

A FLOATING PLATFORM

Field of the Invention

This invention relates to a floating platform that has a buoyant structure that is less exposed to hydrodynamic forces induced by environmental elements such as wave, wind and current. Being of lattice type (space frame) construction, the buoyant structure, which comprises of space frame trusses, is structurally light, rigid, durable and additionally able to handle heavy payloads. In particular, the floating platform comprises a buoyant structure that is provided with a horizontal planar deck whereby the buoyant structure may be connected to other buoyant structures to increase the load handling capability of the floating platform. Additionally, the buoyant structure comprises groups of diagonal tubular members arranged transversely in the vertical plane and connected to each other via a matrix of highly buoyant tubular members arranged longitudinally in the horizontal plane. These are interconnected using connecting nodes to achieve the desired hydrostatic, hydrodynamic and structural properties.

Summary of the Prior Art

In recent times, attempts have been made to design floating platforms that are able to handle various payloads in various water conditions. Unfortunately, the designs proposed thus far suffer from severe limitations of usability as a large section of such platforms substantially interact with the water's surface due to existing platforms' larger water plane area, i.e. the cross section of the platform in the draft at which the floating platform is afloat and also large weather exposed areas. In rough seas and oceans, platforms having large water plane areas and cross sections will be susceptible to high degrees of undesired motions and forces, thereby making it difficult for such platforms to remain stable, level and structurally integral.

In other words, as the platform has a high water plane area, this makes it sensitive to severe wave motions, thereby restricting its usability to only still water bodies such as lakes or dams thereby preventing it from being deployed out at sea. Its deployment in still waters only further reduces the utility of such platform designs. Apart from having poor sea keeping properties, the structure of existing floating platforms are not sufficiently strong and rigid to handle the wave loads in the oceans. Hence such platforms suffer significantly in terms of long design life applicability and scalability; one of the main culprits being fatigue failure.

Existing platforms also commonly utilize designs that allow individual blocks to be chained together using flexible or substantially resilient connecting elements thereby providing

several degrees of freedom to each individual block however, this reduces the system's overall rigidity. In particular, existing platforms tend to be interconnected individual blocks in large arrays whereby overlapping portions of adjacent blocks link these blocks together. Such an approach may be utilized to create a larger floating platform in areas where there are no waves, however, in areas with sustained waves and / or swells, the foresaid interconnections do not have enough strength to hold the blocks together, resulting in the respective connections failing. This loss of rigidity raises major safety concerns as the individual blocks tend to move significantly relative to each other, presenting a serious safety hazard to maintenance crew who board these platforms periodically and also to marine traffic in the vicinity of the platform.

It has also been proposed that heavier mooring systems be deployed in order to handle the rougher water conditions. However, the downside of this approach is that such mooring systems may not be integrated with pontoon shaped floater modules due to its buoyancy limitations and structural weaknesses at the mooring line connection point, as well as connection means between various pontoons. This potentially results in pontoon shaped floaters having numerous mooring lines to distribute the mooring load, more equipment / accessories being unnecessarily used, longer installation times which will eventually lead to increased costs, and failures at the connecting joints as these joints are constantly exposed to undulating waves.

For those above reasons, those skilled in the art are constantly striving to come up with a floating platform module with a low water plane area, has sufficient rigidity and may be expanded to accommodate larger payloads.

Summary of the Invention

The above and other problems are solved and an advance in the art is made by systems and methods provided by embodiments in accordance with the invention.

A first advantage of embodiments of a platform in accordance with the invention is that the floating platform has a small water plane area and high structural rigidity.

A second advantage of embodiments of a platform in accordance with the invention is that the size of the floating platform may be easily expanded to accommodate heavier payloads. This expansion uses standardized components which can be either readily procured or fabricated in-house and assembled quickly as required, even when the platform has been deployed in open water.

As an extension of this second advantage, the increase in payload handling is mainly due to the addition of buoyancy elements below the free surface (waterline) so as to make the floater less susceptible to wave actions.

A third advantage of embodiments of a platform in accordance with the invention is that lighter mooring lines may be used with the floating platform.

A fourth advantage of embodiments of a platform in accordance with the invention is that the platform has reserve buoyancy available in case certain tubulars are damaged due to external factors.

A fifth advantage of embodiments of a platform in accordance with the invention is that the configuration provides inherently strong locations which can be used to connect features such as mooring lines, other green energy producing elements (e.g. tidal turbine), weathervane arrangements (turret), control surfaces and so on.

The above advantages are provided by embodiments of a device or method in accordance with the invention operating in the following manner.

According to the first aspect of the invention, a floating platform is disclosed, the platform comprising: a horizontal planar deck; a buoyant structure for supporting the horizontal planar deck, the structure being formed of: a first space frame truss comprising a first and a second pair of supporting diagonal tubular members, a first buoyant horizontal tubular member and a first part of the horizontal planar deck, the first space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the first pair of diagonal tubular members extends upwards to the first part of the horizontal planar deck from a first end of the first horizontal tubular member and diverging ends of the second pair of diagonal tubular members extends upwards to the first part of the horizontal planar deck from a second end of the first horizontal tubular member, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the first horizontal tubular member using a first or a second corner connecting node; a second space frame truss comprising a third and a fourth pair of supporting diagonal tubular members, a second buoyant horizontal tubular member and a second part of the horizontal planar deck, the second space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the third pair of diagonal tubular members extends upwards to the second part of the horizontal planar deck from a first end of the second horizontal tubular member and diverging ends of the fourth pair of diagonal tubular members extends upwards to the second part of the horizontal planar deck from a second end of the second horizontal tubular member, whereby

converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the second horizontal tubular member using a third or a fourth corner connecting node; whereby the first and second space frame trusses are attached together through a first connecting buoyant tubular member attached to the first and the third corner connecting nodes and through a second connecting buoyant tubular member attached to the second and fourth corner connecting nodes, and wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

With regard to the first aspect of the invention, the first buoyant structure further comprises: a first balancing buoyant tubular member having a first and a second balancing connecting node attached to ends of the first balancing buoyant tubular member, whereby the first balancing connecting node is attached to the first corner connecting node of the first space frame truss and the second balancing connecting node is attached to the second corner connecting node of the first space frame truss such that the first balancing buoyant tubular member is parallel with the buoyant horizontal tubular member of the first space frame truss.

With regard to the first aspect of the invention, the buoyant structure further comprises: a second balancing buoyant tubular member having a first and a second balancing connecting node attached to ends of the second balancing buoyant tubular member, whereby the first balancing connecting node is attached to the third corner connecting node of the second space frame truss and the second balancing connecting node is attached to the fourth corner connecting node of the second space frame truss such that the second balancing buoyant tubular member is parallel with the buoyant horizontal tubular member of the second space frame truss.

With regard to the first aspect of the invention, the buoyant structure further comprises: a lower horizontal buoyant structure formed of four buoyant horizontal tubular members that are connected together using four lower corner connecting nodes, whereby each lower corner connecting node is attached to one of the corner connecting nodes of the first or second space frame trusses.

With regard to the first aspect of the invention, the buoyant structure further comprises: a third space frame truss comprising a fifth and a sixth pair of supporting diagonal tubular members, a third buoyant horizontal tubular member and a third part of the horizontal planar deck, the third space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the fifth pair of diagonal tubular members extends upwards to the third part of the horizontal planar deck from a first end of the third horizontal tubular member

and diverging ends of the sixth pair of diagonal tubular members extends upwards to the third part of the horizontal planar deck from a second end of the third horizontal tubular member, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the third horizontal tubular member using a fifth or a sixth corner connecting node; whereby the second and third space frame trusses are attached together through a third connecting buoyant tubular member attached to the third and the fifth corner connecting nodes and through a fourth connecting buoyant tubular member attached to the fourth and sixth corner connecting nodes, and wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

With regard to the first aspect of the invention, the buoyant structure further comprises: a mini turret affixed to the corner connecting nodes of the first and second space frame trusses to allow the floating platform module to weathervane about the mini turret.

With regard to the first aspect of the invention, the buoyant structure further comprises: a pair of rudders affixed to the corner connecting nodes of the first and second space frame trusses, the pair of rudders being connected to a directional controller provided on the planar deck whereby the directional controller is configured to use one or a plurality of rudder(s) to control a bearing of the floating platform module.

With regard to the first aspect of the invention, the buoyant structure further comprises: one or a plurality of ballast tank(s) provided at a base of the lower horizontal buoyant structure; an accumulator and an air compressor provided on the horizontal planar deck whereby the accumulator is configured to supply compressed air to the ballast tank; and a controller, provided on the horizontal planar deck, to control an amount of compressed air supplied by the accumulator and the air compressor to the ballast tank.

With regard to the first aspect of the invention, the accumulator is further configured to supply compressed air to one or more of the buoyant horizontal tubular members of the lower horizontal buoyant structure.

With regard to the first aspect of the invention, solar panel modules are provided on the horizontal planar deck.

With regard to the first aspect of the invention, the buoyant structure further comprises: a fourth buoyant horizontal tubular member having a first end attached to a centre of the second corner connecting node and having a second end attached to a centre of the seventh corner connecting node; a seventh pair of diagonal tubular members having ends that diverge

upwards from the seventh corner connecting node to a fourth part of the horizontal planar deck; a fifth buoyant horizontal tubular member having a first end attached to the fourth corner connecting node and having a second end attached to an eighth corner connecting node; an eighth pair of diagonal tubular members having ends that diverge upwards from the eighth corner connecting node to a fifth part of the horizontal planar deck, whereby a fifth connecting buoyant tubular member has an end attached to the seventh corner connecting node and another end to the eighth corner connecting node, and wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

With regard to the first aspect of the invention, the floating platform further comprises: another buoyant structure provided below the buoyant structure for supporting the buoyant structure, the another buoyant structure being formed of a fourth space frame truss comprising a seventh and an eighth pair of supporting diagonal tubular members, and a fourth buoyant horizontal tubular, the fourth space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the seventh and eighth pair of diagonal tubular members extends upwards to the corner connecting nodes of the first and second space frame trusses, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the fourth horizontal tubular member using a seventh or an eighth corner connecting node; a fifth space frame truss comprising a ninth and a tenth pair of supporting diagonal tubular members, and a fifth buoyant horizontal tubular, the fifth space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the ninth and tenth pair of diagonal tubular members extends upwards to the corner connecting nodes of the second and third space frame trusses, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the fifth horizontal tubular member using a ninth or a tenth corner connecting node; whereby the fourth and fifth space frame trusses are attached together through a fifth connecting buoyant tubular member attached to the seventh and ninth corner connecting nodes and through a sixth connecting buoyant tubular member attached to the eighth and tenth corner connecting nodes, and wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

Brief Description of the Drawings

The above advantages and features in accordance with this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a two-point perspective of two space frame trusses of a floating platform in accordance with embodiments of the invention;

Figure 2 illustrating a two-point perspective of three space frame trusses of a floating platform in accordance with embodiments of the invention;

Figure 3 illustrating a two-point perspective of a floating platform in accordance with embodiments of the invention;

Figure 4 illustrating a front elevation view of a floating platform in accordance with embodiments of the invention;

Figure 5 illustrating a side elevation view of the floating platform in accordance with embodiments of the invention;

Figure 6 illustrating a plan view of a floating platform with a weathervane attachment and rudder system in accordance with embodiments of the invention;

Figure 7 illustrating a side elevation view of a floating platform with the weathervane attachment and mooring lines in accordance with embodiments of the invention;

Figure 8 illustrating a side elevation view of the floating platform with a ballasting system in accordance with embodiments of the invention;

Figure 9 illustrating a front elevation view of a connecting node in accordance with embodiments of the invention;

Figure 10 illustrating a side elevation view of a connecting node with a longitudinal tubular member in accordance with embodiments of the invention;

Figure 11 illustrating a front elevation view of another embodiment of the floating platform in accordance with embodiments of the invention; and

Figure 12 illustrating a two-point perspective of the floating platform in Figure 11 in accordance with embodiments of the invention.

Detailed Description

This invention relates to a floating platform that has a buoyant structure that is less affected by hydrodynamic forces induced by environmental elements such as wave, wind and current. Being of lattice type (space frame) construction, the buoyant structure, which comprises of space frame trusses, is structurally light, rigid, durable and additionally able to

handle heavy payloads. In particular, the floating platform comprises a buoyant structure that is provided with a horizontal planar deck whereby the buoyant structure may be connected to other buoyant structures to increase the load handling capability of the floating platform. Additionally, the buoyant structure comprises groups of diagonal tubular members arranged transversely in the vertical plane and connected to each other via a matrix of highly buoyant tubular members arranged longitudinally in the horizontal plane. These are interconnected using connecting nodes to achieve the desired hydrostatic, hydrodynamic and structural properties.

Figure 1 illustrates a two-point perspective view of an embodiment of the invention whereby a buoyant structure comprising two space frame trusses is supporting a horizontal planar deck when in use. As illustrated in this figure, floating platform 300 (as shown in Figure 3) comprises a plurality of space frame trusses that are linked together through connecting buoyant tubular members and connecting nodes. It can also be seen that horizontal planar deck 107 is fixedly attached to ends of diagonal tubular members of each of the space frame trusses such that deck 107 is able to support loads when platform 300 is in use. One skilled in the art will recognize that the floating platform may comprise a buoyant structure which comprises a pair of connected space frame trusses or a plurality of space frame trusses that are connected together without departing from the invention. Two or more such buoyant structures may then be connected together to form a larger floating platform such as platform 300 as illustrated in Figure 3. It can be seen that each of these space frame trusses generally comprise a plurality of buoyant horizontal tubular members and supporting diagonal tubular members connected together using a plurality of corner connecting nodes. The space frame trusses are then connected together through the use of connecting buoyant tubular members and the respective corner connecting nodes. In embodiments of the invention, a lower horizontal buoyant structure may be provided to the buoyant structure to improve the buoyancy of the floating platform.

As shown in Figure 1, a buoyant structure formed from two connected space frame trusses are used to support the horizontal planar deck. In particular, it is shown that a space frame truss in accordance with embodiments of the invention comprises two pairs of supporting diagonal tubular members 103a and 103b, a buoyant horizontal tubular member 102 and a part of the horizontal planar deck 107. The two pairs of diagonal members 103a and 103b, the horizontal member 102 and the part of the planar deck 107 are arranged in an inverted triangular prism arrangement such that diverging ends of the pair of diagonal tubular members 103a extends upwards to part of the horizontal planar deck 107 from an end of horizontal tubular member 102 and diverging ends of the pair of diagonal tubular members

103b extends upwards to part of the horizontal planar deck 107 from another end of horizontal tubular member 102. As can be seen from Figure 1, converging ends of the pairs of diagonal tubular members 103a and 103b are attached to an associated end of horizontal tubular member 102 using corner connecting nodes 101a and 101b respectively.

Also shown in Figure 1 is another space frame truss which comprises two pairs of supporting diagonal tubular members 106a and 106b, a buoyant horizontal tubular member 105 and another part of the horizontal planar deck 107. Similarly, the two pairs of diagonal members 106a and 106b, the horizontal member 105 and the another part of the planar deck 107 are arranged in an inverted triangular prism arrangement such that diverging ends of the pair of diagonal tubular members 106a extends upwards to another part of the horizontal planar deck 107 from an end of horizontal tubular member 105 and diverging ends of the pair of diagonal tubular members 106b extends upwards to another part of the horizontal planar deck 107 from another end of horizontal tubular member 105. As can be seen from Figure 1, converging ends of the pairs of diagonal tubular members 106a and 106b are attached to a corresponding end of horizontal tubular member 105 using corner connecting node 104a and a corresponding corner connecting node (not shown) respectively.

These two space frame trusses are then connected together using horizontal connecting buoyant tubular members that are attached to corresponding corner connecting nodes of the two space frame trusses. For example, as illustrated in Figure 1, horizontal connecting buoyant tubular member 108a is attached to corner connecting nodes 104a and 101a; and the other connecting tubular member 108b is attached to corner connecting node 101b and the corresponding corner connecting node of the another space frame truss (that is not shown) thereby connecting the two space frame trusses together.

Such an arrangement provides a reinforced buoyant structure that is able to support horizontal planar deck 107 as this structure has an increased ability to handle heavy loads. The pair of space frame trusses are able to do so as the diagonal and horizontal tubular members will absorb global and local forces applied by the payload, moorings, fenders, and the flexing of the floating platform as it responds to the dynamic wave action and inertial loads. These absorbed forces are then redistributed across the space frame trusses, through the tubular members and through the respective connecting nodes.

In accordance with embodiments of the invention, the ability of the buoyant structure to handle heavier loads may be increased through the addition of a lower horizontal buoyant structure formed of buoyant horizontal tubular members 111a-d and lower corner connecting

nodes 112-115. The lower horizontal buoyant structure is attached to the original buoyant structure (formed from the two space frame trusses) by attaching each lower corner connecting node with a corresponding corner node of the two space frame trusses. For example, as shown in Figure 1, lower corner connecting node 112 is attached to corner connecting node 101a, lower corner connecting node 113 is attached to corner connecting node 101b, lower corner connecting node 114 is attached to corner connecting node 104a, and lower corner connecting node 115 is attached to the corresponding corner connecting node that is not shown. By doing so, the lower horizontal buoyant structure further reinforces the original buoyant structure by providing additional avenues for the absorbed forces to be redistributed across.

In embodiments of the invention, a balancing buoyant tubular member may be attached to a side of the buoyant structure to improve the overall buoyancy / balance, integrity and stability of the buoyant structure and therefore, that of the floating platform. In Figure 1, it is shown that balancing buoyant tubular member 121 is attached to balancing connecting nodes 120 and 122 which are in turn attached to corner connecting nodes 101a and/or 112; and to corner connecting nodes 101b and/or 113 respectively. The balancing tubular member 121 is arranged such that at the very least, it is in parallel with horizontal tubular member 102 and may also be arranged to be parallel with horizontal tubular member 111a if the lower horizontal buoyant structure is attached to the original structure.

In embodiments of the invention, each of the connecting nodes are provided with a connector at the centre of each node and a plurality of connectors around the circumference of each node. The various types of tubular members may then be connected to these nodes using these various connectors.

Additionally, in embodiments of the invention, a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members. This ensures that the buoyant structure is able to maintain good seakeeping when the floating platform is in use, and also ensures that the weight and payload on horizontal deck 107 may be properly handled by the supporting diagonal tubular members. In further embodiments of the invention, solar panels 150 may be provided as the payload on deck 107 however, one skilled in the art will recognize that other types of payloads may be provided without departing from this invention.

In embodiments of the invention, the buoyant horizontal and supporting diagonal pairs of tubular members are filled with air and sealed at both ends such that these tubular members are buoyant when the platform is lowered into a water body. In other embodiments of the

invention, the horizontal and diagonal pairs of tubular members may be filled with a mixture of solids and gases such as being partially filled with air and partially filled with various types of solids such as, but not limited to, polyurethane foam, polyethylene balls and etc. as required to achieve the desired buoyancy and stability. However, in order to achieve the required buoyancy, seakeeping behaviour and stability when in use in a water body, the diameter of each of the buoyant horizontal tubular members is designed to be larger than the diameter of each of the diagonal pairs of tubular members. In an embodiment of the invention, the diameter of the buoyant horizontal tubular members are ≥ 10 inches while the diameter of the diagonal pairs of tubular members are ≤ 10 inches. In an exemplary embodiment of the invention, the buoyant horizontal tubular members may comprise a diameter of 14 inches while the diameter of the diagonal pairs of tubular members may comprise a diameter of 8 inches. In general, the buoyant horizontal tubular members contribute to the buoyancy of the floating platform while the supporting diagonal pairs of tubular members contribute to the hydrostatic and structural stability of the platform.

In another embodiment of the invention, only selected diagonal pairs and buoyant horizontal tubular members are filled with air and sealed whereby tubular members that are not filled with air may be filled with various types of solid to alter the buoyancy and stability of the floating platform as required. For example, PU Foam filling may be used in certain tubular members so that they would be far less permeable to water when damaged.

In order to increase the buoyancy and load handling capability of the buoyant structure of the floating platform, additional space frame trusses and/or sets of horizontal/ longitudinal pairs of tubular members may be added to the buoyant structure as illustrated in Figure 2.

Figure 2 illustrates the addition of a third space frame truss which comprises two pairs of supporting diagonal tubular members 206a and 206b, a buoyant horizontal tubular member 250 and another part of the horizontal planar deck 107. Similarly, the two pairs of diagonal members 206a and 206b, the horizontal member 250 and the another part of the planar deck 107 are arranged in an inverted triangular prism arrangement such that diverging ends of the pair of diagonal tubular members 206a extends upwards to another part of the horizontal planar deck 107 from an end of horizontal tubular member 250 and diverging ends of the pair of diagonal tubular members 206b extends upwards to another part of the horizontal planar deck 107 from another end of horizontal tubular member 250. As can be seen from Figure 3, converging ends of the pairs of diagonal tubular members 206a and 206b are attached to a corresponding end of horizontal tubular member 250 using corner connecting node 204a and a corresponding corner connecting node (not shown) respectively.

This third space frame truss is then connected together to the other two space frame trusses through the use of horizontal connecting buoyant tubular members that are attached to the corresponding corner connecting nodes of the space frame trusses. For example, as illustrated in Figure 2, horizontal connecting buoyant tubular member 208 is attached to corner connecting nodes 204a and 104a; and the other connecting tubular member (not shown) is attached to the corner connecting node of the third space frame truss (also not shown) and the corresponding corner connecting node of the another space frame truss (not shown) thereby connecting the space frame trusses together.

In further embodiments of the invention, in addition to adding the third space frame truss or in place of the third space frame truss, a set of horizontal/diagonal pairs of tubular members may be added to the buoyant structure. As illustrated in Figure 2, the additional set of horizontal/diagonal pairs of tubular members may comprise supporting diagonal tubular members 103c and 106c, three buoyant horizontal tubular members of which only member 202 can be seen and a part of the horizontal planar deck 107. The diagonal pairs of tubular members 103c and 103b, the horizontal member 202 and the part of the planar deck 107 are similarly arranged in an inverted triangular prism arrangement. The diverging ends of the pair of diagonal tubular members 103c are arranged to extend upwards to part of the horizontal planar deck 107 from an end of horizontal tubular member 202 through corner connecting node 201b. Similarly, the diagonal pairs of tubular members 106c and 106b, a horizontal member connecting tubular members 106b and 106c together; and the part of the planar deck 107 are similarly arranged in an inverted triangular prism arrangement. The diverging ends of the pair of diagonal tubular members 106c are then arranged to extend upwards to part of the horizontal planar deck 107 from an end of the horizontal tubular member through a corresponding corner connecting node.

Similarly, in accordance with embodiments of the invention, the ability of the buoyant structure to handle heavier loads may be increased through the addition of a lower horizontal buoyant structure formed of buoyant horizontal tubular members and lower corner connecting nodes. In Figure 2, although only lower corner connecting nodes 213, 214 and buoyant horizontal tubular members 211, 211a are shown, one skilled in the art will recognize that the other connecting nodes and horizontal tubular members may be arranged as described in the earlier sections to provide additional buoyancy support to the original buoyant structure. The lower horizontal buoyant structure is then similarly attached to the original buoyant structure by attaching each lower corner connecting node with a corresponding corner node of the original space frame truss. For example, as shown in Figure 2, lower corner connecting node

214 is attached to corner connecting node 204a, lower corner connecting node 213 is attached to corner connecting node 201b, and etc.

In embodiments of the invention, an additional balancing buoyant tubular member may be attached to a side of the buoyant structure to improve the overall balance of the buoyant structure and indirectly, the balance of the floating platform. In Figure 2, it is shown that the additional balancing buoyant tubular member 221 is attached to balancing connecting nodes 122 and 222 which are in turn attached to corner connecting nodes 101b and/or 113; and to corner connecting nodes 201b and/or 213 respectively.

Hence, by adding additional space frame trusses and/or sets of horizontal/diagonal pairs of tubular members to the buoyant structure, the buoyancy and load handling capability of the floating platform may be increased as required. In accordance with an embodiment of the invention, an exemplary floating platform comprising a plurality of space frame trusses and additional sets of horizontal/diagonal pairs of tubular members is illustrated in Figure 3. Additionally, Figure 3 also illustrates an additional set 302 of buoyant tubular members and their balancing connecting nodes that has been added to an opposing side of the buoyant structure to ensure that floating platform 300 is evenly balanced.

By selectively adding space frame trusses and the sets of horizontal/diagonal pairs of tubular members to the buoyant structure as required, the load bearing deck area of platform 100 may then be sequentially increased as required. Additionally, such a manner of connecting the space frame trusses together is advantageous as the system's overall rigidity will not be compromised and as these connections will have sufficient strength to hold the space frames together, thereby alleviating most major safety concerns as the space frame trusses will not move significantly relative to each other.

In accordance with embodiments of the invention, loads such as solar panels 350 may be provided on horizontal planar deck 107 of floating platform 300. When such an arrangement is used, platform 100 may then be utilized as a floating solar generating platform as such a platform would be able to handle wave motions due to its stable and rigid frame. A walkway or path may also be provided between solar panels 350 to allow maintenance crew to maintain solar panels 350 safely and efficiently.

Figure 4 illustrates a front elevation view of floating platform 100 which clearly shows the connections between the space frame trusses while Figure 5 illustrates a side elevation view of platform 100 which shows the connections between the space frame truss and a set of horizontal/diagonal pairs of tubular members as described in the earlier sections above. By

combining these two methods of connecting the space frames together, the overall size of floating platform 100 may then be increased as required without sacrificing the overall stability and rigidity of the structure. The load bearing capability of floating platform 100 will then be increased accordingly.

Figure 6 illustrates a plan view of another embodiment of the invention whereby a weather-vane system is added to floating platform 100 thereby allowing platform 100 to change its bearing to a path of least resistance as the currents and weather changes, thereby reducing the wave motions acting on platform 100. In this embodiment of the invention, the weather-vane system comprises external mooring node 605 that is attached to a number of anchor lines (704 in Figure 7). The mooring node 605 is also provided with arms 607a and 607b that are connected to the centre of corner connecting nodes; and supporting arm 707 (see Figure 7) that is connected to the centre of a lower corner connecting node. As the arms 607a, 607b and 707 are connected to the connecting nodes and not to the vertical and/or horizontal tubular members, this ensures a stable connection throughout the weather vanning process as there is the strong likelihood that the tubular members would have snapped if arms 607a, 607b and 707 were not connected to the nodes. Additionally, as platform 100 is provided with such connecting nodes, this negates the need for additional devices or systems to be added to the surface of deck 140 or to the space frames to allow the weather-vane system to be implemented on platform 100.

The external mooring node 605 (which is fixed via a number of anchor lines to the seabed) allows platform 100 to freely weather vane around, adopting the direction of the least resistance against waves, wind and currents. This is advantageous for stability purposes as platform 100 is able to automatically adopt a heading that provides the least resistance against the raging elements. Without external mooring node 605, the operator of platform 100 would have to rely on other instruments to determine the most suitable heading to achieve the required stability.

In other embodiments of the invention, external mooring node 605 may be complemented with any configuration of tidal turbines 601a-h which may be provided at the sides of the normal/lower corner connecting nodes. As the tidal turbines are connected to the connecting nodes and not to the vertical and/or horizontal tubular members, this ensures a stable connection throughout the steering process. Similarly, as platform 100 is provided with such connecting nodes, this negates the need for additional devices or systems to be added to the surface of deck 107 or to the space frames to allow the turbines to be added onto platform 100. The bearing of platform 100 may then be controlled using rudder 610 and rudder

actuator 612. In particular, rudder 610 may be controlled by rudder actuator 612 to alter the bearing of platform 100 so that it is able to achieve its desired bearing expeditiously in order to maximize the fluid inflow to the turbine blades and minimize the effects of wave action on the motions / response of platform 100.

Although Figure 6 illustrates eight turbines being used, one skilled in the art will recognize that any number of turbines may be utilized without departing from this invention as any number of turbines may be attached to the existing connectors of platform 100 as required. Additionally, in other embodiments of the invention, the rudder may be used to adjust the bearing of platform 100 so that the solar panels provided on deck 107 may follow the movement of the sun to optimize the generation of power by these panels. Figure 7 illustrates the side elevation view of the weather-vane system shown in Figure 6 and as shown, it can be seen that the mooring lines 704, via a sliding interface 750 will anchor the external mooring node 605 in a stable manner. A skeg area 710 is also provided between part of the original buoyant structure and the lower horizontal buoyant structure to assist platform 100 in aligning with the direction of the current.

In yet another embodiment of the invention, a ballasting system is added to platform 100 so that the draft of platform 100 may be increased or reduced as required, depending on the payload on platform 100. In particular, the ballasting system comprises controller 805 that is communicatively connected to air escape solenoid valve 830, compressed air solenoid valve 812 and discharge/intake solenoid valve 820 to control the opening and closing of these valves. The ballasting system also includes electric air compressor 815 and accumulator 810 that is fluidly connected to variable ballast tank 825 which is in turn fluidly connected to air escape solenoid valve 830 whereby accumulator 810 is used to store air that has been compressed by air compressor 815. As illustrated in Figure 8, variable ballast tank 825 may be connected to the space frame trusses of platform 100 using the connectors provided at the corner connecting nodes.

In operation, controller 805 would receive an input signal from a sensor module (not shown) that would be configured to use a plurality of sensors provided on platform 100 to detect the draft of platform 100, a depth of the water body that platform 100 is floating on, the direction of the water body's current, the height of the tide and any other external parameters that may be required to ensure platform 100 remains stable throughout. Based on the received input signal, controller 805 then determines whether the ballasting system is to perform a ballasting or de-ballasting operation.

When a ballasting operation is performed, controller 805 will cause solenoid valve 820 and air escape solenoid valve 830 to open and will simultaneously cause compressed air solenoid valve 812 to close. When this happens, water will flood ballast tank 825 through a valve connected to solenoid valve 820 and this in turn causes air contained within tank 825 to be discharged through a valve connected to solenoid valve 830, filling tank 825 to the desired level to achieve the draft required of platform 100. Controller 805 will then cause solenoid valve 820 and air escape solenoid valve 830 to close.

Conversely, when a de-ballasting operation is performed, controller 805 will cause discharge solenoid valve 820 and compressed air solenoid valve 812 to open and will simultaneously cause air escape solenoid valve 830 to close. When this happens, compressed air stored within accumulator 810 will flow along the pipes and cause water contained within ballast tank 825 to be displaced and discharged out through a valve connected to discharge solenoid valve 820. When the desired draft of platform 100 has been achieved, controller 805 will then close discharge solenoid valve 820 and compressed air solenoid valve 812.

In further embodiments of the invention, the horizontal tubular members of platform 100 may be used in place of variable ballast tank 825 whereby these tubular members may be ballasted and de-ballasted as described above to adjust the draft of platform 100. In this embodiment, discharge solenoid valve 820 will be attached to the horizontal tubular members so that water may flood the tubular members and conversely, so that water may be discharged from these horizontal tubular members as controlled by controller 805.

Figure 9 illustrates an expanded view of a connecting node that may be used as a lower/corner connecting node in accordance with embodiments of the invention. Connecting node 900 comprises a plurality of connectors 905a-e that are provided around the circumference of node 900 whereby these connectors 905a-e are each configured to receive tubular members of various sizes. For example, as illustrated, diagonal tubular member 901a is connected to connector 905a, diagonal tubular member 901b is connected to connector 905b, and a horizontal tubular member is connected to the centre 903 of the node. Additionally, a turbine 935 may also be connected to one of connectors 905 as required, e.g. connector 905c. A swivel joint 915 is also provided at the base of connecting node 900 to allow the platform to weathervane when connected to the full set of anchoring lines. In embodiments of the invention that require mooring lines to be attached to platform 100, a mooring pad-eye 910 may be provided at connecting node 900. The mooring lines may then be easily attached to

mooring pad-eye 910 without jeopardizing the structural integrity of the space frames that form the support for platform 100.

A side elevation view of connecting node 900 is illustrated in Figure 10. As illustrated, it is shown that a buoyant horizontal tubular member 1020 is connected to the central connector 903 of node 900. Brackets or webs 1005 are used to connect node 900 to a plurality of connectors 905a-h provided around the circumference of node 900 and these brackets/webs 1005 facilitate the connection of bracings, structural ties, columns, mooring pad-eyes, swivels, or any other additional accessories or modules to node 900. It should be noted that any loads acting on node 900 may be transferred to a node ring 1010 which is provided at every one of connectors 905 a-h and brackets/webs 1005. The node ring 1010 interconnects the brackets or webs 1005 as a junction for transfer of forces and moments to the larger buoyant horizontal tubular members. Additionally, node ring 1010 provides a neat interface between the diagonal pairs of tubular members and the node 900, which makes it easy to integrate the assembly. These node rings 1010 may comprise, but are not limited to, thick rings made of the same material as the node that interfaces with a buoyant element of the space frame.

Figure 11 illustrates a front elevation view of another embodiment of the floating platform in accordance with embodiments of the invention. As illustrated in this figure, this floating platform 1100 comprises a plurality of space frame trusses that are linked together through connecting buoyant tubular members and connecting nodes (as previously described the sections above in relation to Figures 1-5).

As shown in Figure 11, a buoyant structure formed from at least three connected space frame trusses are used to support the horizontal planar deck. In particular, it is shown that the first space frame truss comprises two pairs of supporting diagonal tubular members 103a and 103b (not shown), a buoyant horizontal tubular member 102 (not shown) and a part of the horizontal planar deck 107 while the second space frame truss comprises two pairs of supporting diagonal tubular members 106a and 106b (not shown), a buoyant horizontal tubular member 105 (not shown) and another part of the horizontal planar deck 107. The third space frame truss also comprises two pairs of supporting diagonal tubular members 206a and 206b (not shown), a buoyant horizontal tubular member 250 (not shown) and another part of the horizontal planar deck 107.

Additionally, as can be seen from Figure 11, converging ends of the pairs of diagonal tubular members 103a and 103b (not shown) are attached to a corresponding end of

horizontal tubular member 102 (not shown) using corner connecting node 101a and a corresponding corner connecting node (not shown) respectively; converging ends of the pairs of diagonal tubular members 106a and 106b are attached to a corresponding end of horizontal tubular member 105 (not shown) using corner connecting node 104a and a corresponding corner connecting node (not shown) respectively; and converging ends of the pairs of diagonal tubular members 206a and 206b are attached to a corresponding end of horizontal tubular member 250 using corner connecting node 204a and a corresponding corner connecting node (not shown) respectively.

These three space frame trusses are then connected together using horizontal connecting buoyant tubular members that are attached to corresponding corner connecting nodes of the two space frame trusses. For example, horizontal connecting buoyant tubular member 108a is attached to corner connecting nodes 104a and 101a; and as previously described, the other connecting tubular member 108b is attached to corner connecting node 101b and the corresponding corner connecting node of the another space frame truss (that are both not shown) thereby connecting the two space frame trusses together. Similarly, horizontal connecting buoyant tubular member 208 is attached to corner connecting nodes 104a and 204a and the other connecting tubular member is attached to another corner connecting node and the corresponding corner connecting node of the another space frame truss (that are both not shown) thereby connecting the two space frame trusses together. The resulting structure then comprises three space frame trusses that are connected together.

Lower horizontal buoyant structures formed of buoyant horizontal tubular members 111a-d and lower corner connecting nodes 112-115 are also attached to the buoyant structure (formed from the two space frame trusses) by attaching each lower corner connecting node with a corresponding corner node of the two space frame trusses. This was described in detail in the previous sections above.

In the embodiment shown in Figure 11, it is shown that another layer of space frame trusses which is layer 1150 comprises space frame trusses that are connected together, e.g. space frame trusses 1102 and 1104 that are connected together using horizontal connecting buoyant tubular member 1106, and their corresponding horizontal buoyant structures, e.g. comprising corner connecting nodes 1108, 1112 and buoyant horizontal tubular member 1110, may be connected below the original layer of lower horizontal buoyant structures to further improve the buoyancy and stability of the floating platform.

As shown in Figure 11, a buoyant structure formed from at least three connected space frame trusses are used to support the horizontal planar deck. In particular, it is shown that the first space frame truss comprises two pairs of supporting diagonal tubular members 103a and 103b (not shown), a buoyant horizontal tubular member 102 (not shown) and a part of the horizontal planar deck 107 while the second space frame truss comprises two pairs of supporting diagonal tubular members 106a and 106b (not shown), a buoyant horizontal tubular member 105 (not shown) and another part of the horizontal planar deck 107. The third space frame truss also comprises two pairs of supporting diagonal tubular members 206a and 206b (not shown), a buoyant horizontal tubular member 250 (not shown) and another part of the horizontal planar deck 107.

Additionally, as can be seen from Figure 11, converging ends of the pairs of diagonal tubular members 103a and 103b (not shown) are attached to a corresponding end of horizontal tubular member 102 (not shown) using corner connecting node 101a and a corresponding corner connecting node (not shown) respectively; converging ends of the pairs of diagonal tubular members 106a and 106b (not shown) are attached to a corresponding end of horizontal tubular member 105 (not shown) using corner connecting node 104a and a corresponding corner connecting node (not shown) respectively; and converging ends of the pairs of diagonal tubular members 206a and 206b (not shown) are attached to a corresponding end of horizontal tubular member 250 using corner connecting node 204a and a corresponding corner connecting node (not shown) respectively.

One skilled in the art will recognize that layer 1150 may comprise of any number of space frame trusses without departing from this invention. Figure 11 also illustrates another layer of space frame trusses which is layer 1152 which is connected below layer 1150 in a similar manner. One skilled in the art will recognize that any number of additional layers may be added beneath layer 1150 without departing from this invention. Figure 12 illustrates a two-point perspective of the floating platform illustrated in Figure 11 in accordance with embodiments of the invention.

Further, it is useful to note that in all the embodiments of the invention, a diameter of each of the buoyant tubular members is configured to be larger than a diameter of each of the diagonal tubular members. This ensures that the buoyant structure is able to maintain its balance when the floating platform is in use, the floating platform is exposed to less wave loads and also ensures that the weight and payload on horizontal deck 107 may be properly handled by the supporting diagonal tubular members.

The above is a description of embodiments of a platform and modules in accordance with the present invention as set forth in the following claims. It is envisioned that others may and will design alternatives that fall within the scope of the following claims.

CLAIMS:

1. A floating platform comprising:
a horizontal planar deck;
a buoyant structure for supporting the horizontal planar deck, the structure being formed of:

a first space frame truss comprising a first and a second pair of supporting diagonal tubular members, a first buoyant horizontal tubular member and a first part of the horizontal planar deck, the first space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the first pair of diagonal tubular members extends upwards to the first part of the horizontal planar deck from a first end of the first horizontal tubular member and diverging ends of the second pair of diagonal tubular members extends upwards to the first part of the horizontal planar deck from a second end of the first horizontal tubular member, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the first horizontal tubular member using a first or a second corner connecting node;

a second space frame truss comprising a third and a fourth pair of supporting diagonal tubular members, a second buoyant horizontal tubular member and a second part of the horizontal planar deck, the second space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the third pair of diagonal tubular members extends upwards to the second part of the horizontal planar deck from a first end of the second horizontal tubular member and diverging ends of the fourth pair of diagonal tubular members extends upwards to the second part of the horizontal planar deck from a second end of the second horizontal tubular member, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the second horizontal tubular member using a third or a fourth corner connecting node;

whereby the first and second space frame trusses are attached together through a first connecting buoyant tubular member attached to the first and the third corner connecting nodes and through a second connecting buoyant tubular member attached to the second and fourth corner connecting nodes, and

wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

2. The floating platform according to claim 1, wherein the first buoyant structure further comprises:
a first balancing buoyant tubular member having a first and a second balancing connecting node attached to ends of the first balancing buoyant tubular member,

whereby the first balancing connecting node is attached to the first corner connecting node of the first space frame truss and the second balancing connecting node is attached to the second corner connecting node of the first space frame truss such that the first balancing buoyant tubular member is parallel with the buoyant horizontal tubular member of the first space frame truss.

3. The floating platform according to claims 1 or 2, wherein the buoyant structure further comprises:

a second balancing buoyant tubular member having a first and a second balancing connecting node attached to ends of the second balancing buoyant tubular member, whereby the first balancing connecting node is attached to the third corner connecting node of the second space frame truss and the second balancing connecting node is attached to the fourth corner connecting node of the second space frame truss such that the second balancing buoyant tubular member is parallel with the buoyant horizontal tubular member of the second space frame truss.

4. The floating platform according to any one of claims 1 to 3, wherein the buoyant structure further comprises:

a lower horizontal buoyant structure formed of four buoyant horizontal tubular members that are connected together using four lower corner connecting nodes, whereby each lower corner connecting node is attached to one of the corner connecting nodes of the first or second space frame trusses.

5. The floating platform according to claim 1 wherein the buoyant structure further comprises:

a third space frame truss comprising a fifth and a sixth pair of supporting diagonal tubular members, a third buoyant horizontal tubular member and a third part of the horizontal planar deck, the third space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the fifth pair of diagonal tubular members extends upwards to the third part of the horizontal planar deck from a first end of the third horizontal tubular member and diverging ends of the sixth pair of diagonal tubular members extends upwards to the third part of the horizontal planar deck from a second end of the third horizontal tubular member, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the third horizontal tubular member using a fifth or a sixth corner connecting node;

whereby the second and third space frame trusses are attached together through a third connecting buoyant tubular member attached to the third and the fifth corner

connecting nodes and through a fourth connecting buoyant tubular member attached to the fourth and sixth corner connecting nodes, and

wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

6. The floating platform according to claim 1 wherein the buoyant structure further comprises:
a mini turret affixed to the corner connecting nodes of the first and second space frame trusses to allow the floating platform module to weathervane about the mini turret.
7. The floating platform according to claim 6 wherein the buoyant structure further comprises:
a pair of rudders affixed to the corner connecting nodes of the first and second space frame trusses, the pair of rudders being connected to a directional controller provided on the planar deck whereby the directional controller is configured to use the pair of rudders to control a bearing of the floating platform module.
8. The floating platform according to claim 4 wherein the buoyant structure further comprises:
a ballast tank provided at a base of the lower horizontal buoyant structure;
an accumulator and an air compressor provided on the horizontal planar deck whereby the accumulator is configured to supply compressed air to the ballast tank; and
a controller, provided on the horizontal planar deck, to control an amount of compressed air supplied by the accumulator and the air compressor to the ballast tank.
9. The floating platform according to claim 8 whereby the accumulator is further configured to supply compressed air to one or more of the buoyant horizontal tubular members of the lower horizontal buoyant structure.
10. The floating platform according to claim 1 whereby solar panel modules are provided on the horizontal planar deck such that the solar panel modules are elevated from a surface of a water body when the platform is in use.
11. The floating platform according to claim 1 whereby the buoyant structure further comprises:
a fourth buoyant horizontal tubular member having a first end attached to a centre of the second corner connecting node and having a second end attached to a centre of the seventh corner connecting node;
a seventh pair of diagonal tubular members having ends that diverge upwards from the seventh corner connecting node to a fourth part of the horizontal planar deck;

a fifth buoyant horizontal tubular member having a first end attached to the fourth corner connecting node and having a second end attached to an eighth corner connecting node;

an eighth pair of diagonal tubular members having ends that diverge upwards from the eighth corner connecting node to a fifth part of the horizontal planar deck,

whereby a fifth connecting buoyant tubular member has an end attached to the seventh corner connecting node and another end to the eighth corner connecting node, and

wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.

12. The floating platform according to claim 4 wherein the floating platform further comprises:

another buoyant structure provided below the buoyant structure for supporting the buoyant structure, the another buoyant structure being formed of

a fourth space frame truss comprising a seventh and an eighth pair of supporting diagonal tubular members, and a fourth buoyant horizontal tubular, the fourth space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the seventh and eighth pair of diagonal tubular members extends upwards to the corner connecting nodes of the first and second space frame trusses, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the fourth horizontal tubular member using a seventh or an eighth corner connecting node;

a fifth space frame truss comprising a ninth and a tenth pair of supporting diagonal tubular members, and a fifth buoyant horizontal tubular, the fifth space frame truss being arranged in an inverted triangular prism arrangement such that diverging ends of the ninth and tenth pair of diagonal tubular members extends upwards to the corner connecting nodes of the second and third space frame trusses, whereby converging ends of the two pairs of diagonal tubular members are attached to the first or the second ends of the fifth horizontal tubular member using a ninth or a tenth corner connecting node;

whereby the fourth and fifth space frame trusses are attached together through a fifth connecting buoyant tubular member attached to the seventh and ninth corner connecting nodes and through a sixth connecting buoyant tubular member attached to the eighth and tenth corner connecting nodes, and

wherein a diameter of each of the buoyant tubular members is larger than a diameter of each of the diagonal tubular members.