

APPARATUS AND METHOD FOR LAUNCHING AND LANDING OF AERIAL VEHICLES

FIELD OF THE INVENTION

5 [001] The present invention relates to an apparatus and method for launching and landing unmanned aerial vehicles. More particularly, the invention relates to an apparatus that provides a collapsible platform for launching and landing unmanned aerial vehicles.

BACKGROUND OF THE INVENTION

[002] The use of unmanned aerial vehicles (UAVs) in reconnaissance missions, surveillance operations, monitoring of weather conditions and border patrols, has been gaining widespread popularity due to its proven efficiency and effectiveness in such operations. In areas where manned flight operations
15 are highly dangerous or pose a risk to security, UAVs have provided a relatively low cost alternative to obtain access to these areas.

[003] Despite its relatively low cost and characteristically smaller size as compared to manned aerial vehicles, the recovery of UAVs has proven to be a
20 challenge, particularly if a UAV is operating at sea. While recovery systems off the deck of a vessel are known, the recovery of UAVs on the deck of a vessel is considerably challenging due to safety concerns and limited deck space. In addition, the inherent characteristics of UAVs being subjected to higher acceleration and deceleration forces than conventional manned vehicles have
25 made the UAVs prone to being damaged upon landing.

[004] To circumvent the problem of limited deck space and safety concerns, attempts have been made to recover UAVs off the deck of a vessel. For example, net-based recovery systems comprising a net suspended above the

deck of a vessel or off the board of a vessel have been used to capture an UAV while in flight. U.S. Patent No. 7,059,564 discloses an aircraft that can be captured by a recovery line in flight, a process that is aided by a line capture device having a retainer with two portions spaced apart by a distance great
5 enough to receive the recovery line. U.S. Patent No. 7,143,976 discloses a UAV arresting hook coupled to an UAV that facilitates the capture of the UAV via a recovery system. U.S. Patent No. 7,219,856 discloses a rotatable boom having an arresting system for capturing UAVs in flight. These systems, however, are known to be labor intensive, to be prone to causing injury to
10 recovery workers and to cause damage to the UAV.

[005] Recovery of aerial vehicles which occur on the deck of the ship are also known. One such recovery system is disclosed in U.S. Patent No. 1,292,097, which provides for a floating hangar for airplanes. A supporting platform
15 extends downwardly toward the water and is pivotably rotatable about the side of the vessel to form a platform horizontal with the deck of the ship. The objective of the supporting platform is to provide a platform that permits safe and speedy launching and landing of an airplane under varying conditions. However, such a platform is does not provide sufficient deck space for a UAV
20 to adequately land safely.

[006] Another such platform-based system is disclosed in U.S. Patent No. 2,160,449. A floating and self-contained platform is provided at the stern of a ship, which platform is foldable or can be slid in and out. The platform reaches
25 down to the water surface and is intended to facilitate receipt of water aircraft. However, such a platform requires the vessel to be almost stationary to permit the landing of aircraft and a long running platform extending mechanically from the vessel.

30 [007] U.S. Patent No. 5,109,788 discloses a recovery apparatus for unmanned reusable aircraft comprising a flexible surface element arranged on a vessel to

form a trampoline-like extendable or stretchable receiving or retrieval surface for drones. For this purpose, the surface element is brought out from a gathered-in, folded or pivoted-inward stored, stowed position into a mounted expanded position by means of extendable retention and guidance systems.

- 5 Such a system is essentially a net-based system and is prone to causing damage to the UAV.

[008] In some of the recovery systems disclosed above, the vessel will have to be stationary to permit a safe landing of an aerial vehicle or aircraft. In other
10 applications, the platforms require heavy mechanical maintenance and servicing. Further, where the conditions at sea may not be favorable, an aerial vehicle or light aircraft may find landing on a platform challenging as the platform is subjected to the varying movements of the vessel, causing the platform to be unstable for a safe landing.

15

[009] There is, therefore, a need for a UAV recovery system that is capable of allowing a UAV to land at sea without any of the problems described above.

[010] Any discussion of documents, devices, acts or knowledge in this
20 specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms a part of the state of the art or the common general knowledge in the relevant art anywhere on or before the priority date of the disclosure and claims herein. All statements as to the date or representation as to the contents of these documents is based on the
25 information available to the applicants and does not constitute any admission as to the correctness of the date or contents of these documents.

OBJECTS OF THE INVENTION

[011] It is an object of the present invention to provide an improved platform for the launching and landing of unmanned aerial vehicles (UAVs).

5

[012] It is also an object of the present invention to provide an improved platform for the safe launching and safe recovery of UAVs.

[013] It is a further object of the present invention to provide an improved platform that is capable of safe launching and safe recovery of UAVs when the vessel is pitching, rolling or yawing, either alone or in combination.

10

[014] It is a yet further object of the invention to provide an improved collapsible platform that minimizes the risk of damage to the UAV.

15

[015] It is a still further object of the invention to provide an improved platform that minimizes the space taken by the deck of the vessel.

[016] It is a still further object of the invention to provide an improved platform that cause minimal damage to the vessel from a landing UAV.

20

[017] It is a still further object of the present invention to overcome, or at least substantially ameliorate, the disadvantages and shortcomings of the prior art.

[018] These and other objects and advantages of the present invention will become more apparent from the following description, taken in connection with the accompanying drawings, wherein, by way of illustration and example, an embodiment of the present invention is disclosed.

25

SUMMARY OF THE INVENTION

[019] According to the present invention, an apparatus for a collapsible launching and landing platform for a vessel comprises a compensating arm, a multi-axis connector connected to the compensating arm, and a collapsible platform, optionally with supports. The compensating arm has first and second ends, the first end being mounted to a base member adapted for mounting to the vessel. The second end comprises a pivotably connected multi-axis connector. The collapsible platform is adapted for coupling to the multi-axis connector and is capable of movement in at least three axes of rotation. The collapsible platform has at least one sensor or sensor package that is coupled to at least one controller that controls movement of the collapsible platform by providing instructions to activate the platform and to move the collapsible platform to achieve or maintain a desired or predetermined position or orientation. Optionally a counterweight or counterweight system could be installed on the opposite side of the vessel.

[020] In one embodiment of an apparatus of the invention, the platform is movable to a predetermined position such that the collapsible platform becomes and then remains substantially level with the earth's horizon.

[021] In another embodiment of an apparatus of the invention, the compensating arm is rotatable about the central axis of the base member whereby the collapsible platform is rotatable about the central axis of the base member.

[022] In yet another embodiment of an apparatus of the invention, the collapsible platform is rotatable about the transverse axis of the multi-axis connector.

[023] In yet another embodiment of an apparatus of the invention, the collapsible platform is rotatable about the longitudinal axis of the multi-axis connector.

- 5 [024] In yet another embodiment of an apparatus of the invention, the collapsible platform is translatable about the longitudinal axis of the multi-axis connector.

- 10 [025] In yet another embodiment of an apparatus of the invention, the apparatus further comprises a controller or control system operatively connected to at least one sensor or sensor package mounted on the collapsible platform, wherein the control system receives information from the at least one sensor or sensor package to effect movement of the compensating arm.

- 15 [026] In yet another embodiment of an apparatus of the invention, the at least one sensor or sensor package comprises position and level sensors for detecting the yaw, roll and pitch of the vessel body.

- 20 [027] In yet another embodiment of an apparatus of the invention, the collapsible platform rotates about the central axis of the base member in a direction opposite to the direction of rotation of the vessel body with respect to the vertical axis of the vessel body.

- 25 [028] In yet another embodiment of an apparatus of the invention, the collapsible platform rotates about the longitudinal axis of the multi-axis connector in a direction opposite to the direction of rotation of the vessel body with respect to the longitudinal axis of the vessel body.

[029] In yet another embodiment of an apparatus of the invention, the collapsible platform rotates about the transverse axis of the multi-axis connector in a direction opposite to the direction of rotation of the vessel body with respect to the transverse axis of the vessel.

5

[030] In yet another embodiment of an apparatus of the invention, the compensating arm further comprises at least two arm members, each pivotably connectable to each other at one end.

10 [031] In yet another embodiment of an apparatus of the invention, the collapsible platform further comprises a gas-inflatable bag.

[032] In yet another embodiment of an apparatus of the invention, the base member is adapted for connection to the deck of a vessel body.

15

[033] In yet another embodiment of an apparatus of the invention, the collapsible platform is made of a flexible, resilient material.

20 [034] In yet another embodiment of an apparatus of the invention, two or more supporting members extend from the vessel body to the collapsible platform.

[035] In yet another embodiment of an apparatus of the invention, the supporting members are extending hydraulic members.

25 [036] In yet another embodiment of an apparatus of the invention, one or both ends of each hydraulic member has a multi-axis connector.

[037] In yet another embodiment of an apparatus of the invention, the collapsible platform extends along at least a part of the length of the vessel body.

- 5 [038] In yet another embodiment of an apparatus of the invention, an apparatus on a movable vessel for providing a platform for launching or landing of aerial vehicles, comprises:

a base member having a central axis and being adapted for mounting to a vessel body;

- 10 a compensating arm having two ends, a first end being mounted to the base member, and the compensating arm being rotatable about the central axis of the base member;

a multi-axis connector adapted to be pivotably connected to a second end of the compensating arm;

- 15 a platform adapted for coupling to the multi-axis connector, said platform being capable of movement with at least two degrees of freedom;

at least one sensor to sense three-dimensional orientation of the platform; and

- 20 one or more controllers coupled to the at least one sensor to process sensor information and provide instructions to the compensating arm and multi-axis connector to orient the platform thereby, to maintain a stable orientation of said platform.

- [039] In yet another embodiment of the invention, a method for launching and
25 landing unmanned aerial vehicles on a vessel body comprises:

positioning a collapsible platform adapted for connection with a vessel body, said platform having at least one sensor or sensor package mounted thereon;

sensing the movement of the vessel body independent of the collapsible platform based on information collected by the at least one sensor or sensor package; and

5 self-leveling the collapsible platform to a position substantially level with the earth's horizon by moving the collapsible platform in at least three axes of rotation based upon information collected by the at least one sensor or sensor package.

[040] In another embodiment of a method of the invention, the at least one
10 sensor or sensor package further comprises level sensors to detect the yaw, pitch and roll of the vessel.

[041] In another embodiment of a method of the invention, the step of self-leveling further includes the step of processing the information collected by the
15 at least one sensor or sensor package by a control system.

[042] In another embodiment of a method of the invention, the step of self-leveling further includes sending instructions to a compensating arm adapted for connection to the collapsible platform so as to effect movement of the
20 collapsible platform in response to the yaw, pitch and roll of the vessel body.

[043] In another embodiment of a method of the invention, the collapsible platform is maintained in a desired or predetermined position or orientation.

25 [044] This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates,

such known equivalents are deemed to be incorporated herein as if individually set forth.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [045] In order that the invention may be better understood and put into practical effect, reference will now be made to the accompanying drawings, in which:

[046] Figure 1 is a perspective view of a collapsible platform in a closed position mounted on part of a vessel in accordance with an embodiment of the invention;

[047] Figure 2A is a side view of the collapsible platform in a closed position mounted on part of the vessel in accordance with an embodiment of the invention;

[048] Figure 2B is a front view of the collapsible platform in a closed position mounted on part of the vessel in accordance with an embodiment of the invention;

20 [049] Figure 3 is a perspective view of a collapsible platform when in use mounted on part of the vessel in accordance with an embodiment of the invention;

25 [050] Figure 4A is side view of a collapsible platform when in use mounted on part of the vessel in accordance with an embodiment of the invention;

[051] Figure 4B is front view of a collapsible platform when in use mounted on part of the vessel in accordance with an embodiment of the invention;

5 [052] Figure 5 is an underside view of the collapsible platform when in use mounted on part of the vessel in accordance with an embodiment of the invention;

[053] Figure 6A is a perspective view of the collapsible platform when the vessel is pitching in accordance with an embodiment of the invention;

10

[054] Figure 6B is a front view of the collapsible platform when the vessel is pitching in accordance with an embodiment of the invention;

15 [055] Figure 7 is a perspective view of a compensating arm indicating its range of motion when the vessel is pitching in accordance with an embodiment of the invention;

[056] Figure 8A is a side view of the collapsible platform when the vessel is rolling in accordance with an embodiment of the invention;

20

[057] Figure 8B is a side view of the compensating arm indicating its range of motion when the vessel is rolling in accordance with an embodiment of the invention;

25 [058] Figure 9A is a plan view of the collapsible platform when the vessel is yawing in accordance with an embodiment of the invention; and

[059] Figure 9B is a plan view of the compensating arm indicating its range of motion when the vessel is yawing in accordance with an embodiment of the invention.

5 DETAILED DESCRIPTION OF THE INVENTION

[060] The present invention will now be described in detail in connection with preferred embodiments with reference to the accompanying drawings.

[061] Figures 1, 2A and 2B illustrate perspective, side and front views,
10 respectively, of a collapsible platform in its closed position according to an embodiment of the present invention. Figure 1 shows part of a vessel body 10 and a collapsible platform 20 operatively connected to vessel body 10. When collapsible platform 20 is in use, it is stabilized to compensate for motion caused by waves, currents, wind and other motion during sea operations.
15 Collapsible platform 20 is capable of self-leveling or stabilizing in a manner to enable the safe launching and landing of UAVs (not shown) on collapsible platform 20.

[062] As shown in Figure 1, collapsible platform 20 is operatively connected to
20 a compensating arm 30 mounted on an upper surface or deck 42 of vessel body 10. Compensating arm 30 includes a base or base member 32 adapted for mounting on vessel body 10 where base member 32 is capable of supporting the weight of platform 20 and compensating arm 30. Compensating arm 30 may further include a plurality of arm members 34 to allow flexible
25 movement of collapsible platform 20.

[063] A multi-axis connector 36, attached to an arm member 34, and its associated controller (not shown) allow collapsible platform 20 to be operatively connected to compensating arm 30. Multi-axis connector 36 allows platform 20

to be maneuverable and to self-level by allowing collapsible platform 20 to maneuver in at least three axes of rotation. Preferably collapsible platform 20 has the capability of compensating for the pitch, roll and yaw of the vessel. The three axes of rotation correspond to these motions experienced by the vessel
5 when at sea and allow collapsible platform 20 to stabilize itself for the launch or capture of UAVs when in use. The range of motions of collapsible platform 20 and multi-axis connector 36 will be explained in further detail below.

[064] Optionally, collapsible platform 20 also further includes a plurality of
10 extending hydraulic arms 38 operatively connected through a multi-axis connector 44 to the underside 28 of collapsible platform 20 and extending from vessel body 10. The plurality of hydraulic arms 38 assist compensating arm 30 and move correspondingly with the movement of compensating arm 30. Each of hydraulic arms 38 is spaced apart from each other to support the weight of
15 collapsible platform 20 as well as to enable effective and efficient movement of collapsible platform 20. Hydraulic arms 38 are capable of having at least three ranges of motion. Hydraulic arms 38 are capable of extending away and towards the vessel to allow collapsible platform 20 to be collapsed and to operate as a platform when in use. Each of hydraulic arms 38 is operatively
20 connected to vessel body 10, preferably by a multi-axis connector 46. One or more controllers 48 are operatively connected to base 32, compensating arm 30, and multi-axis connectors 36, 44, 46.

[065] Figures 3, 4A and 4B illustrate a perspective view, a side view and a
25 front view of collapsible platform 20 when in use or when collapsible platform 20 is substantially horizontal to an upper surface or deck 42 of vessel body 10. Collapsible platform 20 further includes a floor or surface 24 intended to serve as a launching and/or landing pad for a UAV. Floor 24 may be a separate or external surface of collapsible platform 20 and may be made of various
30 materials, for example, a rigid plastic or a mesh structure which will facilitate the capture or recovery of a UAV. Alternatively, collapsible platform 20 may

include an impact absorbing bag 22 (shown in Figure 2A), preferably inflatable, capable of the launching or landing of UAVs. Impact absorbing bag 22 may be a gas-inflatable bag made of resilient material so as to inflate only when in use and should be capable of supporting the weight of a typical UAV. The
5 advantage of having a collapsible platform 20 that extends horizontally and folds into a vertical position is to provide sufficient space for the launching and landing of UAVs on the platform, but yet not intrude on or interfere with the limited deck space of the vessel.

10 [066] Collapsible platform 20 further includes a recovery system (not shown) for the recovery of UAVs. The UAV recovery system includes an arresting line. The UAV further includes an arresting hook, which engages the arresting line when the UAV is approaching to land. The arresting hook will couple with the arresting line, slowing the UAV down and bringing it to a complete stop. The
15 UAV can then be recovered by removing the UAV from the arresting line. Optionally there may be counterweights or a counterweight system (not shown) on the opposite side of vessel 10 to balance the weight of collapsible platform 20, compensating arm 30, and any UAV.

20 [067] Figure 5 represents the underside of collapsible platform 20, which comprises one or more sensor packages 40 for detecting the motion of the vessel and allowing the platform to self-level. Preferably, a sensor package 40 senses the motion of the vessel, i.e., the yaw, pitch and roll, independent of the motion of the platform. A sensor package 40 may be placed on the underside
25 of collapsible platform 20, on collapsible platform 20, or on various locations throughout collapsible platform 20. It is understood that those skilled in the art will appreciate that appropriate sensor(s) may be remotely located onboard the vessel as well. A sensor package 40 may include motion sensors such as rate sensors, level sensors, gyroscopic sensors, fiber optic gyros, inclinometers,
30 orientation sensors or other sensors that senses the motion of the vessel.

[068] A control system (not shown) for stabilizing the platform is mounted on vessel body 10 or on collapsible platform 20. The control system may be in the form of an analog or a digital system. For the purposes of this invention, it will be understood by the skilled person in the art that the control system is part of the prior art base and will therefore not be elaborated on. The control system uses the information gathered from the sensor packages 40, processes this information, and sends instructions to compensating arm 30 for stabilizing and self-leveling collapsible platform 20 as will be described below.

[069] A sensor package 40 detects the motion of the vessel, for example, the pitch, roll and yaw of the vessel, and provides this information to the control system. Preferably, the sensor package 40 comprises a plurality of motion sensors or level sensors that provide position feedback to the control system. The control system will process the signals and send instructions to compensating arm 30 to maneuver collapsible platform 20 to a substantially horizontal position level with the earth's horizon or to a predetermined position. A user may determine and preset the desired stabilized position of collapsible platform 20 with respect to the earth's horizon.

[070] Figure 6 illustrates a perspective view of a compensating arm 30. Compensating arm 30 has one end mounted to a base member 32. Base member 32 is adapted for mounting on vessel body 10. Preferably, base member 32 is adapted for mounting to a deck 42 of vessel body 10. The opposite other end of compensating arm 30 is adapted for connection with a multi-axis connector 36 which in turn is adapted for connection with or to a collapsible platform 20. Compensating arm 30 comprises a plurality of arm members 34, each arm member 34 being pivotably connected to one another. Preferably, compensating arm 30 comprises at least two arm members 34. Multi-axis connector 36 is in turn adapted for connection to collapsible platform 20. As mentioned above, compensating arm 30 is capable of movement in at

least three axes of rotation to effect movement of the collapsible platform 20, which will be further elaborated on below.

[071] With reference again to Figure 6, compensating arm 30 is rotatable about the central axis X-X of base member 32. By rotating compensating arm 30 about the central axis of base member 32 in either a clockwise and counterclockwise direction, collapsible platform 20 is capable of compensating for yawing of the vessel. Yawing of the vessel occurs when the vessel rotates about its vertical axis to cause the longitudinal axis of the vessel to deviate from the intended course. The effect of yawing causes a vessel to rotate or to move in a sideways manner. Base member 32 contains appropriate sensors, associated controllers, and motors to effect rotation about the central axis and to thereby cause collapsible platform 20 to be stabilized or rotated to a predetermined position.

15

[072] Collapsible platform 20 is rotatable about the central axis Z-Z of multi-axis connector 36. As mentioned above, multi-axis connector 36 is adapted for connection with compensating arm 30 at one end. The rotation of collapsible platform 20 about the Z-Z axis allows collapsible platform 20 to compensate for pitching of the vessel. Pitching occurs when the vessel rotates about its transverse axis causing a forward-backward motion of the vessel. When pitching occurs, multi-axis connector 36 is rotatable about its longitudinal axis, thereby enabling rotation of the collapsible platform about the Z-Z axis or longitudinal axis of multi-axis connector 36. The effect of this compensation is that collapsible platform 20 will be stabilized or movable to a position wherein collapsible platform 20 is substantially level with the earth's horizon to enable a safe launching and landing pad for the UAV.

[073] In further reference to Figure 6, collapsible platform 20 is rotatable about the Y-Y axis or transverse axis of multi-axis connector 36. In this case,

compensating arm 30 may be either static or dynamic. Since multi-axis connector 36 is adapted for connection with collapsible platform 20, rotation of collapsible platform 20 about the Y-Y axis of multi-axis connector 36 enables collapsible platform 20 to rotate within a 180° range. This allows collapsible platform 20 to move into a closed or folded position whereby collapsible platform 20 is folded next to the vessel body (as shown in Figure 1) or to open to a horizontal position (as shown in Figure 3) where collapsible platform 20 can be used as a launching or landing pad. In addition, the rotation of multi-axis connector 36 about the Y-Y axis or transverse axis of multi-axis connector 36 allows collapsible platform 20 to compensate for rolling of the vessel. Rolling of the vessel occurs when the vessel is rotated about the longitudinal axis of the vessel. The movement of collapsible platform 20 in relation to the rolling action of the vessel will be explained in detail below.

[074] As shown in Figure 6, compensating arm 30 is also extendable along the Z-Z axis or the longitudinal axis of multi-axis connector 36. This allows compensating arm 30 to be extended toward or away from vessel body 10, effectively shifting collapsible platform 20 toward or away from vessel body 10. The movement of compensating arm 30 is effected by the pivotable connection with the plurality of arm members 34 within compensating arm 30. This allows arm members 34 to rotate positively or negatively in a manner such as to effect movement of the platform extending away or towards the vessel body.

[075] Figures 7A and 7B illustrate the movement of collapsible platform 20 when the vessel is pitching. Pitching occurs when the vessel is rotated about the vessel's transverse axis. This causes a person standing on the deck of the vessel to be inclined to move forward or backward. In the case of UAVs attempting to launch or land from the platform, pitching of the vessel can cause serious problems or damage to the UAV for takeoff and landing. As shown in Figure 7B, when the vessel is pitching forward, collapsible platform 20 will tend to self-level to be level with the earth's horizon or at a predetermined position.

Collapsible platform 20 will be rotated in a direction opposite to the pitching motion to compensate for the pitch. In this case in Figure 7A and 7B, the platform will be rotated backwards to compensate for the forward pitch of the vessel.

5

[076] Figure 8A illustrates the side view of vessel body 10 when it is rolling, and Figure 8B illustrates the side view of compensating arm 30 when the vessel is rolling. In an exemplary embodiment of the present invention, Figure 8A shows the vessel rolling in a counterclockwise direction about its longitudinal axis. To counter the effects of the rolling vessel, compensating arm 30 rotates about the transverse axis of multi-axis connector 36 (as shown in Figure 8B) in a direction opposite the direction of roll of the vessel. In this case, if the vessel is rolling in a counterclockwise direction, compensating arm 30 will rotate about the transverse axis of multi-axis connector 36 in a clockwise direction. When the sensors in the sensor package 40 located on collapsible platform 20 detect the rolling action of the vessel, information is sent to the control system which processes the information and subsequently sends instructions to compensating arm 30 to actuate and effect the movement of multi-axis connector 36 in a corresponding manner. Accordingly, if hydraulic arms 38 are used as in Figure 8A, the control system will instruct hydraulic arms 38 to extend the arms in a corresponding manner for collapsible platform 20 to stabilize. The user or operator may preset or predetermine the amount of rotation required for multi-axis connector 36 or the length of extension required for hydraulic arms 38 to stabilize or level collapsible platform 20 to the earth's horizon.

[077] Figure 9A is a plan view of vessel body 10 when it is yawing. Figure 9B shows the directional rotation of compensating arm 30 about the central axis of base member 32 when the vessel is yawing. In an exemplary embodiment of the present invention, when the vessel is yawing in a counterclockwise direction about its vertical axis, compensating arm 30 will rotate

correspondingly in a direction opposite the direction of yawing of the vessel to counter the yawing effects. In this case, compensating arm 30 rotates in a clockwise direction about the central axis of base member 32. Accordingly, sensors on collapsible platform 20, upon detecting the yawing of the vessel, will
5 send the information to the control system whereby instructions are sent to compensating arm 30 to effect movement of compensating arm 30 in a corresponding manner. If hydraulic arms 38 are to be used, hydraulic arms 38 will also effect movement in a corresponding manner for collapsible platform 20 to be stabilized. Hydraulic arms 38 will subsequently extend away or toward
10 vessel body 10 to accommodate the movement of the platform away or toward vessel body 10.

[078] The mechanical operation of a landing and launching system of the invention is effected by various motor and hydraulic systems. For example,
15 movement of arm members 34 of compensating arm 30 can result from hydraulic or electrical motor systems known in the art. Rotation of base member 32 is preferably based on electrical motors in base member 32 or on deck 42. Movement of multi-axis connectors 36, 44, 46 could be based upon electrical motors or hydraulics. While longitudinal movement of hydraulic arms
20 38 is based on hydraulics, rotational or lateral movement of hydraulic arms 38 could be based on electrical motors. Examples of useful motors and hydraulic systems can be found in the prior art or are otherwise known to those skilled in the art. See, for example, U.S. Patent No. 7,299,762, incorporated herein by reference.

25

[079] Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures can be made within the scope of the invention, which is not to be limited to the details described herein but is to be accorded the full scope of
30 the appended claims so as to embrace any and all equivalent devices and apparatus.

[080] "Comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

CLAIMS

1. An apparatus on a movable vessel for providing a platform for launching or landing of aerial vehicles, said apparatus comprising:
 - 5 a base member having a central axis and being adapted for mounting to a vessel body;
 - a compensating arm having two ends, a first end being mounted to the base member, and the compensating arm being rotatable about the central axis of the base member;
 - 10 a multi-axis connector adapted to be pivotably connected to a second end of the compensating arm;
 - a platform adapted for coupling to the multi-axis connector, said platform being capable of movement with at least two degrees of freedom;
 - at least one sensor to sense three-dimensional orientation of the platform; and
 - 15 one or more controllers coupled to the at least one sensor to process sensor information and provide instructions to the compensating arm and multi-axis connector to orient the platform thereby, to maintain a stable orientation of said platform.
- 20 2. The apparatus according to claim 1, wherein a predetermined position or orientation is such that the platform remains substantially level with the earth's horizon.
- 25 3. The apparatus according to claim 2, wherein the platform is rotatable about the central axis of the base member.

4. The apparatus according to claim 3, wherein the multi-axis connector has a transverse axis and the platform is rotatable about the transverse axis of the multi-axis connector.
- 5 5. The apparatus according to claim 2, wherein multi-axis connector has a longitudinal axis and the platform is rotatable about the longitudinal axis of the multi-axis connector.
- 10 6. The apparatus according to claim 2, wherein multi-axis connector has a longitudinal axis and the platform is translatable about the longitudinal axis of the multi-axis connector.
- 15 7. The apparatus according to claim 1, further comprising a controller operatively connected to at least one sensor mounted on the platform, wherein the controller receives information from at least one sensor to effect movement of the compensating arm.
- 20 8. The apparatus according to claim 7, wherein the at least one sensor comprises position and level sensors for detecting yaw, roll and pitch of the vessel body.
- 25 9. The apparatus according to claim 1, wherein the vessel has a vertical axis and the platform rotates about the central axis of the base member in a direction opposite to the direction of rotation of the vessel body with respect to the vertical axis of the vessel body.
10. The apparatus according to claim 1, wherein the vessel body has a longitudinal axis and the platform rotates about the longitudinal axis of the

multi-axis connector in a direction opposite to the direction of rotation of the vessel with respect to the longitudinal axis of the vessel body.

5 11. The apparatus according to claim 1, wherein the vessel body has a transverse axis and the platform rotates about the transverse axis of the multi-axis connector in a direction opposite to the direction of rotation of the vessel with respect to the transverse axis of the vessel body.

10 12. The apparatus according to claim 1, wherein the compensating arm further comprises at least two arm members, each pivotably connectable to each other at one end.

15 13. The apparatus according to claim 1, wherein the platform further comprises a gas-inflatable bag.

14. The apparatus according to claim 1, wherein the base member is adapted for connection to an upper deck of the vessel body.

20 15. The apparatus according to claim 1 wherein the platform is made of a flexible, resilient material.

16. The apparatus according to claim 1 wherein the platform extends along at least a part of the length of the vessel body.

25 17. The apparatus according to claim 1, wherein two or more supporting members extend from the vessel body to the platform.

18. The apparatus according to claim 17, wherein the two supporting members are hydraulic members.

5 19. The apparatus according to claim 17, wherein each supporting member has two ends, each operatively coupled to a multi-axis connector.

20. A method for launching and landing of unmanned aerial vehicles, comprising:

10 positioning a platform adapted for connection with a vessel;
sensing the movement of the vessel independent of the platform based on information collected by at least one sensor mounted on the platform; and

15 self-leveling the platform to a position substantially level with the earth's horizon by moving the platform in at least two degrees of freedom based on the information collected by the at least one sensor.

21. The method according to claim 20, wherein the at least one sensor further comprises level sensors to detect the yaw, pitch and roll of the vessel.

20 22. The method according to claim 21, wherein the step of self-leveling further includes the step of processing the information collected by the at least one sensor by a control system.

25 23. The method according to claim 22, wherein the step of self-leveling further includes sending instructions to a compensating arm adapted for connection to the platform so as to effect movement of the platform in response to the yaw, pitch and roll of the vessel.