and a remote element in communication therewith.

In an embodiment, and still referring to FIG. 6, flight controller 604 may include a signal transformation component 608. As used in this disclosure a “signal transformation component” is a component that transforms and/or converts a first signal to a second signal, wherein a signal may include one or more digital and/or analog signals. For example, and without limitation, signal transformation component 608 may be configured to perform one or more operations such as preprocessing, lexical analysis, parsing, semantic analysis, and the like thereof. In an embodiment, and without limitation, signal transformation component 608 may include one or more analog-to-digital convertors that transform a first signal of an analog signal to a second signal of a digital signal. For example, and without limitation, an analog-to-digital converter may convert an analog input signal to a 10-bit binary digital representation of that signal. In another embodiment, signal transformation component 608 may include transforming one or more low-level languages such as, but not limited to, machine languages and/or assembly languages. For example, and without limitation, signal transformation component 608 may include transforming a binary language signal to an assembly language signal. In an embodiment, and without limitation, signal transformation component 608 may include transforming one or more high-level languages and/or formal languages such as but not limited to alphabets, strings, and/or languages. For example, and without limitation, high-level languages may include one or more system languages, scripting languages, domain-specific languages, visual languages, esoteric languages, and the like thereof. As a further non-limiting example, high-level languages may include one or more algebraic formula languages, business data languages, string and list languages, object-oriented languages, and the like thereof.

Still referring to FIG. 6, signal transformation component 608 may be configured to optimize an intermediate representation 612. As used in this disclosure an “intermediate representation” is a data structure and/or code that represents the input signal. Signal transformation component 608 may optimize intermediate representation as a function of a data-flow analysis, dependence analysis, alias analysis, pointer analysis, escape analysis, and the like thereof. In an embodiment, and without limitation, signal transformation component 608 may optimize intermediate representation 612 as a function of one or more inline expansions, dead code eliminations, constant propagation, loop transformations, and/or automatic parallelization functions. In another embodiment, signal transformation component 608 may optimize intermediate representation as a function of a machine dependent optimization such as a peephole optimization, wherein a peephole optimization may rewrite short sequences of code into more efficient sequences of code. Signal transformation component 608 may optimize intermediate representation to generate an output language, wherein an “output language,” as used herein, is the native machine language of flight controller 604. For example, and without limitation, native machine language may include one or more binary and/or numerical languages.

In an embodiment, and without limitation, signal transformation component 608 may include transform one or more inputs and outputs as a function of an error correction code. An error correction code, also known as error correcting code (ECC), is an encoding of a message or lot of data using redundant information, permitting recovery of corrupted data. An ECC may include a block code, in which information is encoded on fixed-size packets and/or blocks of data elements such as symbols of predetermined size, bits, or the like. Reed-Solomon coding, in which message symbols within a symbol set having q symbols are encoded as coefficients of a polynomial of degree less than or equal to a natural number k , over a finite field F with q elements; strings so encoded have a minimum hamming distance of $k+1$, and permit correction of $(q-k-1)/2$ erroneous symbols. Block code may alternatively or additionally be implemented using Golay coding, also known as binary Golay coding, Bose-Chaudhuri, Hocquenghem (BCH) coding, multidimensional parity-check coding, and/or Hamming codes. An ECC may alternatively or additionally be based on a convolutional code.

In an embodiment, and still referring to FIG. 6, flight controller 604 may include a reconfigurable hardware platform 616. A “reconfigurable hardware platform,” as used herein, is a component and/or unit of hardware that may be reprogrammed, such that, for instance, a data

path between elements such as logic gates or other digital circuit elements may be modified to change an algorithm, state, logical sequence, or the like of the component and/or unit. This may be accomplished with such flexible high-speed computing fabrics as field-programmable gate arrays (FPGAs), which may include a grid of interconnected logic gates, connections between
5 which may be severed and/or restored to program in modified logic. Reconfigurable hardware platform 616 may be reconfigured to enact any algorithm and/or algorithm selection process received from another computing device and/or created using machine-learning processes.

Still referring to FIG. 6, reconfigurable hardware platform 616 may include a logic component 620. As used in this disclosure a “logic component” is a component that executes
10 instructions on output language. For example, and without limitation, logic component may perform basic arithmetic, logic, controlling, input/output operations, and the like thereof. Logic component 620 may include any suitable processor, such as without limitation a component incorporating logical circuitry for performing arithmetic and logical operations, such as an arithmetic and logic unit (ALU), which may be regulated with a state machine and directed by
15 operational inputs from memory and/or sensors; logic component 620 may be organized according to Von Neumann and/or Harvard architecture as a non-limiting example. Logic component 620 may include, incorporate, and/or be incorporated in, without limitation, a microcontroller, microprocessor, digital signal processor (DSP), Field Programmable Gate Array (FPGA), Complex Programmable Logic Device (CPLD), Graphical Processing Unit (GPU),
20 general purpose GPU, Tensor Processing Unit (TPU), analog or mixed signal processor, Trusted Platform Module (TPM), a floating point unit (FPU), and/or system on a chip (SoC). In an embodiment, logic component 620 may include one or more integrated circuit microprocessors, which may contain one or more central processing units, central processors, and/or main processors, on a single metal-oxide-semiconductor chip. Logic component 620 may be
25 configured to execute a sequence of stored instructions to be performed on the output language and/or intermediate representation 612. Logic component 620 may be configured to fetch and/or retrieve the instruction from a memory cache, wherein a “memory cache,” as used in this disclosure, is a stored instruction set on flight controller 604. Logic component 620 may be configured to decode the instruction retrieved from the memory cache to opcodes and/or
30 operands. Logic component 620 may be configured to execute the instruction on intermediate representation 612 and/or output language. For example, and without limitation, logic component

620 may be configured to execute an addition operation on intermediate representation 612 and/or output language.

In an embodiment, and without limitation, logic component 620 may be configured to calculate a flight element 624. As used in this disclosure a “flight element” is an element of datum denoting a relative status of aircraft. For example, and without limitation, flight element 624 may denote one or more torques, thrusts, airspeed velocities, forces, altitudes, groundspeed velocities, directions during flight, directions facing, forces, orientations, and the like thereof. For example, and without limitation, flight element 624 may denote that aircraft is cruising at an altitude and/or with a sufficient magnitude of forward thrust. As a further non-limiting example, flight status may denote that is building thrust and/or groundspeed velocity in preparation for a takeoff. As a further non-limiting example, flight element 624 may denote that aircraft is following a flight path accurately and/or sufficiently.

Still referring to FIG. 6, flight controller 604 may include a chipset component 628. As used in this disclosure a “chipset component” is a component that manages data flow. In an embodiment, and without limitation, chipset component 628 may include a northbridge data flow path, wherein the northbridge dataflow path may manage data flow from logic component 620 to a high-speed device and/or component, such as a RAM, graphics controller, and the like thereof. In another embodiment, and without limitation, chipset component 628 may include a southbridge data flow path, wherein the southbridge dataflow path may manage data flow from logic component 620 to lower-speed peripheral buses, such as a peripheral component interconnect (PCI), industry standard architecture (ICA), and the like thereof. In an embodiment, and without limitation, southbridge data flow path may include managing data flow between peripheral connections such as ethernet, USB, audio devices, and the like thereof. Additionally or alternatively, chipset component 628 may manage data flow between logic component 620, memory cache, and a flight component 108. As used in this disclosure (and with particular reference to FIG. 6) a “flight component” is a portion of an aircraft that can be moved or adjusted to affect one or more flight elements. For example, flight component 108 may include a component used to affect the aircrafts’ roll and pitch which may comprise one or more ailerons. As a further example, flight component 108 may include a rudder to control yaw of an aircraft. In an embodiment, chipset component 628 may be configured to communicate with a plurality of flight components as a function of flight element 624. For example, and without limitation,

chipset component 628 may transmit to an aircraft rotor to reduce torque of a first lift propulsor and increase the forward thrust produced by a pusher component to perform a flight maneuver.

In an embodiment, and still referring to FIG. 6, flight controller 604 may be configured generate an autonomous function. As used in this disclosure an “autonomous function” is a mode
5 and/or function of flight controller 604 that controls aircraft automatically. For example, and without limitation, autonomous function may perform one or more aircraft maneuvers, take offs, landings, altitude adjustments, flight leveling adjustments, turns, climbs, and/or descents. As a further non-limiting example, autonomous function may adjust one or more airspeed velocities, thrusts, torques, and/or groundspeed velocities. As a further non-limiting example, autonomous
10 function may perform one or more flight path corrections and/or flight path modifications as a function of flight element 624. In an embodiment, autonomous function may include one or more modes of autonomy such as, but not limited to, autonomous mode, semi-autonomous mode, and/or non-autonomous mode. As used in this disclosure “autonomous mode” is a mode that automatically adjusts and/or controls aircraft and/or the maneuvers of aircraft in its entirety. For
15 example, autonomous mode may denote that flight controller 604 will adjust the aircraft. As used in this disclosure a “semi-autonomous mode” is a mode that automatically adjusts and/or controls a portion and/or section of aircraft. For example, and without limitation, semi-autonomous mode may denote that a pilot will control the propulsors, wherein flight controller 604 will control the ailerons and/or rudders. As used in this disclosure “non-autonomous mode”
20 is a mode that denotes a pilot will control aircraft and/or maneuvers of aircraft in its entirety.

In an embodiment, and still referring to FIG. 6, flight controller 604 may generate autonomous function as a function of an autonomous machine-learning model. As used in this disclosure an “autonomous machine-learning model” is a machine-learning model to produce an autonomous function output given flight element 624 and a pilot signal 636 as inputs; this is in
25 contrast to a non-machine learning software program where the commands to be executed are determined in advance by a user and written in a programming language. As used in this disclosure a “pilot signal” is an element of datum representing one or more functions a pilot is controlling and/or adjusting. For example, pilot signal 636 may denote that a pilot is controlling and/or maneuvering ailerons, wherein the pilot is not in control of the rudders and/or propulsors.
30 In an embodiment, pilot signal 636 may include an implicit signal and/or an explicit signal. For example, and without limitation, pilot signal 636 may include an explicit signal, wherein the

pilot explicitly states there is a lack of control and/or desire for autonomous function. As a further non-limiting example, pilot signal 636 may include an explicit signal directing flight controller 604 to control and/or maintain a portion of aircraft, a portion of the flight plan, the entire aircraft, and/or the entire flight plan. As a further non-limiting example, pilot signal 636 may include an implicit signal, wherein flight controller 604 detects a lack of control such as by a malfunction, torque alteration, flight path deviation, and the like thereof. In an embodiment, and without limitation, pilot signal 636 may include one or more explicit signals to reduce torque, and/or one or more implicit signals that torque may be reduced due to reduction of airspeed velocity. In an embodiment, and without limitation, pilot signal 636 may include one or more local and/or global signals. For example, and without limitation, pilot signal 636 may include a local signal that is transmitted by a pilot and/or crew member. As a further non-limiting example, pilot signal 636 may include a global signal that is transmitted by air traffic control and/or one or more remote users that are in communication with the pilot of aircraft. In an embodiment, pilot signal 636 may be received as a function of a tri-state bus and/or multiplexor that denotes an explicit pilot signal should be transmitted prior to any implicit or global pilot signal.

Still referring to FIG. 6, autonomous machine-learning model may include one or more autonomous machine-learning processes such as supervised, unsupervised, or reinforcement machine-learning processes that flight controller 604 and/or a remote device may or may not use in the generation of autonomous function. As used in this disclosure “remote device” is an external device to flight controller 604. Additionally or alternatively, autonomous machine-learning model may include one or more autonomous machine-learning processes that a field-programmable gate array (FPGA) may or may not use in the generation of autonomous function. Autonomous machine-learning process may include, without limitation machine learning processes such as simple linear regression, multiple linear regression, polynomial regression, support vector regression, ridge regression, lasso regression, elasticnet regression, decision tree regression, random forest regression, logistic regression, logistic classification, K-nearest neighbors, support vector machines, kernel support vector machines, naïve bayes, decision tree classification, random forest classification, K-means clustering, hierarchical clustering, dimensionality reduction, principal component analysis, linear discriminant analysis, kernel principal component analysis, Q-learning, State Action Reward State Action (SARSA), Deep-Q

network, Markov decision processes, Deep Deterministic Policy Gradient (DDPG), or the like thereof.

In an embodiment, and still referring to FIG. 6, autonomous machine learning model may be trained as a function of autonomous training data, wherein autonomous training data may correlate a flight element, pilot signal, and/or simulation data to an autonomous function. For example, and without limitation, a flight element of an airspeed velocity, a pilot signal of limited and/or no control of propulsors, and a simulation data of required airspeed velocity to reach the destination may result in an autonomous function that includes a semi-autonomous mode to increase thrust of the propulsors. Autonomous training data may be received as a function of user-entered valuations of flight elements, pilot signals, simulation data, and/or autonomous functions. Flight controller 604 may receive autonomous training data by receiving correlations of flight element, pilot signal, and/or simulation data to an autonomous function that were previously received and/or determined during a previous iteration of generation of autonomous function. Autonomous training data may be received by one or more remote devices and/or FPGAs that at least correlate a flight element, pilot signal, and/or simulation data to an autonomous function. Autonomous training data may be received in the form of one or more user-entered correlations of a flight element, pilot signal, and/or simulation data to an autonomous function.

Still referring to FIG. 6, flight controller 604 may receive autonomous machine-learning model from a remote device and/or FPGA that utilizes one or more autonomous machine learning processes, wherein a remote device and an FPGA is described above in detail. For example, and without limitation, a remote device may include a computing device, external device, processor, FPGA, microprocessor and the like thereof. Remote device and/or FPGA may perform the autonomous machine-learning process using autonomous training data to generate autonomous function and transmit the output to flight controller 604. Remote device and/or FPGA may transmit a signal, bit, datum, or parameter to flight controller 604 that at least relates to autonomous function. Additionally or alternatively, the remote device and/or FPGA may provide an updated machine-learning model. For example, and without limitation, an updated machine-learning model may be comprised of a firmware update, a software update, an autonomous machine-learning process correction, and the like thereof. As a non-limiting example a software update may incorporate a new simulation data that relates to a modified

flight element. Additionally or alternatively, the updated machine learning model may be transmitted to the remote device and/or FPGA, wherein the remote device and/or FPGA may replace the autonomous machine-learning model with the updated machine-learning model and generate the autonomous function as a function of the flight element, pilot signal, and/or simulation data using the updated machine-learning model. The updated machine-learning model may be transmitted by the remote device and/or FPGA and received by flight controller 604 as a software update, firmware update, or corrected autonomous machine-learning model. For example, and without limitation autonomous machine learning model may utilize a neural net machine-learning process, wherein the updated machine-learning model may incorporate a gradient boosting machine-learning process.

Still referring to FIG. 6, flight controller 604 may include, be included in, and/or communicate with a mobile device such as a mobile telephone or smartphone. Further, flight controller may communicate with one or more additional devices as described below in further detail via a network interface device. The network interface device may be utilized for commutatively connecting a flight controller to one or more of a variety of networks, and one or more devices. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. The network may include any network topology and can may employ a wired and/or a wireless mode of communication.

In an embodiment, and still referring to FIG. 6, flight controller 604 may include, but is not limited to, for example, a cluster of flight controllers in a first location and a second flight controller or cluster of flight controllers in a second location. Flight controller 604 may include one or more flight controllers dedicated to data storage, security, distribution of traffic for load balancing, and the like. Flight controller 604 may be configured to distribute one or more computing tasks as described below across a plurality of flight controllers, which may operate in parallel, in series, redundantly, or in any other manner used for distribution of tasks or memory

between computing devices. For example, and without limitation, flight controller 604 may implement a control algorithm to distribute and/or command the plurality of flight controllers. As used in this disclosure a “control algorithm” is a finite sequence of well-defined computer implementable instructions that may determine the flight component of the plurality of flight components to be adjusted. For example, and without limitation, control algorithm may include one or more algorithms that reduce and/or prevent aviation asymmetry. As a further non-limiting example, control algorithms may include one or more models generated as a function of a software including, but not limited to Simulink by MathWorks, Natick, Massachusetts, USA. In an embodiment, and without limitation, control algorithm may be configured to generate an auto-code, wherein an “auto-code,” is used herein, is a code and/or algorithm that is generated as a function of the one or more models and/or software’s. In another embodiment, control algorithm may be configured to produce a segmented control algorithm. As used in this disclosure a “segmented control algorithm” is control algorithm that has been separated and/or parsed into discrete sections. For example, and without limitation, segmented control algorithm may parse control algorithm into two or more segments, wherein each segment of control algorithm may be performed by one or more flight controllers operating on distinct flight components.

In an embodiment, and still referring to FIG. 6, control algorithm may be configured to determine a segmentation boundary as a function of segmented control algorithm. As used in this disclosure a “segmentation boundary” is a limit and/or delineation associated with the segments of the segmented control algorithm. For example, and without limitation, segmentation boundary may denote that a segment in the control algorithm has a first starting section and/or a first ending section. As a further non-limiting example, segmentation boundary may include one or more boundaries associated with an ability of flight component 108. In an embodiment, control algorithm may be configured to create an optimized signal communication as a function of segmentation boundary. For example, and without limitation, optimized signal communication may include identifying the discrete timing required to transmit and/or receive the one or more segmentation boundaries. In an embodiment, and without limitation, creating optimized signal communication further comprises separating a plurality of signal codes across the plurality of flight controllers. For example, and without limitation the plurality of flight controllers may include one or more formal networks, wherein formal networks transmit data along an authority chain and/or are limited to task-related communications. As a further non-limiting example,

communication network may include informal networks, wherein informal networks transmit data in any direction. In an embodiment, and without limitation, the plurality of flight controllers may include a chain path, wherein a “chain path,” as used herein, is a linear communication path comprising a hierarchy that data may flow through. In an embodiment, and without limitation, the plurality of flight controllers may include an all-channel path, wherein an “all-channel path,” as used herein, is a communication path that is not restricted to a particular direction. For example, and without limitation, data may be transmitted upward, downward, laterally, and the like thereof. In an embodiment, and without limitation, the plurality of flight controllers may include one or more neural networks that assign a weighted value to a transmitted datum. For example, and without limitation, a weighted value may be assigned as a function of one or more signals denoting that a flight component is malfunctioning and/or in a failure state.

Still referring to FIG. 6, the plurality of flight controllers may include a master bus controller. As used in this disclosure a “master bus controller” is one or more devices and/or components that are connected to a bus to initiate a direct memory access transaction, wherein a bus is one or more terminals in a bus architecture. Master bus controller may communicate using synchronous and/or asynchronous bus control protocols. In an embodiment, master bus controller may include flight controller 604. In another embodiment, master bus controller may include one or more universal asynchronous receiver-transmitters (UART). For example, and without limitation, master bus controller may include one or more bus architectures that allow a bus to initiate a direct memory access transaction from one or more buses in the bus architectures. As a further non-limiting example, master bus controller may include one or more peripheral devices and/or components to communicate with another peripheral device and/or component and/or the master bus controller. In an embodiment, master bus controller may be configured to perform bus arbitration. As used in this disclosure “bus arbitration” is method and/or scheme to prevent multiple buses from attempting to communicate with and/or connect to master bus controller. For example and without limitation, bus arbitration may include one or more schemes such as a small computer interface system, wherein a small computer interface system is a set of standards for physical connecting and transferring data between peripheral devices and master bus controller by defining commands, protocols, electrical, optical, and/or logical interfaces. In an embodiment, master bus controller may receive intermediate representation 612 and/or output language from logic component 620, wherein output language

may include one or more analog-to-digital conversions, low bit rate transmissions, message encryptions, digital signals, binary signals, logic signals, analog signals, and the like thereof described above in detail.

Still referring to FIG. 6, master bus controller may communicate with a slave bus. As used in this disclosure a “slave bus” is one or more peripheral devices and/or components that initiate a bus transfer. For example, and without limitation, slave bus may receive one or more controls and/or asymmetric communications from master bus controller, wherein slave bus transfers data stored to master bus controller. In an embodiment, and without limitation, slave bus may include one or more internal buses, such as but not limited to a/an internal data bus, memory bus, system bus, front-side bus, and the like thereof. In another embodiment, and without limitation, slave bus may include one or more external buses such as external flight controllers, external computers, remote devices, printers, aircraft computer systems, flight control systems, and the like thereof.

In an embodiment, and still referring to FIG. 6, control algorithm may optimize signal communication as a function of determining one or more discrete timings. For example, and without limitation master bus controller may synchronize timing of the segmented control algorithm by injecting high priority timing signals on a bus of the master bus control. As used in this disclosure a “high priority timing signal” is information denoting that the information is important. For example, and without limitation, high priority timing signal may denote that a section of control algorithm is of high priority and should be analyzed and/or transmitted prior to any other sections being analyzed and/or transmitted. In an embodiment, high priority timing signal may include one or more priority packets. As used in this disclosure a “priority packet” is a formatted unit of data that is communicated between the plurality of flight controllers. For example, and without limitation, priority packet may denote that a section of control algorithm should be used and/or is of greater priority than other sections.

Still referring to FIG. 6, flight controller 604 may also be implemented using a “shared nothing” architecture in which data is cached at the worker, in an embodiment, this may enable scalability of aircraft and/or computing device. Flight controller 604 may include a distributor flight controller. As used in this disclosure a “distributor flight controller” is a component that adjusts and/or controls a plurality of flight components as a function of a plurality of flight controllers. For example, distributor flight controller may include a flight controller that

communicates with a plurality of additional flight controllers and/or clusters of flight controllers. In an embodiment, distributed flight control may include one or more neural networks. For example, neural network also known as an artificial neural network, is a network of “nodes,” or data structures having one or more inputs, one or more outputs, and a function determining
5 outputs based on inputs. Such nodes may be organized in a network, such as without limitation a convolutional neural network, including an input layer of nodes, one or more intermediate layers, and an output layer of nodes. Connections between nodes may be created via the process of “training” the network, in which elements from a training dataset are applied to the input nodes, a suitable training algorithm (such as Levenberg-Marquardt, conjugate gradient, simulated
10 annealing, or other algorithms) is then used to adjust the connections and weights between nodes in adjacent layers of the neural network to produce the desired values at the output nodes. This process is sometimes referred to as deep learning.

Still referring to FIG. 6, a node may include, without limitation a plurality of inputs x_i that may receive numerical values from inputs to a neural network containing the node and/or
15 from other nodes. Node may perform a weighted sum of inputs using weights w_i that are multiplied by respective inputs x_i . Additionally or alternatively, a bias b may be added to the weighted sum of the inputs such that an offset is added to each unit in the neural network layer that is independent of the input to the layer. The weighted sum may then be input into a function ϕ , which may generate one or more outputs y . Weight w_i applied to an input x_i may indicate
20 whether the input is “excitatory,” indicating that it has strong influence on the one or more outputs y , for instance by the corresponding weight having a large numerical value, and/or a “inhibitory,” indicating it has a weak effect influence on the one more inputs y , for instance by the corresponding weight having a small numerical value. The values of weights w_i may be determined by training a neural network using training data, which may be performed using any
25 suitable process as described above. In an embodiment, and without limitation, a neural network may receive semantic units as inputs and output vectors representing such semantic units according to weights w_i that are derived using machine-learning processes as described in this disclosure.

Still referring to FIG. 6, flight controller may include a sub-controller 640. As used in this
30 disclosure a “sub-controller” is a controller and/or component that is part of a distributed controller as described above; for instance, flight controller 604 may be and/or include a

distributed flight controller made up of one or more sub-controllers. For example, and without limitation, sub-controller 640 may include any controllers and/or components thereof that are similar to distributed flight controller and/or flight controller as described above. Sub-controller 640 may include any component of any flight controller as described above. Sub-controller 640 may be implemented in any manner suitable for implementation of a flight controller as described above. As a further non-limiting example, sub-controller 640 may include one or more processors, logic components and/or computing devices capable of receiving, processing, and/or transmitting data across the distributed flight controller as described above. As a further non-limiting example, sub-controller 640 may include a controller that receives a signal from a first flight controller and/or first distributed flight controller component and transmits the signal to a plurality of additional sub-controllers and/or flight components.

Still referring to FIG. 6, flight controller may include a co-controller 644. As used in this disclosure a “co-controller” is a controller and/or component that joins flight controller 604 as components and/or nodes of a distributed flight controller as described above. For example, and without limitation, co-controller 644 may include one or more controllers and/or components that are similar to flight controller 604. As a further non-limiting example, co-controller 644 may include any controller and/or component that joins flight controller 604 to distributed flight controller. As a further non-limiting example, co-controller 644 may include one or more processors, logic components and/or computing devices capable of receiving, processing, and/or transmitting data to and/or from flight controller 604 to distributed flight control system. Co-controller 644 may include any component of any flight controller as described above. Co-controller 644 may be implemented in any manner suitable for implementation of a flight controller as described above.

In an embodiment, and with continued reference to FIG. 6, flight controller 604 may be designed and/or configured to perform any method, method step, or sequence of method steps in any embodiment described in this disclosure, in any order and with any degree of repetition. For instance, flight controller 604 may be configured to perform a single step or sequence repeatedly until a desired or commanded outcome is achieved; repetition of a step or a sequence of steps may be performed iteratively and/or recursively using outputs of previous repetitions as inputs to subsequent repetitions, aggregating inputs and/or outputs of repetitions to produce an aggregate result, reduction or decrement of one or more variables such as global variables, and/or division

of a larger processing task into a set of iteratively addressed smaller processing tasks. Flight controller may perform any step or sequence of steps as described in this disclosure in parallel, such as simultaneously and/or substantially simultaneously performing a step two or more times using two or more parallel threads, processor cores, or the like; division of tasks between parallel threads and/or processes may be performed according to any protocol suitable for division of tasks between iterations. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which steps, sequences of steps, processing tasks, and/or data may be subdivided, shared, or otherwise dealt with using iteration, recursion, and/or parallel processing.

Referring now to FIG. 7, an exemplary embodiment of a machine-learning module 700 that may perform one or more machine-learning processes as described in this disclosure is illustrated. Machine-learning module may perform determinations, classification, and/or analysis steps, methods, processes, or the like as described in this disclosure using machine-learning processes. A “machine-learning process,” as used in this disclosure, is a process that automatically uses training data 704 to generate an algorithm that will be performed by a computing device/module to produce outputs 708 given data provided as inputs 712; this is in contrast to a non-machine-learning software program where the commands to be executed are determined in advance by a user and written in a programming language.

Still referring to FIG. 7, “training data,” as used herein, is data containing correlations that a machine-learning process may use to model relationships between two or more categories of data elements. For instance, and without limitation, training data 704 may include a plurality of data entries, each entry representing a set of data elements that were recorded, received, and/or generated together; data elements may be correlated by shared existence in a given data entry, by proximity in a given data entry, or the like. Multiple data entries in training data 704 may evince one or more trends in correlations between categories of data elements; for instance, and without limitation, a higher value of a first data element belonging to a first category of data element may tend to correlate to a higher value of a second data element belonging to a second category of data element, indicating a possible proportional or other mathematical relationship linking values belonging to the two categories. Multiple categories of data elements may be related in training data 704 according to various correlations; correlations may indicate causative and/or predictive links between categories of data elements, which may be modeled as relationships such as

mathematical relationships by machine-learning processes as described in further detail below.

Training data 704 may be formatted and/or organized by categories of data elements, for instance by associating data elements with one or more descriptors corresponding to categories of data elements. As a non-limiting example, training data 704 may include data entered in standardized forms by persons or processes, such that entry of a given data element in a given field in a form may be mapped to one or more descriptors of categories. Elements in training data 704 may be linked to descriptors of categories by tags, tokens, or other data elements; for instance, and without limitation, training data 704 may be provided in fixed-length formats, formats linking positions of data to categories such as comma-separated value (CSV) formats and/or self-describing formats such as extensible markup language (XML), JavaScript Object Notation (JSON), or the like, enabling processes or devices to detect categories of data.

Alternatively or additionally, and continuing to refer to FIG. 7, training data 704 may include one or more elements that are not categorized; that is, training data 704 may not be formatted or contain descriptors for some elements of data. Machine-learning algorithms and/or other processes may sort training data 704 according to one or more categorizations using, for instance, natural language processing algorithms, tokenization, detection of correlated values in raw data and the like; categories may be generated using correlation and/or other processing algorithms. As a non-limiting example, in a corpus of text, phrases making up a number “n” of compound words, such as nouns modified by other nouns, may be identified according to a statistically significant prevalence of n-grams containing such words in a particular order; such an n-gram may be categorized as an element of language such as a “word” to be tracked similarly to single words, generating a new category as a result of statistical analysis. Similarly, in a data entry including some textual data, a person’s name may be identified by reference to a list, dictionary, or other compendium of terms, permitting ad-hoc categorization by machine-learning algorithms, and/or automated association of data in the data entry with descriptors or into a given format. The ability to categorize data entries automatically may enable the same training data 704 to be made applicable for two or more distinct machine-learning algorithms as described in further detail below. Training data 704 used by machine-learning module 700 may correlate any input data as described in this disclosure to any output data as described in this disclosure. As a non-limiting illustrative example flight elements and/or pilot signals may be inputs, wherein an output may be an autonomous function.

Further referring to FIG. 7, training data may be filtered, sorted, and/or selected using one or more supervised and/or unsupervised machine-learning processes and/or models as described in further detail below; such models may include without limitation a training data classifier 716. Training data classifier 716 may include a “classifier,” which as used in this disclosure is a machine-learning model as defined below, such as a mathematical model, neural net, or program generated by a machine learning algorithm known as a “classification algorithm,” as described in further detail below, that sorts inputs into categories or bins of data, outputting the categories or bins of data and/or labels associated therewith. A classifier may be configured to output at least a datum that labels or otherwise identifies a set of data that are clustered together, found to be close under a distance metric as described below, or the like. Machine-learning module 700 may generate a classifier using a classification algorithm, defined as a processes whereby a computing device and/or any module and/or component operating thereon derives a classifier from training data 704. Classification may be performed using, without limitation, linear classifiers such as without limitation logistic regression and/or naive Bayes classifiers, nearest neighbor classifiers such as k-nearest neighbors classifiers, support vector machines, least squares support vector machines, fisher’s linear discriminant, quadratic classifiers, decision trees, boosted trees, random forest classifiers, learning vector quantization, and/or neural network-based classifiers. As a non-limiting example, training data classifier 716 may classify elements of training data to sub-categories of flight elements such as torques, forces, thrusts, directions, and the like thereof.

Still referring to FIG. 7, machine-learning module 700 may be configured to perform a lazy-learning process 720 and/or protocol, which may alternatively be referred to as a “lazy loading” or “call-when-needed” process and/or protocol, may be a process whereby machine learning is conducted upon receipt of an input to be converted to an output, by combining the input and training set to derive the algorithm to be used to produce the output on demand. For instance, an initial set of simulations may be performed to cover an initial heuristic and/or “first guess” at an output and/or relationship. As a non-limiting example, an initial heuristic may include a ranking of associations between inputs and elements of training data 704. Heuristic may include selecting some number of highest-ranking associations and/or training data 704 elements. Lazy learning may implement any suitable lazy learning algorithm, including without limitation a K-nearest neighbors algorithm, a lazy naïve Bayes algorithm, or the like; persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various lazy-

learning algorithms that may be applied to generate outputs as described in this disclosure, including without limitation lazy learning applications of machine-learning algorithms as described in further detail below.

Alternatively or additionally, and with continued reference to FIG. 7, machine-learning processes as described in this disclosure may be used to generate machine-learning models 724. A “machine-learning model,” as used in this disclosure, is a mathematical and/or algorithmic representation of a relationship between inputs and outputs, as generated using any machine-learning process including without limitation any process as described above, and stored in memory; an input is submitted to a machine-learning model 724 once created, which generates an output based on the relationship that was derived. For instance, and without limitation, a linear regression model, generated using a linear regression algorithm, may compute a linear combination of input data using coefficients derived during machine-learning processes to calculate an output datum. As a further non-limiting example, a machine-learning model 724 may be generated by creating an artificial neural network, such as a convolutional neural network comprising an input layer of nodes, one or more intermediate layers, and an output layer of nodes. Connections between nodes may be created via the process of “training” the network, in which elements from a training data 704 set are applied to the input nodes, a suitable training algorithm (such as Levenberg-Marquardt, conjugate gradient, simulated annealing, or other algorithms) is then used to adjust the connections and weights between nodes in adjacent layers of the neural network to produce the desired values at the output nodes. This process is sometimes referred to as deep learning.

Still referring to FIG. 7, machine-learning algorithms may include at least a supervised machine-learning process 728. At least a supervised machine-learning process 728, as defined herein, include algorithms that receive a training set relating a number of inputs to a number of outputs, and seek to find one or more mathematical relations relating inputs to outputs, where each of the one or more mathematical relations is optimal according to some criterion specified to the algorithm using some scoring function. For instance, a supervised learning algorithm may include flight elements and/or pilot signals as described above as inputs, autonomous functions as outputs, and a scoring function representing a desired form of relationship to be detected between inputs and outputs; scoring function may, for instance, seek to maximize the probability that a given input and/or combination of elements inputs is associated with a given output to

minimize the probability that a given input is not associated with a given output. Scoring function may be expressed as a risk function representing an “expected loss” of an algorithm relating inputs to outputs, where loss is computed as an error function representing a degree to which a prediction generated by the relation is incorrect when compared to a given input-output pair provided in training data 704. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various possible variations of at least a supervised machine-learning process 728 that may be used to determine relation between inputs and outputs. Supervised machine-learning processes may include classification algorithms as defined above.

Further referring to FIG. 7, machine learning processes may include at least an unsupervised machine-learning processes 732. An unsupervised machine-learning process, as used herein, is a process that derives inferences in datasets without regard to labels; as a result, an unsupervised machine-learning process may be free to discover any structure, relationship, and/or correlation provided in the data. Unsupervised processes may not require a response variable; unsupervised processes may be used to find interesting patterns and/or inferences between variables, to determine a degree of correlation between two or more variables, or the like.

Still referring to FIG. 7, machine-learning module 700 may be designed and configured to create a machine-learning model 724 using techniques for development of linear regression models. Linear regression models may include ordinary least squares regression, which aims to minimize the square of the difference between predicted outcomes and actual outcomes according to an appropriate norm for measuring such a difference (e.g. a vector-space distance norm); coefficients of the resulting linear equation may be modified to improve minimization. Linear regression models may include ridge regression methods, where the function to be minimized includes the least-squares function plus term multiplying the square of each coefficient by a scalar amount to penalize large coefficients. Linear regression models may include least absolute shrinkage and selection operator (LASSO) models, in which ridge regression is combined with multiplying the least-squares term by a factor of 1 divided by double the number of samples. Linear regression models may include a multi-task lasso model wherein the norm applied in the least-squares term of the lasso model is the Frobenius norm amounting to the square root of the sum of squares of all terms. Linear regression models may include the elastic net model, a multi-task elastic net model, a least angle regression model, a LARS lasso

model, an orthogonal matching pursuit model, a Bayesian regression model, a logistic regression model, a stochastic gradient descent model, a perceptron model, a passive aggressive algorithm, a robustness regression model, a Huber regression model, or any other suitable model that may occur to persons skilled in the art upon reviewing the entirety of this disclosure. Linear regression models may be generalized in an embodiment to polynomial regression models, whereby a polynomial equation (e.g. a quadratic, cubic or higher-order equation) providing a best predicted output/actual output fit is sought; similar methods to those described above may be applied to minimize error functions, as will be apparent to persons skilled in the art upon reviewing the entirety of this disclosure.

Continuing to refer to FIG. 7, machine-learning algorithms may include, without limitation, linear discriminant analysis. Machine-learning algorithm may include quadratic discriminate analysis. Machine-learning algorithms may include kernel ridge regression. Machine-learning algorithms may include support vector machines, including without limitation support vector classification-based regression processes. Machine-learning algorithms may include stochastic gradient descent algorithms, including classification and regression algorithms based on stochastic gradient descent. Machine-learning algorithms may include nearest neighbors algorithms. Machine-learning algorithms may include Gaussian processes such as Gaussian Process Regression. Machine-learning algorithms may include cross-decomposition algorithms, including partial least squares and/or canonical correlation analysis. Machine-learning algorithms may include naïve Bayes methods. Machine-learning algorithms may include algorithms based on decision trees, such as decision tree classification or regression algorithms. Machine-learning algorithms may include ensemble methods such as bagging meta-estimator, forest of randomized trees, AdaBoost, gradient tree boosting, and/or voting classifier methods. Machine-learning algorithms may include neural net algorithms, including convolutional neural net processes.

Referring now to FIG. 8, an exemplary embodiment of a fuel pod 800 for a hybrid electric aircraft is illustrated. Fuel pod may also be referred to as an auxiliary power pod or an auxiliary power unit (APU) herein. Hybrid electric aircraft can be the same, substantially the same or similar to any of the aircrafts as disclosed in the entirety of the present disclosure. For purposes of readability, some of the same reference numerals as used in FIG. 1 and FIG. 2 may be used to refer to like elements in FIG. 8.

Still referring to FIG. 8, in some embodiments, fuel pod 800 includes a housing 804, a fuel tank 808, a generator 812 and a connection mechanism 816. Fuel tank 808 is contained within housing 804. Fuel tank 808 is configured to hold a fuel therein. In some cases, fuel may already be contained in fuel tank 808. Generator 812 is contained within housing 804 and is connected to fuel tank 804. This connection can enable fuel tank 808 to provide fuel to generator 812 and/or an associated engine or turbine, for example, for combustion or burning of the fuel. Generator 812 (and/or fuel pod 800) is configured to power at least one of a plurality of flight components of hybrid electric aircraft. Hybrid electric aircraft may include any of the hybrid electric aircrafts as disclosed herein such as those described above with reference to at least FIG. 1 and FIG. 2 (e.g. aircraft 100 and 200). Flight components may include any of the flight components as disclosed herein such as those described above with reference to at least FIG. 1 and FIG. 2 (e.g. flight components 108).

Still referring to FIG. 8, connection mechanism 816 is at housing 804. Housing 804 may include connection mechanism 816 so that it is a part of housing or connection mechanism may be a separate element or combination of elements. Connection mechanism 816 is configured to removably or detachably attach or connect fuel pod 800 to hybrid electric aircraft. Connection mechanism 816 includes an electrical interface (or link) 820 configured to electrically link to at least one of plurality of flight components of hybrid electric aircraft. Connection mechanism 816 includes a communication interface (or link) 824 configured to communicatively link to a flight controller communicatively connected to hybrid electric aircraft. Flight controller may include any of the flight controllers as disclosed herein including those described with reference to at least FIG. 1, FIG. 2 (e.g. flight controller 124) and FIG. 6. For the purposes of this disclosure, “removably attached” means attached to an object such that it may be removed without damaging the object.

Continuing to refer to FIG. 8, and as also noted above, a “fuel pod” as used in this disclosure, is a pod with at least a fuel therein or a pod designed to hold at least a fuel therein. Fuel pod 800 may also be referred to as a ‘drop tank’, auxiliary power pod, or an auxiliary power unit (APU). In accordance with some embodiments, fuel pod 800 advantageously can be a self-contained unit which is selectively used with aircraft 200 as and when needed or desired. For example, fuel pod 800 may be utilized with aircraft 200 to achieve greater flight range, carry heavier payloads, carry extra passenger, and the like. Fuel pod 800 may not be used when

aircraft 200 may carry out its flight plan without it. Fuel pod 800 may be replaced with extra payload, as needed or desired, which may be mounted to aircraft instead of fuel pod. Fuel pod 800 may be removably attached to any suitable surface of aircraft 200. In an embodiment, fuel pod 800 may be removably attached to a lower surface of a boom of aircraft 200. Two fuel pods 800 may be removably mounted on each of two booms of aircraft 200. Fuel pod 800 may be removably attached to fuselage of aircraft 200. Fuel pod 800, if needed, may be removably mounted internal to aircraft 800.

With continued reference to FIG. 8, as also noted above, for the purposes of this disclosure, a “fuel tank” is a container designed to hold fuel or a container with fuel therein.

Each fuel tank 808 may contain a hydrocarbon fuel or a petroleum-based fuel which may be in a liquid or gaseous form and which may be compressed or pressurized. As used in this disclosure, a “pod” is a container or housing. Pod may be a detachable and/or self-contained unit. As used in this disclosure, a “fuel” is a material that is burned or undergoes combustion to produce power. Fuel may include, without limitation, a hydrocarbon fuel, a petroleum-based fuel, a gaseous fuel, a liquid fuel, a solid fuel, natural gas, oil, coal, gasoline, diesel, ethanol, hydrogen, or the like, among others.

Still referring to FIG. 8, and as also noted above, as used in this disclosure, a “generator” is a device that converts mechanical energy to electrical energy. For example, a generator may convert motive power (mechanical energy or kinetic energy) into electrical power for use in an external circuit such as an electric motor. Sources of mechanical energy may include, without limitation, steam turbines, gas turbines, water turbines, internal combustion engines, wind turbines, and the like, among others. As used in this disclosure, a “turbine” is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator. As used in this disclosure, a “turbine generator” is an electric generator driven by a steam, gas or hydraulic turbine. As used in this disclosure, an “engine” is a machine that converts one or more forms of energy into mechanical energy. For example, and without limitation, an engine may convert energy from a source of heat, such as the burning or combustion of a fuel, into mechanical energy, force or motion. As used in this disclosure, an “internal combustion engine” or “ICE” is an engine in which the burning of a fuel occurs in a confined space called a combustion chamber.

Still referring to FIG. 8, housing 804 of fuel pod 800 may include, house or contain various self-contained components, as needed or desired. As used in this disclosure, a “housing” is a physical component within which other internal components are located. In some cases, internal components with housing will be functional while function of housing may largely be to protect the internal components. Housing 804 and/or fuel pod 800 may have a streamlined configuration, or the like, so as to minimize drag forces on aircraft 200 during flight, for example, and without limitation, an airfoil shape or configuration. Housing 804 may contain fuel tank 808 and generator 812 therein. Housing 804 may also contain, include or be attached to connection mechanism 816. Housing mechanism may also contain or include a computing device (or controller) and/or one or more sensors therein for facilitation communication between fuel pod 800 and aircraft 200 and/or monitoring diagnostics of fuel pod 800. Housing 804 may also contain a turbine 836 and/or engine 840. Turbine 836 and engine 840 may include any of the turbines and engines as disclosed in the entirety of the present disclosure. In an embodiment, and without limitation, housing may include a skin. Skin may be layered over the body shape of housing 804 which may be constructed by trusses as described above with reference to fuselage 104 of FIG. 1. Housing 804 and/or housing skin may comprise a plurality of materials such as plywood sheets, aluminum, fiberglass, and/or carbon fiber.

Still referring to FIG. 8, in an embodiment, connection mechanism 816 includes electrical interface (or link) 820 and communication interface (or link) 824. Connection mechanism 816 may include a connector 844 for facilitating removable or detachable interfacing between connection mechanism 816 and aircraft 200. Connection mechanism 816 may also include a mechanical interface 828 for removable mechanical attachment to aircraft 200. Alternatively, mechanical interface 828 may be separate from connection mechanism. As used in this disclosure, “connection mechanism” is a structure that facilitates connection or interfacing between two elements or relata. This may include an electrical connection, mechanical connection, fluidic connection, optical connection, magnetic connection, and the like, among others.

Continuing to refer to FIG. 8, as used in this disclosure, a “connector” is a distal end of a tether or a bundle of tethers, e.g., hose, tubing, cables, wires, and the like, which is configured to removably attach with a mating component, for example without limitation a port. As used in this disclosure, a “port” is an interface configured to receive another component or an interface

configured to transmit and/or receive signal on a computing device. For example in the case of an electric vehicle port, the port may interface with a number of conductors. In the case of a computing device port, the port may provide an interface between a signal and a computing device. A connector may include a male component having a penetrative form and port may include a female component having a receptive form, receptive to the male component.

Alternatively or additionally, connector may have a female component and port may have a male component. In some cases, connector may include multiple connections, which may make contact and/or communicate with associated mating components within port, when the connector is mated with the port.

With continued reference to FIG. 8, connection mechanism 816, housing 804 and/or connector 844 may be configured to mate with a port, for example aircraft port 832. As used in this disclosure, “mate” is an action of attaching two or more components together. As used in this disclosure, an “aircraft port” is a port located on electric aircraft 200. Mating may be performed using a mechanical or electromechanical means described in this disclosure. For example, without limitation mating may include an electromechanical device used to join electrical conductors and create an electrical circuit. In some cases, mating may be performed by way of gendered mating components. A gendered mate may include a male component or plug which is inserted within a female component or socket. In some cases, mating may be removable. In some cases, mating may be permanent. In some cases, mating may be removable, but require a specialized tool or key for removal. Mating may be achieved by way of one or more of plug and socket mates, pogo pin contact, crown spring mates, and the like. In some cases, mating may be keyed to ensure proper alignment between connecting elements. In some cases, mating may be lockable. As used in this disclosure, a “mating component” is a component that is configured to mate with at least another component, for example in a certain (i.e., mated) configuration. Connector 844 may also be referred to as a “mating connector” in the present disclosure. Aircraft port 832 may also be referred to as a “mating aircraft port” in the present disclosure. In modified embodiments, aircraft port may be substituted for by a male connector.

Still referring to FIG. 8, as used in this disclosure, an “electrical interface” is a connection or link between two or more relata which facilitates transmission of electric current or electrical flow therebetween. As used in this disclosure, a “communication interface” is a connection or link between two or more relata which facilitates the transmission of communication and/or

control signals therebetween. As used in this disclosure, a “mechanical interface” is a mechanical connection or link between two or more relata using mechanical means. Any of these interfaces may be temporary connections which can allow detachable connection or removable attachment between.

5 Still referring to FIG. 8, in some embodiments, mechanical interface 828 may include a latching mechanism which enables or facilitates removable or detachable mechanical attachment to or mating with aircraft 200. Aircraft 200 may have a compatible and/or mating latching mechanism to facilitate such removable attachment. Advantageously, this adds a new dimension of versatility as, depending on the payload, flight conditions, and/or destination of the aircraft, 10 fuel pod(s) 800 may be selectively utilized. A mating latching mechanism may be provided at any suitable location on aircraft such as, and without limitations, internal or external to booms, wings and fuselage of aircraft. As used in this disclosure, a “latching mechanism” is any mechanism or device that allows for removable or detachable connection between two elements. Latching mechanism may include, without limitation, latches, fasteners, clamps, buckles, locks, 15 clips, actuators, bolts, screws, bolt-nut combinations, connectors which may be manually, electronically, magnetically and/or remotely operable to detachably connect, attach or fasten elements. Compatible and/or mating latching mechanism and elements may be provided on both fuel pod and aircraft. Connection mechanism 816, connector 844 and/or mechanical interface 828 may include a fastener. As used in this disclosure, a “fastener” is a physical component that 20 is designed and/or configured to attach or fasten two (or more) components together. Fasteners may include threads, snaps, canted coil springs, and the like. Fasteners may include without limitation hook-and-loop fasteners such as or fasteners held together by a plurality of flanged or “mushroom”-shaped elements. In some cases, Fastener may be configured to provide removable attachment between fuel pod 800 and aircraft 200. Removable attachment can be considered to 25 be an attributive term that refers to an attribute of one or more relata to be attached to and subsequently detached from another relata; removable attachment is a relation that is contrary to permanent attachment wherein two or more relata may be attached without any means for future detachment without damage to at least one of the relata. Exemplary non-limiting methods of permanent attachment include certain uses of adhesives, glues, nails, engineering interference 30 (i.e., press) fits, and the like. In some cases, detachment of two or more relata permanently attached may result in breakage of one or more of the two or more relata.

Still referring to FIG. 8, fuel pod 800 may be removably attachable to at least a boom (e.g. booms 136 of FIG. 1) of hybrid electric aircraft 200. Fuel pod 800 may be removably attachable to a lower surface of boom. A pair of fuel pods 800 may be provided with each fuel pod respectively attachable to a respective boom. Alternatively, or in addition, one or more fuel pods 800 may be removably attachable to wings, fuselage and other structures of aircraft, as needed or desired.

Continuing to refer to FIG. 8, generator 812 may include any of the generators as disclosed in the present disclosure. Generator 812 may be configured to electrically connect to at least an electric motor 220 of plurality of flight components 108. Generator 812 may be configured to power at least an electric motor 220 of plurality of flight components 108. Generator 812 may be configured to power at least a lift component (e.g. lift component 112 of FIG. 1) of plurality of flight components 108 either directly or indirectly via an intervening electric motor or the like. Generator 812 may be configured to power at least a pusher component (e.g. pusher component 116 of FIG. 1) of plurality of flight components 108 either directly or indirectly via an intervening electric motor or the like. Generator 812 may be configured to power at least a propulsor of plurality of flight components 108 either directly or indirectly via an intervening electric motor. These electrical connections and powering may be via or facilitated by electrical interface 820.

Still referring to FIG. 8, generator 812 may be configured to electrically connect to at least a battery 232 of hybrid electric aircraft 200. Generator 812 may be configured to charge or recharge at least a battery 232 of hybrid electric aircraft 200. These electrical connections and charging (or recharging) may be via or facilitated by electrical interface 820.

Still referring to FIG. 8, fuel pod 800 may further include a computing device or controller configured to communicatively connect with flight controller 124 of hybrid electric aircraft 200. Computing device or controller may be configured to communicatively connect with flight controller 124 of hybrid electric aircraft 200 via communication interface 824. Communication interface may be configured to conduct signals (e.g. communication signals, control signals, monitoring signals, and the like) between flight pod computing device or controller and flight controller 124.

Still referring to FIG. 8, fuel pod 800 may further include at least a sensor. Sensor may include any suitable sensor, plurality of sensors or sensor suite as disclosed in the entirety of the

present disclosure. Sensor may be communicatively connected to computing device or controller of fuel pod 800. Alternatively, or in addition, sensor may be communicatively connected to flight controller 124. Sensor may be configured to detect an electric current emanating from or through generator 812, fuel pod 800 and/or electrical interface 820. Sensor may be configured to detect a fuel level (or remaining fuel capacity) of fuel tank 808. Sensor may include a temperature sensor, or the like.

Continuing to refer to Fig. 8, connection mechanism 816 may further include connector or mating connector 844 configured to mate with hybrid electric aircraft 200. Connector or mating connector 844 may be configured to mate with aircraft port 832 of hybrid electric aircraft 200. Connector or mating connector 844 may be configured to mate with aircraft port 832 at a boom of hybrid electric aircraft 200. At least a portion of electrical interface 820 and at least a portion of communication interface 824 may be located at connector or mating connector 844. Electrical interface 820 may be configured to conduct an electrical flow from fuel pod 800 to hybrid electric aircraft 200.

With continued reference to FIG. 8, connection mechanism 816 may further include mechanical interface 828 configured to removably attach fuel pod 800 to hybrid electric aircraft 200. Alternatively, or in addition, mechanical interface 828 or a portion of it may be separate from connection mechanism 816 and/or connector 844. Mechanical interface 828 may include a latching mechanism, or the like, to removably connect or attach fuel pod 800 to aircraft 200.

Referring now to FIG. 9, a power unit pod system 900 is depicted. Power unit pod system 900 includes a power unit pod 904. For the purposes of this disclosure, a “power unit pod” is an enclosed body, separate from the fuselage of the aircraft, containing an auxiliary power unit. With continued reference to FIG. 9, power unit pod 904 includes an auxiliary power unit 908 (APU 908). An “auxiliary power unit,” for the purposes of this disclosure, is an aircraft engine that does not produce thrust. The APU 908 is configured to generate electric power. An APU 908 may be said to be configured to generate electric power, if the APU 908 drives an electric generator. In some embodiments, APU 908 may include an electric generator. An “electric generator,” for the purposes of this disclosure, is a device that converts motive power to electric power. As a non-limiting example, in some embodiments, APU 908 may include a turbine engine. As a non-limiting example, in some embodiments, APU 908 may include a reciprocating engine. As a non-limiting example, in some embodiments, APU 908 may include a fuel cell

engine. As a non-limiting example, in some embodiments, APU 908 may include a fuel reformer. In some embodiments, the APU 908 may have a power rating of over 100 kW. In some embodiments, the APU 908 may have a power rating of 150-200 kW. In some embodiments, the APU 908 may have a power rating of less than 100 kW. A person of ordinary skill in the art would recognize, after having reviewed the entirety of this disclosure, that APU 908 may have a wide range of power ratings, depending on the power demands required by the specific application.

With continued reference to FIG. 9, power unit pod 904 includes a fuel tank 912. For the purposes of this disclosure, a “fuel tank” is a container designed to hold fuel. In some embodiments, fuel tank 912 may contain a fuel. As a non-limiting example, fuel tank 912 may contain aviation fuel. As a non-limiting example, aviation fuel may include jet fuel such as Jet A-1 and Jet B. As a non-limiting example, aviation fuel may include unleaded kerosene or naphtha-kerosene. As a non-limiting example, aviation fuel may include gasoline suitable for the aviation context. In some embodiments, fuel tank 912 may contain gasoline. In some embodiments, fuel tank 912 may include diesel. In some embodiments, fuel tank 912 may contain hydrogen gas. A person of ordinary skill in the art, after having reviewed the entirety of this disclosure, would understand that the fuel contained in fuel tank 912 must be compatible with APU 908 in order to ensure operability. Fuel tank 912 is in fluid communication with APU 908. For the purposes of this disclosure being in “fluid communication” means that fluid is able to flow from one of the fluidly connected elements to the other, notwithstanding any elements that temporarily or optionally restrict fluid flow, such as, as non-limiting examples, a check valve or a pressure disk. In some embodiments, fuel tank 912 may include a fuel line. The fuel line may be in fluid communication with APU 908. The fuel line may be a hose, tube, conduit, and the like. In some embodiments, fuel tank 912 may include a fuel pump. The fuel pump may transfer fuel from fuel tank 912 to APU 908. In some embodiments, fuel tank 912 may include a fuel valve. A “valve,” for the purposes of this disclosure, is a device for restricting or otherwise controlling the flow of a liquid, gas, or fluid. In some embodiments, fuel valve may control the flow of fuel between fuel tank 912 and APU 908. In some embodiments, fuel valve may include a gate valve. In some embodiments, fuel valve may include a solenoid-operated valve. In some embodiments, fuel valve may include a spray valve.

With continued reference to FIG. 9, in some embodiments, power unit pod 904 may be contained within a nacelle 916. A “nacelle” for the purposes of this disclosure, is an aerodynamically streamlined body, that is streamlined according to what it contains. As a nonlimiting example, wherein nacelle 916 contains APU 908 and fuel tank 912, nacelle 916 may be streamlined to fit around these contents, while remaining aerodynamic. As a non-limiting example, nacelle 916 may have a tear drop shape. In some embodiments, nacelle 916 may be shaped (or streamlined) to reduce drag, when the airplane that it is attached to is in edgewise flight. In some embodiments, nacelle 916 may be shaped so as to ensure beneficial aerodynamic interaction with the other components of the aircraft, such as the wings, engines, fuselage, and the like. As a non-limiting example, nacelle 916 may be shaped so as to not disturb airflow over the wings of an aircraft.

With continued reference to FIG. 9, nacelle may include one or more inlet 920. Inlet 920 may provide an opening into the interior of nacelle 916 through which air may flow. In some embodiments, inlet 920 may be designed to provide airflow to APU 908. As a non-limiting example this airflow may be used to cool APU 908. Inlet 920 may have a variety of profile shapes. As a non-limiting example, the profile shape inlet 920 may be rectangular. In some embodiments, the profile shape of inlet 920 may be tear drop shaped. For the purposes of this disclosure, the “profile shape” of inlet 920 is the shape of the opening formed by inlet 920 in nacelle 916 as projected onto a 2D surface. In some embodiments, where there is more than one inlet 920, inlet 920 may be spaced around the circumference of nacelle 916 at regular intervals. In some embodiments, inlet 920 may be annular. In some embodiments, inlet 920 may be a low drag air inlet. As a non-limiting example, inlet 920 may include a NACA duct.

With continued reference to FIG. 9, nacelle may include an outlet 924. Outlet 924 may allow air to pass out of nacelle 916. Outlet 924 may be in fluid connection with an exhaust of APU 908. In some embodiments, outlet 924 may have a circular profile shape. In some embodiments, outlet 924 may have a rectangular profile shape. In some embodiments, outlet 924 may have an irregular shape. For the purposes of this disclosure, the “profile shape” of outlet 924 is the shape of the opening formed by outlet 924 in nacelle 916 as projected onto a 2D surface.

With continued reference to FIG. 9, in some embodiments, system 900 may include a local controller 928. Local controller 928 may be communicatively connected to APU 908 and/or fuel tank 912. In some embodiments, local controller 928 may be communicatively connected to

various components on board the aircraft. In some embodiments, local controller 928 may be communicatively connected to a controller on board the aircraft, such as a flight controller.

“Communicatively connected,” for the purpose of this disclosure, means connected such that data can be transmitted, whether wirelessly or wired. In some embodiments, local controller 928 may send control signals to APU 908 to operate APU 908. In some embodiments, local controller 928 may send control signals to components of fuel tank 912. As a non-limiting example, local controller 928 may send a control signal to the fuel pump to turn fuel pump on and/or off.

With continued reference to FIG. 9, local controller 928 may include any computing device as described in this disclosure, including without limitation a microcontroller, microprocessor, digital signal processor (DSP) and/or system on a chip (SoC) as described in this disclosure. Computing device may include, be included in, and/or communicate with a mobile device such as a mobile telephone or smartphone. local controller 928 may include a single computing device operating independently, or may include two or more computing device operating in concert, in parallel, sequentially or the like; two or more computing devices may be included together in a single computing device or in two or more computing devices. local controller 928 may interface or communicate with one or more additional devices as described below in further detail via a network interface device. Network interface device may be utilized for connecting local controller 928 to one or more of a variety of networks, and one or more devices. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (e.g., data, software etc.) may be communicated to and/or from a computer and/or a computing device. local controller 928 may include but is not limited to, for example, a computing device or cluster of computing devices in a first location and a second computing device or cluster of computing

devices in a second location. local controller 928 may include one or more computing devices dedicated to data storage, security, distribution of traffic for load balancing, and the like. local controller 928 may distribute one or more computing tasks as described below across a plurality of computing devices of computing device, which may operate in parallel, in series, redundantly, or in any other manner used for distribution of tasks or memory between computing devices. local controller 928 may be implemented using a “shared nothing” architecture in which data is cached at the worker, in an embodiment, this may enable scalability of system 900 and/or computing device.

With continued reference to FIG. 9, local controller 928 may be designed and/or configured to perform any method, method step, or sequence of method steps in any embodiment described in this disclosure, in any order and with any degree of repetition. For instance, local controller 928 may be configured to perform a single step or sequence repeatedly until a desired or commanded outcome is achieved; repetition of a step or a sequence of steps may be performed iteratively and/or recursively using outputs of previous repetitions as inputs to subsequent repetitions, aggregating inputs and/or outputs of repetitions to produce an aggregate result, reduction or decrement of one or more variables such as global variables, and/or division of a larger processing task into a set of iteratively addressed smaller processing tasks. local controller 928 may perform any step or sequence of steps as described in this disclosure in parallel, such as simultaneously and/or substantially simultaneously performing a step two or more times using two or more parallel threads, processor cores, or the like; division of tasks between parallel threads and/or processes may be performed according to any protocol suitable for division of tasks between iterations. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which steps, sequences of steps, processing tasks, and/or data may be subdivided, shared, or otherwise dealt with using iteration, recursion, and/or parallel processing.

With continued reference to FIG. 9, system 900 includes a power output line 932. In some embodiments, power output line 932 is electrically connected to an energy source of an electric aircraft when system 900 is attached to an electric aircraft. In some embodiments, power output line 932 may be electrically connected to a propulsor of an electric aircraft when system 900 is attached to an electric aircraft. In some embodiments, power output line 932 may be electrically connected to a component of an electric aircraft when system 900 is attached to an

electric aircraft. “Electrically connected,” for the purposes of this disclosure, means connected such that electricity may flow between the connected components. In some cases, components may be electrically connected, even when electricity must flow through an intermediary component in between the electrically connected components. As used in this disclosure a

5 “propulsor” is a component and/or device used to propel a craft by exerting force on a fluid medium, which may include a gaseous medium such as air or a liquid medium such as water. Power output line 932 may carry the electric power produced by APU 908 to the energy source of the electric aircraft, thereby charging the energy source. Power output line 932 may carry the electric power produced by APU 908 to a propulsor of the electric aircraft, thereby powering the
10 propulsor. In some embodiments, power unit pod 904 may include a high voltage power line. For the purposes of this disclosure, a “high voltage power line” is a conductor configured to transmit high voltage electricity. High voltage power line may provide components of power unit pod 904 with high voltage power. As a non-limiting example, high voltage power line in may provide APU 908 with high voltage power. As another non-limiting example, high voltage power line
15 may provide high voltage power to components of fuel tank 912, such as, as a non-limiting example, the fuel pump. In some embodiments, system 900 may include a communications line. The communications line may carry signals between components of system 900 and components of electric aircraft 100. In some embodiments, the communications line may communicatively connect local controller 928 with another controller, such as a flight controller on the aircraft.

20 With continued reference to FIG. 9, in some embodiments, system 900 may include a pod support 936. For the purposes of this disclosure, a “pod support” is a support structure for power unit pod 904 designed to hold power unit pod 904 in place. In some embodiments, power unit pod 904 may be connected to pod support 936. As a non-limiting example, the top of power unit pod 904 may be connected to the bottom of pod support 936. “Top” and “bottom,” in this case,
25 are defined with reference to the orientation of the components in FIG. 9. In some embodiments, pod support 936 may be directly connected to power unit pod 904. Pod support 936 may include various interior support structures designed to provide structural rigidity, withstand loading, and support power unit pod 904. In some embodiments, particularly when system 900 does not contain a pod support 936, power unit pod 904 may be directly connected to an aircraft. As a
30 non-limiting example, power unit pod 904 may be directly connected to a laterally extending element of the aircraft. In some embodiments, pod support 936 may have an airfoil cross-section.

An “airfoil” as used in this disclosure is a shape designed such that a fluid flowing over it exerts differing levels of pressure against the top and bottom surface. This pressure differential creates lift when the fluid flowing over the lower surface creates a higher pressure than the fluid flowing over the upper surface. An airfoil may have a leading edge and a trailing edge. As used in this disclosure a “leading edge” is a foremost edge of an airfoil that first intersects with the fluid medium. The “trailing edge” is the back end of the airfoil and is the last point on the airfoil that the fluid medium comes in contact with. Airfoils may have a centerline, wherein the centerline is the locus of points halfway between the top and bottom surface of the airfoil. Thus, for a symmetrical airfoil, the centerline is a straight line from the leading edge to the trailing edge. Airfoils may also have a chord line, wherein the chord line is a straight line from the leading edge to the trailing edge. Accordingly, for a symmetric airfoil, the chord line and the centerline are identical. The position of an airfoil may be described using an angle of attack. An angle of attack is the angle between the chord line of the airfoil and the direction of the oncoming flow of the fluid. Many airfoils create lift at an angle of attack of zero; however, symmetric airfoils do not create lift at an angle of attack of zero. Symmetric airfoils create lift when the angle of attack is greater than zero and create downforce when the angle of attack is less than zero. In some embodiments, this airfoil cross section may be symmetrical. In some embodiments, the airfoil cross-section may be chosen to reduce drag. As a non-limiting example, the airfoil cross-section may be chosen from the NACA “00” airfoil family.

With continued reference to FIG. 9, in some embodiments, system 900 may include a power supply 940. For the purposes of this disclosure, a “power supply” is a device that converts electrical power from a source current, voltage, and/or frequency to a load current, voltage, and/or frequency. One of ordinary skill in the art, after having reviewed the entirety of this disclosure, would appreciate that power supply 940 may convert the source power to a variety of different load currents, voltages, and/or frequencies depending on the electrical requirements of the loads electrically connected to power supply 940. In some embodiments, local controller 928 may be electrically connected to power supply 940. In some embodiments, fuel tank 912, and any components thereof, may be electrically connected to power supply 940. In some embodiments, APU 908 may provide the source power for power supply 940. In some embodiments, power supply 940 may output low voltage as a load voltage. In some embodiments, power supply 940 may output 28V as the load voltage.

With continued reference to FIG. 9, in some embodiments, an electric aircraft and/or a power unit pod may be configured to display information to a pilot. In some embodiments, local controller is configured to transmit data to an interface for display to a pilot.

Referring now to FIG. 10, an assembly 1000 of laterally extending element 104, pod support 136, and power unit pod 904 is shown. In some embodiments, laterally extending element 104 may include a lift generating body. For the purposes of this disclosure, a “lift generating body” is a portion of an object that is contoured so as to produce lift. In some embodiment, the lift generating body may have an airfoil cross section. The airfoil cross section may be consistent with any airfoil cross section discussed as this disclosure. As a non-limiting example, the airfoil cross section may be chosen from the NACA 4-digit series or NACA 5-digit series of airfoils.

With continued reference to FIG. 10, power unit pod 1004 is attached to the at least a laterally extending element 108. In some embodiments, power unit pod 1004 may be removably attached to the at least a laterally extending element 108. For the purposes of this disclosure, “removably attached” means attached to an object such that it may be removed without damaging the object. In some embodiments, power unit pod 104 may be removably attached to the underside of the at least a laterally extending element 108. As a non-limiting example, power unit pod 1004 may be removably attached using bolts, screws, and the like. A person of ordinary skill in the art, after reviewing the entirety of this disclosure, would appreciate that a wide variety of fasteners may be used to removably attach power unit pod 1004. In some embodiments, power unit pod may be connected to pod support 1036, wherein pod support 1036 is removably attached to the underside of the at least a laterally extending element. As a non-limiting example, pod support 1036 may be removably attached using bolts, screws, and the like. A person of ordinary skill in the art, after reviewing the entirety of this disclosure, would appreciate that a wide variety of fasteners may be used to removably attach pod support 1036. For the sake of explanation, when pod support 1036 is connected to power unit pod 1004 and pod support is removably attached to laterally extending element 108, then power unit pod 1004 is also removably attached to laterally extending element 108.

Referring now to FIG. 11, another exemplary embodiment of electric aircraft 100 is depicted. In this embodiment, electric aircraft 100 has power unit pod 904 attached. Additionally, electric aircraft 100 includes an energy source 1100. In some embodiments, energy

source 400 may include multiple energy sources. Energy source 1100 may be consistent with any energy source disclosed as part of this disclosure. Energy source 1100 is electrically connected to APU 908; as a non-limiting example, using power output line 1032. In some embodiments, the electricity generated by APU 1008 may be used to recharge energy source 1100.

5 With continued reference to FIG. 11, electric aircraft includes a laterally extending element 108. Electric aircraft 100 may include at least a lift propulsor 112 and a pusher propulsor 116. Each of the at least a lift propulsor 112 and the pusher propulsor 116 may be electrically connected to energy source 1100. In some embodiments, each of the at least a lift propulsor 112 and the pusher propulsor 116 may be electrically connected to APU 108. Each of the at least a
10 lift propulsor 112 shown in FIG. 4 may be connected to a second propulsor boom 124. It should be noted, for the sake of clarity, that electric aircraft 100 also may include another pair of lift propulsor 112 attached to a first propulsor boom 124, however, those elements are hidden in FIG. 11.

 With continued reference to FIG. 11, in some embodiments, electric aircraft 100 may
15 include a flight controller 1104. Flight controller 1104 may be communicatively connected to the APU 108. In some embodiments, Flight controller 1104 may be communicatively connected to each of the at least a propulsor. In some embodiments, flight controller 1104 may be communicatively connected to local controller 928. Flight controller 1104 may be consistent with any flight controller 1104 disclosed as part of this disclosure. Flight controller 1104 may
20 include any computing device as described in this disclosure, including without limitation a microcontroller, microprocessor, digital signal processor (DSP) and/or system on a chip (SoC) as described in this disclosure. Computing device may include, be included in, and/or communicate with a mobile device such as a mobile telephone or smartphone. flight controller 404 may include a single computing device operating independently, or may include two or more
25 computing device operating in concert, in parallel, sequentially or the like; two or more computing devices may be included together in a single computing device or in two or more computing devices. flight controller 1104 may interface or communicate with one or more additional devices as described below in further detail via a network interface device. Network interface device may be utilized for connecting flight controller 1104 to one or more of a variety
30 of networks, and one or more devices. Examples of a network interface device include, but are not limited to, a network interface card (e.g., a mobile network interface card, a LAN card), a

modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (e.g., the Internet, an enterprise network), a local area network (e.g., a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (e.g., a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (e.g., data, software etc.) may be communicated to and/or from a computer and/or a computing device. flight controller 1104 may include but is not limited to, for example, a computing device or cluster of computing devices in a first location and a second computing device or cluster of computing devices in a second location. flight controller 1104 may include one or more computing devices dedicated to data storage, security, distribution of traffic for load balancing, and the like. flight controller 1104 may distribute one or more computing tasks as described below across a plurality of computing devices of computing device, which may operate in parallel, in series, redundantly, or in any other manner used for distribution of tasks or memory between computing devices. flight controller 1104 may be implemented using a “shared nothing” architecture in which data is cached at the worker, in an embodiment, this may enable scalability of system 900 and/or computing device.

With continued reference to FIG. 11, in some embodiments, electric aircraft 100 may include a fuel tank 912 located in a laterally extending element of an aircraft. A fuel tank in a laterally extending element of an aircraft may be in fluid communication with an auxiliary power unit, such as through a fuel interface. A fuel interface may include a connection between a laterally extending element and a power unit pod that facilitates fuel exchange. In some embodiments, a power unit pod is removably attached to an aircraft, and a fuel interface may be closed (as in, fuel exchange through the fuel interface may be stopped) in preparation for, or as a result of, removal of a power unit pod from an aircraft.

With continued reference to FIG. 11, flight controller 1104 may be designed and/or configured to perform any method, method step, or sequence of method steps in any embodiment described in this disclosure, in any order and with any degree of repetition. For instance, flight controller 1104 may be configured to perform a single step or sequence repeatedly until a desired or commanded outcome is achieved; repetition of a step or a sequence of steps may be performed

iteratively and/or recursively using outputs of previous repetitions as inputs to subsequent repetitions, aggregating inputs and/or outputs of repetitions to produce an aggregate result, reduction or decrement of one or more variables such as global variables, and/or division of a larger processing task into a set of iteratively addressed smaller processing tasks. flight controller 1104 may perform any step or sequence of steps as described in this disclosure in parallel, such as simultaneously and/or substantially simultaneously performing a step two or more times using two or more parallel threads, processor cores, or the like; division of tasks between parallel threads and/or processes may be performed according to any protocol suitable for division of tasks between iterations. Persons skilled in the art, upon reviewing the entirety of this disclosure, will be aware of various ways in which steps, sequences of steps, processing tasks, and/or data may be subdivided, shared, or otherwise dealt with using iteration, recursion, and/or parallel processing.

Referring now to FIG. 12, a power distribution system 1200 is illustrated. Power distribution system 1200 may be located on the electric aircraft, such as electric aircraft 100. In some embodiments, system 1200 may include a first high voltage front end 1204. For the purposes of this disclosure, a “high voltage front end” is an interface between one or more sources of energy and one or more loads, wherein the interface is configured to handle high voltage power. First high voltage front end 1204 may be electrically connected to energy source 1100. In some embodiments, first high voltage front end 1204 may be electrically connected to each of the at least a propulsor. In some embodiments, first high voltage front end 1204 may provide power to each of the at least a propulsor. In some embodiments, first high voltage front end 1204 may be electrically connected to power output line 1032 of power unit pod 1004. First high voltage front end 1204 may receive power from the energy sources 1100 and power output line 932 of the power unit pod 904 (i.e. it may receive power from APU 108). First high voltage front end 1204 may send power to the lift propulsors 112 and pusher propulsor 116. First high voltage front end 1204 may send power to energy sources 400.

As depicted in FIG. 12, first high voltage front end 1204 may be electrically connected to only a subset of energy sources 1200 and APU 108. As depicted in FIG. 12, first high voltage front end 1204 may be electrically connected to two of energy source 400. First high voltage front end 1204 may be electrically connected to APU 108. First high voltage front end 1204 can distribute the power from these components to lift propulsors 112 and pusher propulsor 116.

With continued reference to FIG. 12, in some embodiments, system 1200 may include a second high voltage front end 1208. Second high voltage front end 1208 may be electrically connected to energy source 400. In some embodiments, second high voltage front end 1208 may be electrically connected to each of the at least a propulsor. In some embodiments, second high voltage front end 1208 may provide power to each of the at least a propulsor. In some embodiments, second high voltage front end 1208 may be electrically connected to power output line 932 of power unit pod 904. Second high voltage front end 1208 may receive power from the energy sources 400 and power output line 932 of the power unit pod 904 (i.e. it may receive power from APU 908). Second high voltage front end 1308 may send power to the lift propulsors 112 and pusher propulsor 116. Second high voltage front end 1208 may send power to energy sources 400.

As depicted in FIG. 12, second high voltage front end 1208 may be electrically connected to only a subset of energy sources 400 and APU 908. As depicted in FIG. 12, second high voltage front end 1208 may be electrically connected to two of energy source 400 and not electrically connected to APU 908. Second high voltage front end 1208 can distribute the power from these components to lift propulsors 112 and pusher propulsor 116.

With continued reference to FIG. 12, in some embodiments, first high voltage front end 1204 and/or second high voltage front end 1208 may be communicatively connected to a controller. As a non-limiting example, first high voltage front end 1204 and/or second high voltage front end 1208 may be communicatively connected to a controller using a Controller Area Network (CAN) bus. A “CAN bus,” for the purposes of this disclosure is a specialized internal communications network for a vehicle, configured to allow a controller to communicate with other components in the vehicle without the need for a host computer.

Referring now to FIG. 13, another power distribution system 1300 is diagrammed in an exemplary embodiment. System 1200 may be consistent with system 1300. System 1300 includes first high voltage front end 1204 and second high voltage front end 1208. In some embodiments, first high voltage front end and second high voltage front end may be connected by an interlock component 1304. For the purposes of this disclosure, an “interlock component” is a component that ensures that one or more conditions are met before enabling or disabling an electric connection. Interlock component 1304 may include any device configured to allow current flow in one state and disallow current flow in another state. As a non-limiting example,

interlock component 1304 may be a relay. A relay is an electrically and/or electromechanically operated switch that can receive control signals. A relay can be engaged or disengaged by the control signals. A relay need not have any moving parts and can be solid state. As another non-limiting example, interlock component 1304 may be a mechanical switch. In its engaged state, interlock component 1304 may electrically connect first high voltage front end 1204 to second high voltage front end. In its disengaged state, in some embodiments, interlock component 1304 does not electrically connect first high voltage front end 1204 to first high voltage front end 1208. In some embodiments, interlock component 1304 may be electrically connected to a computing device, such as a flight controller. In some embodiments, the computing device may engage and/or disengage interlock component 1304 by sending electrical signals to interlock component 1304.

With continued reference to FIG. 13, the electrical connections going into/out of first high voltage front end 1204 are indicated using solid lines. The electrical connections going into/out of second high voltage front end 1208 are indicated using dashed lines. First high voltage front end 1204 may receive electrical power from an energy source 1200. In some embodiments, first high voltage front end 1204 may receive electrical power from multiple energy sources 1200. First high voltage front end 1204 may also receive electrical power from a power unit pod 1004. In some embodiments, power unit pod 1004 may include a fuel tank 1012 and APU 1008. First high voltage front end 1204 may supply electrical power to any of the at least a propulsor. In some embodiments, first high voltage front end 1204 may be electrically connected to each lift propulsor 112. In some embodiments, first high voltage front end 1204 may be electrically connected to a pusher propulsor 116.

With continued reference to FIG. 13, Second high voltage front end 1208 may receive electrical power from an energy source 1200. In some embodiments, second high voltage front end 1208 may receive electrical power from multiple energy sources 1200. Second high voltage front end 1208 may also receive electrical power from a power unit pod 1004. In some embodiments, this may be a separate power unit pod 1004 then the power unit pod to which first high voltage front end 1204 is electrically connected. In some embodiments, power unit pod 1004 may include a fuel tank 112 and APU 108. Second high voltage front end 1208 may supply electrical power to any of the at least a propulsor. In some embodiments, second high voltage

front end 1208 may be electrically connected to each lift propulsor 112. In some embodiments, second high voltage front end 1208 may be electrically connected to a pusher propulsor 116.

With continued reference to FIG. 13, in some embodiments, each of the propulsors (lift propulsors 112 and pusher propulsor 116) may be each electrically connected to a set of
5 inverters, a first inverter and a second inverter. An “inverter,” for the purposes of this disclosure, is a frequency converter that converts DC power into AC power. Specifically, first inverter and/or second inverter may supply AC power to drive the propulsors. In some embodiments, first high voltage front end 1204 may be electrically connected to each of the first inverters which are electrically connected to each of the propulsors, but not electrically connected to each of the
10 second inverters which are electrically connected to each of the propulsors. In these same embodiments, second high voltage front end 1208 may be electrically connected to each of the second inverters which are electrically connected to each of the propulsors, but not electrically connected to each of the first inverters which are electrically connected to each of the propulsors.

It is to be noted that any one or more of the aspects and embodiments described herein
15 may be conveniently implemented using one or more machines (e.g., one or more computing devices that are utilized as a user computing device for an electronic document, one or more server devices, such as a document server, etc.) programmed according to the teachings of the present specification, as will be apparent to those of ordinary skill in the computer art. Appropriate software coding can readily be prepared by skilled programmers based on the
20 teachings of the present disclosure, as will be apparent to those of ordinary skill in the software art. Aspects and implementations discussed above employing software and/or software modules may also include appropriate hardware for assisting in the implementation of the machine executable instructions of the software and/or software module.

Such software may be a computer program product that employs a machine-readable
25 storage medium. A machine-readable storage medium may be any medium that is capable of storing and/or encoding a sequence of instructions for execution by a machine (e.g., a computing device) and that causes the machine to perform any one of the methodologies and/or embodiments described herein. Examples of a machine-readable storage medium include, but are not limited to, a magnetic disk, an optical disc (e.g., CD, CD-R, DVD, DVD-R, etc.), a magneto-
30 optical disk, a read-only memory “ROM” device, a random access memory “RAM” device, a magnetic card, an optical card, a solid-state memory device, an EPROM, an EEPROM, and any

combinations thereof. A machine-readable medium, as used herein, is intended to include a single medium as well as a collection of physically separate media, such as, for example, a collection of compact discs or one or more hard disk drives in combination with a computer memory. As used herein, a machine-readable storage medium does not include transitory forms of signal transmission.

Such software may also include information (e.g., data) carried as a data signal on a data carrier, such as a carrier wave. For example, machine-executable information may be included as a data-carrying signal embodied in a data carrier in which the signal encodes a sequence of instruction, or portion thereof, for execution by a machine (e.g., a computing device) and any related information (e.g., data structures and data) that causes the machine to perform any one of the methodologies and/or embodiments described herein.

Examples of a computing device include, but are not limited to, an electronic book reading device, a computer workstation, a terminal computer, a server computer, a handheld device (e.g., a tablet computer, a smartphone, etc.), a web appliance, a network router, a network switch, a network bridge, any machine capable of executing a sequence of instructions that specify an action to be taken by that machine, and any combinations thereof. In one example, a computing device may include and/or be included in a kiosk.

FIG. 14 shows a diagrammatic representation of one embodiment of a computing device in the exemplary form of a computer system 1400 within which a set of instructions for causing a control system to perform any one or more of the aspects and/or methodologies of the present disclosure may be executed. It is also contemplated that multiple computing devices may be utilized to implement a specially configured set of instructions for causing one or more of the devices to perform any one or more of the aspects and/or methodologies of the present disclosure. Computer system 1400 includes a processor 1404 and a memory 1408 that communicate with each other, and with other components, via a bus 1412. Bus 1412 may include any of several types of bus structures including, but not limited to, a memory bus, a memory controller, a peripheral bus, a local bus, and any combinations thereof, using any of a variety of bus architectures.

Processor 1404 may include any suitable processor, such as without limitation a processor incorporating logical circuitry for performing arithmetic and logical operations, such as an arithmetic and logic unit (ALU), which may be regulated with a state machine and directed

by operational inputs from memory and/or sensors; processor 1404 may be organized according to Von Neumann and/or Harvard architecture as a non-limiting example. Processor 1404 may include, incorporate, and/or be incorporated in, without limitation, a microcontroller, microprocessor, digital signal processor (DSP), Field Programmable Gate Array (FPGA),
5 Complex Programmable Logic Device (CPLD), Graphical Processing Unit (GPU), general purpose GPU, Tensor Processing Unit (TPU), analog or mixed signal processor, Trusted Platform Module (TPM), a floating point unit (FPU), system on module (SOM), and/or system on a chip (SoC).

Memory 1408 may include various components (*e.g.*, machine-readable media)
10 including, but not limited to, a random-access memory component, a read only component, and any combinations thereof. In one example, a basic input/output system 1416 (BIOS), including basic routines that help to transfer information between elements within computer system 1400, such as during start-up, may be stored in memory 1408. Memory 1408 may also include (*e.g.*, stored on one or more machine-readable media) instructions (*e.g.*, software) 1420 embodying
15 any one or more of the aspects and/or methodologies of the present disclosure. In another example, memory 1408 may further include any number of program modules including, but not limited to, an operating system, one or more application programs, other program modules, program data, and any combinations thereof.

Computer system 1400 may also include a storage device 1424. Examples of a storage
20 device (*e.g.*, storage device 1424) include, but are not limited to, a hard disk drive, a magnetic disk drive, an optical disc drive in combination with an optical medium, a solid-state memory device, and any combinations thereof. Storage device 1424 may be connected to bus 1412 by an appropriate interface (not shown). Example interfaces include, but are not limited to, SCSI, advanced technology attachment (ATA), serial ATA, universal serial bus (USB), IEEE 1394
25 (FIREWIRE), and any combinations thereof. In one example, storage device 1424 (or one or more components thereof) may be removably interfaced with computer system 1400 (*e.g.*, via an external port connector (not shown)). Particularly, storage device 1424 and an associated machine-readable medium 1428 may provide nonvolatile and/or volatile storage of machine-readable instructions, data structures, program modules, and/or other data for computer system
30 1400. In one example, software 1420 may reside, completely or partially, within machine-

readable medium 1428. In another example, software 1420 may reside, completely or partially, within processor 1404.

Computer system 1400 may also include an input device 1432. In one example, a user of computer system 1400 may enter commands and/or other information into computer system 1400 via input device 1432. Examples of an input device 1432 include, but are not limited to, an alpha-numeric input device (*e.g.*, a keyboard), a pointing device, a joystick, a gamepad, an audio input device (*e.g.*, a microphone, a voice response system, etc.), a cursor control device (*e.g.*, a mouse), a touchpad, an optical scanner, a video capture device (*e.g.*, a still camera, a video camera), a touchscreen, and any combinations thereof. Input device 1432 may be interfaced to bus 1412 via any of a variety of interfaces (not shown) including, but not limited to, a serial interface, a parallel interface, a game port, a USB interface, a FIREWIRE interface, a direct interface to bus 1412, and any combinations thereof. Input device 1432 may include a touch screen interface that may be a part of or separate from display 1436, discussed further below. Input device 1432 may be utilized as a user selection device for selecting one or more graphical representations in a graphical interface as described above.

A user may also input commands and/or other information to computer system 1400 via storage device 1424 (*e.g.*, a removable disk drive, a flash drive, etc.) and/or network interface device 1440. A network interface device, such as network interface device 1440, may be utilized for connecting computer system 1400 to one or more of a variety of networks, such as network 1444, and one or more remote devices 1448 connected thereto. Examples of a network interface device include, but are not limited to, a network interface card (*e.g.*, a mobile network interface card, a LAN card), a modem, and any combination thereof. Examples of a network include, but are not limited to, a wide area network (*e.g.*, the Internet, an enterprise network), a local area network (*e.g.*, a network associated with an office, a building, a campus or other relatively small geographic space), a telephone network, a data network associated with a telephone/voice provider (*e.g.*, a mobile communications provider data and/or voice network), a direct connection between two computing devices, and any combinations thereof. A network, such as network 1444, may employ a wired and/or a wireless mode of communication. In general, any network topology may be used. Information (*e.g.*, data, software 1420, etc.) may be communicated to and/or from computer system 1400 via network interface device 1440.

Computer system 1400 may further include a video display adapter 1452 for communicating a displayable image to a display device, such as display device 1436. Examples of a display device include, but are not limited to, a liquid crystal display (LCD), a cathode ray tube (CRT), a plasma display, a light emitting diode (LED) display, and any combinations thereof. Display adapter 1452 and display device 1436 may be utilized in combination with processor 1404 to provide graphical representations of aspects of the present disclosure. In addition to a display device, computer system 1400 may include one or more other peripheral output devices including, but not limited to, an audio speaker, a printer, and any combinations thereof. Such peripheral output devices may be connected to bus 1412 via a peripheral interface 1456. Examples of a peripheral interface include, but are not limited to, a serial port, a USB connection, a FIREWIRE connection, a parallel connection, and any combinations thereof.

The foregoing has been a detailed description of illustrative embodiments of the invention. Various modifications and additions can be made without departing from the spirit and scope of this invention. Features of each of the various embodiments described above may be combined with features of other described embodiments as appropriate in order to provide a multiplicity of feature combinations in associated new embodiments. Furthermore, while the foregoing describes a number of separate embodiments, what has been described herein is merely illustrative of the application of the principles of the present invention. Additionally, although particular methods herein may be illustrated and/or described as being performed in a specific order, the ordering is highly variable within ordinary skill to achieve methods, systems, and software according to the present disclosure. Accordingly, this description is meant to be taken only by way of example, and not to otherwise limit the scope of this invention.

Exemplary embodiments have been disclosed above and illustrated in the accompanying drawings. It will be understood by those skilled in the art that various changes, omissions and additions may be made to that which is specifically disclosed herein without departing from the spirit and scope of the present invention.

WHAT IS CLAIMED IS:

1. A hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising:
5 a fuselage;
a pair of wings connected to the fuselage and extending generally laterally therefrom, wherein each wing is on either side of the fuselage;
a pair of booms with each boom connected to a respective one of the wings, wherein each boom extends generally longitudinally and parallel to the fuselage;
10 a plurality of flight components configured to provide thrust to the hybrid electric VTOL aircraft; and
a power system configured to power the plurality of flight components, wherein the power system comprises:
at least a fuel tank and a generator, wherein the at least a fuel tank is mounted to
15 at least one of the booms; and
at least a battery configured to power the plurality of flight components.
2. The hybrid electric VTOL aircraft of claim 1, wherein the generator is configured to recharge the at least a battery.
3. The hybrid electric VTOL aircraft of claim 1, wherein the at least a fuel tank is mounted
20 to an outer lower surface of at least one of the booms.
4. The hybrid electric VTOL aircraft of claim 1, wherein the at least a fuel tank is mounted to a latching mechanism on an outer surface of at least one of the booms.
5. The hybrid electric VTOL aircraft of claim 1, wherein the generator is configured to convert mechanical energy to electrical energy.
- 25 6. The hybrid electric VTOL aircraft of claim 1, wherein the generator comprises a turbine generator.
7. The hybrid electric VTOL aircraft of claim 1, wherein the at least a fuel tank contains a hydrocarbon fuel.
8. The hybrid electric VTOL aircraft of claim 1, wherein the generator further comprises an
30 internal combustion engine.

9. The hybrid electric VTOL aircraft of claim 1, wherein the electric generator is connected to at least one electric motor of the plurality of flight components.
10. The hybrid electric VTOL aircraft of claim 1, wherein the plurality of flight components comprises at least a lift component.
- 5 11. The hybrid electric VTOL aircraft of claim 1, wherein the plurality of flight components comprises at least a pusher component.
12. The hybrid electric VTOL aircraft of claim 1, wherein the plurality of flight components comprises at least a propulsor.
13. The hybrid electric VTOL aircraft of claim 1, wherein the power system is further
10 configured to allow selection between the at least a battery and the generator for powering the plurality of flight components.
14. The hybrid electric VTOL aircraft of claim 1, wherein the hybrid electric VTOL aircraft further comprises a flight controller configured to select at least one of the at least a battery and the generator for powering at least one of the plurality of flight components.
- 15 15. The hybrid electric VTOL aircraft of claim 14, wherein the selection of at least one of the at least a battery and the generator by the flight controller is based on a machine-learning model.
16. The hybrid electric VTOL aircraft of claim 1, wherein the at least a battery is part of a battery pack.
- 20 17. The hybrid electric VTOL aircraft of claim 1, wherein the at least a battery is mounted in the fuselage.
18. The hybrid electric VTOL aircraft of claim 1, wherein the at least a battery is mounted in a bay at a lower portion of the fuselage.
19. The hybrid electric VTOL aircraft of claim 1, wherein the hybrid electric VTOL aircraft
25 is configured for flight without the at least a fuel tank and the generator.
20. The hybrid electric VTOL aircraft of claim 1, wherein the hybrid electric VTOL aircraft further comprises at least a sensor.
21. The hybrid electric VTOL aircraft of claim 20, wherein the at least a sensor comprises a sensor configured to detect a state of charge (SOC) of the at least a battery.
- 30 22. The hybrid electric VTOL aircraft of claim 20, wherein the at least a sensor comprises a sensor configured to detect a flight mode of the hybrid electric VTOL aircraft.

23. A hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising:
a fuselage;
a pair of wings connected to the fuselage and extending generally laterally therefrom,
5 wherein each wing is on either side of the fuselage;
a pair of booms with each boom connected to a respective one of the wings, wherein each boom extends generally longitudinally and parallel to the fuselage;
a plurality of flight components configured to provide thrust to the hybrid electric VTOL aircraft, wherein a flight component of the plurality of flight components
10 comprises a propulsor;
a power system configured to power the plurality of flight components, wherein the power system comprises:
at least a fuel tank and a generator, wherein the at least a fuel tank is mounted to one boom of the pair of booms; and
15 at least a battery configured to power the plurality of flight components; and
a flight controller configured to command the plurality of flight components into a flight mode, wherein the flight mode comprises at least a regenerative drag operation.
24. The hybrid electric VTOL aircraft of claim 23, wherein the generator is configured to recharge the at least a battery.
- 20 25. The hybrid electric VTOL aircraft of claim 23, wherein the at least a fuel tank is mounted to an outer lower surface of the one boom.
26. The hybrid electric VTOL aircraft of claim 23, wherein the at least a fuel tank is mounted to a latching mechanism on an outer surface of the one boom.
27. The hybrid electric VTOL aircraft of claim 23, wherein the generator is configured to
25 convert mechanical energy to electrical energy.
28. The hybrid electric VTOL aircraft of claim 23, wherein the generator comprises a turbine generator.
29. The hybrid electric VTOL aircraft of claim 23, wherein the at least a fuel tank contains a hydrocarbon fuel.
- 30 30. The hybrid electric VTOL aircraft of claim 23, wherein the generator further comprises an internal combustion engine.

31. The hybrid electric VTOL aircraft of claim 23, wherein the electric generator is connected to at least an electric motor.
32. The hybrid electric VTOL aircraft of claim 23, wherein the plurality of flight components comprises at least a lift component.
- 5 33. The hybrid electric VTOL aircraft of claim 23, wherein the plurality of flight components comprises at least a pusher component.
34. The hybrid electric VTOL aircraft of claim 23, wherein the plurality of flight components comprises at least a propulsor.
35. The hybrid electric VTOL aircraft of claim 23, wherein the power system is further
10 configured to allow selection between the at least a battery and the generator for powering the plurality of flight components.
36. The hybrid electric VTOL aircraft of claim 23, wherein the hybrid electric VTOL aircraft further comprises a flight controller configured to select at least one of the at least a battery and the generator for powering at least one of the plurality of flight components.
- 15 37. The hybrid electric VTOL aircraft of claim 36, wherein the selection of at least one of the at least a battery and the generator by the flight controller is based on a machine-learning model.
38. The hybrid electric VTOL aircraft of claim 23, wherein the at least a battery is part of a battery pack.
- 20 39. The hybrid electric VTOL aircraft of claim 23, wherein the at least a battery is mounted in the fuselage.
40. The hybrid electric VTOL aircraft of claim 23, wherein the at least a battery is mounted in a bay at a lower portion of the fuselage.
41. The hybrid electric VTOL aircraft of claim 23, wherein the hybrid electric VTOL aircraft
25 further comprises at least a sensor.
42. The hybrid electric VTOL aircraft of claim 41, wherein the at least a sensor comprises a sensor configured to detect a state of charge (SOC) of the at least a battery.
43. The hybrid electric VTOL aircraft of claim 41, wherein the at least a sensor comprises a sensor configured to detect a flight mode of the hybrid electric VTOL aircraft.
- 30 44. A fuel pod for a hybrid electric aircraft, the fuel pod comprising:
a housing;

a fuel tank contained within the housing, wherein the fuel tank is configured to hold a fuel therein;

a generator contained within the housing and connected to the fuel tank, wherein the generator is configured to power at least one of a plurality of flight components of a hybrid electric aircraft; and

a connection mechanism at the housing, wherein the connection mechanism is configured to removably attach the fuel pod to the hybrid electric aircraft, and wherein the connection mechanism comprises:

an electrical interface configured to electrically link to at least one of the plurality of flight components of the hybrid electric aircraft; and

a communication interface configured to communicatively link to a flight controller communicatively connected to the hybrid electric aircraft.

45. The fuel pod of claim 44, wherein the fuel pod is removably attachable to at least a boom of the hybrid electric aircraft.

46. The fuel pod of claim 44, wherein the generator is configured to electrically connect to at least an electric motor of the plurality of flight components.

47. The fuel pod of claim 44, wherein the generator is configured to power at least an electric motor of the plurality of flight components.

48. The fuel pod of claim 44, wherein the generator is configured to electrically connect to at least a battery of the hybrid electric aircraft.

49. The fuel pod of claim 44, wherein the generator is configured to recharge at least a battery of the hybrid electric aircraft.

50. The fuel pod of claim 44, wherein the generator is configured to power at least a lift component of the plurality of flight components.

51. The fuel pod of claim 44, wherein the generator is configured to power at least a pusher component of the plurality of flight components.

52. The fuel pod of claim 44, wherein the generator is configured to power at least a propulsor of the plurality of flight components.

53. The fuel pod of claim 44, wherein the fuel pod further comprises a computing device configured to communicatively connect with the flight controller of the hybrid electric aircraft.

54. The fuel pod of claim 53, wherein the computing device is configured to communicatively connect with the flight controller of the hybrid electric aircraft via the communication interface.
55. The fuel pod of claim 54, wherein the communication interface is configured to conduct signals between the computing device and the flight controller.
56. The fuel pod of claim 44, wherein the fuel pod further comprises at least a sensor.
57. The fuel pod of claim 56, wherein the at least a sensor is communicatively connected to a computing device of the fuel pod.
58. The fuel pod of claim 56, wherein the at least a sensor is configured to detect an electric current emanating from the generator.
59. The fuel pod of claim 56, wherein the at least a sensor is configured to detect a fuel level of the fuel tank.
60. The fuel pod of claim 44, wherein the connection mechanism further comprises a mating connector configured to mate with the hybrid electric aircraft.
61. The fuel pod of claim 60, wherein the mating connector is configured to mate with an aircraft port of the hybrid electric aircraft.
62. The fuel pod of claim 61, wherein the mating connector is configured to mate with an aircraft port at a boom of the hybrid electric aircraft.
63. The fuel pod of claim 61, wherein at least a portion of the electrical interface and at least a portion of the communication interface is located at the mating connector.
64. A fuel pod for a hybrid electric aircraft, the fuel pod comprising:
a housing;
a fuel tank contained within the housing, wherein the fuel tank is configured to hold a fuel therein;
a generator contained within the housing and connected to the fuel tank, wherein the generator is configured to power at least one of a plurality of flight components of a hybrid electric aircraft; and
a connection mechanism at the housing, wherein the connection mechanism is configured to removably attach the fuel pod to the hybrid electric aircraft, and wherein the connection mechanism comprises:

a mechanical interface comprising a keyed locking mechanism configured to selectively lock the housing to the hybrid electric aircraft;
 an electrical interface configured to electrically link to at least one of the plurality of flight components of the hybrid electric aircraft; and
 5 a communication interface configured to communicatively link to a flight controller communicatively connected to the hybrid electric aircraft.

65. The fuel pod of claim 64, wherein the hybrid electric aircraft comprises at least a boom, wherein the fuel pod is removably attached to the at least a boom of the hybrid electric aircraft.

10 66. The fuel pod of claim 64, wherein the generator is configured to electrically connect to at least an electric motor of the plurality of flight components.

67. The fuel pod of claim 64, wherein the generator is configured to power at least an electric motor of the plurality of flight components.

68. The fuel pod of claim 64, wherein the generator is configured to power at least a lift
 15 component of the plurality of flight components.

69. The fuel pod of claim 64, wherein the generator is configured to power at least a pusher component of the plurality of flight components.

70. The fuel pod of claim 64, wherein the generator is configured to power at least a propulsor of the plurality of flight components.

20 71. The fuel pod of claim 64, wherein the fuel pod further comprises a computing device configured to communicatively connect with the flight controller of the hybrid electric aircraft.

72. The fuel pod of claim 71, wherein the computing device is configured to communicatively connect with the flight controller of the hybrid electric aircraft via the
 25 communication interface.

73. The fuel pod of claim 72, wherein the communication interface is configured to conduct signals between the computing device and the flight controller.

74. The fuel pod of claim 64, wherein the fuel pod further comprises at least a sensor.

75. The fuel pod of claim 74, wherein the at least a sensor is communicatively connected to a
 30 computing device of the fuel pod.

76. The fuel pod of claim 74, wherein the at least a sensor is configured to detect an electric current emanating from the generator.
77. The fuel pod of claim 74, wherein the at least a sensor is configured to detect a fuel level of the fuel tank.
- 5 78. The fuel pod of claim 64, wherein the connection mechanism further comprises a mating connector configured to mate with the hybrid electric aircraft.
79. The fuel pod of claim 78, wherein the mating connector is configured to mate with an aircraft port of the hybrid electric aircraft.
80. The fuel pod of claim 79, wherein the mating connector is configured to mate with an aircraft port at a boom of the hybrid electric aircraft.
- 10 81. The fuel pod of claim 79, wherein at least a portion of the electrical interface and at least a portion of the communication interface is located at the mating connector.
82. A combination, comprising:
the fuel pod of claim 64; and
15 a hybrid electric aircraft, wherein the hybrid electric aircraft comprises:
a fuselage; and
at least a battery, wherein the at least a battery is mounted in the fuselage and configured to selectively power at least one flight component of a plurality of flight component.
- 20 83. A hybrid propulsion system for an electric aircraft, the system comprising:
an electric aircraft, the electric aircraft comprising:
a fuselage, the fuselage comprising an energy source, wherein the energy source is configured to store electric power;
at least a laterally extending element, wherein:
25 the at least a laterally extending element is attached to the fuselage; and
the at least a laterally extending element extends laterally from the fuselage; and
at least a propulsor, wherein the at least a propulsor is electrically connected to the energy source; and
30 at least a power unit pod, wherein the at least a power unit pod is attached to the at least a laterally extending element, the at least a power unit pod comprising:

an auxiliary power unit, the auxiliary power unit configured to generate electric power; and

a fuel tank, wherein the fuel tank is in fluid communication with the auxiliary power unit; and

5 a power output line, the power output line electrically connected to the

84. The system of claim 83, wherein the at least a power unit pod further comprises a high voltage power line, the high voltage power line electrically connected to the auxiliary power unit.

85. The system of claim 83, wherein the at least a propulsor further comprises:

10 at least a pusher propulsor, wherein the pusher propulsor is configured to provide forward thrust to the electric aircraft; and

at least a lift propulsor, wherein the lift propulsor is configured to provide lift to the electric aircraft.

86. The system of claim 83, wherein the at least a power unit pod is removably attached to
15 the underside of the at least a laterally extending element.

87. The system of claim 86, wherein the at least a power unit pod is connected to a pod support, wherein the pod support is removably attached to the underside of at least a laterally extending element.

88. The system of claim 87, wherein the pod support has an airfoil cross section.

20 89. The system of claim 83, wherein the laterally extending element comprises a lift generating body, wherein the lift generating body has an airfoil cross section.

90. The system of claim 83, wherein the electric aircraft further comprises a first high voltage front end, wherein the first high voltage front end is electrically connected to:

the energy source;

25 each of the at least a propulsor; and

the power output line of the at least a power unit pod.

91. The system of claim 90, wherein the first high voltage front end is configured to:

receive high voltage power from the energy source and the power output line of the at least a power unit pod; and

30 provide power to each of the at least a propulsor.

92. The system of claim 86, wherein:

the at least a lift propulsor comprises two lift propulsors; and
each of the two lift propulsors connected to the at least a laterally extending element.

93. The system of claim 86, wherein the electric aircraft further comprises:
a first propulsor boom connected to the at least a laterally extending element; and
5 a second propulsor boom connected to the at least a laterally extending element.

94. The system of claim 93, wherein:
a first lift propulsor of the at least a lift propulsor is connected to the first
propulsor boom;
a second lift propulsor of the at least a lift propulsor is connected to the second
10 propulsor boom.

95. The system of claim 93, wherein:
a first set of lift propulsors of the at least a lift propulsor is connected to the first
propulsor boom; and
a second set of lift propulsors of the at least a lift propulsor is connected to the second
15 propulsor boom.

96. The system of claim 86, wherein the at least a pusher propulsor is connected to a tail end
of the electric aircraft.

97. The system of claim 83, wherein the at least a power unit pod is contained within a
nacelle, wherein the nacelle has been shaped to reduce drag when in edgewise flight.

20 98. The system of claim 83, wherein electric aircraft comprises a flight controller.

99. The system of claim 99, wherein the flight controller is communicatively connected to
the auxiliary power unit of the at least a power unit pod.

100. The system of claim 83, wherein the auxiliary power unit of the at least a power unit pod
has a power rating of over 100 kW.

25 101. The system of claim 83, wherein the auxiliary power unit of the at least a power unit has
a 150-200kW power rating.

102. The system of claim 92, wherein the electric aircraft further comprises a second high
voltage front end, wherein:

the second high voltage front end is electrically connected to:

30 the energy source;
each of the at least a propulsor; and

the power output line of the power unit pod; and
the second high voltage front end is configured to:

receive high voltage power from the energy source and the power output
line of the at least a power unit pod; and
provide power to each of the at least a propulsor.

103. A hybrid propulsion system for an electric aircraft, the system comprising:
an electric aircraft, the electric aircraft comprising:

a fuselage, the fuselage comprising an energy source, wherein the energy source
is configured to store electric power;

at least laterally extending element, wherein:

the at least laterally extending element is attached to the fuselage; and
the at least laterally extending element extends laterally from the fuselage;
and

at least a propulsor, wherein the at least propulsor is electrically connected to the
energy source; and

at least a power unit pod, wherein the at least power unit pod is attached to the at least a
laterally extending element, the at least power unit pod comprising:

an auxiliary power unit, the auxiliary power unit configured to generate electric
power;

a fuel tank, wherein the fuel tank is in fluid communication with the auxiliary
power unit and includes a fuel pump for transferring fuel from the fuel
tank to the auxiliary power unit;

a local controller communicatively connected to the auxiliary power unit, the fuel
tank and a flight controller onboard the electric aircraft, wherein the local
controller is configured to:

transmit a control signal to at least the fuel pump of the fuel tank to control
operation of the fuel pump;

a power supply electrically connected to the auxiliary power unit, the local
controller and the fuel tank, wherein the power supply is configured to
convert source power from the auxiliary power unit to load power and

provide the load power to the local controller and the fuel tank including the fuel pump; and

a power output line, the power output line electrically connected to the energy source of the electric aircraft for recharging the energy source.

- 5 104. The system of claim 103, wherein the at least power unit pod further comprises a predetermined voltage power line, the predetermined voltage power line electrically connected to the auxiliary power unit.
105. The system of claim 103, wherein the at least propulsor further comprises:
10 at least a pusher propulsor, wherein the at least a pusher propulsor is configured to provide forward thrust to the electric aircraft; and
at least a lift propulsor, wherein the at least a lift propulsor is configured to provide lift to the electric aircraft.
106. The system of claim 103, wherein the at least power unit pod is removably attached to an underside of the at least laterally extending element.
- 15 107. The system of claim 106, wherein the at least power unit pod is connected to a pod support, wherein the pod support is removably attached to the underside of the at least laterally extending element.
108. The system of claim 107, wherein the pod support has an airfoil cross section.
109. The system of claim 103, wherein the at least laterally extending element comprises a lift
20 generating body, wherein the lift generating body has an airfoil cross section.
110. The system of claim 103, wherein the electric aircraft further comprises a first predetermined voltage interface, wherein the first predetermined voltage interface is electrically connected to:
the energy source;
25 each of the at least a propulsor; and
the power output line of the at least a power unit pod.
111. The system of claim 110, wherein the first predetermined voltage interface is configured to:
receive a first predetermined voltage power from the energy source and the power output
30 line of the at least power unit pod; and
provide power to each of the at least propulsor.

112. The system of claim 106, wherein:
the at least lift propulsor comprises two lift propulsors; and
each of the two lift propulsors connected to the at least laterally extending element.
113. The system of claim 106, wherein the electric aircraft further comprises:
5 a first propulsor boom connected to the at least laterally extending element; and
a second propulsor boom connected to the at least laterally extending element.
114. The system of claim 113, wherein:
a first lift propulsor of the at least lift propulsor is connected to the first propulsor boom;
10 a second lift propulsor of the at least lift propulsor is connected to the second propulsor boom.
115. The system of claim 113, wherein:
a first set of lift propulsors of the at least lift propulsor is connected to the first propulsor boom; and
15 a second set of lift propulsors of the at least lift propulsor is connected to the second propulsor boom.
116. The system of claim 113, wherein the at least pusher propulsor is connected to a tail end of the electric aircraft.
117. The system of claim 103, wherein the at least power unit pod is contained within a nacelle, wherein the nacelle is shaped to reduce drag when in edgewise flight.
20
118. The system of claim 103, wherein the electric aircraft comprises a flight controller.
119. The system of claim 118, wherein the flight controller is communicatively connected to the auxiliary power unit of the at least power unit pod.
120. The system of claim 103, wherein the auxiliary power unit of the at least power unit pod has a power rating of over 100 kW.
25
121. The system of claim 103, wherein the auxiliary power unit of the at least power unit has a 150-200kW power rating.
122. The system of claim 112, wherein the electric aircraft further comprises a second predetermined voltage interface, wherein:
30 the second predetermined voltage interface is electrically connected to:
the energy source;

each of the at least a propulsor; and
the power output line of the power unit pod; and
the second predetermined voltage interface is configured to:
receive a second predetermined voltage power from the energy source and
5 the power output line of the at least power unit pod; and
provide power to each of the at least propulsor.

123. A hybrid propulsion system for an electric aircraft, the system comprising:
an electric aircraft, the electric aircraft comprising:

a fuselage;

10 at least laterally extending element, wherein:

the at least laterally extending element is attached to the fuselage; and

the at least laterally extending element extends laterally from the fuselage;

an energy source, wherein the energy source is configured to store electric power;

at least a propulsor, wherein the at least propulsor is electrically connected to the

15 energy source; and

a fuel tank; and

at least a power unit pod, wherein the at least power unit pod is attached to the at least
laterally extending element, the at least power unit pod comprising:

an auxiliary power unit in fluid communication with the fuel tank, the auxiliary power
20 unit configured to generate electric power;

a local controller communicatively connected to the auxiliary power unit, the fuel tank
and a flight controller onboard the electric aircraft;

a power supply electrically connected to the auxiliary power unit, the local controller
and the fuel tank, wherein the power supply is configured to convert source power
25 from the auxiliary power unit to load power and provide the load power to the local
controller; and

a power output line electrically connected to the at least a propulsor for powering the at
least a propulsor.

124. The hybrid propulsion system of claim 123, wherein the fuel tank is positioned within the
30 at least laterally extending element.

125. The hybrid propulsion system of claim 124, wherein the laterally extending element and the at least a power unit pod are in fluid communication through a fuel interface.
126. The hybrid propulsion system of claim 123, wherein the local controller is configured to manage the temperature of the auxiliary power unit.
- 5 127. The hybrid propulsion system of claim 123, wherein the local controller is configured to manage the temperature of the power supply.
128. The hybrid propulsion system of claim 123, wherein the local controller is configured to transmit data to the flight controller.
129. The hybrid propulsion system of claim 123, wherein the local controller is configured to transmit data to an interface for display to a pilot.
- 10 130. The hybrid propulsion system of claim 123, wherein the fuel tank includes a fuel pump for transferring fuel from the fuel tank to the auxiliary power unit.
131. The hybrid propulsion system of claim 130, wherein the local controller is configured to transmit a control signal to at least the fuel pump of the fuel tank to control operation of the fuel pump.
- 15 132. The hybrid propulsion system of claim 130, wherein the power supply is configured to provide load power to the fuel tank including the fuel pump.
133. The hybrid propulsion system of claim 123, wherein the power unit pod is detachable from the electric aircraft.
- 20 134. The system of claim 123, wherein the at least power unit pod further comprises a predetermined voltage power line, the predetermined voltage power line electrically connected to the auxiliary power unit.
135. The system of claim 123, wherein the at least propulsor further comprises:
at least a pusher propulsor, wherein the at least pusher propulsor is configured to provide
25 forward thrust to the electric aircraft; and
at least a lift propulsor, wherein the at least lift propulsor is configured to provide lift to the electric aircraft.
136. The system of claim 123, wherein the at least power unit pod is removably attached to an underside of the at least laterally extending element.

137. The system of claim 136, wherein the at least power unit pod is connected to a pod support, wherein the pod support is removably attached to the underside of the at least laterally extending element.

138. The system of claim 137, wherein the pod support has an airfoil cross section.

5 139. The system of claim 123, wherein the at least laterally extending element comprises a lift generating body, wherein the lift generating body has an airfoil cross section.

140. The system of claim 123, wherein the electric aircraft further comprises a first predetermined voltage interface, wherein the first predetermined voltage interface is electrically connected to:

10 the energy source;
each of the at least propulsor; and
the power output line of the at least power unit pod.

141. The system of claim 140, wherein the first predetermined voltage interface is configured to: receive a first predetermined voltage power from the energy source and the power output

15 line of the at least power unit pod; and
provide power to each of the at least propulsor.

142. The system of claim 135, wherein:

the at least lift propulsor comprises two lift propulsors; and
each of the two lift propulsors are connected to the at least laterally extending element.

20 143. The system of claim 135, wherein the electric aircraft further comprises:
a first propulsor boom connected to the at least laterally extending element; and
a second propulsor boom connected to the at least laterally extending element.

144. The system of claim 143, wherein:

25 a first lift propulsor of the at least lift propulsor is connected to the first propulsor boom;
and
a second lift propulsor of the at least lift propulsor is connected to the second propulsor boom.

145. The system of claim 143, wherein:

30 a first set of lift propulsors of the at least lift propulsor is connected to the first propulsor boom; and

a second set of lift propulsors of the at least lift propulsor is connected to the second propulsor boom.

146. The system of claim 135, wherein the at least pusher propulsor is connected to a tail end of the electric aircraft.

5 147. The system of claim 123, wherein the at least power unit pod is contained within a nacelle, wherein the nacelle is shaped to reduce drag when in edgewise flight.

148. The system of claim 123, wherein the electric aircraft comprises a flight controller.

149. The system of claim 148, wherein the flight controller is communicatively connected to the auxiliary power unit of the at least power unit pod.

10 150. The system of claim 123, wherein the auxiliary power unit of the at least power unit pod has a power rating of over 100 kW.

151. The system of claim 123, wherein the auxiliary power unit of the at least power unit has a 150-200 kW power rating.

15 152. The system of claim 151, wherein the electric aircraft further comprises a second predetermined voltage interface, wherein:

the second predetermined voltage interface is electrically connected to:

the energy source;

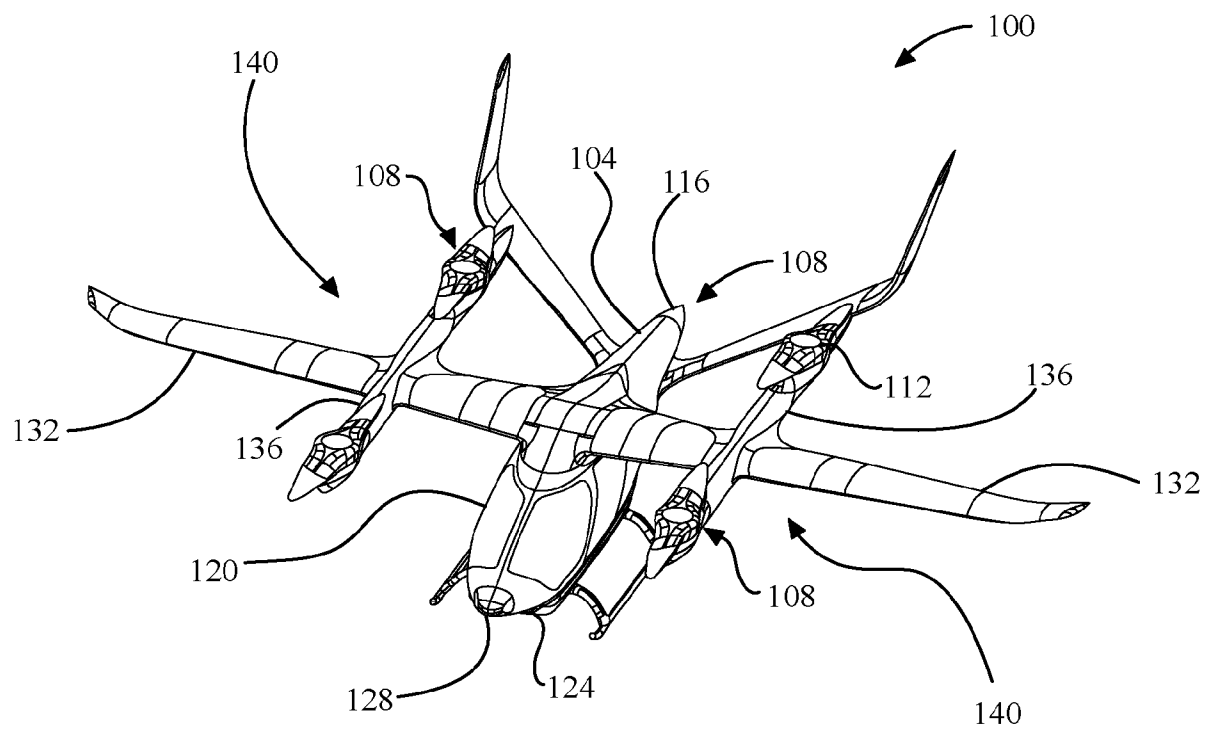
each of the at least propulsor; and

the power output line of the power unit pod; and

20 the second predetermined voltage interface is configured to:

receive a second predetermined voltage power from the energy source and the power output line of the at least power unit pod; and

provide power to each of the at least propulsor.

**FIG. 1**

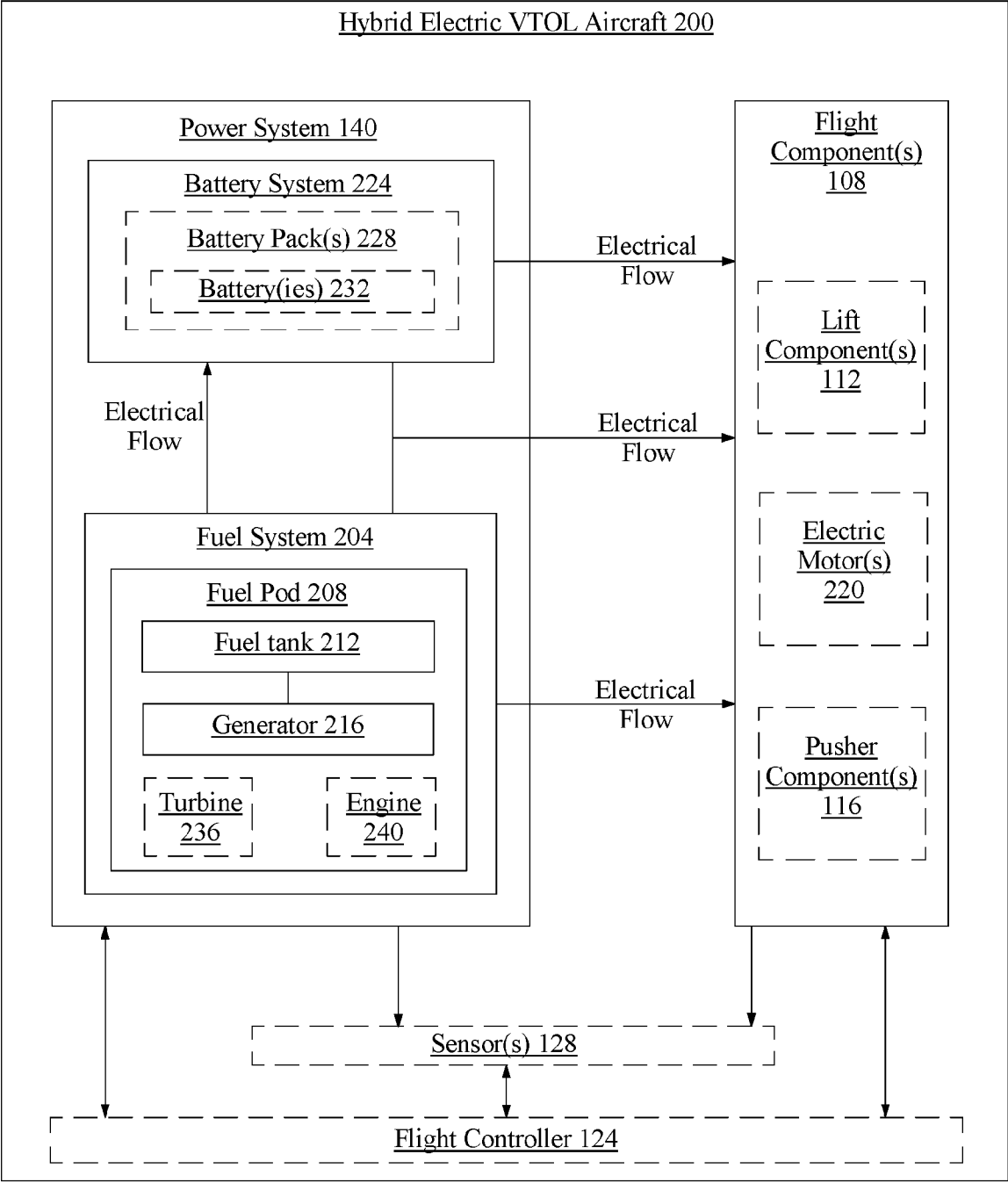
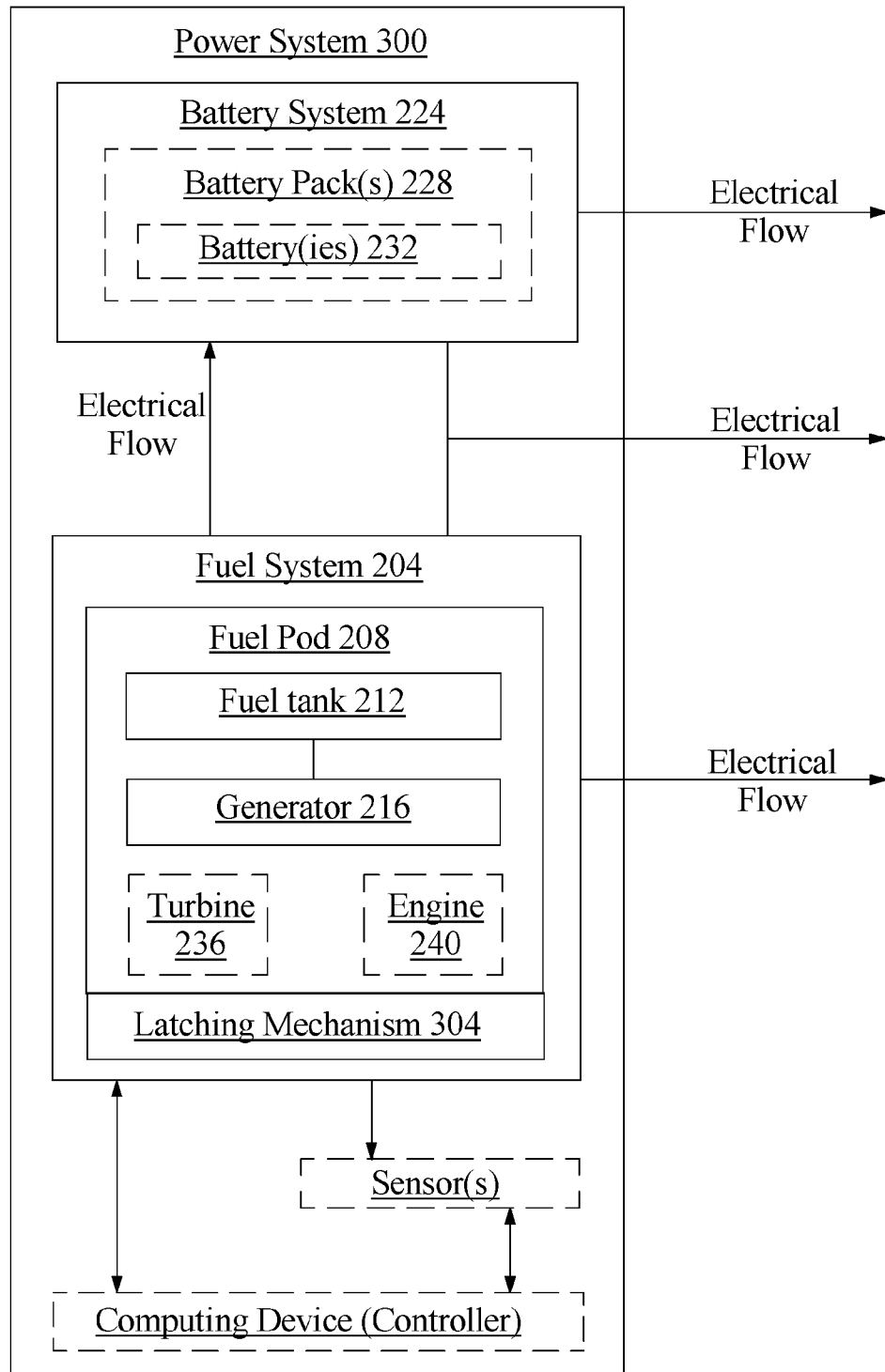


FIG. 2

**FIG. 3**

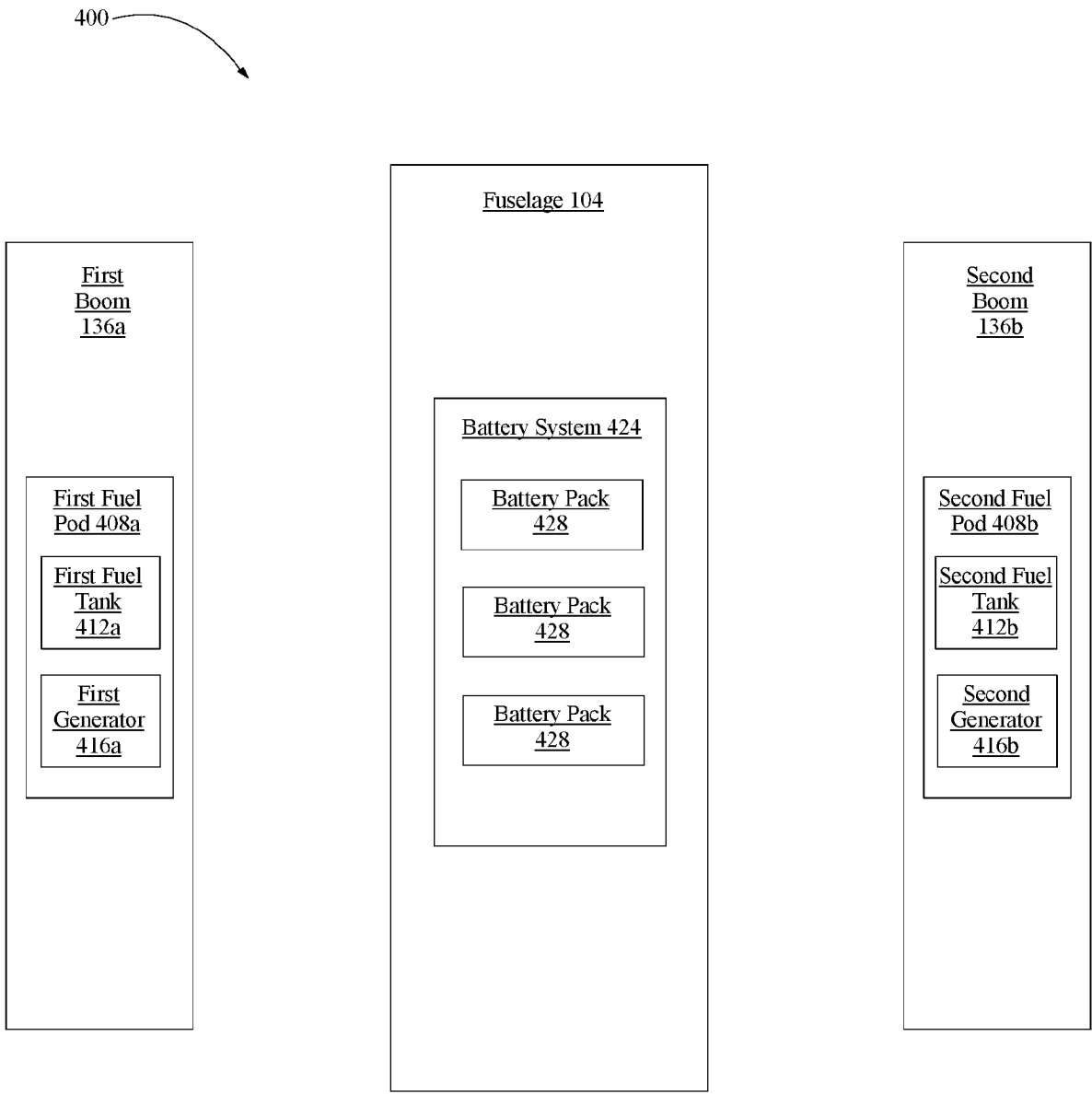
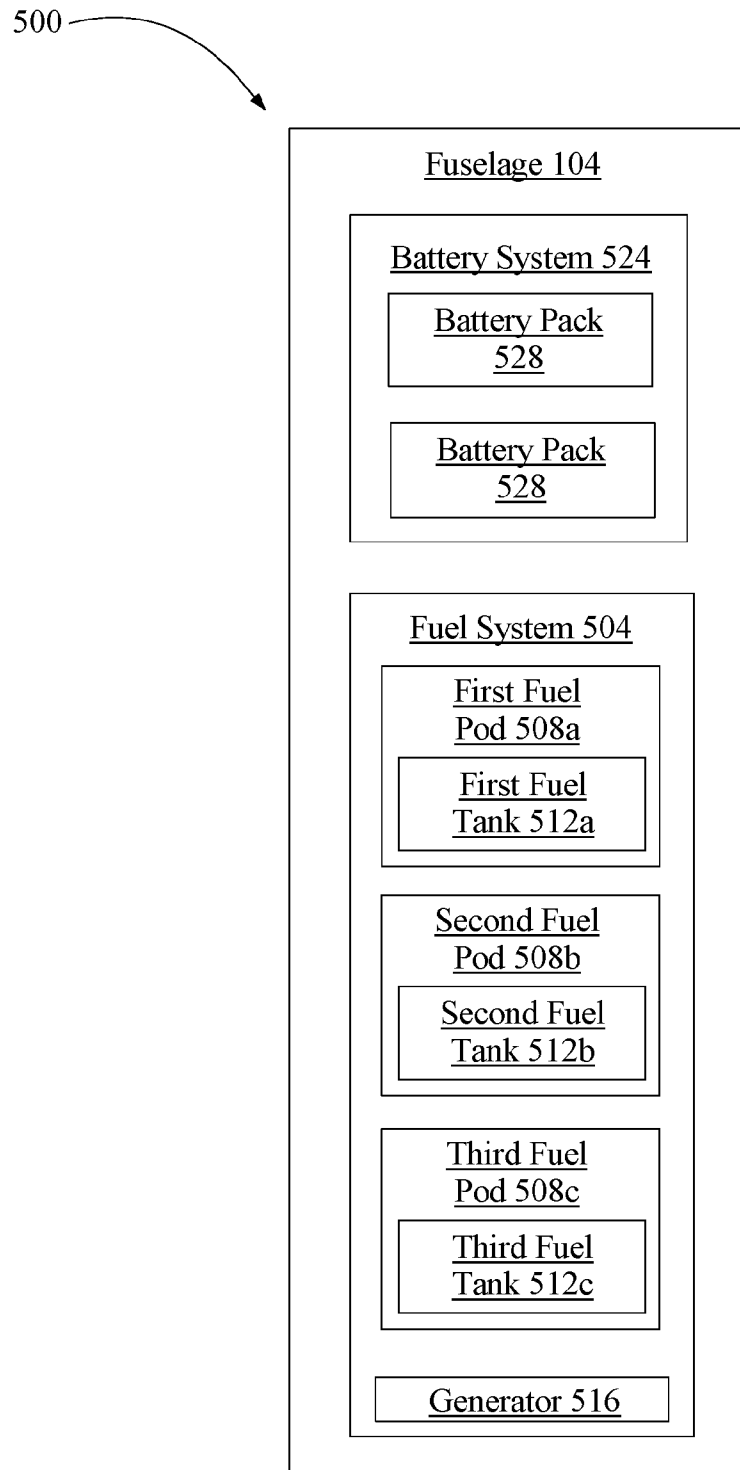
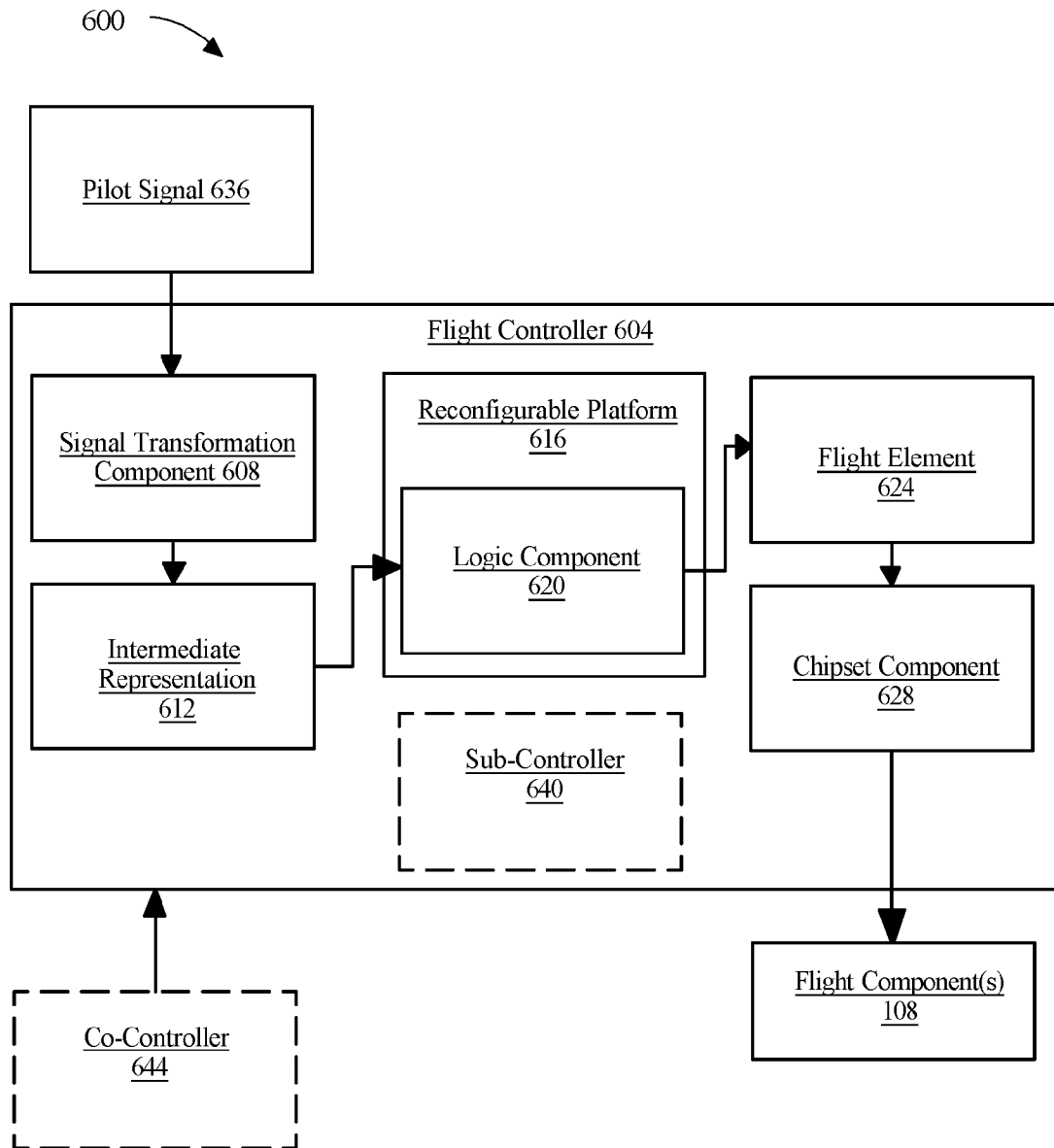
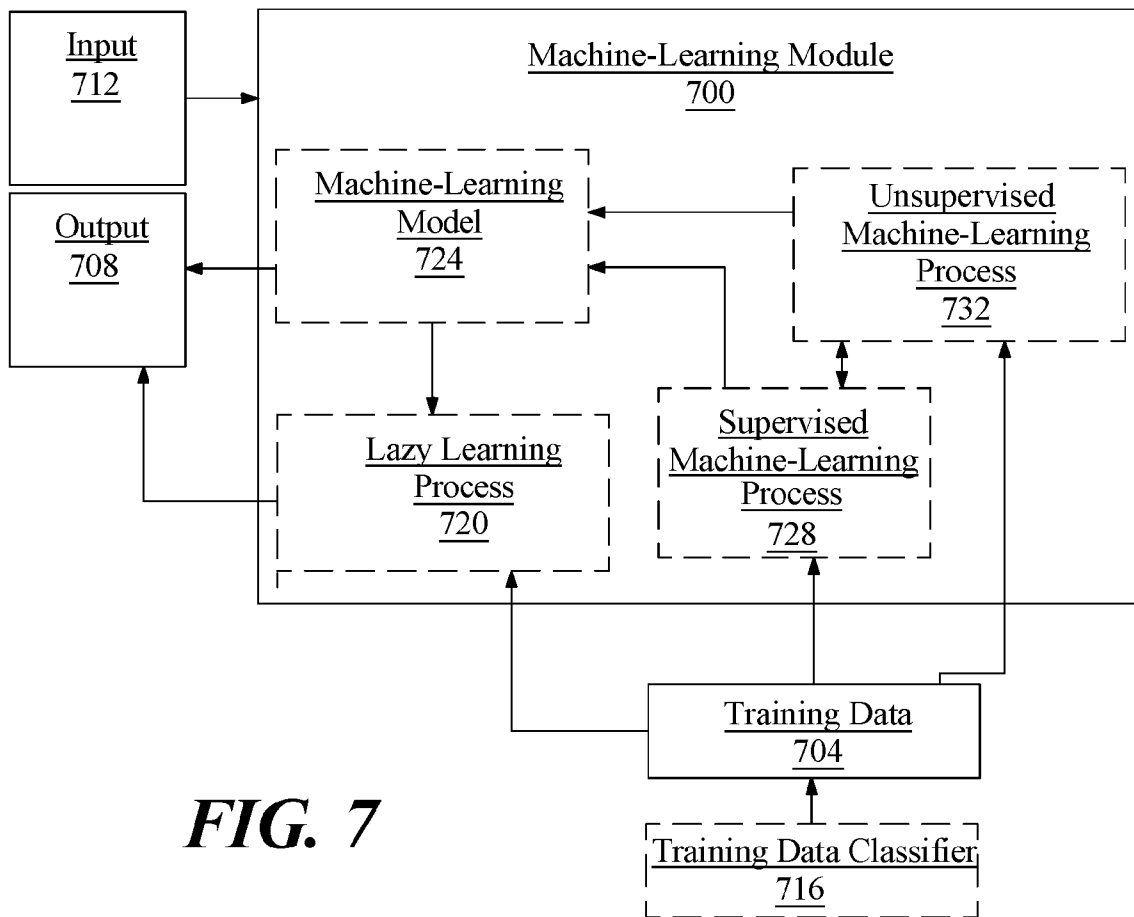
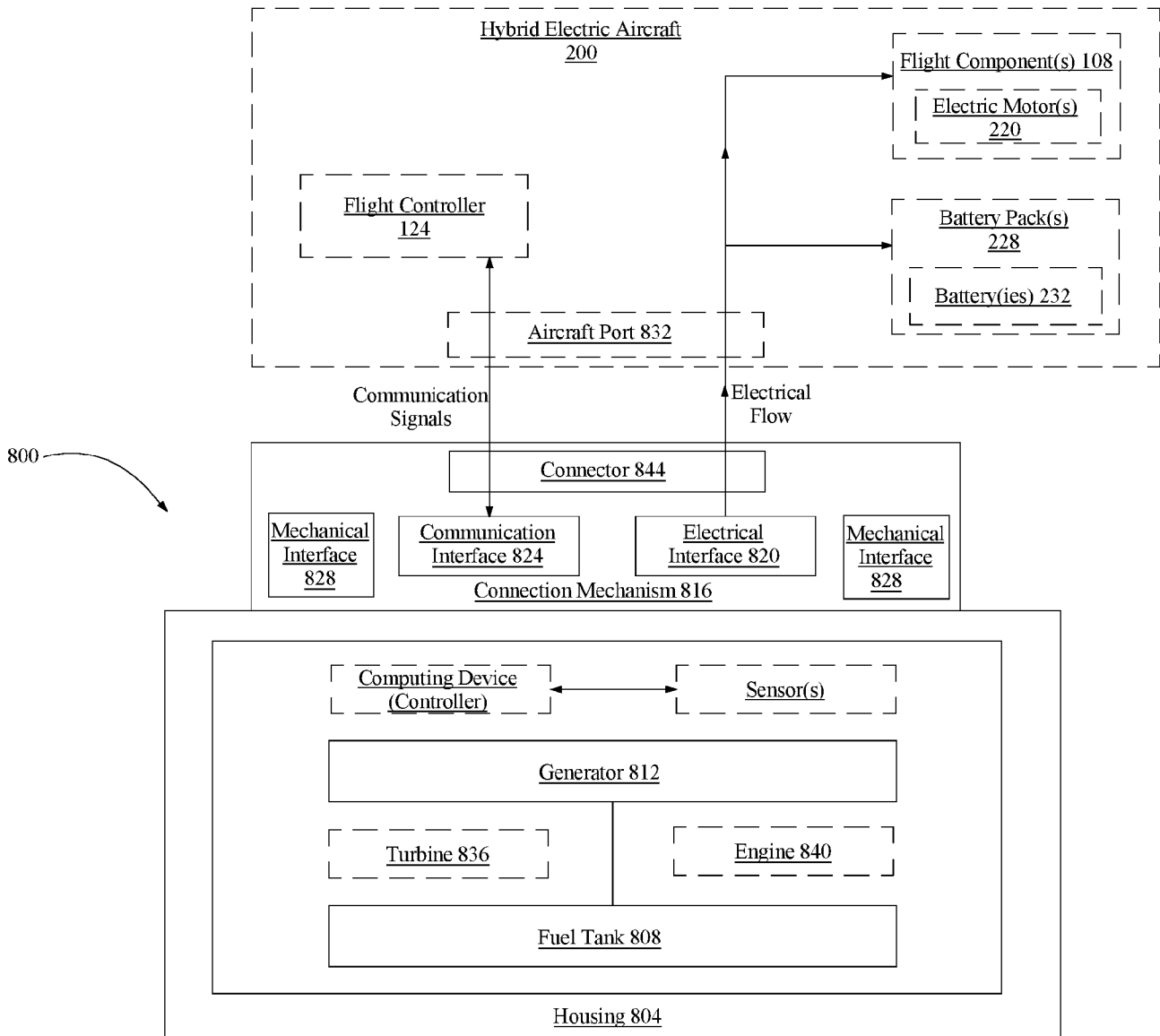


FIG. 4

**FIG. 5**

**FIG. 6**

**FIG. 7**

**FIG. 8**

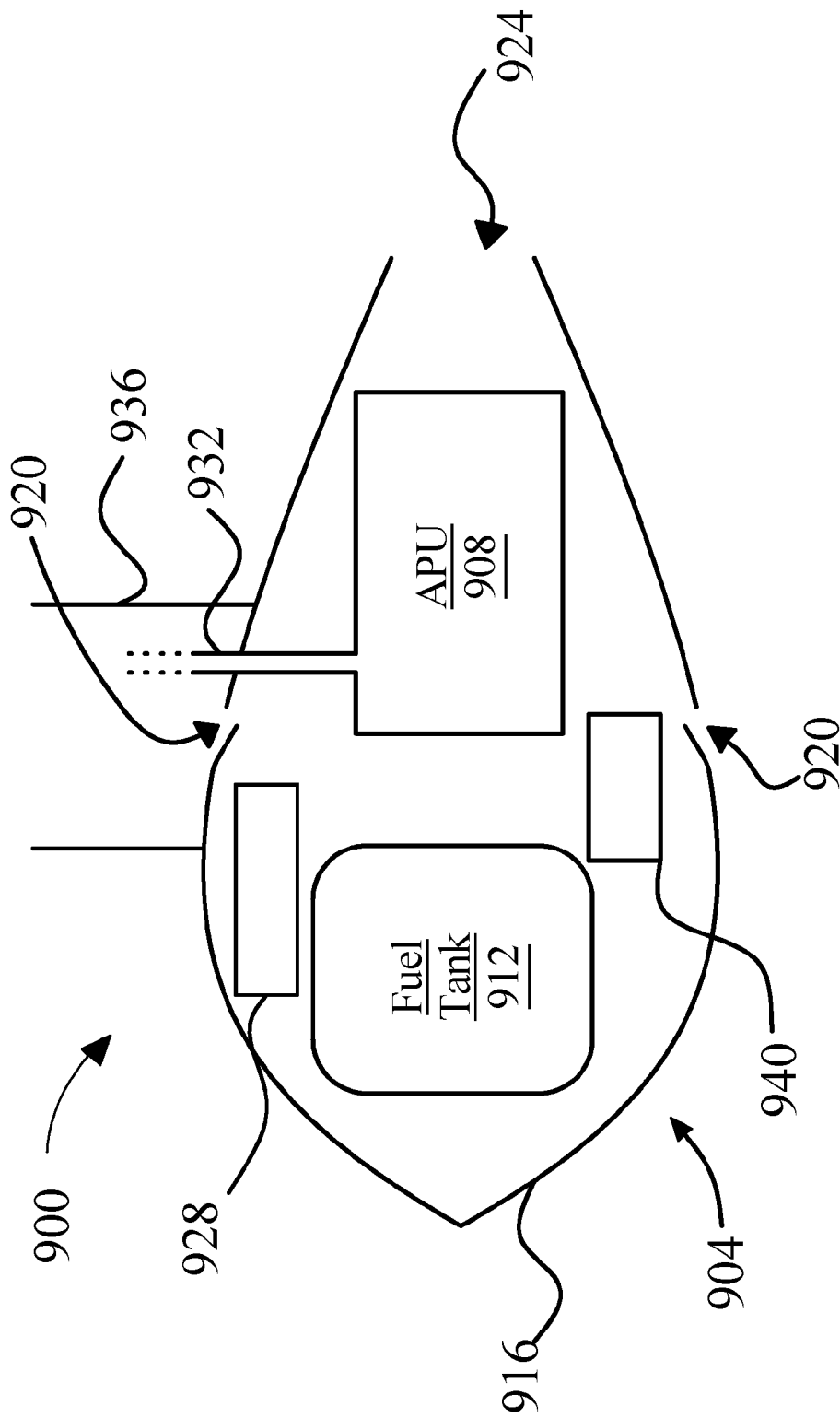


FIG. 9

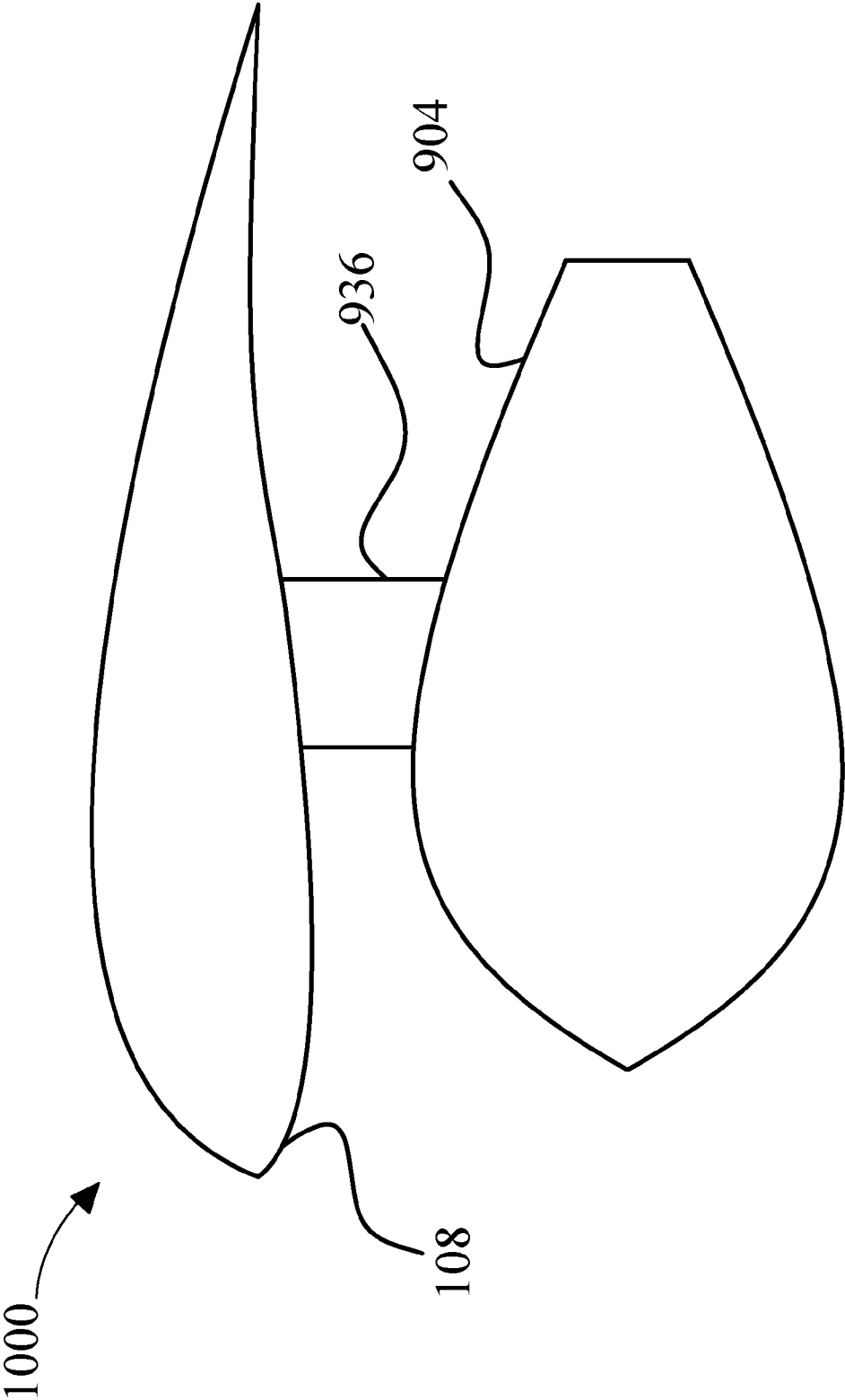


FIG. 10

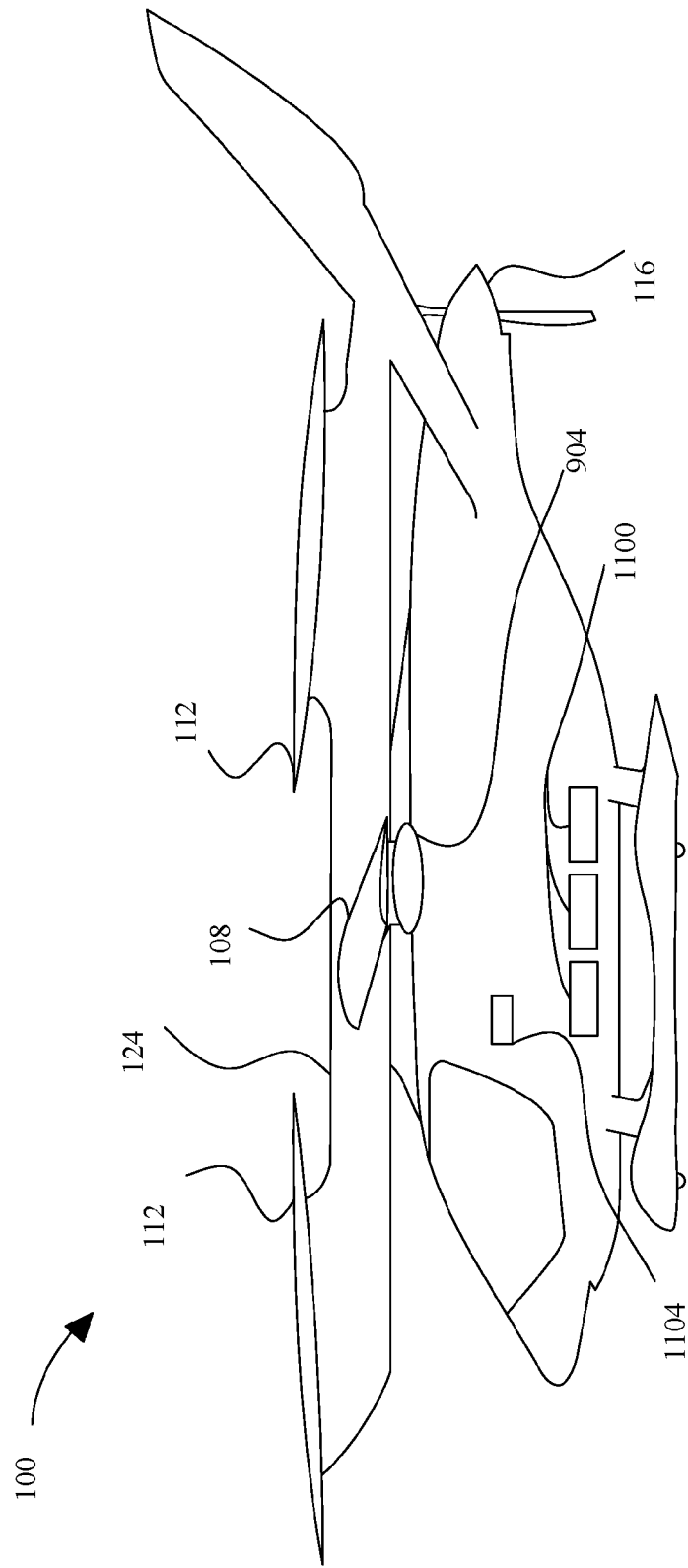


FIG. 11

1200 

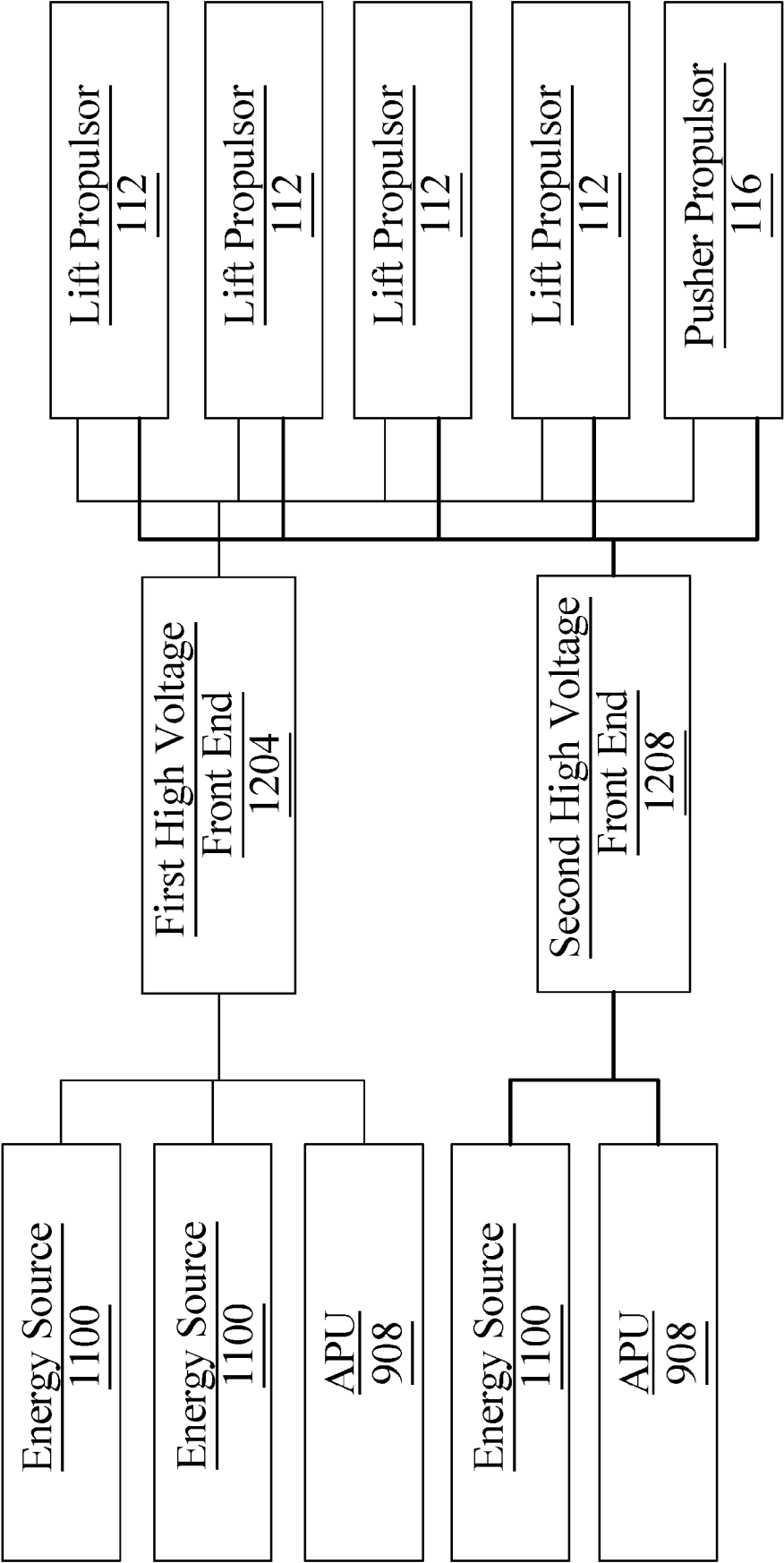


FIG. 12

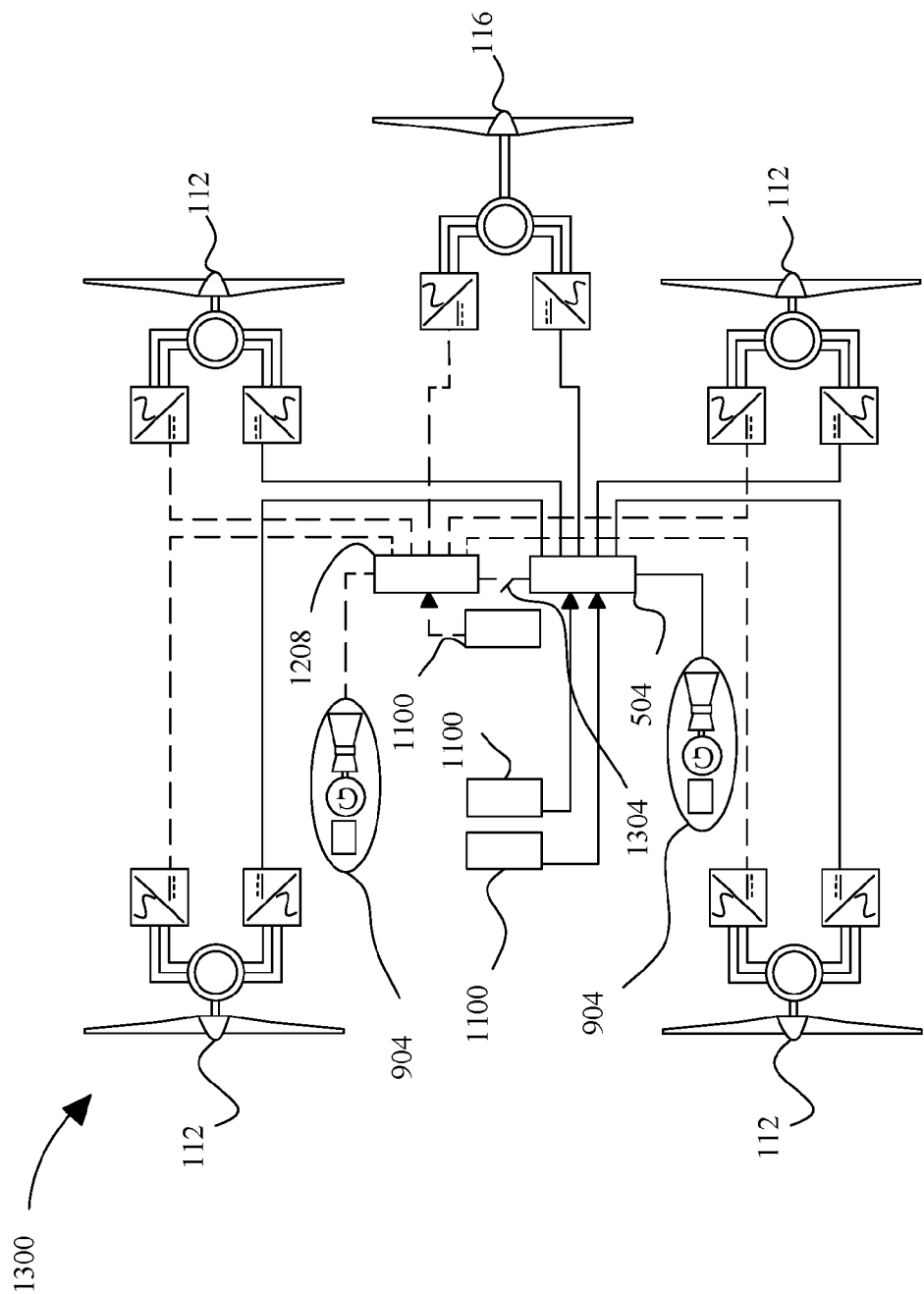
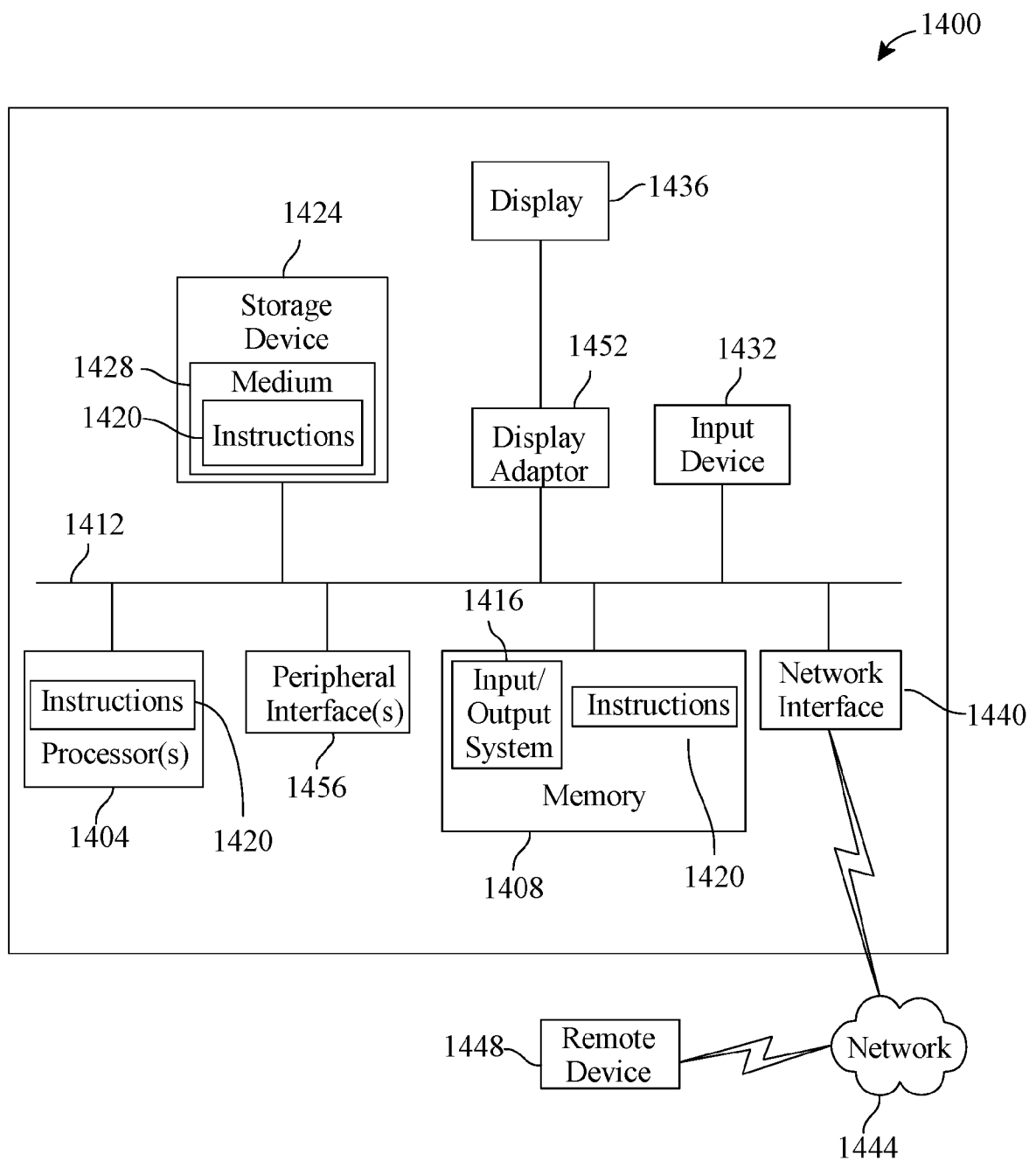


FIG. 13

**FIG. 14**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/17382

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B64C 29/00, B64C 29/02, B64D 27/00 (2023.01)

ADD. B64D 27/04, B64D 27/08, B64D 27/10, B64D 27/14 (2023.01)

CPC - INV. B64C 29/00, B64C 29/0033, B64C 29/02, B64D 27/00

ADD. B64C 29/0083, B64D 27/04, B64D 27/08, B64D 27/10, B64D 27/16, B64D 27/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2021/0309382 A1 (Volsani, Inc.) 07 October 2021 (07.10.2021), entire document, especially para [0006], para [0012], para [0013], para [0036], para [0039]; fig. 1, fig. 3A.	1-43
A	US 2014/0158816 A1 (DELOREAN AEROSPACE, LLC) 12 June 2014 (12.06.2014), entire document, especially para [0085]; fig. 6B.	1-43
A, P	US 11,353,890 B1 (BETA AIR, LLC) 07 June 2022 (07.06.2022), entire document, especially	1-43
A	US 2021/0309382 A1 (Volsani, Inc.) 07 October 2021 (07.10.2021), entire document, especially para [0006], para [0013]; fig. 3A.	1-43
A	US 2019/0127056 A1 (ELOY AIR, INC.) 02 May 2019 (02.05.2019), entire document, especially para [0019], para [0068]; fig. 1.	1-43

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 July 2023

Date of mailing of the international search report

AUG 11 2023

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Kari Rodriguez

Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/17382

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-43 are directed towards a hybrid electric vertical takeoff and landing (VTOL) aircraft. (Fig. 1, 11)

Group II: Claims 44-82 are directed towards a fuel pod for a hybrid electric aircraft. (Fig. 4-5, 9)

Group III: Claims 83-152 are directed towards a hybrid propulsion system for an electric aircraft. (Fig. 3)

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

-*-Continued in Supplemental Box-*-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-43

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

-*-Continuation of Box No. III - Observations where unity of invention is lacking--*-

SPECIAL TECHNICAL FEATURES

The invention of Group I includes the special technical feature a hybrid electric vertical takeoff and landing (VTOL) aircraft comprising a fuselage, a pair of wings connected to the fuselage and extending generally laterally therefrom, wherein each wing is on either side of the fuselage, a pair of booms with each boom connected to a respective one of the wings, wherein each boom extends generally longitudinally and parallel to the fuselage, a plurality of flight components configured to provide thrust to the hybrid electric VTOL aircraft, and a power system configured to power the plurality of flight components, wherein the power system comprises at least a fuel tank and a generator, wherein the at least a fuel tank is mounted to at least one of the booms, and at least a battery configured to power the plurality of flight components, not required by the claims of Groups II-III.

The invention of Group II includes the special technical feature of a fuel pod for a hybrid electric aircraft comprising a housing, a fuel tank contained within the housing, wherein the fuel tank is configured to hold a fuel therein, a generator contained within the housing and connected to the fuel tank, wherein the generator is configured to power at least one of a plurality of flight components of a hybrid electric aircraft, and a connection mechanism at the housing, wherein the connection mechanism is configured to removably attach the fuel pod to the hybrid electric aircraft, and wherein the connection mechanism comprises, an electrical interface configured to electrically link to at least one of the plurality of flight components of the hybrid electric aircraft, and a communication interface configured to communicatively link to a flight controller communicatively connected to the hybrid electric aircraft, not required by the claims of Groups I and III.

The invention of Group III includes the special technical feature of a hybrid propulsion system for an electric aircraft comprising an electric aircraft, the electric aircraft comprising, a fuselage, the fuselage comprising an energy source, wherein the energy source is configured to store electric power, at least a laterally extending element, wherein, the at least a laterally extending element is attached to the fuselage, and the at least a laterally extending element extends laterally from the fuselage, and at least a propulsor, wherein the at least a propulsor is electrically connected to the energy source, and at least a power unit pod, wherein the at least a power unit pod is attached to the at least a laterally extending element, the at least a power unit pod comprising, an auxiliary power unit, the auxiliary power unit configured to generate electric power, and a fuel tank, wherein the fuel tank is in fluid communication with the auxiliary power unit, and a power output line, the power output line electrically connected to the, not required by the claims of Groups I-II.

COMMON TECHNICAL FEATURES

Groups I-II share the common technical features of a hybrid electric aircraft comprising a fuel tank, and a generator configured to power at least one of a plurality of flight components.

However, this shared technical feature does not represent a contribution over prior art as being anticipated by US 11,353,890 to BETA AIR, LLC (hereinafter 'BETA AIR'), which discloses a hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising:

a fuselage (404 fig. 4);

a pair of wings (fig. 4 – see the pair of wings extending from the left-most and right-most sides of the fuselage) connected to the fuselage and extending generally laterally therefrom (fig. 4 – see how the pair of wings are connected to the fuselage and extend laterally therefrom), wherein each wing is on either side of the fuselage (fig. 4 – see how a first wing extends from the left-most side of the fuselage and a second wing extends from the right-most side of the fuselage);

a pair of booms (fig. 4 – see the pair of booms, each boom extending from a corresponding wing) with each boom connected to a respective one of the wings (fig. 4 – see how each boom of the pair of booms is connected to a corresponding wing of the pair of wings), wherein each boom extends generally longitudinally and parallel to the fuselage (fig. 4 – see how each boom extends longitudinally and parallel to the fuselage);

a plurality of flight components (408 fig. 4 – see the plurality of lift components 408 along the front-most and rear-most portions of each boom of the pair of booms) configured to provide thrust to the hybrid electric VTOL aircraft (col 19, In 52-60, 'plurality of actuators 408 may include at least a propulsor component. As used in this disclosure a 'propulsor component' or 'propulsor' is a component and/or device used to propel a craft by exerting force on a fluid medium, which may include a gaseous medium such as air or liquid medium such as water. In an embodiment, when a propulsor twists and pulls air behind it, it may, at the same time, push an aircraft forward with an amount of force and/or thrust'); and

a power system configured to power the plurality of flight components (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; 408 fig. 4 – see how the plurality of flight components 408 comprise a power system), wherein the power system comprises:

at least a fuel tank and a generator (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; 408 fig. 4 – see how the power system may comprise a fuel cell, considered to be a fuel tank, and a generator), wherein the at least a fuel tank is mounted to at least one of the booms (408 fig. 4 – see how the flight components, which further comprise the power system having a fuel tank is mounted to at least one of the booms); and

at least a battery (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; fig. 4 – see how the aircraft comprises a battery) configured to power the plurality of flight components (col 18, In 24-32, 'Referring now to FIG. 4, an exemplary embodiment of an aircraft 400 is illustrated. Aircraft 400 may include an electrically powered aircraft. In some embodiments, electrically powered aircraft may be an electric vertical takeoff and landing (eVTOL) aircraft. Electric aircraft may be capable of rotor-based cruising flight, rotor-based takeoff, rotor-based landing, fixed-wing cruising flight, airplane-style takeoff, airplane-style landing, and/or any combination thereof – see how the battery may supply electric power to the plurality of flight components to allow for the aircraft to operate as an electrically powered aircraft).

Groups I and III share the common technical features of a hybrid electric aircraft comprising a fuselage containing an energy source configured to supply energy to a propulsor mounted to a laterally extending element that is attached to the fuselage, and a generator.

-*-Continuation of Supplemental Box - Box No. III - Observations where unity of invention is lacking*-

However, this shared technical feature does not represent a contribution over prior art as being anticipated by BETA AIR, which discloses a hybrid electric vertical takeoff and landing (VTOL) aircraft, the hybrid electric VTOL aircraft comprising:

a fuselage (404 fig. 4);

a pair of wings (fig. 4 – see the pair of wings extending from the left-most and right-most sides of the fuselage) connected to the fuselage and extending generally laterally therefrom (fig. 4 – see how the pair of wings are connected to the fuselage and extend laterally therefrom), wherein each wing is on either side of the fuselage (fig. 4 – see how a first wing extends from the left-most side of the fuselage and a second wing extends from the right-most side of the fuselage);

a pair of booms (fig. 4 – see the pair of booms, each boom extending from a corresponding wing) with each boom connected to a respective one of the wings (fig. 4 – see how each boom of the pair of booms is connected to a corresponding wing of the pair of wings), wherein each boom extends generally longitudinally and parallel to the fuselage (fig. 4 – see how each boom extends longitudinally and parallel to the fuselage);

a plurality of flight components (408 fig. 4 – see the plurality of lift components 408 along the front-most and rear-most portions of each boom of the pair of booms) configured to provide thrust to the hybrid electric VTOL aircraft (col 19, In 52-60, 'plurality of actuators 408 may include at least a propulsor component. As used in this disclosure a 'propulsor component' or 'propulsor' is a component and/or device used to propel a craft by exerting force on a fluid medium, which may include a gaseous medium such as air or liquid medium such as water. In an embodiment, when a propulsor twists and pulls air behind it, it may, at the same time, push an aircraft forward with an amount of force and/or thrust'); and

a power system configured to power the plurality of flight components (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; 408 fig. 4 – see how the plurality of flight components 408 comprise a power system), wherein the power system comprises:

at least a fuel tank and a generator (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; 408 fig. 4 – see how the power system may comprise a fuel cell, considered to be a fuel tank, and a generator), wherein the at least a fuel tank is mounted to at least one of the booms (408 fig. 4 – see how the flight components, which further comprise the power system having a fuel tank is mounted to at least one of the booms); and

at least a battery (col 21, In 4-9, 'plurality of actuators may include and energy source. An energy source may include, for example, a generator, a photovoltaic device, a fuel cell such as a hydrogen fuel cell, direct methanol fuel cell, and/or solid oxide fuel cell, an electric energy storage device (e.g. a capacitor, an inductor, and/or a battery)'; fig. 4 – see how the aircraft comprises a battery) configured to power the plurality of flight components (col 18, In 24-32, 'Referring now to FIG. 4, an exemplary embodiment of an aircraft 400 is illustrated. Aircraft 400 may include an electrically powered aircraft. In some embodiments, electrically powered aircraft may be an electric vertical takeoff and landing (eVTOL) aircraft. Electric aircraft may be capable of rotor-based cruising flight, rotor-based takeoff, rotor-based landing, fixed-wing cruising flight, airplane-style takeoff, airplane-style landing, and/or any combination thereof – see how the battery may supply electric power to the plurality of flight components to allow for the aircraft to operate as an electrically powered aircraft).

As the common technical features were known in the art at the time of the invention, these cannot be considered special technical feature that would otherwise unify the groups.

Therefore, Groups I-III lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.

*Note

Claim 4: Regarding claim 4, the term 'latching mechanism' is confusing and lacks clarity. Specifically, the term is not well known in the art, and it is unclear exactly what structure is required by the term. The lack of clarity surrounding the term makes it difficult to ascertain the structure required by the claims. Accordingly, for purposes of this opinion, and as best understood by this ISA based on the Applicant's specification, claims and drawings, the term 'latching mechanism' has been interpreted to be any mechanism or device that allows for removable or detachable connection between two elements. Latching mechanism may include latches, fasteners, clamps, locks, clips, actuators, bolts, screws, bolt-nut combinations, connectors which may be manually, electronically, magnetically and/or remotely operable to detachably connect, attach or fasten elements.

Regarding claim 83, the claim language is confusing and lacks clarity. Specifically, the term 'the power output line electrically connected to the'. The term 'the power output line electrically connected to the' appears to be a typographical error that is inconsistent with known grammatical standards and fails to complete the sentence structure. Accordingly, for purposes of this opinion, and as best understood by this ISA based on the Applicant's specification, claims and drawings, the term 'the power output line electrically connected to the' has been interpreted to be 'the power output line electrically connected to the energy source of the electric aircraft for recharging the energy source'.

Regarding claim 99, claim 99 improperly depends from itself. In order to give life and meaning to the claim such that a reasonable opinion can be rendered, claim 99 has been interpreted to depend from claim 98.