

SYSTEMS, DEVICES, AND METHODS FOR MANAGING AN UNDERWATER VEHICLE

Technical Field

[0001] The present disclosure relates generally to underwater vehicles, and more specifically, to systems, methods, and devices for managing underwater vehicles.

Background

[0002] Underwater exploration, inspection, transport, work etc. (referred to herein as an “**underwater mission**”, or the like) can be performed in a variety of ways. For example, professional divers have been traditionally dispatched to perform certain underwater missions, such as for those in relatively shallow depths and/or high underwater visibility. Technological developments have enabled manned underwater vehicles (i.e., underwater vehicles operated by onboard personnel) to perform underwater missions. Recent technological developments have enabled the use of unmanned underwater vehicles to be remotely controlled by personnel (e.g., personnel onboard a vessel floating above the unmanned underwater vehicle). Recently, autonomous underwater vehicles (AUV) have been introduced in an attempt to more seamlessly, accurately, efficiently, and safely perform underwater missions, including performing inspection of and/or interaction with (e.g., perform measurements, repairs, etc.) underwater structures, such as oil and gas pipelines.

Brief Summary

[0003] The use of underwater vehicles, including manned underwater vehicles, unmanned underwater vehicles, and autonomous underwater vehicles (AUV) have become the preferred choice when underwater missions involve deeper locations, low visibility conditions, low light conditions, strong or unpredictable surface wave/current conditions, strong or unpredictable under-current conditions, and/or inclement weather/water conditions.

[0004] In general, underwater vehicles are deployed from a floating vessel to a bottom of the body of water (e.g., seabed, bottom of an ocean, bottom of a lake, bottom of a river, etc.) by lowering the underwater vehicle via a chain, cable, line, or the like (referred to herein as a “**line**”, or the like). In terms of transporting the underwater vehicle between the floating vessel and the bottom of the body of water (e.g., lowering, raising, etc.), the underwater vehicle itself is normally placed/housed in a protective housing, cage, box, container, or the like (referred to herein as a “**housing**”, or the like), which is secured to the floating vessel (and transported to/from the bottom of the body of water) via the line.

[0005] Oftentimes, however, deployment of such underwater vehicles may become challenging due to a variety of factors. For example, surface wave/current conditions may cause the floating vessel that is deploying the underwater vehicle to change in orientation, elevation, position, etc., which may in turn cause the housing (with the underwater vehicle) that is being transported to/from the bottom of the body of water to change in orientation, elevation, position, etc. as a result. As another example, under-current conditions may be present at one or more depths between the floating vessel and the bottom of the body of water, which may cause the housing (with the underwater vehicle) to change in orientation, depth, position, etc. while being transported as a result. In yet another example, underwater visibility may cause the underwater vehicle to encounter difficulties when conducting underwater missions and/or when attempting to find and/or return into the housing (e.g., for transporting back up to the floating vessel).

[0006] Present examples embodiments relate generally to and/or include, among other things, systems, subsystems, processors, devices, methods, and processes for addressing conventional problems, including those described above and in the present disclosure, and more specifically, example embodiments relate to underwater vehicles and systems, subsystems, processors, devices, methods, and processes for managing underwater vehicles.

[0007] In an exemplary embodiment, a system for managing an autonomous underwater vehicle is described. The system includes a main housing system. The main housing system includes a main cavity for housing an underwater vehicle. The main cavity is formed by at least a top side of the main housing, a bottom side of the main housing, the bottom side of the main housing opposite to the top side of the main housing, and surrounding sides of the main housing formed between the top and bottom sides.

[0008] The system also includes an access control assembly. The access control assembly may be provided on at least one of the surrounding sides of the main housing. The access control assembly is configured to transition between a closed position (and/or fully closed position) and an opened position (and/or fully opened position). The closed position (which may include a fully closed position, a not-fully-closed position, and a not-fully opened position) is a position in which the access control assembly prevents an underwater vehicle housed in the main cavity from leaving the main cavity. The opened position (i.e., a fully opened position) is a position in which the access control assembly does not prevent an underwater vehicle housed in the main cavity from leaving the main cavity.

[0009] The system further includes a sensor. The sensor is configured to generate at least one of the following real-time measurements, including a surrounding pressure of the main housing, an underwater depth of the main housing, and a distance remaining for the main housing to reach a bottom surface of the body of water when the main housing is submerged in a body of water.

[0010] The system also includes an access control controller assembly. The access control controller assembly is configured to control the access control assembly based on the real-time measurements of the sensor by transitioning the access control assembly from the closed position to the opened position when the real-time measurements of the sensor indicate at least a depth of the main housing has reached a depth equal to or greater than a target depth, a surrounding pressure of the main housing has reached a pressure equal to or greater than a target surrounding pressure, and a distance between the main housing and the bottom surface of the body of water is equal to or less than a target distance. The access control controller assembly is configured to transition the access control assembly from the opened position to the closed position when the real-time measurements of the sensor indicate at least a depth of the main housing is no longer at a depth that is greater than or equal to the target depth, a surrounding pressure of the main housing is no longer at a pressure that is greater than or equal to the target surrounding pressure, and/or a distance between the main housing and the bottom surface of the body of water is no longer at a distance that is less than or equal to the target distance.

[0011] In another exemplary embodiment, a system for managing an underwater vehicle is described. The system includes a main housing. The main housing also includes a main cavity for housing an underwater vehicle. The main cavity is formed by at least a top side of the main housing, a bottom side of the main housing opposite to the top side of the main housing, and surrounding sides of the main housing formed between the top and bottom sides.

[0012] The system further includes an access control assembly provided on at least one of the surrounding sides of the main housing. The access control assembly may be configured to transition between a fully closed position and a fully opened position.

[0013] The system also includes an access control assembly which is provided on at least one of the surrounding sides of the main housing. The access control assembly is configured to transition between a fully closed position and a fully opened position. The fully closed position is a position in which the access control assembly is fully closed and the fully opened position is a position in which the access control assembly is fully closed.

[0014] The system also includes an access control controller assembly. The access control controller assembly includes an access control assembly portion that is securable to at least a portion of the

access control assembly. The access control controller assembly also includes a main housing portion that is securable to at least a portion of the main housing. The access control controller assembly also includes a control portion that is in communication with the access control assembly portion and the main housing portion. The control portion includes a pressure actuator assembly configured to pneumatically actuate the access control assembly portion relative to the main housing portion based on a surrounding pressure. This includes actuating the access control assembly portion relative to the main housing portion in such a way as to transition the access control assembly towards the fully opened position when the control portion detects an increase in surrounding pressure; and actuating the access control assembly portion relative to the main housing portion in such a way as to transition the access control assembly towards the fully closed position when the control portion detects a decrease in surrounding pressure.

[0015] In another exemplary embodiment, a method for transporting an underwater vehicle between top and bottom surfaces of a body of water via a housing system is described. The housing system includes a main housing, an access control assembly, an access control controller assembly, and a sensor for measuring a surrounding pressure.

[0016] The method includes performing a configuration process. The configuration process includes receiving, by a processor, a target depth. The target depth may be an estimated total depth or distance to the bottom surface of the body of water. The configuration process may also include generating, by the processor, a target surrounding pressure. The target surrounding pressure may be determined based on the target depth.

[0017] The method further includes performing an underwater vehicle access process. The underwater vehicle access process includes receiving, by the processor from the sensor, real-time measurements of surrounding pressure. The underwater vehicle access process may also include performing, by the processor, a determination as to whether or not the main housing has reached the bottom surface of the body of water. This may be determined by comparing the real-time measurements of surrounding pressure with the target surrounding pressure. When the processor determines that the real-time measurements of surrounding pressure are greater than or equal to the target surrounding pressure, the underwater vehicle access process further includes actuating the access control assembly to the opened position (i.e., the fully opened position).

[0018] In yet another exemplary embodiment, a system for managing underwater vehicle is described. The system includes a main housing system. The main housing system includes a main cavity for housing an underwater vehicle. The system also includes an access control assembly. The

access control assembly is configured to transition between a closed position (or fully closed position or not-fully-closed position) and an opened position (or fully opened position or not-fully-opened position). The system may also include a sensor. The sensor may be configured to generate one or more real-time measurements. For example, the sensor may generate a real-time measurement of a surrounding pressure (e.g., surrounding pressure on or surrounding the main housing, surrounding pressure on, surrounding, detected, and/or measured by the sensor, etc.). The system may also include an access control controller assembly. The lock assembly may be configured to transition the access control assembly towards the opened position (or fully opened position, or not-fully-opened position) when the surrounding pressure (e.g., as measured by the sensor) increases towards a target surrounding pressure. The lock assembly may also be configured to transition the access control assembly towards the closed position (or fully closed position, or not-fully-closed position) when a surrounding pressure (e.g., as measured by the sensor) decreases away from the target surrounding pressure.

Brief Description of the Figures

[0019] For a more complete understanding of the present disclosure, example embodiments, and their advantages, reference is now made to the following description taken in conjunction with the accompanying figures, in which like reference numbers indicate like features, and:

[0020] **Figure 1** is an illustration of an example embodiment of a system for managing an underwater mission;

[0021] **Figure 2** is an illustration of an example embodiment of an underwater vehicle processor;

[0022] **Figure 3A** is an illustration of an example embodiment of a system for managing an underwater vehicle with an access control assembly at a fully closed position;

[0023] **Figure 3B** is an illustration of an example embodiment of a system for managing an underwater vehicle with an access control assembly in a position between the opened position and the closed position;

[0024] **Figure 3C** is an illustration of an example embodiment of a system for managing an underwater vehicle at an access control assembly at a fully opened position;

[0025] **Figure 3D** is an illustration of an example embodiment of a system for managing an underwater vehicle with various positions of an access control assembly based on surrounding pressure;

[0026] **Figure 3E** is an illustration of an example embodiment of an access control controller assembly secured to a portion of the access control assembly and a portion of the main housing;

[0027] **Figure 3F** is an illustration of an example embodiment of a housing processor;

[0028] **Figure 3G** is an illustration of a side view of an example embodiment of a system for managing an underwater vehicle having an access control assembly provided at a top of the main housing;

[0029] **Figure 3H** is an illustration of a side view of an example embodiment of a system for managing an underwater vehicle having an access control assembly provided at a side of the main housing; and

[0030] **Figure 4** is an illustration of an example embodiment of a method of managing an underwater vehicle.

[0031] Although similar reference numbers may be used to refer to similar elements in the figures for convenience, it can be appreciated that each of the various example embodiments may be considered to be distinct variations. Example embodiments will now be described with reference to the accompanying figures, which form a part of the present disclosure and which illustrate example embodiments which may be practiced. As used in the present disclosure and the appended claims, the terms "embodiment", "example embodiment", "exemplary embodiment", and "present embodiment" do not necessarily refer to a single embodiment, although they may, and various example embodiments may be readily combined and/or interchanged without departing from the scope or spirit of example embodiments. Furthermore, the terminology as used in the present disclosure and the appended claims is for the purpose of describing example embodiments only and is not intended to be limitations. In this respect, as used in the present disclosure and the appended claims, the term "in" may include "in" and "on", and the terms "a", "an", and "the" may include singular and plural references. Furthermore, as used in the present disclosure and the appended claims, the term "by" may also mean "from," depending on the context. Furthermore, as used in the present disclosure and the appended claims, the term "if" may also mean "when" or "upon", depending on the context. Furthermore, as used in the present disclosure and the appended claims, the words "and/or" may refer to and encompass any and all possible combinations of one or more of the associated listed items.

Detailed Description

[0032] In conventional approaches, a vessel may be used to transport an underwater vehicle to a target or desired location where the underwater vehicle is to be deployed for an underwater mission. Once at the target or desired location, a conventional housing that is housing the underwater vehicle is then transported (i.e., lowered) to a target or desired underwater location (e.g., a bottom 30 of the

body of water). In such conventional approaches, a conventional housing is used to transport (e.g., lower and raise) the underwater vehicle. Such conventional housing will generally include a sufficiently sized opening (e.g., a missing wall or cage side) on one or more sides of the conventional housing. Such sufficiently sized opening(s) are ideally used by the underwater vehicle (that is housed in and transported by the conventional housing) to exit the conventional housing only once the conventional housing is lowered to the target or desired underwater location (e.g., a bottom 30 of the body of water). It is recognized in the present disclosure, however, that problems oftentimes arise when using such conventional approaches and conventional housings. For example, surface wave/current conditions may cause the floating vessel that is deploying the underwater vehicle to change in orientation, elevation, position, etc., which may in turn cause the conventional housing (with the underwater vehicle) that is being transported to/from the target or desired underwater location to move, shake, change in orientation, elevation, position, etc., and also cause the underwater vehicle to prematurely or undesirably exit (e.g., fall out of) the conventional housing. As another example, under-current conditions may be present at one or more depths between the floating vessel and the target or desired underwater location, which may cause the conventional housing (with the underwater vehicle) to change in orientation, depth, position, etc. while being transported, and also cause the underwater vehicle to prematurely or undesirably exit (e.g., fall out of) the conventional housing. In yet another example problem arising from conventional approaches and conventional housings, underwater visibility may cause the underwater vehicle to encounter difficulties in finding and/or return into the conventional housing (e.g., for transporting back up to the floating vessel 10).

[0033] Present example embodiments relate generally to and/or include systems, subsystems, processors, devices, methods, and processes for addressing conventional problems, including those described above and in the present disclosure, and more specifically, example embodiments relate to underwater vehicles (including autonomous underwater vehicles (AUV)) and systems, subsystems, processors, devices, methods, and processes for managing underwater vehicles in performing underwater missions.

[0034] As used in the present disclosure, the term "response" may also be referred to as an "output", or the like, and may include, but is not limited to, "determination", "goal", "measurement", or "result", which may be construed as a reaction, data or a signal that one or more processors, subsystems, and/or elements generated as feedback or response to a process, processing, receipt of data/information, action, or the like, in the system. The response may include, but is not limited to, whether the system receives measurements pertaining to a depth, a surrounding pressure of the main

housing, and/or a distance (e.g., distance between the main housing and the bottom surface of the body of water), whether a target depth is achieved, whether a target surrounding pressure is determined, whether a distance between the main housing and the bottom surface of the body of water is achieved, whether the system performs a configuration process, whether the system performs an underwater vehicle access process, whether the system actuates the access control assembly to an opened position, whether the system actuates the access control assembly to a closed position, whether the system actuates the access control assembly to a position between the opened position and the closed position and/or the rest, etc.

[0035] Present example embodiments are directed to systems (e.g., system 100, as illustrated in Figure 1) and methods for managing underwater missions.

[0036] **Example embodiments of a system for managing underwater missions (e.g., system 100).**

[0037] As illustrated in at least **FIGURE 1**, an example embodiment of a system (e.g., system 100) for managing underwater missions is disclosed. The system 100 is configurable or configured to perform one or more of a plurality of functions, operations, actions, methods, and/or processes using one or more of the elements described in the present disclosure.

[0038] To perform the actions, functions, processes, and/or methods described above and in the present disclosure, the system 100 for managing underwater missions may include a vessel (e.g., vessel 10, as illustrated in Figure 1) floating on a surface of a body of water (e.g., water surface 20, as illustrated in Figure 1). The system 100 also includes one or more underwater vehicles (e.g., underwater vehicle 200, as illustrated in Figure 1). The underwater vehicle 200 may be or include an autonomous underwater vehicle (AUV), manned underwater vehicle (MUV), or unmanned underwater vehicle (UUV). The floating vessel 10 may be used to transport the underwater vehicle 200 and other elements of the system 100 to a target or desired location (e.g., a bottom 30 of the body of water, as illustrated in Figure 1) where the underwater vehicle 200 is to be deployed. Once at the target or desired location, an example embodiment of a housing system (e.g., housing system 300, as illustrated in at least Figures 1 and 3) that is housing the underwater vehicle 200 is then transported (e.g., lowered and/or raised) to and/or from the target or desired underwater location via a line (e.g., line 40, as illustrated in at least Figure 1) that secures the vessel 10 to the housing system 300. Example embodiments are configurable or configured to determine whether the housing system 300 reaches its desired or target depth. In an example embodiment, the desired or target depth may be determined based on one or more tension sensors, or the like (not shown). An example embodiment of the tension sensor may be provided, equipped, installed, attached, set up, fixed, connected, and/or

otherwise in communication with the line 40 and/or the housing system 300. Such tension sensor may be configurable or configured to detect a tension force, or the like, of the line 40 so as to determine whether the housing system 300 has reached the target or desired underwater location. For example, if the target or desired underwater location is a bottom of a body of water, the tension sensor may detect a high tension (or tension above a certain threshold) in the line 40 prior to reaching the target or desired underwater location. The tension sensor may detect a lower tension (or tension below a certain threshold) in the line 40 when the housing system 300 has reached the target or desired underwater location (e.g., less pull, force, tension, weight, etc. on the line 40 since the housing system 300 is now resting on the bottom of the body of water). Alternatively or in addition, the system 100 may include one or more image capturing subsystems which are provided, equipped, installed, attached, set up, fixed, connected, and/or otherwise in communication with the housing system 300 to capture real-time or near real-time information, such as the direction, tension, slack, or the like, of the line 40 so as to determine (and/or assist one or more other elements of the system 100 in determining) whether the housing system 300 has reached the target or desired underwater location (e.g., when the housing system 300 is resting on the bottom of the body of water). Alternatively or in addition, the system 100 may include one or more pressure sensors. The pressure sensor is configurable or configured to determine a change of pressure corresponding to an underwater depth when the housing system 300 has traveled deeper into the body of water. Alternatively or in addition, the system 100 may include one or more inertial measurement units (IMU) to provide inertia information in real-time or near real-time based on the current orientation of the housing system 300 when the housing system 300 has reached the target or desired underwater location. The IMU is configurable or configured to determine (and/or assist one or more other elements of the system 100 in determining) whether the housing system 300 is in a correct orientation (i.e., in predetermined roll, pitch, and/or yaw angle.) Alternatively or in addition, the system 100 may include one or more ocean current sensors, turbidity sensors, or the like, to determine (or assist one or more other elements of the system 100 in determining) whether the surrounding environment is suitable for the underwater vehicle 200 to start a mission. When the underwater vehicle 200 has reached its desired or target depth, an example embodiment of the housing system 300 (e.g., access control controller assembly 350) is configurable or configured to selectively or dynamically control an access control assembly (e.g., access control assembly 320, such as an access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) of the housing system 300 to open and close so as to allow (and not allow) the underwater vehicle 200 to exit and enter the main housing

310 of the housing system 300 (e.g., so as to perform its underwater mission of inspecting one or more underwater structures 50).

[0039] In an example embodiment, the housing system 300 is configurable or configured to manage, control, and/or otherwise transport the underwater vehicle 200 for underwater missions using one or more elements.

[0040] For example, the housing system 300 may include a main housing (e.g., main housing 310, as illustrated in at least Figures 1 and 3A-C). As illustrated in the Figures, the main housing 310 may be formed in a cubical shape, but may also be formed in any other shape, size, configuration, material, etc. to appropriately house and transport one or more underwater vehicles 200.

[0041] The housing system 300 may also include one or more access control assemblies (e.g., access control assembly 320). Such access control assemblies 320 may be configurable or configured to control whether or not an underwater vehicle 200 housed in the main housing 310 can exit or not exit the main housing 310. As will be further described in the present disclosure, the access control assembly 320 will be in (or transition to) a closed position and/or state when the housing system 300 has not yet reached the target or desired underwater location (e.g., when the housing system 300 is being lowered from the vessel 10); and the access control assembly 320 will be in (or transition to) an opened position and/or state when the housing system 300 has reached the target or desired underwater location (e.g., when the housing system 300 has been fully lowered from the vessel 10 to the target or desired underwater location). In an example embodiment, the access control assembly 320 may include one or more access doors (e.g., access door 320, as illustrated in at least Figures 1 and 3A-C). The one or more access doors 320 are for use in preventing an underwater vehicle 200 housed in the main housing 310 from exiting the main housing 310 when the access doors are in the closed position (and/or not in the opened position). Alternatively or in addition to the access door 320, the access control assembly 320 may include an actuatable mechanism 320, protrudable portion 320, brake 320, or the like, secured to the main housing 310 which may transition between a closed position/state and an opened position/state. As a more specific example, as illustrated in at least Figures 3G and 3H, such actuatable mechanism 320, protrudable portion 320, brake 320, or the like, may be or may include a member 320 (e.g., elongated member 320) that is actuatable to be extended, move, rotate, or the like, when in the closed position/state, so as to contact with (and/or secure, press on, hold, anchor, or the like) an upper portion 200a of the underwater vehicle 200 (and/or bottom portion, side portion 200b and/or 200c, front portion, and/or back portion of the underwater vehicle 200) and prevent the underwater vehicle 200 from exiting the main housing 310. Such actuatable

member of the actuatable mechanism 320, protrudable portion 320, brake 320, or the like, may be secured or attached to a portion of the main housing 310. The actuatable member 320 (e.g., elongated member 320) of the actuatable mechanism 320, protrudable portion 320, brake 320, or the like, may be actuatable to be contract, retract, move, rotate, or the like, when in (or when transitioning to) the opened position, so as to not contact with (or no longer contact with) an upper portion 200a of the underwater vehicle 200 (and/or bottom portion, side portion 200b and/or 200c, front portion, and/or back portion of the underwater vehicle 200) and thereby not prevent (or no longer prevent) the underwater vehicle 200 from exiting the main housing 310.

[0042] The housing system 300 may also include a main cavity (e.g., main cavity 330, as illustrated in at least Figures 3B and 3C). The main cavity 330 may be formed by at least a portion of the main housing 310. The main cavity 330 is the cavity, space, volume, or the like, that receives and houses the underwater vehicle 200.

[0043] The housing system 300 may also include one or more sensors (e.g., sensor 340, first sensor 340, second sensor 340, etc., as illustrated in at least Figures 3B and 3C) for use in generating one or more measurements. For example, the sensor 340 may be configurable or configured to generate a measurement of a pressure, such as a pressure surrounding the sensor 340, main housing 310, housing system 300, etc. Alternatively or in addition, the sensor 340 may be configurable or configured to generate a measurement of an underwater depth, such as a depth of the sensor 340, main housing 310, housing system 300, etc. Alternatively or in addition, the sensor 340 may be configurable or configured to generate a measurement of a distance remaining for the housing system 300 (or the sensor 340, main housing 310, housing system 300, etc.) to reach the target or desired underwater location (e.g., bottom 30 of the body of water).

[0044] The housing system 300 may also include one or more access control controller assemblies (e.g., access control controller assembly 350, as illustrated in at least Figures 3A-C and 3E). In an example embodiment, the access control controller assembly 350 may include one or more pressure actuators (not shown). An example embodiment of the pressure actuator is configurable or configured to move, slide, push, displace, extend, contract, retract, rotate, or the like (each as applicable), the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) relative to the main housing 310 based on a surrounding pressure applied to the one or more pressure actuators (e.g., transition the access control assembly 320 towards the fully opened position as a surrounding pressure increases; transition the access control assembly 320 towards the fully closed position as a surrounding pressure decreases;

etc.). Alternatively or in addition to the pressure actuator, the access control controller assembly 350 may receive instructions, commands, and/or actions from one or more other elements of the housing system 300, such as the housing processor 360 (as further described in the present disclosure), to move, slide, push, displace, extend, contract, retract, rotate, or the like (each as applicable), the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) relative to the main housing 310.

[0045] In an example embodiment, the access control controller assembly 350 can be controlled by electric-driven motor and/or generator which is configurable or configured to associate with at least one sensor. In example embodiments, the access control controller assembly 350 may be configurable or configured to selectively (e.g., based on a command, instruction, and/or information received by an example embodiment of the housing processor 360) and/or dynamically (e.g., via one or more of the pressure actuators, based on a pressure received at or by the access control controller assembly 350, and/or based on a measurement generated by one or more sensors 340) perform one or more of the following: controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to remain in a fully closed position, controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition towards a fully opened position, controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position), controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position), controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) to the fully opened position, controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to remain in the fully opened position, controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position), controlling the access control assembly 320 (e.g., access door 320,

actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards the fully closed position, controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position), controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) to the fully closed position, and controlling the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) to remain in the fully closed position.

[0046] The housing system 300 may also include one or more housing processors (e.g., housing processor 360, as illustrated in at least Figures 3B, 3C, and 3F). The housing processor 360 is configurable or configured to receive a target depth wherein the target depth is an estimated distance from the current position of the main housing 310 to the bottom 30 of the body of water. Alternatively or in addition, the target depth may be an estimated distance from the current position of the main housing 310 to the depth (or location) to carry out underwater missions (e.g., not the bottom 30 of the body of water). Alternatively or in addition, the housing processor 360 may be configurable or configured to connected to a manual control on the vessel 10. The housing processor 360 is also configurable or configured to determine a target surrounding pressure. Further, the housing processor 360 is configurable or configured to receive measurements from the sensor 340 and to process the measurements. Alternatively or in addition, the sensor 340 may be configurable or configured to associate with the control portion 356 of the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) such that the access control assembly 320 is transitioned based on the information received from the sensor 340. The housing processor 360 is also configurable or configured to determine whether the main housing 310 has reached the bottom 30 of the body of water or reached a target depth. The determination is performed by the housing processor 30 by comparing the measurements of the surrounding pressure of the main housing 110 at the bottom 30 of the body of water with the target surrounding pressure that is based on the target depth. The housing processor 360 is also configurable or configured to communicate with the control portion 356 of the access control controller assembly 350. Responsive to a determination that the main housing 310 has reached the bottom 30 of the body of the water or

reached the target depth, the housing processor 360 may communicate with the control portion 356 of the access control controller assembly 350 to actuate the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) from a closed position (or fully closed position, not fully closed position, or not fully opened position; each as applicable) to an opened position (or fully opened position, not fully opened position, or not fully closed position; each as applicable). Alternatively or in addition, the control portion 356 of the access control controller assembly 350 may also automatically actuate the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) from a closed position (or fully closed position, not fully closed position, or not fully opened position; each as applicable) to an opened position (or fully opened position, not fully opened position, or not fully closed position; each as applicable) based on the depth of the main housing 310, the surrounding pressure of the main housing 310, and/or the distance between the main housing 310 and the bottom 30 of the body of water.

[0047] The housing system 300 may also include one or more positional markers (e.g., positional marker 370, as illustrated in at least Figures 3A-C). The positional markers 370 are configurable or configured to assist and/or enable an underwater vehicle 200 to appropriately and accurately return into the main cavity 330 and be housed in the main housing 310. In an example embodiment, one or more positional markers 370 are provided on one or more portions (e.g., a portion of an exterior side (e.g., top side, bottom side, front side, back side, left side, right side, etc.) of the main housing 310, a portion of an interior side of the main housing 310, a bottom portion of an access door 320 (as illustrated in at least Figures 3B and 3C), etc.) of the main housing 110. In example embodiments, one or more of the positional markers 370 may assist the housing processor 360 in generating one or more trajectories for the underwater vehicle 200 to travel in order to return into the main housing 310.

[0048] Although the figures may illustrate one vessel 10, one line 40, one underwater vehicle 200, and one housing system 300, it is to be understood that the system 100 may include more or less than one vessel 10, more or less than one line 40, more or less than one underwater vehicle 200, and/or more or less than one housing system 300 without departing from the teachings of the present disclosure.

[0049] Example embodiments will now be described below with reference to the accompanying figures, which form a part of the present disclosure.

[0050] **The underwater vehicle (e.g., underwater vehicle 200).**

[0051] As illustrated in **FIGURE 1**, an example embodiment of the system 100 includes one or more underwater vehicle (e.g., underwater vehicle 200). The underwater vehicle 200 may be configurable or configured to communicate with one or more elements of the system 100. For example, the underwater vehicle 200 may be configured or configurable to communicate with one or more housing processor (e.g., housing processor 360).

[0052] The underwater vehicle 200 is configurable or configured to perform a plurality of actions, functions, operations, methods, and/or processes, including exiting from the housing system 300, carrying out its underwater mission (e.g., inspect one or more underwater structures 50, such as underwater oil and/or gas pipelines 50), find the housing system 300 after carrying out its underwater mission, finding a path or trajectory to return into the main cavity 330, and appropriately return into the main cavity 330 so as to be housed in the main housing 310. In example embodiments, the underwater vehicle 200 may be an autonomous underwater vehicle (AUV) 200 configurable or configured to navigate, ascend, descend, rotate, change orientation, and/or otherwise transport itself in a desired trajectory and/or path. As used in the present disclosure, the underwater vehicle 200 may be and/or include an underwater vehicle that is guided autonomously (e.g., AUV) and/or remotely, underwater drones or robots, or any other underwater vehicles which may be applicable.

[0053] The underwater vehicle 200 is configurable or configured to maneuver, navigate, ascend, descend, rotate, change orientate and otherwise based on one or more commands and/or information received and/or communicated by the housing system 300. For example, the underwater vehicle 200 may establish a connection with the housing system 300 and/or one or more other elements of the system 100 via one or more channels and/or one or more forms of underwater communication, including sonar and/or other communication protocols to share and/or communicate the commands and/or information.

[0054] The one or more commands and/or information communicated by and/or to the underwater vehicle 200 may include those pertaining to one or more trajectories generated by and/or for the underwater vehicle 200 to navigate towards the housing system 300, a particular destination and/or points of interest, or the like. Commands and/or information may include information pertaining to location, trajectory, orientation information, distance, directions, a destination or a point of interest, a geolocation of the destination or point of interest and any other which may be applicable.

[0055] Before navigation or during navigation along a trajectory, the underwater vehicle 200 may be configurable or configured to continuously, periodically, on demand, etc. receive and/or generate one or more information and/or commands pertaining to one or more objects, items, structures, obstacles,

or the likes that is/are present along the trajectory of the underwater vehicle 200 and/or the surrounding areas of the underwater vehicle 200. Commands and/or information may include details on the objects, items, structures, obstacles, or the likes such as geometries, shapes, dimensions, etc., and any other which may be applicable.

[0056] The underwater vehicle 200 may also include one or more positional markers 370 on one or more portions (e.g., a portion of an exterior side (e.g., top side, bottom side, front side, back side, left side, right side, etc.) of the underwater vehicle 200 and/or a portion of an interior side of the underwater vehicle 200. The positional markers 370 may be configurable or configured to enable one or more elements of the housing system 300 (e.g., an image capturing system secured to or on the main housing 310) to locate and/or identify a position, orientation, direction, speed, acceleration/deceleration, pitch, yaw, roll, etc., of the underwater vehicle 200 (e.g., based on capturing and processing continuous or multiple images (or video images) of one or more positional markers 370 and/or other parts of the underwater vehicle 200). When the one or more positional markers 370 on the underwater vehicle 200 are captured by an imaging subsystem 240 and/or the housing processor 360, the path or trajectory for the underwater vehicle 200 to return into the main cavity 330 can be generated. Alternatively or in addition, the positional markers 370 are configurable or configured to verify that the underwater vehicle 200 are completely docked.

[0057] Further, the underwater vehicle 200 is configurable or configured to capture one or more images of the housing system 300. The underwater vehicle 200 is also configurable or configured to capture one or more images of one or more surrounding areas/regions/directions of the underwater vehicle 200 and/or the surrounding areas of the housing system 300. The underwater vehicle 200 is configurable or configured to process, analyze, provide, send, transmit and/or make available the captured images to the housing processor 360 to determine and/or assist in determining a position and/or location of the housing system 300 and to generate one or more trajectories for the underwater vehicle 200 based on the position and/or location determined. Further, the underwater vehicle 200 is also configurable or configured to generate, process, provide, send, and transmit information, signals, notifications, and/or commands that the underwater vehicle 200 is running low on power/battery level, and may require a recharge by the housing system 300 (battery charging assembly of the housing system 300, not shown).

[0058] To perform the actions, functions, processes, and/or methods described above and in the present disclosure, the underwater vehicle 200 includes one or more elements. As an example, the underwater vehicle 200 may include one or more transceivers (e.g., transceiver 210). The underwater

vehicle 200 may also include one or more navigation subsystems (e.g., navigation subsystem 220). The underwater vehicle 200 may also include one or more object identifying subsystems (e.g., object identifying subsystem 230). The underwater vehicle 200 may also include one or more imaging subsystems (e.g., imaging subsystem 240).

[0059] Although the figures may illustrate two transceivers 210, one navigation subsystem 220, one object identifying subsystem 230, and one imaging subsystem 240, it is to be understood that the underwater vehicle 200 may include more or less than two transceivers 210, more or less than one navigation subsystem 220, more or less than one object identifying subsystem 230, and/or more or less than one imaging subsystem 240 without departing from the teachings of the present disclosure.

[0060] These and other elements of the underwater vehicle 200 will now be further described with reference to the accompanying figures.

[0061] The transceiver (e.g., transceiver 210).

[0062] As illustrated in **FIGURE 2**, an example embodiment of the underwater vehicle 200 includes one or more transceivers (e.g., transceiver 210). The transceiver 210 is configurable or configured to communicate with one or more elements of the system 100. In an example embodiment, the transceiver 210 is configurable or configured to enable one or more elements of the underwater vehicle 200 to receive and/or obtain information and communicate such information to one or more other elements of the underwater vehicle 200 and/or one or more elements of the housing system 300.

[0063] In an example embodiment, the transceiver 210 is configurable or configured to receive one or more commands and/or information. The one or more commands and/or information is then transmitted to one or more navigation subsystems 220, one or more object identifying subsystems 230, and/or one or more imaging subsystems 240. Examples of commands and/or information may include images captured by the underwater vehicle 200 (e.g., still and/or video images of the housing system 300, including one or more positional markers 370), speed information of the underwater vehicle 200, acceleration/deceleration of the underwater vehicle 200, orientation information of the underwater vehicle 200, pitch/roll/yaw information of the underwater vehicle 200, position of the underwater vehicle 200, underwater current conditions around the underwater vehicle 200, surrounding pressure of the underwater vehicle, depth of the underwater vehicle, and/or one or more trajectories generated by and/or for the underwater vehicle 200 to navigate towards the housing system 300 or to navigate towards a particular destination and/or points of interest. The transceiver 210 may also receive commands and/or information to position and/or orientate the underwater

vehicle 200 (e.g., for navigation purposes and for docking process). The transceiver 210 may also receive commands and/or information on one or more objects, items, structures, obstacles, or the likes that is present along the trajectory of the underwater vehicle 200 and/or the surrounding areas of the underwater vehicle 200.

[0064] The commands and/or information received may be received continuously in real-time and/or near real-time. Alternatively or in addition, such information may be received in a periodic, intermittent, and/or sporadic manner (e.g., every 1 minute, every 2 minutes, at a depth of 500 m, at a depth of 1000 m, at a surrounding pressure of 1 atm, at a surrounding pressure of 2 atm, no fixed period or pattern; etc.). Alternatively or in addition, such information may be received upon the occurrence (and/or non-occurrence) of an event, sequence of events, action, sequence of actions, condition, sequence of conditions, receipt of certain information, receipt of a sequence of certain information, process, sequence of processes, etc. (e.g., movements and/or changes in positions, locations, orientations, trajectories, etc.).

[0065] The transceiver 210 is also configurable or configured to communicate commands and/or information between itself and/or one or more navigation subsystems 220, one or more object identifying subsystems 230, and/or one or more imaging subsystems 240. Each of the commands and/or information communicated between the navigation subsystem 220, object identifying subsystem 230, and/or imaging subsystem 240 may also be communicated with the housing system 300.

[0066] The navigation subsystem (e.g., navigation subsystem 220)

[0067] As illustrated in Figure 2, an example embodiment of the underwater vehicle 200 includes a navigation subsystem (e.g., navigation subsystem 220). The navigation subsystem 220 is configurable or configured to generate and/or obtain navigation-related information and to communicate such information with the transceiver 210 and/or one or more other elements of the system 100.

[0068] In example embodiments, the navigation subsystem 220 is configurable or configured to perform one or more of a plurality of functions, operations, actions, methods, and/or processes, including, but not limited to, communicating with, managing, and/or controlling movements (e.g., navigate, ascend, descend, rotate, change orientate, return to the main housing 310, etc.) of the underwater vehicle 200. The navigation subsystem 220 is configurable or configured to receive information from one or more elements of the underwater vehicle 200 to search for, locate, determine, and/or generate a trajectory or path for the underwater vehicle 200, a direction for the underwater

vehicle 200, a speed for the autonomous underwater vehicle 200, acceleration/deceleration of the underwater vehicle 200, orientation information of the underwater vehicle 200, pitch/roll/yaw information of the underwater vehicle 200, position of the underwater vehicle 200, underwater current conditions around the underwater vehicle 200, surrounding pressure of the underwater vehicle, depth of the underwater vehicle, or the like.

[0069] Information and/or commands received and/or generated by the navigation subsystem 220 may include, but is not limited to, details on the trajectories, orientations, distances, positions, directions, destinations or points of interest, geolocations of the destination or point of interest, and/or any other information which may be applicable to the performance of the underwater vehicle 200.

[0070] Alternatively or in addition, the navigation subsystem 220 may be configured or configurable to receive, search for, and/or obtain historical information (e.g., historic trajectories, positions, relative information, orientation, acceleration/deceleration, orientation, pitch/roll/yaw information, underwater current conditions, surrounding pressure conditions, depth information, etc.) and/or to navigate the underwater vehicle 200 based on selected historical information. These one or more historical information may (or may not be) generated from previous underwater missions which may have similar based conditions, parameters, locations, etc. as the current mission. These historical information may be stored in and/or retrieved by the navigation subsystem 220 from the navigation subsystem 220 itself and/or from one or more information sources, databases, onboard memory storage, etc. (not shown). For example, the current underwater mission may be performed at a same location as previous underwater mission, in which case historical information may indeed be useful.

[0071] The navigation subsystem 220 may retrieve the one or more historical information (including historic trajectories) which were generated, received, obtained, and/or otherwise searched for previously instead of generating a new trajectory. With the received commands and/or information, the navigation subsystem 220 is configurable or configured to perform the following including, but not limited to, navigating the underwater vehicle 200 towards the housing system 300 for docking, positioning and/or repositioning the underwater vehicle 200 based on information pertaining to and/or obtained from one or more positional markers 370 in order to align with the housing system 300, navigating the underwater vehicle 200 away from the housing system 300 so as to commence the underwater mission, and any other commands and/or information which may be applicable.

[0072] The navigation subsystem 220 is also configurable or configured to receive commands and/or information that are dynamically generated by the underwater vehicle 200 and/or one or more other elements of the system 100 based on real-time or near real-time information obtained by one or more

elements of the underwater vehicle 200 (e.g., object identifying subsystem 230 and/or image capturing subsystem 240) and/or by one or more elements of the housing system 300. Further, the navigation subsystem 220 may also receive, in real-time or in near real-time, one or more commands and/or information such as a command to reposition, a command to cease navigation or movements, a command to navigate along a different trajectory, a change in trajectories generated, a new trajectory that is generated, presence of one or more objects, items, structures, obstacles, and/or the like that are not detected in the initial images, and any other commands and/or information which may be applicable to the performance of the navigation subsystem 220.

[0073] The object identifying subsystem (e.g., object identifying subsystem 230).

[0074] As illustrated in Figure 2, an example embodiment of the underwater vehicle 200 includes an object identifying subsystem (e.g., object identifying subsystem 230). The object identifying subsystem 230 is configurable or configured to communicate with and/or to receive, send, and/or transmit information to the transceiver 210. The object identifying subsystem 230 may also be configurable or configured to communicate with and/or to receive, send or transmit information to one or more elements of the system, including one or more elements of the housing system 300.

[0075] In example embodiments, the object identifying subsystem 230 is configurable or configured to perform one or more of a plurality of functions, operations, actions, methods, and/or processes, including, but not limited to, identifying (either whole, portion or geometries) positional markers 370, objects, items, structures, obstacles, or the like, that are present along the trajectory of the underwater vehicle 200 and/or the surrounding area of the underwater vehicle 200. The object identifying subsystem 230 is configurable or configured to detect, capture information pertaining to, identify, and/or avoid one or more positional markers 370, objects, items, structures, obstacles, and/or the likes (e.g., housing system 300, underwater structures 50, etc.) that are present along the trajectory of the underwater vehicle 200 and/or the surrounding area of the underwater vehicle 200.

[0076] The object identifying subsystem 230 may be configurable or configured to detect, capture information pertaining to, and/or identify positional markers 370 and/or one or more other objects using and/or in cooperation with artificial intelligence (AI), machine learning, and/or deep learning algorithms, including Region Based Convolutional Neural Networks (R-CNN), You Only Look Once (YOLO) and/or any other algorithms which may be used.

[0077] The object identifying subsystem 230 is configurable or configured to transmit and/or make available some, most, or all of its information or details of the detected objects, items, structures, obstacles, and/or the like to one or more other elements of the underwater vehicle 200 and/or the

housing system 300. The information may include, but not limited to, information or details relating to objects, items, structures, obstacles, or the likes that may be present along the trajectory of the underwater vehicle 200 and/or the surrounding area of the underwater vehicle 200. Such information and/or details may include geometries, dimensions, measurements, colors, sizes, textures, shapes, and any other information which may describe the one or more objects. The one or more information of details is then processed and communicated to the navigation subsystem 230 to navigate the autonomous underwater vehicle 200 to avoid the detected objects, items, structures, obstacles, and/or the like along the trajectory. The processed information may also include a determination that the housing system 300 is present and the location of the housing system 300.

[0078] The imaging subsystem (e.g., imaging subsystem 240).

[0079] As illustrated in Figure 2, an example embodiment of the underwater vehicle includes one or more imaging subsystems (e.g., imaging subsystem 240). The imaging subsystem 240 is provided on the underwater vehicle 200 and/or outside the housing system 300. The imaging subsystem 240 is configurable or configured to capture still image and/or video images, and to communicate with and/or to receive, send or transmit information to the transceiver 210. The imaging subsystem 240 may also be configurable or configured to communicate with and to receive, send or transmit information to one or more elements of the housing system 300.

[0080] In example embodiments, the imaging subsystem 240 is configurable or configured to perform one or more of a plurality of functions, operations, actions, methods, and/or processes, including, but not limited to, capturing one or more images (e.g., still images and/or video images) from the autonomous underwater vehicle 200. The imaging subsystem 240 may include an optical imaging, a thermal imaging, a laser imaging, imaging sonar, or any other imaging systems that may be applicable. The imaging subsystem 240 is configurable or configured to capture one or more images of the housing system 300, including one or more positional markers 370, to determine the position and/or location of the housing system 300 relative to the underwater vehicle 200; and to generate one or more trajectories for the underwater vehicle 200 to follow. In addition, a distance of the housing system 300 from the underwater vehicle 200 may also be determined based on the images captured.

[0081] As described in the present disclosure, the imaging subsystem 240 is configurable or configured to detect, scan, and/or capture one or more images of the positional markers 370 of the housing system 300. The captured images or the detection and/or scanning of the positional markers 370 enable the underwater vehicle to know of the position and/location of the underwater vehicle

200 relative to the housing system 300 (e.g., a capture or scan of a positional marker 370 for the top surface of the main housing 310 is indicative of the underwater vehicle hovering or floating above and pointing or directing towards the main housing 310; a capture or scan of a positional marker 370 for the access door 320 is indicative of the underwater vehicle on a similar or same depth as the main housing 310 and pointing or directing towards the main cavity 330; a capture or scan of more than one positional marker 370 is indicative of the underwater vehicle hovering above the underwater vehicle 200 and pointing or directing towards an area or location between two or more sides of the main housing 310; etc.). With such information, the underwater vehicle 200 is able to align, change depth/orientation/direction/pitch/yaw/roll, speed, acceleration/deceleration, and/or position itself for returning into the main cavity 330 and be housed in the main housing 310. The imaging subsystem 240 is also configurable or configured to detect or capture images of one or more positional markers in an interior portion (i.e., in the main cavity 330) of the housing system 300. The detection or captured images of the positional markers in the main cavity 330 are indicative of the underwater vehicle 200 entering into and docking completely in the housing system 300. In this regard, a signal, message, notification, or the like, may be sent to one or more elements of the system 100 to inform of a successful docking and return to the housing system 300. The images captured by the imaging subsystem 240 may be provided, transmitted, stored, and/or otherwise made available to one or more elements of the underwater vehicle 200 and/or other elements of the system 100.

[0082] Alternatively or in addition, the imaging subsystem 240 may be configurable or configured to capture one or more images of the surrounding areas of the underwater vehicle 200 and/or the surrounding areas of the housing system 300. Alternatively or in addition, the images of the surrounding areas of the underwater vehicle 200 and/or the surrounding areas of the housing system 300 captured by the imaging subsystem 240 may also be provided, transmitted, stored, and/or otherwise made available to one or more elements of the underwater vehicle 200 and/or other elements of the system 100 to assess the surroundings for possible events or occurrences, environmental conditions, objects, items, structures, obstacles, and/or the likes and subsequently to generate one or more trajectories (if required) for the underwater vehicle 200 to navigate.

[0083] Further, the imaging subsystem 240 may also be configurable or configured to receive one or more commands and/or information. The commands and/or information may be received from the transceiver 210 or one or more other elements of the underwater vehicle and/or system 100 and may include, but not limited to, a command to recapture one or more images, storing the one or more images, and/or any other information which may be applicable to the imaging subsystem 240. In

example embodiments, the imaging subsystem 240 may include, but is not limited to, Close Circuit Television (CCTV), remotely operated vehicle (ROV) camera, optical camera, diving camera, deep water camera, etc.

[0084] The housing system (e.g., housing system 300).

[0085] As illustrated in at least Figures 3A to 3C, an example embodiment of the housing system (e.g., housing system 300) is configurable or configured to manage, control, and/or otherwise transport the underwater vehicle 200 for underwater missions using one or more elements.

[0086] To perform the actions, functions, processes, and/or methods described above and in the present disclosure, the housing system 300 includes a main housing (e.g., main housing 310) for housing one or more underwater vehicles 200. The housing system 300 may also include one or more access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) secured to the main housing 310 (e.g., via an example embodiment of an access control controller assembly 350). The one or more access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) may be configurable or configured to prevent an underwater vehicle 200 housed in the main housing 310 from exiting the main housing 310 when the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is in the closed position (and/or not in the opened position). The housing system 300 may also include one or more main cavities (e.g., main cavity 330) formed by at least a portion of the main housing 310, which is the cavity, space, volume, or the like, that receives and houses the underwater vehicle 200.

[0087] In example embodiments, the housing system 300 may also include one or more sensors (e.g., sensor 340, first sensor 340, second sensor 340, etc.) for use in generating one or more measurements, such as a measurement of a pressure surrounding the sensor 340, main housing 310, housing system 300, etc.; a measurement of an underwater depth; and/or a measurement of a distance remaining for the main housing 310 to reach the target or desired underwater location (e.g., bottom 30 of the body of water).

[0088] The housing system 300 also includes one or more access control controller assemblies (e.g., access control controller assembly 350). The access control controller assembly 350 may include one or more pressure actuators (not shown) configurable or configured to transition the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) relative to the main housing 310 based on a surrounding pressure applied to the one or more pressure actuators. Alternatively or in addition to the pressure actuator, the access control

controller assembly 350 may receive instructions, commands, and/or actions from the housing processor 360 to move, slide, push, displace, extend, retract, contract, rotate, or the like, the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) relative to the main housing 310.

[0089] In example embodiments, the housing system 300 may also include one or more housing processors (e.g., housing processor 360) configurable or configured to receive and process information, including target information (e.g., target depth, target surround pressure, etc.); determine a target surrounding pressure (e.g., based on the target depth, and/or vice versa); receive and process measurements from the sensor 340; determine whether or not one or more elements of the housing system 300 has reached the bottom 30 of the body of water and/or reached a target depth; communicate with (e.g., control, command, instruct, and/or actuate) the control portion 356 of the access control controller assembly 350 to actuate the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) between a closed position (or fully closed position, not fully closed position, or not fully opened position; each as applicable) and an opened position (or fully opened position, not fully opened position, or not fully closed position; each as applicable); automatically actuate the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) between a closed position (or fully closed position, not fully closed position, or not fully opened position; each as applicable) and an opened position (or fully opened position, not fully opened position, or not fully closed position; each as applicable) based on the depth of the main housing 310, the surrounding pressure of the main housing 310, and/or the distance between the main housing 310 and the bottom 30 of the body of water. The housing system 300 may also include one or more positional markers (e.g., positional marker 370, as illustrated in at least Figures 3A-C) for assisting and/or enabling an underwater vehicle 200 to appropriately and accurately return into the main cavity 330 and be housed in the main housing 310 (e.g., after a mission is completed, batteries of the underwater vehicle require recharging, etc.).

[0090] Although the figures may illustrate one main housing 310, one access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like), one main cavity 330, one sensor 340, one access control controller assembly 350, one housing processor 360, and three positional markers 370, it is to be understood that the housing system 300 may include more or less than one main housing 310, more or less than one access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like), more or less than one main cavity 330, more or less than one sensor 340, more or less than one access control controller assembly 350, more or less than one housing processor 360, and more or less than three positional markers 370.

like), more or less than one main cavity 330, more or less than one sensor 340, more or less than one access control controller assembly 350, more or less than one housing processor 360, and/or more or less than three positional markers 370 without departing from the teachings of the present disclosure.

[0091] Example embodiments will now be described below with reference to the accompanying figures, which form a part of the present disclosure.

[0092] The main housing (e.g., main housing 310).

[0093] As illustrated in at least Figures 1 and 3A-C, an example embodiment of the housing system 300 includes one or more main housings (e.g., main housing 310). The main housing 310 may be configurable or configured to perform a variety of functions and/or actions. For example, the main housing 310 is configurable or configured to house one or more underwater vehicles 200. The main housing 310 is also configurable or configured to receive, attach to, secure to, include, and/or communicate with one or more other elements of the housing system 300.

[0094] For example, the main housing 310 may include the main cavity 330 (which may be formed by the main housing 310). Alternatively, the main cavity 330 may be formed by one or more other elements (e.g., another inner cage or housing; not shown), in which case such one or more other elements are provided into and housed by the main housing 310.

[0095] As another example, the main housing 310 may include and/or have one or more access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) secured and/or attached to it (either directly or indirectly). For example, as illustrated in Figures 3A-C, at least one access door 320 is secured to the main housing 310 (e.g., secured via the access control controller assembly 350).

[0096] The main housing 310 may also include and/or have one or more sensors 340 secured and/or attached to it (either directly or indirectly). For example, as illustrated in Figures 3A-C, at least one sensor 340 is secured to an interior portion of the main housing 310.

[0097] As another example, the main housing 310 may include and/or have one or more access control controller assemblies 350 secured and/or attached to it (either directly or indirectly). For example, as illustrated in Figures 3A-C, a portion of at least one access control controller assembly 350 (i.e., the main housing portion 354 of the access control controller assembly 350) is secured to a portion of the main housing 310 (and another portion of the access control controller assembly 350 (i.e., the access control assembly portion 352 of the access control controller assembly 350) is secured to a portion of an access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like)).

[0098] The main housing 310 may also include and/or have one or more housing processors 360. For example, as illustrated in Figures 3B and 3C, one or more housing processors 360 may be secured to an interior portion of the main housing 310.

[0099] To enable the underwater vehicle 200 to be able to look for and navigate into the main housing 310, the main housing 310 may also include and/or have one or more positional markers 370 secured and/or attached to it (either directly or indirectly). For example, as illustrated in Figures 3A-C, one or more sides of the main housing 310 may include at least one positional marker 370 visibly displayed.

[00100] The main housing 310 may be formed in any shape, size, configuration, material, etc. so long as it is configurable or configured to house and transport one or more underwater vehicles 200. For example, the main housing 310 may be formed in a cubical shape or any other geometrically shaped metal cage, or the like.

[00101] The access control assembly (e.g., access control assembly 320).

[00102] As illustrated in at least Figures 1, 3A-C, and 3G-H, an example embodiment of the housing system 300 includes one or more access control assemblies 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like). The access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) may be provided on (and/or provided to form) at least a portion of one of the surrounding sides of the main housing 310. The access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is configurable or configured to prevent an underwater vehicle (housed in the main housing 310) from exiting the main housing 310 when the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is in the closed position and/or state (referred to herein as "closed position") (and/or not in the fully opened position and/or state). The access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is also configurable or configured to allow the underwater vehicle (housed in the main housing) to exit (and enter) the main housing 310 when the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is in the fully opened position and/or state (referred to herein as "opened position") (and/or not in the closed position).

[00103] In an example embodiment, the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is configurable or configured to perform one or more functions, including transitioning between a closed position and

an opened position. More specifically, the access control assembly 320 (e.g., access door 320, actuatable mechanism 320, protrudable portion 320, brake 320, or the like) is configurable or configured to cooperate and/or work operationally with at least one access control controller assembly 350 to transition between a closed position and an opened position. For example, as illustrated in Figure 3A and represented by position (A) in **FIGURE 3D**, when the underwater vehicle 200 is housed in the main cavity 330 of the main housing 310 for deployment, an example embodiment of the access control assembly 320 in the form of an access door 320 may cooperate with at least one access control controller assembly 350 to remain in the fully closed position or nearly fully closed position (e.g., the access control controller assembly 350 may be set up to actuate the access control assembly 320 to the fully closed position when a surrounding pressure is within a certain pressure (e.g., a first pressure, which may be ambient pressure and/or when the main housing 310 is in shallow water)). In the fully closed position, the access control assembly 320 prevents the underwater vehicle 200 from leaving or exiting the main cavity 330 of the main housing 310.

[00104] As the main housing 310 (with the underwater vehicle 200) is further submerged into deeper waters (as illustrated in Figure 3B and represented by position (B) in Figure 3D), the access control assembly 320 may cooperate with at least one access control controller assembly 350 to transition from the fully closed position towards a fully opened position (or not fully closed position or not fully opened position). More specifically, the access control controller assembly 350 may be set up to actuate the access control assembly 320 to transition from the fully closed position to a not fully closed position (or not fully opened position) when a surrounding pressure is within a certain pressure (e.g., a second pressure, which may be a pressure indicative of when the main housing 310 is in more deeper waters). At this depth, the access control assembly 320 continues to prevent the underwater vehicle 200 from exiting the main cavity 330 of the main housing 310 since the main housing 310 is not yet (or no longer) at a target depth and/or the surrounding pressure of the main housing 310 is not yet (or no longer) equal to or greater than a target surrounding pressure.

[00105] When the main housing 310 (with the underwater vehicle 200) has reached a target depth (as illustrated in Figure 3C and represented by position (C) in Figure 3D), which may be the bottom 30 of the body of water and/or set to any other depth as needed, the access control assembly 320 may cooperate with at least one access control controller assembly 350 to transition to the fully opened position. More specifically, the access control controller assembly 350 may be set up to actuate the access control assembly 320 to transition from the not fully closed position (or not fully opened position) to the fully opened position when a surrounding pressure is greater than or equal to a certain

threshold pressure (e.g., a third pressure or threshold pressure, which may be a pressure indicative of when the main housing 310 has reached the target depth or target surrounding pressure). At this depth, the access control assembly 320 no longer prevents the underwater vehicle 200 from exiting the main cavity 330 of the main housing 310. In this regard, the underwater vehicle 200 can now exit the main cavity 330 of the main housing 310 and commence the underwater mission. As the main housing 310 remains at the or greater than the target depth (and/or target surrounding pressure), the access control assembly 320 will cooperate with the access control controller assembly 350 to keep the access control assembly 320 in the fully opened position.

[00106] Although the access control assembly 320 may be illustrated as a metal door formed by metal bars, it is to be understood that the access control assembly 320 may be formed in any one or more other shapes, forms, sizes, configurations (e.g., formed with one or more panels, or the like, in addition to or in replacement of horizontal bars; etc.), and/or dimensions without departing from the teachings of the present disclosure. For example, the access control assembly 320 may be in the form of steel gates, wavegate, sliding gate, swing barrier, swing access, vertical pivot gate, or retractable gate that may be movable between the closed position and the opened position. The access control assembly 320 may be configured or configured to be rotated or moved in a horizontal and/or vertical direction.

[00107] Alternatively or in addition, in order to prevent the underwater vehicle 200 from exiting the main housing 310, the access control assembly 320 may be in the form of an actuatable mechanism 320, protrudable portion 320, brake 320, or the like, secured to a top, one or more sides, and/or bottom of the main housing 310. An example embodiment of an access control assembly 320 secured to a top portion of the main housing 320 is illustrated in **FIGURE 3G**, and an example embodiment of an access control assembly 320 secured to a side portion of the main housing 320 is illustrated in **FIGURE 3H**. When in the secured state, the access control assembly 320 is protruded from the top side of the main housing 310 to contact with a top portion 200a of the underwater vehicle 200. As such, the underwater vehicle 200 is housed in the main housing 310 and/or is prevented from exiting the main housing 310. In such example, the housing system 300 may or may not include the access door 320.

[00108] Alternatively or in addition, in order to prevent the underwater vehicle 200 from exiting the main housing 310, the access control assembly 320 may be in the form of a lifting mechanism 320, elevator 320, moveable platform 320, or the like, for receiving and holding the underwater vehicle 200 at a first position when in the closed position (e.g., no opening available at this first position for

the underwater vehicle 200 to exit the main housing 310) and at a second position (e.g., elevated from the first position) when in the opened position (e.g., an opening is available at this second position for the underwater vehicle 200 to exit the main housing 310). The lifting mechanism is provided inside the main housing 310 and can be moved up and down direction relative to the height of the main housing 310.

[00109] The main cavity (e.g., main cavity 330).

[00110] The housing system 300 may also include a main cavity (e.g., main cavity 330, as illustrated in at least Figures 3B and 3C). The main cavity 330 is configurable or configured to receive and/or house an underwater vehicle 200. The main cavity 330 may be formed by at least a portion of the main housing 310. Alternatively or in addition, the main cavity 330 may also be formed by one or more other elements, in which case such one or more other elements are provided into and housed in the main housing 310.

[00111] Although the main cavity 330 may be illustrated as a cubical shape (i.e., based on the shape of the main housing 310, which is also illustrated as a cubical shape), it is to be understood that the main cavity 330 may be formed in any one or more other shapes, forms, sizes, and/or dimensions without departing from the teachings of the present disclosure, and may be and/or include any one or more other cavity, space, volume, or the like, so long as the main cavity 330 is configurable or configured to receive and house the underwater vehicle 200. In example embodiments in which the main cavity 330 is formed by at least a portion of the main housing 310, an upper portion of the main cavity 330 may be formed by at least a portion of a top side of the main housing 310; a bottom portion of the main cavity 330 may be formed by at least a portion of a bottom side of the main housing 310 (wherein the bottom side of the main housing 310 may be a side that is opposite to the top side of the main housing 310); one or more surrounding sides of the main cavity 330 may be formed by at least a portion of one or more surrounding sides of the main housing 310 that are formed between the top and bottom sides of the main housing 310.

[00112] The sensor (e.g., sensor 340, first sensor 340, second sensor 340, etc.).

[00113] As illustrated in at least Figures 3B and 3C, an example embodiment of the housing system 300 may include one or more sensors (e.g., sensor 340, first sensor 340, second sensor 340, etc.). The sensor 340 may be configurable or configured to generate, obtain, estimate, and/or receive one or more measurements, which may then be provided to and/or for use by the housing system 300 and/or one or more other elements of the system 100 (e.g., the underwater vehicle 200). For example, the sensor 340 may be configurable or configured to generate a measurement of a pressure, such as a

pressure surrounding the sensor 340, main housing 310, housing system 300, etc. Alternatively or in addition, the sensor 340 may be configurable or configured to generate a measurement of an underwater depth, such as a real-time or current depth of the sensor 340, main housing 310, housing system 300, and/or one or more other elements of the system 100. Alternatively or in addition, the sensor 340 may be configurable or configured to generate a measurement of a distance remaining for the housing system 300 (or the sensor 340, main housing 310, housing system 300, etc.) to reach a target or desired underwater depth and/or location (e.g., bottom 30 of the body of water).

[00114] In an example embodiment, the sensor 340 is configurable or configured to perform one or more functions, including performing measurements, monitoring, detecting, determining, estimating, quantifying, or the like, of a surrounding pressure of the housing system 300 (or the sensor 340, main housing 310, etc.). For example, the sensor 340 is configurable or configured to perform real-time surrounding pressure measurements as the housing system 300 is deployed and is being submerged deeper into the body of water. The sensor 340 is also configurable or configured to measure, monitor, detect, determine, estimate, quantify, or the like, a real-time depth of the housing system 300 (or the sensor 340, main housing 310, etc.) as the housing system 300 submerges into deeper waters. The sensor 340 is also configurable or configured to measure, monitor, detect, determine, estimate, quantify, or the like, a distance remaining for the housing system 300 (or the sensor 340, main housing 310, etc.) before reaching the target or desired underwater location.

[00115] The sensor 340 is configurable or configured to determine or obtain one or more measurements of surrounding pressure, depth, and/or distance (e.g., remaining distance to target) in real-time or near real-time. Alternatively or in addition, the measurements of the surrounding pressure may also be obtained or received in a periodic, intermittent, or sporadic manner (e.g., every 1 minute, every 2 minutes, at a depth of 500 m, at a depth of 1000 m, no fixed period or pattern; etc.). Further, the sensor 340 is also configurable or configured to provide, send, transmit and/or make available the one or more measurements of the surrounding pressure, one or more measurements of the underwater depths, one or more measurements of the distances remaining for the housing system 300 (or the sensor 340, main housing 310, etc.) to reach the target or desired underwater location (e.g., bottom 30 of the body of water) to one or more other elements of the housing processors 360 (as further described in the present disclosure).

[00116] In an example embodiment, the sensors 340 may be and/or include one or more tension sensors (not shown). The tension sensor can be provided, equipped, installed, attached, set up, fixed or connected at least on the housing system 300. The tension sensor is configurable or configured to

detect a tension force of the line 40 to determine whether the housing system 300 has reached the target or desired underwater location. Under dynamic environment (e.g., strong currents and underwater conditions), the housing system 300 can be raised upward or lowered downward which results in tension force deviation. As the housing system 300 deviates upward from its desired or target depth (without the line 40 being pulled upwards from the vessel 10), the tension force will decrease. As the housing system 300 is lowered by the vessel 10 downward to its desired or target depth, the tension force will be high (or exceed a certain threshold). If less and/or no tension force is detected, this may indicate that the main housing 300 has reached the bottom of the body of water (i.e., the target or desired underwater location). When this is detected, an additional 1-10 m of cable 40 may be provided downward to account for the height of waves present at the vessel 10.

[00117] In an example embodiment, the sensors 340 may be and/or include one or more pressure sensors (not shown). The pressure sensor is configurable or configured to determine a change of pressure corresponding to an underwater depth when the housing system 300 has traveled deeper into the body of water. The pressure sensor may be configurable or configured to provide depth information, the relative speed of the housing system 300 in travelling into the body of water, the corresponding location of the housing system 300 relative to the top surface 20 or to the bottom surface 30 of the body of water or to the target depth, etc.

[00118] In an example embodiment, the sensors 340 may be and/or include one or more inertial measuring units (IMUs). The IMU may be configurable or configured to provide inertia information in real-time or near real-time based on the current/present orientation of the housing system 300 when the housing system 300 has reached the target or desired underwater location. The IMU may also be configurable or configured to determine whether the housing system 300 and other elements of the system 100 are in desired location and/or in a correct orientation (i.e., in predetermined roll, pitch, and/or yaw angle). If the system 100 includes at least one IMU, the system 100 may be configurable or configured to include only one line 40.

[00119] In an example embodiment, the sensors 340 may be and/or include one or more ocean current sensors. The ocean current sensor is configurable or configured to at least receive ocean current observation data. The ocean current sensor can be fitted, equipped, installed, attached, set up, fixed or connected on the housing system 300 and/or the underwater vehicle 200 to measure ocean currents (including underwater currents). Alternatively or in addition, the ocean current sensor is configurable or configured to generate measurement of the speed and direction of currents throughout the body of water. The ocean current sensor is also configurable or configured to determine whether the

surrounding environment, including surrounding underwater current, is suitable for the underwater vehicle 200 to start a mission.

[00120] In an example embodiment, the sensor 340 may be and/or include one or more turbidity sensors. The turbidity sensor can be equipped, installed, attached, set up, fixed or connected on or to the main housing 310 to detect the optical measurement of the surrounding environment. If the optical measurement generated from the turbidity sensor is exceeded the predetermined ranges, the housing system 300 (e.g. access control controller assembly 350) may not allow the underwater vehicle 200 to start the mission.

[00121] Alternatively or in addition, other examples of sensors 340 that may be used include, but not limited to, depth sensors, pressure sensors, distance sensors, optical sensors, hydrostatic sensors, piezoresistive sensors, ultrasonic sensors, sonars, and any other sensors which may be applicable. The one or more sensors 340 above may be fitted, equipped, installed, attached, set up, fixed or connected at one or more locations/positions on the main housing 310 (as illustrated in at least Figures 3a, 3b and 3c) including at any top corners of the front portion of the main housing 310, at any top corners of the back portion of the main housing 310, at any bottom corners of the back portion of the main housing 310, and/or a combination of locations/positions thereof. Alternatively or in addition, the one or more locations/positions on the main housing 310 may be fitted, equipped, installed, attached, set up, fixed or connected with one or more different sensors 340 at each of the location/position. For example, the top corners of the front portion of the main housing 310 may be fitted, equipped, installed, attached, set up, fixed or connected with a pressure sensor and the top corners of the back portion of the main housing 310 may be fitted, equipped, installed, attached, set up, fixed or connected with a depth sensor.

[00122] Although Figures 3B and 3C may illustrate one sensor 340, it is to be understood that the housing system 300 may include more or less than one sensor 340 without departing from the teachings of the present disclosure.

[00123] The access control controller assembly (e.g., access control controller assembly 350).

[00124] As illustrated in at least Figures 3A-C and 3E, an example embodiment of the housing system 300 includes one or more access control controller assemblies (e.g., access control controller assembly 350). The access control controller assembly 350 is configurable or configured to control the access control assembly 320, as described in the present disclosure.

[00125] In an example embodiment, the access control controller assembly 350 is configurable or configured to selectively (e.g., based on a command, instruction, and/or information received by an

example embodiment of the housing processor 360) and/or dynamically (e.g., via one or more of the pressure actuators, based on a pressure received at or by the access control controller assembly 350, and/or based on a measurement generated by one or more sensors 340) control the access control assembly 320.

[00126] For example, the access control controller assembly 350 may include one or more pressure actuators (not shown), such as pneumatic actuators, configurable or configured to actuate, move, slide, push, displace, or the like, the access control assembly 320 relative to the main housing 310 based on a surrounding pressure. More specifically, the pressure actuator of the access control controller assembly 350 may be configurable or configured to perform one or more of the following: control the access control assembly 320 to remain in a fully closed position when the pressure actuator receives or detects a surrounding pressure below a first threshold pressure (e.g., an ambient pressure when the main housing 310 is not yet submerged into water), control the access control assembly 320 to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) when the pressure actuator receives or detects an increase in a surrounding pressure, control the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) when the pressure actuator receives or detects a further increase in surrounding pressure, control the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) to the fully opened position when the pressure actuator receives or detects a surrounding pressure that reaches or exceeds a target surrounding pressure (and/or target depth), control the access control assembly 320 to remain in the fully opened position when the pressure actuator receives or detects a surrounding pressure that maintains at or greater than a target surrounding pressure (and/or target depth), control the access control assembly 320 to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) when the pressure actuator receives or detects a surrounding pressure that decreases below a target surrounding pressure (and/or target depth), control the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) when the pressure actuator receives or detects further decrease in a surrounding pressure, control the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the

fully opened position) to the fully closed position when the pressure actuator receives or detects a surrounding pressure that further decreases to be equal to or less than the first threshold pressure, and control the access control assembly 320 to remain in the fully closed position when the pressure actuator receives or detects a surrounding pressure that remains equal to or less than the first threshold pressure.

[00127] In an example embodiment, the housing processor 360 may be configurable or configured to connected to a manual control on the vessel 10. When the housing processor 360 determines that the main housing 310 has reached the bottom 30 of the body of water or reached a target depth, the housing processor 360 is also configurable or configured to send the signal to an operator on the vessel 10 (not shown). In one embodiment, the housing processor 360 determines that the main housing 310 has reached the bottom 30 of the body of water or reached a target depth based on the depth of the main housing 310, the surrounding pressure of the main housing 310, and/or the distance between the main housing 310 and the bottom 30 of the body of water. The operator on the vessel 10, upon receiving the information from the housing processor 360, then controls the access control assembly 320 such that the access control assembly 320 is transitioned based on the command received from the operator on the vessel 10.

[00128] Alternatively or in addition to the pressure actuator, the access control controller assembly 350 may receive instructions, commands, and/or actions (referred to herein as “communications”) from one or more other elements of the housing system 300, such as the housing processor 360 and/or sensor 340, to actuate, move, slide, push, displace, extend, contract, retract, rotate, or the like, the access control assembly 320 relative to the main housing 310. More specifically, the access control controller assembly 350 may be configurable or configured to perform one or more of the following: control the access control assembly 320 to remain in a fully closed position when the housing processor 360 and/or sensor 340 determines that the main housing 310 is not yet submerged in water, control the access control assembly 320 to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) when the housing processor 360 and/or sensor 340 determines that the main housing 310 is submerged and lowered into the water, control the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) when the housing processor 360 and/or sensor 340 determines that the main housing 310 has traveled deeper into the water, control the access control assembly 320 to transition from a not-fully-opened position

(e.g., closer to the fully opened position than the fully closed position) to the fully opened position when the housing processor 360 and/or sensor 340 determines that the main housing 310 has further submerged deeper into water, control the access control assembly 320 to remain in the fully opened position when the housing processor 360 and/or sensor 340 determines that the main housing 310 has reached a target depth (and/or target surrounding pressure), control the access control assembly 320 to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) when the housing processor 360 and/or sensor 340 determines that the main housing 310 is at a depth that is less than the target depth (or at a surround pressure that is less than the target surrounding pressure), control the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) when the housing processor 360 and/or sensor 340 determines that the main housing 310 has traveled into less deep waters, control the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) to the fully closed position when the housing processor 360 and/or sensor 340 determines that the main housing 310 is no longer submerged in water, and control the access control assembly 320 to remain in the fully closed position when the housing processor 360 and/or sensor 340 determines that the main housing 310 remains out of the water.

[00129] In an example embodiment, the access control controller assembly 350 (as illustrated in at least Figure 3E) may include one or more access control assembly portions (e.g., access control assembly portion 352). The access control assembly portion 352 of the access control controller assembly 350 is securable or secured to at least a portion of the access control assembly 320, which enables the access control controller assembly 350 to control movement of the access control assembly 320 relative to one or more other elements of the access control controller assembly 350 (e.g., relative to the control portion 356 and/or main housing portion 354). Alternatively or in addition, the sensor 340 may be configurable or configured to associate with the control portion 356 of the access control assembly 320 such that the access control assembly 320 is transitioned based on the information received from the sensor 340. As illustrated in Figures 3A-C, such movement of the access control assembly portion 352 (and therefore also the access control assembly 320) relative to the control portion 356 and/or main housing portion 354 (and therefore also the main housing 310) may be a sliding or upward movement of the access control assembly 320 relative to the control portion 356 and/or main housing portion 354 (and therefore also the main housing 310). Although

not shown, other movements of the access control assembly portion 352 (and therefore also the access control assembly 320) relative to the control portion 356 and/or main housing portion 354 (and therefore also the main housing 310) are contemplated without departing from the teachings of the present disclosure. For example, whereas Figures 3A-C illustrate the sliding or upward movement of the access control assembly 320 in such a way that movement of the access control assembly 320 remains in a same plane (e.g., linear movement along a Y-axis), the access control assembly 320 may also be rotated relative to an axis (e.g., rotatory movement around an X-axis). In such example embodiment (not shown), the access control controller assembly 350 may secure a top edge of the access control assembly 320 to a front top edge of the main housing 310.

[00130] The access control controller assembly 350 may also include one or more main housing portions (e.g., main housing portion 354). The main housing portion 354 of the access control controller assembly 350 is securable or secured to at least a portion of the main housing 310 (e.g., a front right edge of the main housing 310, a front left edge of the main housing 310, a front top edge of the main housing 310, a front bottom edge of the main housing, etc.), which enables the access control controller assembly 350 to control movement of the access control assembly 320 relative to the main housing portion 354 (and therefore the main housing 350).

[00131] The access control controller assembly 350 may also include one or more control portions (e.g., control portion 356). The control portion 356 of the access control controller assembly 350 may be securable or secured to at least a portion of one or more access control assembly portions 352 on one side/end and securable or secured to at least a portion of one or more main housing portions 354 on another side/end. In an example embodiment, the control portion 356 of the access control controller assembly 350 includes one or more pressure actuators (not shown). As described above and in the present disclosure, such pressure actuator is configurable or configured to pneumatically actuate the access control assembly 320 relative to the control portion 356 and/or main housing portion 354 based on a surrounding pressure received or detected by the pressure actuator. More specifically, the pressure actuator is configurable or configured to actuate, move, slide, push, displace, or the like, the access control assembly 320 relative to the main housing 310 based on a surrounding pressure. As the surrounding pressure increases (e.g., the depth reached by the main housing 310 increases), the pressure actuator moves (or slides, pushes, displaces, etc.) the access control assembly 320 towards a fully opened position. When the surrounding pressure decreases (e.g., the depth reached by the main housing 310 decreases), the pressure actuator moves the access control assembly 320 towards a fully closed position.

[00132] As illustrated in at least Figure 3d, as the housing system 300 descends from a top surface 20 to a bottom surface 30 of the body of water (or to a target depth), the surrounding pressure of the housing system 300 increases. The surrounding pressure that is applied to the pressure actuator of the control portion 356 of the access control controller assembly 350 moves (or slides, pushes, displaces, etc.) the access control assembly 320 towards a fully opened position. When the housing system 300 has reached a target depth (e.g., bottom surface 30 of the body of water, etc.), the access control assembly 320 has transitioned from a fully closed position to a fully opened position to allow the underwater vehicle 200 to exit the main housing 310 through the access control assembly 320. Similarly, as the housing system 300 ascends from the bottom surface 30 (or target depth) to the top surface 20 of the body of water, the surrounding pressure of the housing system 300 decreases. The surrounding pressure that is applied to the pressure actuator of the control portion 356 of the access control controller assembly 350 moves (or slides, pushes, displaces, etc.) the access control assembly 320 towards a fully closed position. When the housing system 300 has reached the top surface 20 of the body of water, the access control assembly 320 has transitioned from a fully opened position to a fully closed position to prevent the underwater vehicle 200 from exiting the main housing 310 through the access control assembly 320.

[00133] Alternatively or in addition to the pressure actuator provided in the control portion 356, an example embodiment of the control portion 356 may include a locking processor (not shown) and/or communicate with a processor (e.g., the housing processor 360 and/or sensor 340). As described above and in the present disclosure, such processor is configurable or configured to process (e.g., by the locking processor) and/or receive communications from one or more other elements of the housing system 300 (e.g., the housing processor 360 and/or sensor 340) to actuate, move, slide, push, displace, or the like, the access control assembly portion 352 (and therefore the access control assembly 320) relative to the main housing portion 354 (and therefore the main housing 310).

[00134] The housing processor (e.g., housing processor 360).

[00135] In an example embodiment, the housing system 300 may include one or more housing processors (e.g., housing processor 360). The housing processor 360 is configurable or configured to perform one or more of a plurality of functions, operations, actions, methods, and/or processes using one or more of the elements described in the present disclosure.

[00136] For example, the housing processor 360 is configurable or configured to receive and/or generate a target depth (e.g., during setup). The target depth may be an exact or estimated underwater

depth or distance to a desired depth where the underwater mission is to commence (e.g., the bottom 30 of the body of water).

[00137] The housing processor 360 is also configurable or configured to receive and/or generate a target surrounding pressure. The target surrounding pressure may be an exact or estimated underwater surrounding pressure where the underwater mission is to commence (e.g., the bottom 30 of the body of water).

[00138] The housing processor 360 is also configurable or configured to receive measurements, readings, estimates, and/or other information from one or more other elements of the housing system 300 (e.g., one or more sensors 340, one or more other housing processors 360, one or more other processors (e.g., locking processor of the control portion 356), etc.) and to process such information. In processing the information, the housing processor 360 is configurable or configured to determine whether or not the main housing 310 has reached the bottom 30 of the body of water, reached a target depth, and/or reached a target surrounding pressure. In an example embodiment, such determination may be performed by the housing processor 360 by comparing real-time or current measurements of the surrounding pressure of the main housing 310 with the target surrounding pressure.

[00139] The housing processor 360 may then communicate with the control portion 356 of the access control controller assembly 350. More specifically, responsive to a determination that the main housing 310 has reached the bottom 30 of the body of the water or reached the target depth (or target surrounding pressure), the housing processor 360 may communicate with the control portion 356 of the access control controller assembly 350 to actuate the access control assembly portion 352 (and therefore the access control assembly 320) to a fully opened position. Alternatively or in addition, the control portion 356 of the access control controller assembly 350 may also cooperate with the housing processor 360 to actuate the access control assembly 320 to a fully opened position. The housing processor 360 is also configurable or configured to receive and/or process one or more instructions, commands, information and/or action received relating to power/battery levels for the underwater vehicle 200 from one or more elements of the system 100, the underwater vehicle 200, and the housing system 300.

[00140] To perform the actions, functions, processes, and/or methods described above, the housing processor 360 may include one or more elements. For example, the housing processor 360 may include one or more transceiver (e.g., transceiver 362). The housing processor 360 may include one or more sensor subsystem (e.g., sensor subsystem 364). The housing processor 360 may include one or more locking subsystem (e.g., locking subsystem 366). The housing processor 360 may include

one or more power subsystem (e.g., power subsystem 368). Example embodiments will now be described below with reference to the accompanying figures, which form a part of the present disclosure.

[00141] *The transceiver (e.g., transceiver 362).*

[00142] The housing processor 360 may include one or more transceivers (e.g., transceiver 362, as illustrated in at least **FIGURE 3F**). The transceiver 362 is configurable or configured to communicate with one or more elements of the system 100. In an example embodiment, the transceiver 362 is configurable or configured to communicate with one or more elements of the housing processor 360, including the sensor subsystem 364, the locking subsystem 366, and/or the power subsystem 368. In yet another example embodiment, the transceiver 362 is configurable or configured to enable one or more elements of the housing processor 360 (e.g., the sensor subsystem 364, the locking subsystem 366, and/or the power subsystem 368) to communicate with the underwater vehicle 200, one or more other elements of the housing system 300, and any other one or more elements of the system 100.

[00143] In an example embodiment, the transceiver 362 is configurable or configured to receive one or more commands and/or information from the underwater vehicle 200 and/or one or more elements of the housing system 300 (e.g., sensor 340, access control controller assembly 350, etc.). The one or more information and/or commands may then be communicated to the one or more sensor subsystems 364, one or more locking subsystems 366, and/or one or more power subsystems 368. Examples of information received may include information pertaining to a surrounding pressure (e.g., real-time surrounding pressure, target surrounding pressure, etc.), information pertaining to a depth (e.g., real-time depth, target depth, etc.), measurements of distance between the housing system 300 and a target or desired location (e.g., a bottom 30 of the body of water, etc.). Other information may also include the levels of power/battery of the underwater vehicle 200, levels of power/battery remaining in the underwater vehicle 200, recharging of the underwater vehicle 200 by the housing system 300 (or the battery charging assembly of the housing system 300, not shown).

[00144] Examples of commands received may include a command to re-measure the surrounding pressure, a command to re-measure the depth reached by the underwater vehicle 200, and/or a command to re-measure a distance between the housing system 300 and the target or desired location (e.g., a bottom 30 of the body of water, etc.). Other commands may also include a command to provide power source to recharge or replenish power to the underwater vehicle 200.

[00145] The information and/or commands received may be received in real-time and/or near real-time. Alternatively or in addition, such information may be received in a periodic, intermittent, or sporadic manner (e.g., every 1 minute, every 2 minutes, at a depth of 500 m, at a depth of 1000 m, at a surrounding pressure of 1 atm, at a surrounding pressure of 2 atm, no fixed period or pattern, etc.). Alternatively or in addition, such information may be received upon the occurrence (and/or non-occurrence) of an event, sequence of events, action, sequence of actions, condition, sequence of conditions, receipt of certain information, receipt of a sequence of certain information, process, sequence of processes, etc. (e.g., movement and/or change of position, location, orientation, trajectories, etc.).

[00146] Although Figure 3f may illustrate two transceivers 362, it is to be understood that the housing processor 360, the housing system 300 and/or the system 100 may include more or less than two transceivers 362 without departing from the teachings of the present disclosure.

[00147] The sensor subsystem (e.g., sensor subsystem 364).

[00148] The housing processor 360 may include one or more sensor subsystems (e.g., sensor subsystem 364, as illustrated in at least Figure 3F). The sensor subsystem 364 is configurable or configured to communicate with one or more elements of the system 100. In an example embodiment, the sensor subsystem 364 is configurable or configured to communicate with one or more elements of the housing processor 360, including the transceiver 362, the locking subsystem 366, and/or the power subsystem 368.

[00149] In an example embodiment, the sensor subsystem 364 is configurable or configured to receive one or more information from one or more elements of the housing system 300 (e.g., sensor 340). Examples of information received may include information pertaining to a surrounding pressure (e.g., real-time surrounding pressure, target surrounding pressure, etc.), information pertaining to a depth (e.g., real-time depth, target depth, etc.), measurements of distance between the housing system 300 and a target or desired location (e.g., a bottom 30 of the body of water, etc.). In another example embodiment, the sensor subsystem 364 is configurable or configured to generate one or more instructions, commands, and/or actions to the housing system 300 (e.g., sensor 340). Examples of commands that may be generated and provided to the sensor 340 include a command to re-measure the surrounding pressure, a command to re-measure the depth reached by the underwater vehicle 200, and/or a command to re-measure the distance between the main housing 310 and the target or desired location (e.g., a bottom 30 of the body of water, etc.).

[00150] Further, the sensor subsystem 364 may be configurable or configured to process one or more information (e.g., measurements) received. The sensor subsystem 364 may be configurable or configured to determine whether the surrounding pressure of the main housing 310 is greater than or equal to a target surrounding pressure. The sensor subsystem 364 may also be configurable or configured to determine whether the depth of the main housing 310 is greater than or equal to a target depth. Further, the sensor subsystem 364 may also be configurable or configured to determine whether the distance between the main housing 310 and a target or desired location (e.g., a bottom 30 of the body of water) less than or equal to a target distance.

[00151] In yet another example embodiment, the sensor subsystem 364 may also be configurable or configured to receive, generate, determine and/or provide one or more target depths to be reached by the underwater vehicle 200. The one or more target depths may be an estimated total distance to the bottom surface 30 of the body of water and/or any other target or desired locations. The target depths may be measured or determined in real-time by the underwater vehicle 200, housing processor 360, and/or one or more other elements of the system 100. Alternatively or in addition, the target depths may be known. Alternatively or in addition, the target depths may be historical measurements that were determined or obtained under similar or same conditions (e.g., same or similar location, time of day/week/month/year, etc.).

[00152] Once the target depth has been determined, the sensor subsystem 364 configurable or configured to receive, generate, determine and/or provide one or more target surrounding pressures based on the target depth (of course, target surrounding pressures may be first determined, followed by determining target depths based on the target surrounding pressures). That is, the target surrounding pressure may be known. Alternatively or in addition, the target surrounding pressure may be historical measurements that were determined or obtained under similar or same conditions (e.g., same or similar location, time of day/week/month/year, etc.). The sensor subsystem 364 is configurable or configured to make determinations (e.g., whether the surrounding pressure of the main housing 310 is greater than or equal to a target surrounding pressure, whether the depth of the main housing 310 is greater than or equal to a target depth, whether the distance between the main housing 310 and a target or desired location (e.g., a bottom 30 of the body of water) less than or equal to a target distance, etc.) based on the determined target depths and/or the determined target surrounding pressure.

[00153] Although Figure 3F may illustrate one sensor subsystem 364, it is to be understood that the housing processor 360, the housing system 300 and/or the system 100 may include one or more sensor subsystems 364 without departing from the teachings of the present disclosure.

[00154] *The locking subsystem (e.g., locking subsystem 366).*

[00155] The housing processor 360 may include one or more locking subsystems (e.g., sensor subsystem 366, as illustrated in at least Figure 3F). The sensor subsystem 364 is configurable or configured to communicate with one or more elements of the system 100. In an example embodiment, the locking subsystem 366 is configurable or configured to communicate with one or more elements of the housing processor 360, including the transceiver 362, the sensor subsystem 364, and/or the power subsystem 368.

[00156] In an example embodiment, the locking subsystem 366 is configurable or configured to receive one or more information from the sensor subsystem 364. The information received may include a surrounding pressure of the main housing 310, a determination that the surrounding pressure of the main housing 310 is greater than or equal to a target surrounding pressure, a depth of the main housing 310, a determination that the depth of the main housing 310 is greater than or equal to a target depth, a distance between the main housing 310 and a target or desired location (e.g., a bottom 30 of the body of water), and/or a determination that the distance between the main housing 310 and a target or desired location (e.g., a bottom 30 of the body of water) less than or equal to a target distance.

[00157] In yet another example embodiment, the locking subsystem 366 may also be configurable or configured to generate one or more signals, information, commands, and/or notifications to the housing system 300 or specifically to the access control controller assembly 350. As described in the present disclosure, the locking subsystem 366 may generate instructions, commands, and/or actions to the access control controller assembly 350 to actuate, move, slide, push, displace, or the like, the access control assembly 320 relative to the main housing 310 based on the information received from the sensor subsystem 364.

[00158] For example, the locking subsystem 366 may generate instructions, commands, and/or actions to the access control controller assembly 350 to selectively and/or dynamically perform one or more of the following: controlling the access control assembly 320 to remain in a fully closed position, controlling the access control assembly 320 to transition towards a fully opened position, controlling the access control assembly 320 to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position), controlling

the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position), controlling the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) to the fully opened position, controlling the access control assembly 320 to remain in the fully opened position, controlling the access control assembly 320 to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position), controlling the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards the fully closed position, controlling the access control assembly 320 to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position), controlling the access control assembly 320 to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) to the fully closed position, and controlling the access control assembly 320 to remain in the fully closed position.

[00159] Although Figure 3F may illustrate one locking subsystem 366, it is to be understood that the housing processor 360, the housing system 300, and/or the system 100 may include more or less than one locking subsystems 366 without departing from the teachings of the present disclosure.

[00160] *The power subsystem (e.g., power subsystem 368).*

[00161] The housing processor 360 may include one or more power subsystems (e.g., power subsystem 368, as illustrated in at least Figure 3F). The power subsystem 368 is configurable or configured to communicate with one or more elements of the system 100. In an example embodiment, the power subsystem 368 is configurable or configured to communicate with one or more elements of the housing processor 360, including the transceiver 362, the sensor subsystem 364, and/or the locking subsystem 366.

[00162] In an example embodiment, the power subsystem 368 is configurable or configured to receive one or more signals, information, commands or notifications from the underwater vehicle 200. Such signals, information, commands or notifications may include that the underwater vehicle 200 is running low on power/battery level, that the underwater vehicle 200 may require a recharge by the housing system 300 (battery charging assembly of the housing system 300, not shown), or the like. The power subsystem 368 may also be configurable or configured to generate one or more signals, information, commands or notifications to the housing system 300 (battery charging

assembly of the housing system 300, not shown) to recharge the underwater vehicle 200 when the underwater vehicle is positioned in the main cavity 330 of the housing system 300.

[00163] Examples of the power subsystem 368 that may be used include, but not limited to, battery charging subsystem, fuel cell subsystem, solar power subsystem, wave power converters, etc.

[00164] Although Figure 3F may illustrate one power subsystem 366, it is to be understood that the housing processor 360, the housing system 300 and/or the system 100 may include more or less than one power subsystems 368 without departing from the teachings of the present disclosure.

[00165] The positional markers (e.g., positional marker 370).

[00166] As illustrated in at least Figures 3A-C, an example embodiment of the housing system 300 may include one or more positional markers (e.g., positional marker 370). The positional markers 370 are configurable or configured to assist and/or enable an underwater vehicle 200 to appropriately and accurately return into the main cavity 330 and be housed in the main housing 310.

[00167] In an example embodiment, one or more positional markers 370 are provided on one or more portions (e.g., a portion of an exterior side (e.g., top side, bottom side, front side, back side, left side, right side, etc.) of the main housing 310, a portion of an interior side of the main housing 310, a bottom portion of an access door 320 (as illustrated in at least Figures 3B and 3C), etc.) of the main housing 110.

[00168] In example embodiments, one or more of the positional markers 370 may assist the housing processor 360 in generating one or more trajectories for the underwater vehicle 200 to travel in order to return into the main housing 310.

[00169] Examples of positional markers that may be used include, but not limited to, a quick response (QR) code, a barcode, a symbol, an augmented reality (AR) code, a fiducial marker, a light source, etc.

[00170] Example embodiments of a method for managing an autonomous underwater vehicle (e.g., method 200).

[00171] FIGURE 4 illustrates an example embodiment of a method for managing an underwater vehicle (e.g., method 400). The method 400 may include managing, navigating, controlling, and/or otherwise transporting an underwater vehicle (e.g., an autonomous underwater vehicle (AUV)). One or more actions of method 400 may be performed by one or more elements of the system 100, one or more elements of the underwater vehicle 200, and/or one or more elements of the housing system 300, as described above and in the present disclosure.

[00172] In an example embodiment, the method 400 may include performing a configuration process. The configuration process may include receiving (and/or generating, estimating, measuring, obtaining, or the like) a target depth (e.g., method 410). The target depth may be a depth where the underwater vehicle (e.g., underwater vehicle 200) will be deployed to perform the underwater mission. The target depth may be an estimated total depth or distance to the bottom surface 30 of the body of water. Alternatively or in addition, the target depth may also be an estimated total depth or distance to reach a particular desired depth or location from the top surface 20 of the body of water. The target depth or estimated distance may be measured and/or determined in real-time (or near real-time) by the underwater vehicle 200, the housing system 300, and/or one or more other elements of the system 100 before submerging the housing system 300 (with the underwater vehicle 200) in a body of water. Alternatively or in addition, the target depths or estimated distance may be one or more known input that is provided to the processor (e.g., the housing processor 360 and/or the sensor subsystem 364). Alternatively or in addition, the target depths or distances may be historical measurements that were determined or obtained at the same or similar locations previously.

[00173] Alternatively or in addition, the configuration process may include generating a target surrounding pressure (e.g., method 420), which may be an underwater pressure that represents an underwater depth where the underwater vehicle (e.g., underwater vehicle 200) will be deployed to perform the underwater mission. Alternatively or in addition, the target surrounding pressure may be one or more known input that is provided to the processor (e.g., the housing processor 360 and/or the sensor subsystem 364). Alternatively or in addition, the surrounding pressure may be historical measurements that were determined or obtained at same or similar underwater depths at the same or similar locations previously.

[00174] The method 400 may also include lowering the underwater vehicle (e.g., underwater vehicle 200) using a housing system (e.g., housing system 300), which includes a main housing (e.g., main housing 310) that houses the underwater vehicle (e.g., underwater vehicle 200) in a main cavity (e.g., main cavity 330), one or more access control assemblies (e.g., access control assembly 320), and one or more access control controller assemblies (e.g., access control controller assembly 350). In some example embodiments, the main housing (e.g., main housing 310) also includes one or more sensors (e.g., sensor 340; to measure real-time underwater depth, surrounding pressure, and/or distance remaining to a target depth, etc.), one or more housing processors (e.g., housing processor 360), and/or one or more positional markers (e.g., positional marker 370).

[00175] Alternatively or in addition, the method 400 may also include determining whether the housing system 300 reaches its desired or target depth by using multiple types of sensors. In an example embodiment, the desired or target depth can be determined by one or more tension sensors (not shown). The method 400 may also include detecting the tension force of the line 40 to determine whether the housing system 300 reaches the target or desired underwater location. The method 400 may also include capturing real-time or near real-time information, such as tension force obtained by the tension sensor, and output the captured information to the vessel 10. When the underwater vehicle 200 has reached its desired or target depth, an example embodiment of the housing system 300 is configurable or configured to selectively or dynamically control an access control assembly 320 of the housing system 300 to open and close so as to allow (and not allow) the underwater vehicle 200 to exit and enter the main housing 310 of the housing system 300 (e.g., so as to perform its underwater mission of inspecting one or more underwater structures 50).

[00176] The method 400 may also include performing an underwater vehicle access process. The underwater vehicle access process may include receiving measurements of surrounding pressure (e.g., method 430) of the main housing (e.g., main housing 310). The measurements of the surrounding pressure may be determined by the one or more sensors 340. Examples of sensors that may be used in determining or measuring a surrounding pressure include, but not limited to, pressure sensors, depth sensors, pressure sensors, hydrostatic sensors, piezoresistive sensors, ultrasonic sensors, and any other sensors which may be applicable. The measurements of the surrounding pressure of the main housing 310 may be obtained in real-time or near real-time. However, the measurements of the surrounding pressure may also be obtained or received in a periodic, intermittent, or sporadic manner (e.g., every 1 minute, every 2 minutes, at a depth of 500 m, at a depth of 1000 m, no fixed period or pattern; etc.).

[00177] The method 400 may also include performing a determination as to whether or not the main housing 310 has reached a target or desired depth (e.g., bottom surface of the body of water, desired depth or location from the top surface of the body of water and/or target or desired location). The target depth may be an estimated distance from the real-time or current position of the main housing (e.g., main housing 310) to the bottom 30 of the body of water. Alternatively or in addition, the target depth may be an estimated distance from the real-time or current position of the main housing (e.g., main housing 310) to the target depth (or location) to carry out the underwater mission (e.g., not the bottom 30 of the body of water). The determination as to whether or not the main housing (e.g., main housing 310) has reached the bottom 30 of the body of water may be performed by comparing real-

time measurements with target values (e.g., target depths as obtained in the configuration process, target surrounding pressure as obtained in the configuration process) (e.g., method 440). For example, the determination may be based on whether or not the real-time depth has reached a depth that is equal to or greater than a target depth; whether or not the real-time surrounding pressure is equal to or greater than a target surrounding pressure; and/or whether or not the real-time distance between the main housing (e.g., main housing 310) and the bottom 30 of the body of water is equal or lesser than a target distance.

[00178] The method 400 may also include transitioning the position of an access control assembly (e.g., access control assembly 320) of the main housing 310 (e.g., method 450). The transitioning may be performed by one or more pressure actuators of the control portion (e.g., control portion 356) of the access control controller assembly (e.g., access control controller assembly 350) by moving, sliding, pushing, displacing, or the like, the access control assembly 320 relative to the main housing 310.

[00179] The method 400 includes selectively (e.g., based on a command, instruction, and/or information received by the housing processor (e.g., housing processor 360)) and/or dynamically (e.g., via one or more pressure actuators, based on a pressure received at or by the access control controller assembly (e.g., access control controller assembly 350), and/or based on a measurement generated by one or more sensors (e.g., sensor 340)) performing one or more of the following: controlling the access control assembly (e.g., access control assembly 320) to remain in a fully closed position; controlling the access control assembly (e.g., access control assembly 320) to transition towards a fully opened position; controlling the access control assembly (e.g., access control assembly 320) to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) to the fully opened position; controlling the access control assembly (e.g., access control assembly 320) to remain in the fully opened position; controlling the access control assembly (e.g., access control assembly 320) to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position); controlling the access control assembly (e.g., access control assembly 320) to

transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards the fully closed position; controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) to the fully closed position; and/or controlling the access control assembly (e.g., access control assembly 320) to remain in the fully closed position.

[00180] In yet another example embodiment, the method 400 may further include detecting one or more positional markers 370 that are provided on one or more portions (e.g., a portion of an exterior side (e.g., top side, bottom side, front side, back side, left side, right side, etc.) of the main housing 310, a portion of an interior side of the main housing 310, a bottom portion of an access control assembly 320 of the main housing 310.

[00181] The method 400 may also further include generating one or more trajectories based on one or more of the positional markers 370 to assist the housing processor 360 for the underwater vehicle 200 to travel in order to return into the main housing 310. Alternatively or in addition, the method 400 may also include generating one or more trajectories based on one or more of the positional markers 370 to assist and/or enable an underwater vehicle 200 to appropriately and accurately return into the main cavity (e.g., main cavity 330) and be housed in the main housing 310.

[00182] In yet another example embodiment, the method 400 may further include providing a power source to the underwater vehicle 200. The method 400 includes providing power source to recharge the underwater vehicle 200. A signal from the underwater vehicle 200 may be transmitted to the power subsystem 368 to indicate that the underwater vehicle 200 is running low on power or has run out of power, and may require a recharge. Examples of the power subsystem 340 that may be used include, but not limited to battery charging subsystem, fuel cell subsystem, solar power subsystem, wave power converters, etc. The method 400 further includes recharging the underwater vehicle 200 once it has docked safely and securely in the main cavity (e.g., main cavity 330) of the main housing 310.

[00183] In yet another example embodiment, the method 400 may include providing permanent docking of the main housing 310 next to an offshore platform. The determination as to whether or not the main housing (e.g., main housing 310) has reached the bottom 30 of the body of water may be performed by detecting at least the movement of the underwater vehicle 200, the sonar beam of

seafloor measurements, and/or the change in depth profile within a period of time. Then, the method includes transitioning the position of an access control assembly (e.g., access control assembly 320) of the main housing 310 (e.g., method 450). The method includes: controlling the access control assembly (e.g., access control assembly 320) to remain in a fully closed position; controlling the access control assembly (e.g., access control assembly 320) to transition towards a fully opened position; controlling the access control assembly (e.g., access control assembly 320) to transition from the fully closed position to a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) towards a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) to the fully opened position; controlling the access control assembly (e.g., access control assembly 320) to remain in the fully opened position; controlling the access control assembly (e.g., access control assembly 320) to transition from the fully opened position to a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards the fully closed position; controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-opened position (e.g., closer to the fully opened position than the fully closed position) towards a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position); controlling the access control assembly (e.g., access control assembly 320) to transition from a not-fully-closed position (e.g., closer to the fully closed position than the fully opened position) to the fully closed position; and/or controlling the access control assembly (e.g., access control assembly 320) to remain in the fully closed position. The method of controlling the access control assembly 320 is based on whether the underwater vehicle 200 has completed the mission and/or has docked in the main housing 310.

[00184] While various embodiments in accordance with the disclosed principles have been described above, it should be understood that they have been presented by way of example only and are not limiting. Thus, the breadth and scope of the example embodiments described in the present disclosure should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the claims and their equivalents issuing from this disclosure.

Furthermore, the above advantages and features are provided in described embodiments, but shall not limit the application of such issued claims to processes and structures accomplishing any or all of the above advantages.

[00185] Various terms used herein have special meanings within the present technical field. Whether a particular term should be construed as such a "term of art" depends on the context in which that term is used. Such terms are to be construed in light of the context in which they are used in the present disclosure and as one of ordinary skill in the art would understand those terms in the disclosed context. The above definitions are not exclusive of other meanings that might be imparted to those terms based on the disclosed context.

[00186] Additionally, the section headings and topic headings herein are provided for consistency with the suggestions under various patent regulations and practice, or otherwise to provide organizational cues. These headings shall not limit or characterize the embodiments set out in any claims that may issue from this disclosure. For example, a description of a technology, or the like, in the "Background" shall not be construed as an admission that such technology is prior art to any example embodiments in this disclosure. Furthermore, any reference in this disclosure to an "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be considered on their own merits in light of this disclosure, but should not be constrained by the headings herein.

Claims

What is claimed is:

1. A system for managing an underwater vehicle, the system comprising:
 - a main housing, the main housing including:
 - a main cavity for housing an underwater vehicle, the main cavity formed by at least:
 - a top side of the main housing;
 - a bottom side of the main housing, the bottom side of the main housing opposite to the top side of the main housing; and
 - surrounding sides of the main housing formed between the top and bottom sides;
 - an access control assembly, the access control assembly configured to transition between a closed position and an opened position;
 - wherein the closed position is a position in which the access control assembly prevents an underwater vehicle housed in the main cavity from leaving the main cavity;
 - wherein the opened position is a position in which the access control assembly does not prevent an underwater vehicle housed in the main cavity from leaving the main cavity;
 - a first sensor, the first sensor configured to generate at least one of the following real-time measurements when the main housing is submerged in a body of water:
 - a surrounding pressure of the main housing;
 - an underwater depth of the main housing; and
 - a distance remaining for the main housing to reach a bottom surface of the body of water; and
 - an access control controller assembly, the access control controller assembly configured to control the access control assembly based on the real-time measurements of the first sensor, including:
 - transitioning the access control assembly from the closed position to the opened position when the real-time measurements of the first sensor indicate at least one of the following:
 - a depth of the main housing has reached a depth equal to or greater than a target depth;
 - a surrounding pressure of the main housing has reached a pressure equal to or greater than a target surrounding pressure; and

a distance between the main housing and the bottom surface of the body of water is equal to or less than a target distance; and

transitioning the access control assembly from the opened position to the closed position when the real-time measurements of the first sensor indicate at least one of the following:

a depth of the main housing is no longer at a depth that is greater than or equal to the target depth;

a surrounding pressure of the main housing is no longer at a pressure that is greater than or equal to the target surrounding pressure; and

a distance between the main housing and the bottom surface of the body of water is no longer at a distance that is less than or equal to the target distance.

2. The system of claim 1, wherein at least one of the following apply:

the main housing is formed as a cage; and

the access control controller assembly includes a pressure actuator configured to pneumatically actuate the access control assembly relative to the main housing.

3. The system of claim 1, wherein:

when the access control assembly is at the closed position or in a position between the opened position and the closed position, the underwater vehicle is prevented from leaving the main cavity via the access control assembly.

4. The system of claim 1, further comprising a processor;

wherein the processor is configured to:

receive the real-time measurements from the first sensor; and

perform a determination, based on the received real-time measurements from the first sensor, as to whether or not the main housing has reached the bottom surface of the body of water.

5. The system of claim 4, wherein the processor is further configured to:

responsive to a determination that the main housing has reached the bottom surface of the body of water:

actuate the access control assembly to the opened position.

6. The system of claim 4, wherein the processor is further configured to:

responsive to a determination that the main housing has not reached the bottom surface of the body of water:

actuate the access control assembly to the closed position.

7. The system of claim 4, wherein:

the determination as to whether or not the main housing has reached the bottom surface of the body of water is based on at least one of the following:

a determination as to whether or not a depth of the main housing is greater than or equal to the target depth;

a determination as to whether or not a surrounding pressure of the main housing is greater than or equal to the target surrounding pressure; and

a determination as to whether or not a distance between the main housing and the bottom surface of the body of water is less than or equal to the target distance.

8. The system of claim 1, further comprising a processor;

wherein the processor is configured to:

receive the real-time measurements from the first sensor;

perform a determination, based on the received real-time measurements from the first sensor, as to whether or not a target goal has been achieved, the target goal including at least one of the following:

a depth of the main housing is greater than or equal to the target depth;

a surrounding pressure of the main housing is greater than or equal to the target surrounding pressure; and

a distance between the main housing and the bottom surface of the body of water is less than or equal to the target distance;

responsive to a determination that the target goal has been achieved:

actuate the access control assembly to the opened position; and

responsive to a determination that the target goal has not been achieved:

actuate the access control assembly to the closed position.

9. The system of claim 1, wherein at least one of the following apply:

the target depth is determined based on an estimated total distance to the bottom surface of the body of water; and

the target surrounding pressure is determined based on an estimated surrounding pressure present at the bottom surface of the body of water.

10. The system of claim 1, wherein:
the first sensor is configured to generate a surrounding pressure of the main housing; and
the system further includes a second sensor, the second sensor configured to generate an underwater depth of the main housing.
11. A system for managing an underwater vehicle, the system comprising:
a main housing, the main housing including:
a main cavity for housing an underwater vehicle, the main cavity formed by at least:
a top side of the main housing;
a bottom side of the main housing opposite to the top side of the main housing;
and
surrounding sides of the main housing formed between the top and bottom sides;
an access control assembly, the access control assembly provided on at least one of the surrounding sides of the main housing, the access control assembly configured to transition between a fully closed position and a fully opened position;
wherein the fully closed position is a position in which the access control assembly is fully closed;
wherein the fully opened position is a position in which the access control assembly is fully opened;
an access control controller assembly, the access control controller assembly including:
an access control assembly portion, the access control assembly portion securable to at least a portion of the access control assembly;
a main housing portion, the main housing portion securable to at least a portion of the main housing;
a control portion, the control portion in communication with the access control assembly portion and the main housing portion, the control portion including a pressure actuator assembly configured to pneumatically actuate the access control assembly portion relative to the main housing portion based on a surrounding pressure, including:
actuate the access control assembly portion relative to the main housing portion in such a way as to transition the access control assembly towards the fully opened position when the control portion detects an increase in surrounding pressure; and

actuate the access control assembly portion relative to the main housing portion in such a way as to transition the access control assembly towards the fully closed position when the control portion detects a decrease in surrounding pressure.

12. The system of claim 11, wherein:

when the access control assembly is at the fully closed position or in a position between the fully opened position and the fully closed position, the underwater vehicle is prevented from leaving the main cavity via the access control assembly.

13. The system of claim 11, further comprising:

a first sensor; and

a processor, the processor configured to:

receive real-time measurements of surrounding pressure from the first sensor; and

perform a determination, based on the received real-time measurements from the first sensor, as to whether or not the main housing has reached the bottom surface of the body of water.

14. The system of claim 13, wherein the processor is further configured to:

responsive to a determination that the main housing has reached the bottom surface of the body of water:

communicate with the control portion to actuate the access control assembly to the opened position.

15. The system of claim 13, wherein the processor is further configured to:

responsive to a determination that the main housing is approaching but has not reached the bottom surface of the body of water:

communicate with the control portion to actuate the access control assembly towards the opened position.

16. The system of claim 13, wherein:

the determination as to whether or not the main housing has reached the bottom surface of the body of water is based at least one of the following:

a determination as to whether or not a depth of the main housing is greater than or equal to a target depth;

a determination as to whether or not a surrounding pressure of the main housing is greater than or equal to a target surrounding pressure; and

a determination as to whether or not a distance between the main housing and the bottom surface of the body of water is less than or equal to a target distance.

17. The system of claim 16, wherein at least one of the following apply:

the target depth is determined based on an estimated total distance to a bottom surface of a body of water; and

the target surrounding pressure is determined based on an estimated surrounding pressure present at the bottom surface of the body of water.

18. The system of claim 11, further comprising:

a first sensor, the first sensor configured to generate at least one of the following real-time measurements when the main housing is submerged in a body of water:

a surrounding pressure of the main housing;

an underwater depth of the main housing; and

a distance remaining for the main housing to reach a bottom surface of the body of water;

wherein the control portion is further configured to actuate the access control assembly portion relative to the main housing portion based on real-time measurements of the first sensor.

19. A method of transporting an underwater vehicle between top and bottom surfaces of a body of water via a housing system, the housing system including a main housing, an access control assembly, an access control controller assembly, and a first sensor for measuring a surrounding pressure, the method comprising:

performing a configuration process, the configuration process including:

receiving, by a processor, a target depth, the target depth being an estimated total depth to the bottom surface of the body of water; and

generating, by the processor, a target surrounding pressure, the target surrounding pressure determined based on the target depth;

performing an underwater vehicle access process, the underwater vehicle access process including:

receiving, by the processor from the first sensor, real-time measurements of surrounding pressure;

performing, by the processor, a determination as to whether or not the main housing has reached the bottom surface of the body of water by comparing the real-time measurements of surrounding pressure with the target surrounding pressure; and

responsive to a determination, by the processor, that the real-time measurements of surrounding pressure are greater than or equal to the target surrounding pressure:

actuate the access control assembly to the opened position.

20. The method of claim 19, further comprising:

responsive to a determination, by the processor, that the real-time measurements of surrounding pressure are less than the target surrounding pressure:

actuating the access control assembly to the closed position.

21. The method of claim 19, wherein at least one of the following apply:

the main housing is formed as a cage; and

the access control controller assembly includes a pressure actuator configured to pneumatically actuate the access control assembly relative to the main housing.

22. The method of claim 19, wherein:

when the access control assembly is at the closed position or in a position between the opened position and the closed position, the underwater vehicle is prevented from leaving the main cavity via the access control assembly.

23. The method of claim 19, wherein:

the housing system further includes a second sensor, the second sensor configured to generate an underwater depth of the main housing.

24. A system for managing an underwater vehicle, the system comprising:

a main housing, the main housing including:

a main cavity for housing an underwater vehicle;

an access control assembly, the access control assembly configured to transition between a closed position and an opened position;

a first sensor, the first sensor configured to generate a real-time measurement of a surrounding pressure of the main housing;

an access control controller assembly, the access control controller assembly configured to:

transition the access control assembly towards the opened position when a surrounding pressure of the main housing increases towards a target surrounding pressure;

transition the access control assembly towards the closed position when a surrounding pressure of the main housing decreases away from the target surrounding pressure.

25. The system of claim 24, wherein at least one of the following apply:
 - the main housing is formed as a cage; and
 - the access control controller assembly includes a pressure actuator configured to pneumatically actuate the access control assembly relative to the main housing.
26. The system of claim 24, wherein:
 - when the access control assembly is at the closed position or in a position between the opened position and the closed position, the underwater vehicle is prevented from leaving the main cavity via the access control assembly.
27. The system of claim 24, further comprising a processor;
 - wherein the processor is configured to:
 - receive the real-time measurements from the first sensor; and
 - perform a determination, based on the received real-time measurements from the first sensor, as to whether or not the main housing has reached a bottom surface of a body of water.
28. The system of claim 27, wherein the processor is further configured to:
 - responsive to a determination that the main housing has reached the bottom surface of the body of water:
 - actuate the access control assembly to the opened position.
29. The system of claim 27, wherein:
 - the determination as to whether or not the main housing has reached the bottom surface of the body of water is based on at least one of the following:
 - a determination as to whether or not a depth of the main housing is greater than or equal to a target depth;
 - a determination as to whether or not a surrounding pressure of the main housing is greater than or equal to the target surrounding pressure; and
 - a determination as to whether or not a distance between the main housing and the bottom surface of the body of water is less than or equal to a target distance.

30. The system of claim 24, further comprising a processor;
wherein the processor is configured to:
 receive the real-time measurements from the first sensor;
 perform a determination, based on the received real-time measurements from the first sensor, as to whether or not a target goal has been achieved, the target goal including at least one of the following:
 a depth of the main housing is greater than or equal to a target depth;
 a surrounding pressure of the main housing is greater than or equal to a target surrounding pressure; and
 a distance between the main housing and a bottom surface of a body of water is less than or equal to a target distance;
 responsive to a determination that the target goal has been achieved:
 actuate the access control assembly to the opened position; and
 responsive to a determination that the target goal has not been achieved:
 actuate the access control assembly to the closed position.
31. The system of claim 24, wherein:
 the target surrounding pressure is determined based on an estimated surrounding pressure present at a bottom surface of a body of water.
32. The system of claim 24, wherein:
 the system further includes a second sensor, the second sensor configured to generate a real-time measurement of an underwater depth of the main housing.