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(54) WATERCRAFT POSITION MANAGEMENT SYSTEM & METHOD

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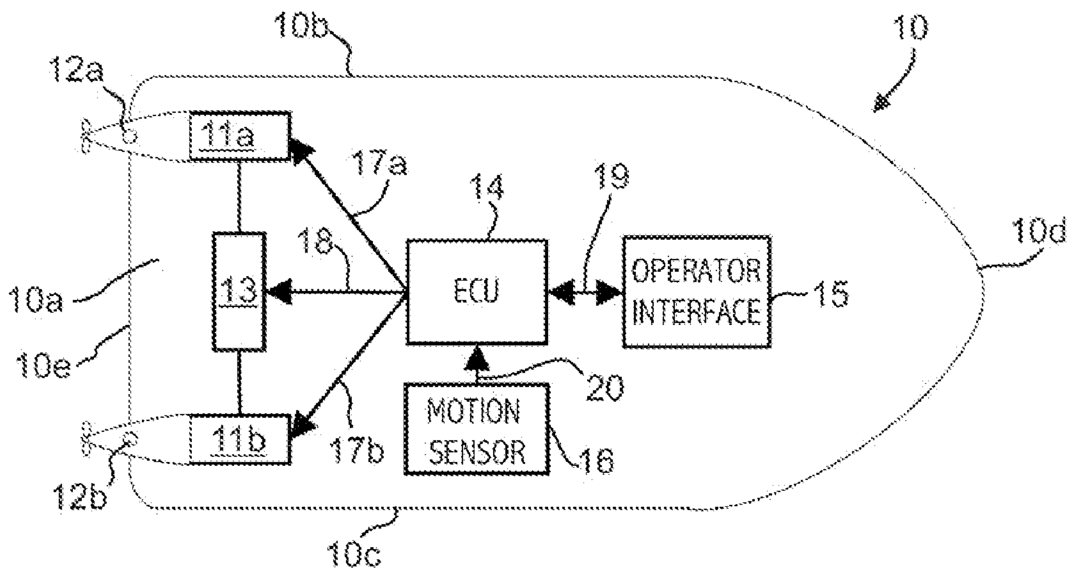
(57) ABSTRACT

Movement of a watercraft/vehicle is precisely controlled for operations such as docking, remaining on-station, and rotating about the craft's center of mass. The system uses the primary propulsion units used to operate the watercraft under normal conditions without the need for thrusters. Two or more primary propulsion units are controlled to move the watercraft/vehicle forward/aft, laterally, obliquely lateral and may include rotation as desired. One propulsion unit produces reverse thrust and one propulsion unit produces forward thrust while the propulsion angles of the propulsion units are controlled. A variable length draglink simplifies operation of the system. An engine control unit and user interface generate signals to control the thrust magnitude and propulsion angles of the propulsion units. Movement sensors provide data to the control unit for improved control of the watercraft/vehicle.



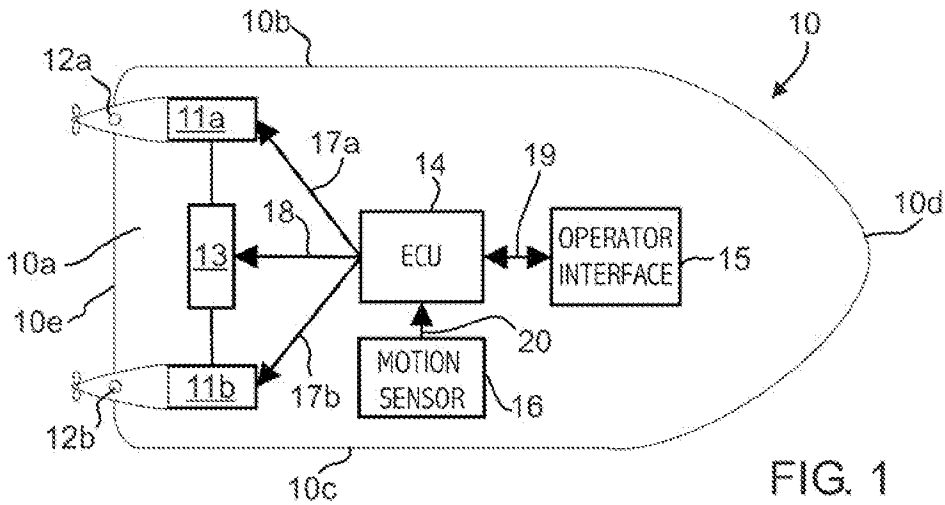



FIG. 1

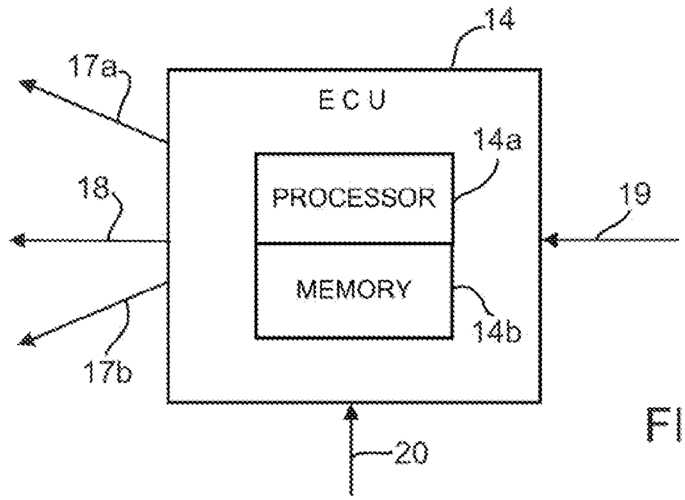



FIG. 2

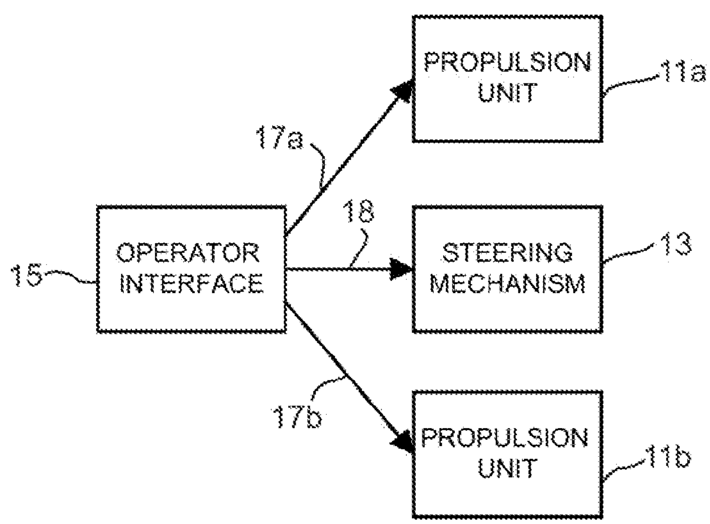



FIG. 3

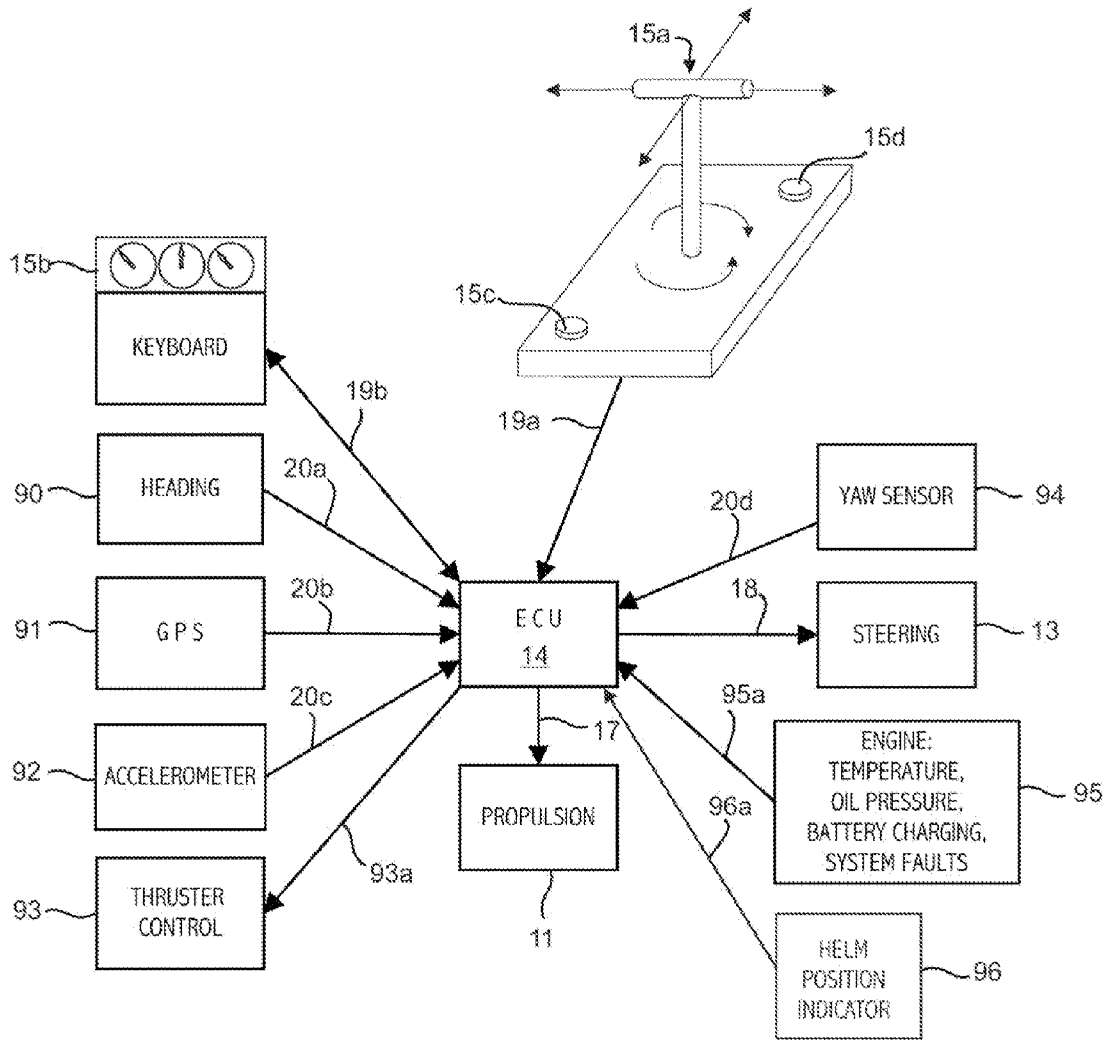

15a
15d
15b
15c
KEYBOARD
19b
19a
HEADING
90
20a
20d
YAW SENSOR
94
91
GPS
20b
ECU
14
18
STEERING
13
20c
95a
92
ACCELEROMETER
17
ENGINE:
TEMPERATURE,
OIL PRESSURE,
BATTERY CHARGING,
SYSTEM FAULTS
95
96a
PROPULSION
93
THRUSTER
CONTROL
93a
11
HELM
POSITION
INDICATOR
96

FIG. 10

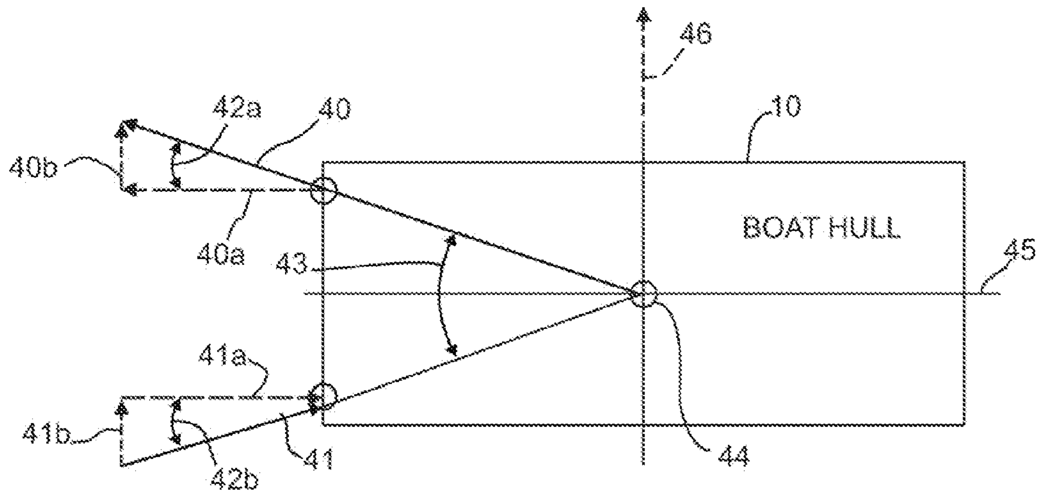



FIG. 4

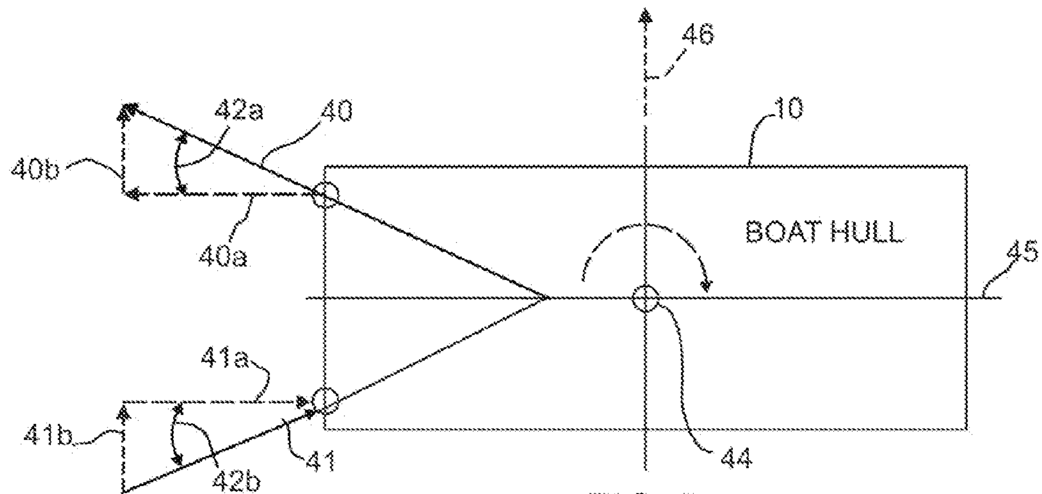



FIG. 5

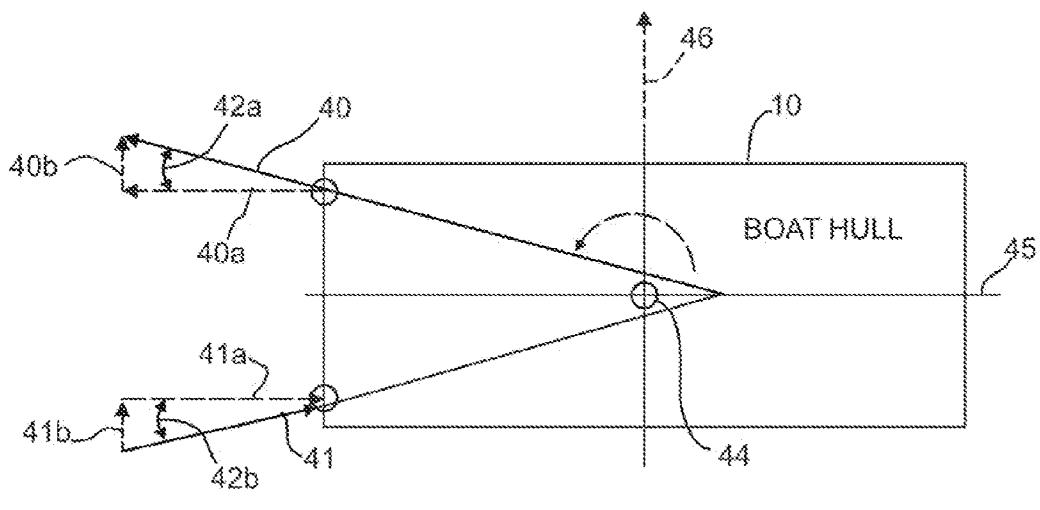



FIG. 6

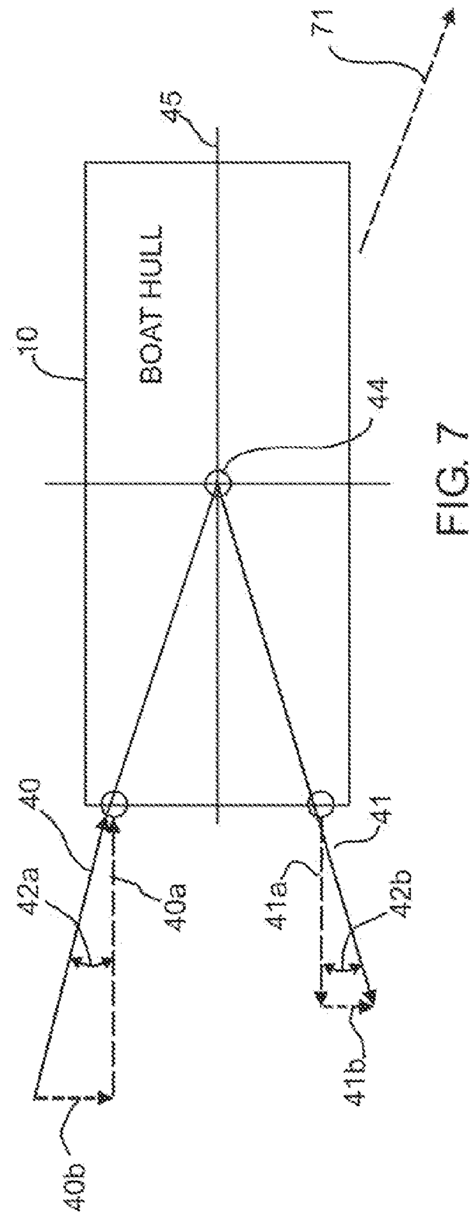



FIG. 7

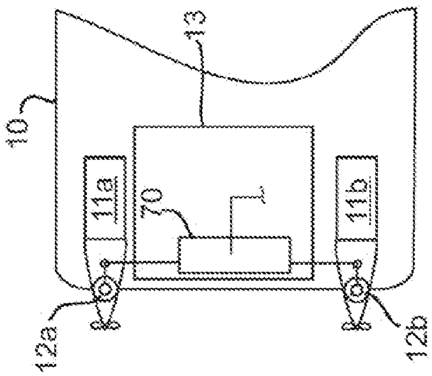



FIG.8

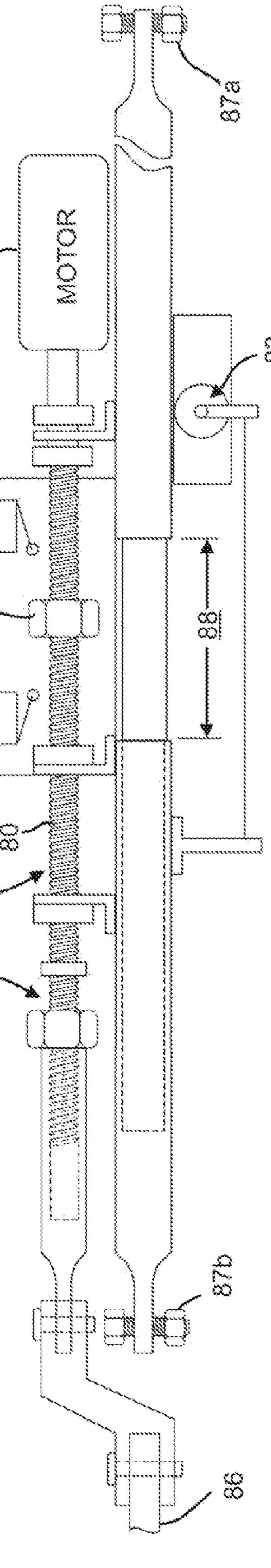



FIG.9

# WATERCRAFT POSITION MANAGEMENT SYSTEM & METHOD

## BACKGROUND OF THE INVENTION

**[0001]** The present invention relates primarily to propulsion control systems for watercraft. More specifically, the present invention relates to a method and apparatus for controlling multi-propulsion unit systems capable of precisely maneuvering watercraft using the primary propulsion units without the need for thrusters.

**[0002]** In recent years, the popularity of watercraft for sport, recreation, and transportation has increased. As such, various systems for controlling and maneuvering watercraft have been developed. Prior art systems provide a simple means of controlling thrust and turning of a watercraft. More complex systems provide for additional maneuvering capabilities but are prohibitively expensive and typically require thrusters, cannot be easily retrofit to existing watercraft, or they are difficult to operate.

**[0003]** With the increased popularity of watercraft as a sport and recreational activity, watercraft equipment has drastically increased in performance, ease of use, utility and accordingly, in price. Many of the recreational watercraft cost many thousands of dollars, yet many owners of such watercraft use them only a few times per year and consequently desire watercraft that are easy to operate, control, and maneuver.

**[0004]** In general, watercraft provide one or more engines (or propulsion units) on the stern of the watercraft to provide thrust and thereby propulsion of the craft. Larger craft typically use two or more engines for propulsion. While these systems operate satisfactorily for propelling a watercraft in a substantially forward direction, they are less satisfactory in precisely maneuvering the watercraft in tasks such as docking, remaining on station, and generally maneuvering where precise control is desired. Prior systems have used complicated schemes to overcome these deficiencies. For example, many watercraft have additional engines or propulsion units (e.g. thrusters) that are dedicated to moving the watercraft into docks and similar precise positions. These systems are expensive, complicated, require much more attention of the operator, and often cause stress on the operator or crew. In addition, the deficiencies in the current systems are a significant cause of damage to watercraft and docks.

**[0005]** Accordingly, a need exists for an improved system for controlling the position and heading of watercraft that is cost effective, easy to use, precisely controls a watercraft, and can be retrofit to existing watercraft. Therefore, a watercraft position management system that solves the aforementioned disadvantages and having the aforementioned advantages is desired.

## SUMMARY OF THE PRESENT INVENTION

**[0006]** The aforementioned drawbacks and disadvantages of these prior art position management systems have been identified and a solution is set forth herein by the inventive position management system and method which comprises two propulsion units, a steering mechanism for controlling the propulsion angle of the propulsion units, and a unique method of manipulating thrust vectors to achieve precision maneuvering. Additionally the invention comprises art engine control unit for communicating propulsion angle commands and for communicating thrust commands for the at least two propulsion units; an operator interface for communicating operator commands; and movement sensors for communicating information on the motion of the craft. The preferred embodiment also includes a variable length draglink that simplifies controlling the propulsion angle of the propulsion units. The invention enables a watercraft to move forward/aft, laterally, obliquely lateral, with or without rotation such that docking the craft is much easier and more precise than the prior art.

**[0007]** One feature of the present invention is the variable length draglink that is coupled to the propulsion units. In the preferred embodiment, the draglink comprises a screw jack system comprising a jack screw and an electric motor. The electric motor turns the jack screw and thereby changes the length of the draglink. The length of the draglink controls the vector angle between the thrust vectors of the propulsion units and enables simple yet precise maneuvering of the craft. In the preferred embodiment, the draglink is shortened to increase the vector angle and, conversely, it is lengthened to decrease the vector angle. When the appropriate vector angle is achieved the thrust vectors from the propulsion units combine to yield a desired net thrust vector on the craft. An advantage of the draglink is that by controlling the length of the draglink, precision maneuvers are easily achieved. Precision maneuvers comprise rotation of the craft about a stationary point, lateral motion of the craft without forward velocity or rotation, obliquely lateral movement, and combinations of these maneuvers. An aspect of the invention is that it does not require independent steering of the propulsion units since the steering is accomplished with a draglink coupled to both propulsion units.

**[0008]** Another feature of the present invention is an engine control unit that generates thrust commands and propulsion angle commands to achieve desired maneuvers. Initial thrust commands and propulsion angles are preferably selected from predetermined data generated during sea trials. This predetermined data is stored in memory. The control unit uses these initial values as a "first guess" and then makes adjustments to the thrust and propulsion angles to compensate for environmental conditions such as wind, eddy currents, or the like that affect movement of the craft. Another aspect of the invention is that it simplifies the maneuvering process to such an extent that an engine control unit is not required for a basic installation of the system.

**[0009]** And still in another feature of the present invention is a single point user interface used to communicate the watercraft operator's commands. In the preferred embodiment the operator moves a joystick to communicate a desired movement of the craft in any direction. For example, rotation of the joystick indicates a desire to rotate the watercraft and movement of the joystick to the left or right indicate lateral movement to port and starboard respectively. The interface includes an on-station button to command the control unit to keep the watercraft at the current position. The joystick simplifies operation of the watercraft.

**[0010]** Yet another feature of the present invention are movement sensors that are used to provide data on the position, movement, yaw, and heading of the watercraft. Accelerometers provide data related to movement laterally, forward, and rearward. A global positioning system (GPS) unit provides data related to position, movement, and velocity. A compass, gyro, or heading sensing device provides data related to watercraft heading, rotational movement; and rotational velocity. A yaw sensor provides data indicative of the yaw angle of the watercraft. Using data from these sensors the operator and/or engine control unit can initiate appropriate thrust and propulsion angle commands to achieve a desired maneuver.

**[0011]** Another feature of the invention is that precision maneuvers can be achieved while the thrust magnitude of the propulsion units is equal but opposite. This is yet another simplifying aspect of the invention. Similarly, precision maneuvers can be achieved with propulsion angles that are equal but opposite. This is another simplifying aspect of the invention. These two features greatly simplify control of the craft.

**[0012]** To address the goals stated above, the inventive position management system and method combines the unique steering mechanism and the method of thrust and propulsion angle control to allow a watercraft to be easily and precisely maneuvered. By simplifying operation and improving control of a watercraft the inventive system reduces the risk of damage to watercraft and docks and reduces stress on the crew. The present invention is useful in many applications where a craft or vehicle benefits from improved and simplified control. While the primary application of the invention will likely be small to medium size twin engine watercraft, those skilled in the art understand that the invention is applicable to various other vehicles including, but not limited to, multi-engine watercraft, large ships, hovercraft, lighter than air ships, spacecraft, and aircraft. The invention may also be practiced with virtually any propulsion system including, but not limited to, inboard motors, outboard motors, propeller systems, jet drives, or even thrusters or rockets. Application of the invention is not limited to docking maneuvers but is also useful wherever precision control or maneuvering is desirable. For example, the invention is useful in remaining on-station, compensating for variable winds, eddy currents, and the like. Of course, this description is in no way meant to be limiting in any manner.

**[0013]** The present invention includes a method of maneuvering a watercraft which includes using a variable length draglink that is actuated to achieve a desired vector angle and consequently achieves the desired movement of the watercraft.

**[0014]** Other objects, advantages, and features of the invention will become apparent upon consideration of the following detailed description, when taken in conjunction with the accompanying drawings. The above brief description sets forth rather broadly the more important features of the present disclosure so that the detailed description that follows may be better understood, and so that the present contributions to the art may be better appreciated. There are, of course, additional features of the disclosures that will be described hereinafter which will form the subject matter of the claims.

**[0015]** In this respect, before explaining the preferred embodiment of the disclosure in detail. It is to be understood that the disclosure is not limited in its application to the details of the construction and the arrangement set forth in the following description or illustrated in the drawings. The position management system of the present disclosure is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for description and not limitation.

**[0016]** As such, those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be used as a basis for designing other structures, methods, and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims are regarded as including such equivalent constructions as far as they do not depart from the spirit and scope of the present invention.

**[0017]** Further, the purpose of the Abstract is to enable the U.S. Patent and Trademark Office and the public generally, and especially the scientists, engineers, and practitioners in the art who are not familiar with the patent or legal terms of phraseology, to learn quickly, from a cursory inspection, the nature of the technical disclosure of the application. Accordingly, the Abstract is intended to define neither the invention nor the application, which is only measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

**[0018]** These and other objects, along with the various features, and structures that characterize the invention, are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the position management system of the present disclosure, its advantages, and the specific objects attained by its uses, reference should be made to the accompanying drawings and descriptive matter in which there are illustrated and described the preferred embodiments of the invention.

**[0019]** As such, while embodiments of the position management system are herein illustrated and described, it is to be appreciated that various changes, rearrangements and modifications maybe made therein, without departing from the scope of the invention as defined by the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0020]** As a compliment to the description and for better understanding of the specification presented herein, four pages of drawings are disclosed with an informative, but not limiting, intention.

**[0021]** FIG. **1** shows a schematic representation of the invention embodied on a twin engine watercraft;

**[0022]** FIG. **2** illustrates the engine control unit;

**[0023]** FIG. **3** is a simplified schematic representation of an embodiment of the invention without an engine control unit;

**[0024]** FIG. **4** shows a thrust vector diagram for moving the watercraft laterally;

**[0025]** FIG. **5** shows a thrust vector diagram for moving the watercraft laterally and rotating the watercraft clockwise;

**[0026]** FIG. **6** shows a thrust vector diagram for moving the watercraft laterally and rotating the watercraft counter clockwise;

**[0027]** FIG. **7** shows a thrust vector diagram for moving the watercraft in a lateral oblique angle;

**[0028]** FIG. **8** is a schematic representation of a variable length draglink implemented in a typical steering mechanism;

**[0029]** FIG. **9** shows partial detail of the a variable length draglink; and

**[0030]** FIG. **10** is a schematic diagram of the ECU and the components that communicate with the ECU.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0031]** The best mode for carrying out the invention is presented in terms of the preferred embodiment, wherein similar referenced characters designate corresponding features throughout the several figures of the drawings.

[0032] For purposes of description herein, the terms “forward”, “reverse”, “aft”, “fore”, “port”, “starboard”, “clockwise”, “counter clockwise”, “lateral”, and derivatives thereof, shall relate to the invention as oriented in FIG. **1** and viewed from above. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings and described in the following specification are exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

[0033] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, these same referenced numerals will be used throughout the drawings to refer to the same or like parts. Like features between the various embodiments utilize similar numerical designations. Where appropriate, the various similar features have been further differentiated by an alphanumeric designation, wherein the corresponding alphabetic designator has been changed. Further, the dimensions illustrated in the drawings (if provided) are included for purposes of example only and are not intended to limit the scope of the present invention.

[0034] An exemplary embodiment of the invention is shown in FIG. **1**. While the preferred embodiment is a twin engine watercraft, the invention is not meant to be so limited. As used herein, the term watercraft is meant to be used and defined in its general and ordinary sense. However, those skilled in the art will understand that the invention may be adapted to other types of vehicles.

[0035] The components of the invention will first be briefly described and then described in detail. The watercraft **10** on which the invention is implemented is viewed from the top. Watercraft **10** includes an aft portion **10**A, a port side **10**B, a starboard side **10**C, and fore portion **10**D. Twin propulsion units **11**A and **11**B are attached to the aft portion of the watercraft **10** and more precisely to the transom **10**E. Pivot points **12**A and **12**B represent the point on which propulsion units **11** rotate. Steering mechanism **13** is connected to propulsion units **11** and turns the propulsion drive units **11** about pivot points **12**. It should be noted that storing mechanism **13** will attach to various portions of the the propulsion units **13** depending on the type of propulsion unit **31** used. For example, if propulsion units **11** are stationary inboard units, then the steering mechanism **13** would only move the outdrive portion of the propulsion units **11**. Engine control unit (ECU) **14** is in communication with steering mechanism **13**, propulsion units **11**, operator interface **15**, and sensor **16**. ECU **14** communicates thrust commands **17**A and **17**B to propulsion units **11** and communicates propulsion angle commands **18** to steering mechanism **13**. Operator interface **15** communicates operator commands **19** to ECU **14** and motion sensor **16** communicates motion data **20** to ECU **14**.

[0036] The preferred embodiment of the invention is implemented on a twin engine sport watercraft **10**. However, those skilled in the art recognize that the invention is applicable to large ships, various types of propulsion units, aircraft, hovercraft, spacecraft to mention some representative examples. A specific advantage of the invention is that it is readily retrofit to existing watercraft.

[0037] Propulsion units **11** are commercially available and may be of virtually any type including, but not limited to, propeller driven units, jet propulsion units, gasoline or diesel fuel engines, inboard or outboard. The invention can be adapted for use on watercraft with more that two propulsion units **11**, but only two propulsion units are required for implementation.

[0038] Steering mechanism **13** is conventional in nature except for a variable length draglink feature that is explained below and is used in some embodiments. Steering mechanism **13** may be of virtually any design so long as it is capable of responding to commands to change the propulsion angle of the propulsion units **11**. A propulsion angle command **18** communicated to steering mechanism **13** may be implemented as a mechanical linkage, an electrical signal or even as a fiber optic light signal or electromagnetic signal.

[0039] ECU **14** inputs operator commands **19** and translates operator commands **19** into appropriate thrust commands **17** and propulsion angle commands **18**. The preferred embodiment of ECU **14** comprises a processing unit **14**A and memory **14**B (see FIG. **2**) that are programmed to accomplish the desired tasks.

[0040] Operator interface **15** permits an operator to communicate desired maneuvers to ECU **14**. Operator command signal **19** communicates information such as the direction the craft should move, the desired velocity, rotation or change in heading data, and an operator desire to remain on-station. The preferred embodiment uses a joystick and push buttons but other input arrangements may also be used.

[0041] Motion sensor **16** comprises one or more devices that detect various types of movement of the watercraft. Sensors include accelerometers to detect forward and rearward motion, and lateral motion; heading sensors such as a compass that detect heading and rotation; and global positioning system (GPS) devices that detect position and velocity.

[0042] A patent that is useful for background and prior art information is U.S. Pat. No. 6,234,853, entitled “Simplified Docking Method And Apparatus For A Multiple Engine Marine Vessel” by Lanyi et al., dated May 22, 2001, it discloses a method and apparatus for controlling the thrust and propulsion angles of a watercraft and it is hereby incorporated by reference.

[0043] Referring now to FIG. **2**, the ECU **14** is shown in more detail. ECU **14** comprises processor **14**A and memory **14**B. Memory **14**B stores program instructions and also predetermined data such as thrust magnitude and propulsion angles corresponding to various maneuvers. Predetermined data comprises, for example, data generated during sea trials or calculated from available data. This data is generated for nominal conditions. Actual conditions may require the values to be changed or adjusted by the ECU **14**. Some examples of actual conditions may include wind, water currents, weight or configuration of the watercraft.

[0044] In the preferred embodiment the processor **14**A will retrieve data from memory **14**B corresponding to a desired maneuver. Processor **14**A will communicate thrust commands **17** and propulsion commands **18** responsive to the data retrieved from memory. Because conditions may not be identical to the initial sea trials, the watercraft **10** may not respond precisely as desired. ECU **14** is notified of deviations by either operator command **19** or motion data **20** and computes changes to thrust commands **17** and/or propulsion angle commands **18**.

**[0045]** The invention enables the ECU **14** to easily generate appropriate commands to compensate for deviations. In most eases the ECU **14** merely has to make equal magnitude changes to the propulsion angle commands. If velocity deviation needs to be corrected the ECU **14** merely makes changes to the thrust commands **17** that are equal in magnitude for each engine. Should undesired forward or aft movement be detected then the engine thrust commands will be unequal to cancel the undesired movement. This method greatly simplifies the precision control of the watercraft and is described in detail below.

**[0046]** Turning to FIG. **3** there is shown a schematic representation of a simplified embodiment of the invention. An advantage of the invention is that precision control is made so simple that an ECU **14** is not an essential element and an operator may control the propulsion angle and thrust manually to achieve precision maneuvers. Operator interface **15** is similar to the operator interface **15** in FIG. **1** but instead of communicating operator commands **19** to an ECU **14**, the operator interface **15** communicates propulsion angle commands **18** and thrust commands **17** directly to steering mechanism **13** and propulsion units **11**. An example of the operation of this simple manual configuration is described in another section of this specification.

**[0047]** A discussion of the method of the invention is described in relation to thrust vectors in the following figures. This discussion is intended to communicate an understanding of the invention and it is not intended to limit the invention.

**[0048]** FIG. **4** is a vector diagram illustrating a configuration for moving a watercraft laterally in the port direction as indicated by dashed arrow **46**. The illustration is shown using two propulsion units **11** generating port thrust vector **40** and starboard thrust vector **41**. The propulsion units are located symmetrically about the centerline **45** of the watercraft **10**. In other words, each propulsion unit is located equidistant from the centerline. The arrows on the vectors indicate direction and the length is indicative of magnitude. The dashed lines show the lateral, forward and aft components of the thrust vectors **40** and **41**.

**[0049]** Propulsion angles **42** are the angles between the thrust vector and a line parallel to the centerline of the watercraft **10**. In this example the magnitude of thrust is equal for both propulsion units **11** and the propulsion angle **42** for each propulsion unit **11** is equal in magnitude but opposite in direction such that the propulsion units **11** are in a toe-in configuration. Unequal thrust to the propulsion units will provide lateral movement at an oblique angle, fore or aft of 90 degrees, based on the thrust vector summation as shown in FIG. **7** below. Throughout this specification this will be referred to as propulsion angles that are equal but opposite. A vector angle **43** is defined as the angle between the thrust vectors **40** and **41**.

**[0050]** The center of mass **44** is typically located at or near the center of the watercraft **10**. Thrust vectors **40** and **41** are shown extended to intersect exactly at the center of mass **44**. Net forward/aft thrust is calculated:

$$\text{Forward/aft thrust}=PtF+StF=0$$

**[0051]** Where PtF **40**A is port thrust forward **40**A and StF **41**A is starboard thrust forward. Since port thrust is reverse (i.e. negative forward thrust) and starboard thrust is forward (i.e. positive) the net forward/aft thrust is zero.

**[0052]** Similarly, net port lateral thrust is calculated:

$$\text{Net port lateral thrust}=PtL+StL=2PtL$$

**[0053]** Where PtL **40**B is port thrust lateral and StL **41**B is starboard thrust lateral. Since PtL and StL are theoretically equal, net port lateral thrust equals 2PtL.

**[0054]** Since the thrust vectors intersect at the center of mass **44** there is no net rotational torque exerted on watercraft **10**. The only net thrust is lateral in the port direction. The watercraft is thereby moved in a lateral direction without forward/aft velocity and without rotation. Moving the watercraft **10** to starboard is easily accomplished by reversing the thrust and angles of this example.

**[0055]** Referring to FIG. **5** there is illustrated a vector diagram for moving the watercraft laterally and rotating the watercraft clockwise. This can also be thought of as moving the watercraft laterally while exerting clockwise torque on the watercraft. The computations are similar to the previous example. The magnitude of thrust is again equal for both propulsion units **11** and the propulsion angle **42** for each propulsion unit **11** is equiangular but opposite such that the propulsion units **11** are in a toe-in configuration. The propulsion angles **42** are larger thereby causing the extended vector to intersect aft of the center of mass **44**. The net forward/aft thrust is calculated:

$$\text{Forward/aft thrust}=PtF+StF=0$$

**[0056]** Since port thrust is reverse (i.e. negative forward thrust) and starboard thrust is forward (i.e. positive) the net forward/aft thrust is again zero.

**[0057]** Similarly, the net port lateral thrust is calculated:

$$\text{Net port lateral thrust}=PtL+StL=2PtL$$

**[0058]** Where PtL **40**B is port thrust lateral and StL **41**B is starboard thrust lateral. Since PtL and StL are theoretically equal, net port lateral thrust equals 2PtL.

**[0059]** Since the thrust vectors intersect aft of the center of mass **44** there is clockwise rotational torque exerted on the watercraft **10**. Watercraft **10** is thereby rotated about the center of mass **44** without substantial forward/aft velocity and with substantial lateral movement. Rotating watercraft **10** to counter clockwise is easily accomplished by changing the propulsion angles as illustrated below. Substantial in this context is intended to represent small movement as viewed by an operator of the watercraft. In actual application of the invention there are many forces that preclude exact movement control. Wind, eddy currents, changes to the center of mass and other factors can introduce variations to watercraft's movement.

**[0060]** Continuing to FIG. **6** there is illustrated a vector diagram for moving the watercraft laterally and rotating the watercraft counter clockwise. The computations are similar to the previous examples. The magnitude of thrust is again equal for both propulsion units **11** and the propulsion angle **42** for each propulsion unit **11** is equiangular but opposite such that the propulsion units **11** are in a toe-in configuration. The propulsion angles **42** are smaller thereby causing the extended vector to intersect fore (i.e. forward) of the center of mass **44**. The net forward/aft thrust is calculated:

$$\text{Forward/aft thrust}=PtF+StF=0$$

**[0061]** Since port thrust is reverse (i.e. negative forward thrust) and starboard thrust is forward (i.e. positive) the net forward/aft thrust is again zero.

**[0062]** Similarly, the net port lateral thrust is calculated:

$$\text{Net port lateral thrust}=PtL+StL=2PtL$$

**[0063]** Where PtL **40**B is port thrust lateral and StL **41**B is starboard thrust lateral. Since PtL and StL are theoretically equal, net port lateral thrust equals 2PtL.

**[0064]** Since the thrust vectors intersect fore of the center of mass **44** there is counter clockwise rotational torque exerted on watercraft **10**. Watercraft **10** is thereby rotated about the center of mass **44** without substantial forward/aft velocity and with substantial lateral movement.

**[0065]** Moving to FIG. **7** there is illustrated a vector diagram for moving the watercraft laterally at an oblique angle as indicated by dashed arrow **71**. The computations are similar to the previous examples. However, in this example the magnitude of thrust is unequal for the propulsion units **11**. The propulsion angle **42** for each propulsion unit **11** is equiangular but opposite such that the propulsion units **11** are in a toe-in configuration. The propulsion angles **42** are set to such that the extended vectors intersect at the center of mass **44**. Port thrust is larger than starboard thrust. The net forward/aft thrust is calculated:

$$\text{Forward/aft thrust}=PtF+StF=0$$

**[0066]** Since port thrust is forward (i.e. positive) and starboard thrust is reverse (i.e. negative) the net forward/aft thrust is greater than zero.

**[0067]** Similarly, the net starboard lateral thrust is calculated:

$$\text{Net port lateral thrust}=PtL+StL$$

**[0068]** Where PtL **40**B is port thrust lateral and StL **41**B is starboard thrust lateral. PtL and StL are unequal in this example and therefore net port lateral thrust is the sum of PtL and StL.

**[0069]** Since the thrust vectors intersect at the center of mass **44** there is no net rotational torque exerted on watercraft **10**. The net thrust is lateral in the starboard direction and forward. The watercraft is thereby moved in a lateral direction at an oblique angle as indicated by clashed arrow **71** without rotation. Moving the watercraft **10** to port at an oblique angle is easily accomplished by reversing the thrust and angles of this example. Using this approach the watercraft may be moved in any direction.

**[0070]** Those skilled in the art understand that these three examples are illustrative of the invention and that many other configurations of thrust and propulsion angles can be extrapolated from these examples.

**[0071]** These examples illustrate the advantage of the invention. For example, in the examples of FIGS. **4**, **5**, and **6**, the only change is the propulsion angles **42**. The magnitude of the thrust vectors **42** remains constant. Consequently, the watercraft can be precisely moved laterally and torque may be exerted either clockwise or counter clockwise by simply changing the propulsion angles **42** equally. Those skilled in the art understand that variations of these examples can be used to move the craft laterally and either clockwise or counterclockwise. Similarly, the craft may be moved at various oblique angles. Another advantage is that compensation for wind or currents is easily achieved. For example, if watercraft **10** begins to rotate counter clockwise while the operator is attempting a lateral movement to port, the propulsion angles **42** can be increased until rotational torque counteracts the rotation.

**[0072]** Another advantage is that the invention is so simple that it may be implemented manually without the need for an ECU **14**. Using a manual configuration as described in FIG. **3** above, the operator need only follow some simple steps. For example, an operator would use the following steps to use the invention for moving the watercraft **10** laterally to port. First, put the port propulsion unit **11**A in reverse and the starboard propulsion unit **11**B in forward. Set both propulsion units **11** to idle thrust. Set the propulsion angle **42** for each propulsion unit to be equal but opposite such that the extended propulsion vectors intersect at the center of mass **44** of the watercraft **10**. This can be simplified by having presets or detents in the operator interface **15** that indicate settings for achieving this result. To exert rotational torque on the watercraft **10**, the operator simply changes the propulsion angles **42** so that the intersection of the thrust vectors **40** and **41** intersect either tore or aft of the center of mass **44**. This process is further simplified by using the variable length draglink **70** described below. Variable length draglink **70** enables the operator to change the propulsion angles **42** with a single control such as a switch, thumb wheel, knob, or the like.

**[0073]** FIG. **8** is a schematic representation of a variable length draglink implemented in a typical steering mechanism. Variable length draglink **70** is part of the steering mechanism **13** and connects the propulsion units **11** together. Typically a draglink is a fixed length so that the propulsion units are turned at the same time with equal angles. Variable length draglink **70** can be either shortened or extended to alter the relative propulsion angles **42** of each propulsion unit **11**. Variable length draglink **70** greatly simplifies implementation of the inventive methods illustrated in FIGS. **4**, **5**, and **6**. This enables an operator or an ECU **14** to control the vector angle **43** with a single signal. The signal to the draglink **70** merely tells the draglink **70** to shorten or lengthen or remain in the current position.

**[0074]** FIG. **9** shows partial detail of the variable length draglink. Draglink **70** comprises jack screw **80**, motor **81**, electromechanical stops **82**, position feedback sensor **83**, and jack screw stop **84**. Screw jack systems are known in the mechanical arts and therefore only a brief description is given below. Motor **81** turns jack screw **80** either clockwise or counter clockwise to enable shortening or lengthening draglink **70**. Motor **81** is preferably an electric motor. As jack screw **80** is turned, the length of draglink **70** is changed as shown by arrows **88**. Damage is prevented by jack screw stop **84** activating electromechanical stops **82**A and **82**B. Electromechanical stops **82** are preferably micro switches which generate a signal to stop motor **81** when the micro switch is activated. Position feedback sensor **83** generates a signal indicative of the length of draglink **70**. Draglink **70** is coupled to the balance of the steering mechanism **13** via helm connector **86**. Draglink **70** connects to the starboard propulsion unit **11**B at yoke **878** and similarly connects to port propulsion unit **11**A at yoke **87**A. In the preferred embodiment, jack screw **80** has two different thread pitches. The helm portion **80**a of jack screw **80** connects to the helm control (e.g. steering wheel) and has threads that are 2× the thread pitch of the propulsion unit portion **80**b. The two pitches keep the center reference of the propulsion units on the centerline of the watercraft. The connection to the helm control, (operator steering wheel) via helm connector **86**, changes distance at one half the change in length of the jackshaft connection between the propulsion units. This dual thread pitch feature allows the propulsion units to move in and out on a constant centerline for the watercraft.

**[0075]** While prior art systems require independently steerable propulsion units **11** to maneuver a watercraft, the instant invention eliminates this requirement by using a dependent steering mechanism equipped with a variable length draglink **70**. In the preferred embodiment, the helm command steering position is set to zero before operating the drag link length changes.

**[0076]** FIG. **10** is a schematic diagram of the ECU **14** and the components that communicate with ECU **14**. Many of the components in FIG. **10** are not required to implement the invention. However, the preferred embodiment includes a system having a full spectrum of functions and capabilities to improve the maneuvering and navigation of a watercraft and therefore they are described briefly.

**[0077]** Engine control unit (ECU) **14** receives signals from joystick **15**A, keyboard/display **15**B heading sensor **90**, GPS unit **91**, accelerometers **92**, thruster control **93**, yaw sensor **94**, and engine status **95**. ECU **14** communicates signals to keyboard/display **15**B, thruster control **93**, propulsion units **11**, and steering mechanism **13**.

**[0078]** Joystick **15**A and keyboard/display **15**B comprise the user interface discussed above. Joystick **15**A can be moved in the X and Y directions and also may be rotated. Each position is representative of an operator's desired movement of the watercraft **10**. Joystick also includes a "remain on station" button **15**C and a precision maneuver button **15**D. The remain on station button **15**C signals the ECU **14** to keep the watercraft at the current position. Signals from the GPS and heading sensors are used to develop the appropriate thrust and drag link jack screw settings. The precision maneuver button **15**D signals the ECU **14** to configure for precision maneuvers (e.g. place on propulsion unit in reverse and one propulsion unit in forward and use the variable length draglink). Keyboard/display **15**B enables an operator to send alphanumeric data to ECU **14** and displays information such as heading, speed, engine parameters, and the like. These signals are communicated via operator commands **19**A and **19**B.

**[0079]** Heading sensor **90** detects the magnetic heading, true heading, or both. Heading sensor **90** may comprise a compass, a gyroscopic device, an electromagnet navigation system, or the like. The heading signal **20**A is communicated to the ECU **14** where it is either communicated to the operator or used in navigation computations.

**[0080]** GPS unit **91** uses the global positioning system of satellites to compute location and speed data. The GPS signal **20**B is communicated to the ECU **14** where is either communicated to the operator or used in navigation computations.

**[0081]** Accelerometer sensor **92** uses one or more accelerometers to detect changes in either forward velocity, lateral velocity, or both. The accelerometer signal **20C** is communicated to the ECU **14** where it is either communicated to the operator or used in navigation or maneuver calculations.

**[0082]** Thruster control **93** controls the magnitude and direction of thrust generated by thrusters. Thrusters are generally smaller propulsion units located at various positions on a large watercraft and they are used primarily for docking maneuvers. Typically one or more thrusters are located on the fore portion of the watercraft. Although thrusters are not required to be used in the instant invention, some watercraft may still be equipped with thrusters and therefore the ECU **14** will incorporate thrusters to improve the watercraft's maneuvering capabilities. ECU **14** sends a thruster command signal **93**A to thruster control **93** for controlling thruster.

**[0083]** Yaw sensor **94** detects yaw movement or position. To reduce drag it is advantageous to have a yaw angle of zero for open water travel. For docking operations yaw angles are necessary to overcome tides, wind, eddy currents, and other disturbance to the intended direction of travel. The yaw signal **20**D is communicated to ECU **14** where it is either communicated to the operator or used in navigation or maneuver calculations.

**[0084]** Engine status **95** monitors parameters of the propulsion units **11** and communicates a status signal **95**A to ECU **14**. Examples of parameters that are monitored comprise temperature, oil pressure, battery charging, and faults. Helm position indicator **96** communicates the position of the helm (e.g. steering wheel) and provides a helm data signal **96**.A indicative of the position of the helm. A primary purpose of helm position indicator **96** is confirmation that the helm is at zero (i.e. centered) so that various maneuvers can begin to be executed.

**[0085]** Propulsion units **11** are the two primary engines on the watercraft. Those skilled in the art understand that the invention can also be practiced with more than two engines using the same vector analysis concepts. Thrust commands **17** are communicated to the propulsion units **11** and thereby control the magnitude of thrust and weather it is forward or reverse. The exact method of controlling thrust will vary depending on the type of propulsion unit used. However, those skilled in the art can understand the various techniques available for controlling thrust magnitude.

**[0086]** Steering mechanism **13** controls the propulsion angle of the propulsion units **11**. Steering mechanism **13** may be any steering device known in the art capable of being implemented with the instant invention or discussed in this specification. Steering mechanism **13** may be of a variable draglink design as disclosed above, or two individual steering mechanisms, controlled mechanically, electrically, hydraulically, optically or any combination thereof.

**[0087]** The method of the invention follows from the description of the apparatus above. The method steps comprise:

**[0088]** providing a first propulsion unit attached to the aft portion of said watercraft;

**[0089]** providing a second propulsion unit attached to the aft portion of said watercraft;

**[0090]** providing a steering mechanism coupled to said first and second propulsion units;

**[0091]** causing said first propulsion unit to produce reverse thrust;

**[0092]** causing said second propulsion unit to produce forward thrust;

**[0093]** controlling the propulsion angles of said propulsion units such that the angles are equiangular and opposite thereby defining a vector angle between the thrust vectors of said first and second propulsion units;

**[0094]** controlling said propulsion angles to affect precision maneuvers of said watercraft;

**[0095]** wherein said precision maneuver comprises lateral movement of said watercraft while the forward velocity and the rotational speed of said watercraft are essentially zero;

**[0096]** wherein said precision maneuver comprises lateral and rotational movement of said watercraft while the forward velocity of said watercraft are essentially zero;

**[0097]** wherein said precision maneuver comprises oblique lateral movement of said watercraft while the rotational speed of said watercraft is essentially zero;

**[0098]** wherein said precision maneuver comprises oblique lateral movement and rotation of said watercraft;

**[0099]** providing an operator interface in communication with said steering mechanism and generating operator commands responsive to operator inputs;

**[0100]** changing the propulsion angles responsive to operator commands;

**[0101]** controlling said propulsion angles using a variable length draglink connected between said first and second propulsion units;

**[0102]** providing a draglink position sensor coupled to said draglink and generating a signal indicative of the length of said draglink;

**[0103]** providing an engine control unit in communication with said steering mechanism and

**[0104]** generating propulsion angle commands;

**[0105]** generating a propulsion angle command responsive to said operator command from said operator interface;

**[0106]** wherein the magnitude of thrust from said first and second propulsion units is determined by the need for lateral motion, oblique motion, and rotational motion;

**[0107]** wherein said first propulsion unit is attached to the port side of said aft portion;

**[0108]** wherein said second propulsion unit is attached to the starboard side of said aft portion;

**[0109]** causing the thrust vector intersection point to be aft of the center of mass of the watercraft to induce clockwise torque and lateral movement on said watercraft;

**[0110]** causing the thrust vector intersection point to be forward of the center of mass of the watercraft to induce counter-clockwise torque and lateral movement on said watercraft;

**[0111]** causing the thrust vector intersection point to be at the center of mass of the watercraft to induce lateral movement of said watercraft in the port or starboard direction based on propulsion thrust vector;

**[0112]** providing a movement sensor in communication with said control unit; and

**[0113]** generating a movement signal indicative of movement of said watercraft; and, generating a propulsion angle command responsive to said movement signal.

**[0114]** The specific configurations and features of the invention may vary according to specific requirements. In the preferred embodiment, the invention is generally used for twin engine personal use watercraft. However, the invention may be adapted to various vessels, vehicles, and craft of many types and sizes. Further, although only a few embodiments of the invention have been illustrated, if is understood that many adaptations of the invention may be implemented without departing from the spirit of the invention.

**[0115]** The solutions offered by the invention disclosed herein have thus been attained in an economical, practical, and facile manner. To whit, a novel apparatus and method of watercraft position management which is cost effective, easily installed or retrofit, and simple to use has been invented. While preferred embodiments and example configurations of the inventions have been herein illustrated, shown, and described, it is to be appreciated that various changes, rearrangements, and modifications may be made therein, without departing from the scope of the invention as defined by the claims. It is intended that the specific embodiments and configurations disclosed herein are illustrative of the preferred, and best modes for practicing the invention, and should not be interpreted as limitations on the scope of the invention as defined by the claims, and it is to appreciated that various changes, rearrangements, and modifications may be made therein, without departing from the scope of the invention as defined by the claims.

The invention claimed is:

**1**. A position management system for a watercraft comprising:

a first propulsion unit suitable for providing a first thrust, said first propulsion unit attached to the aft portion of said watercraft;

a second propulsion unit suitable for providing a second thrust, said second propulsion unit attached to the aft portion of said watercraft; and

a steering mechanism coupled to said first propulsion unit and said second propulsion unit, said mechanism comprising a variable length draglink.

**2**. The position management system according to claim **1**, wherein:

said draglink changes the propulsion angle of said first propulsion unit opposite to the change in propulsion angle of said second propulsion unit.

**3**. The position management system according to claim **2**, wherein:

said variable length draglink comprises a screw jack.

**4**. The position management system according to claim **3**, wherein:

said screw jack includes a jack screw having two thread pitches.

**5**. The position management system according to claim **3**, wherein:

said steering mechanism comprises a motor coupled to said variable length draglink and suitable for changing the length of said draglink.

**6**. The position management system according to claim **5**, further comprising:

an operator interface in communication with said motor and generating an operator command indicative of a desired change in the length of said draglink.

**7**. The position management system according to claim **6**, wherein:

said first propulsion unit is generating reverse thrust; and

said second propulsion unit is generating forward thrust as determined by the lateral direction of desired travel.

**8**. The position management system according to claim **7**, further comprising:

an engine control unit in communication with said operator interface and generating propulsion angle commands responsive to said operator command.

**9**. The position management system according to claim **8**, wherein:

said control unit generates a predetermined propulsion angle command responsive to an operator command indicative of a lateral movement of said watercraft.

**10**. The position management system according to claim **7**, wherein:

said propulsion units are attached to the transom of said watercraft;

said first propulsion unit is on the port side of transom;

said second propulsion unit is on the starboard side of the transom;

said first and second propulsion units are equidistant from the centerline of said watercraft; and

the vector angle between said propulsion units is set to cause lateral movement of said watercraft while forward movement and rearward movement are substantially zero, and rotational torque is substantially zero.

**11**. The position management system according to claim **10**, wherein:

port lateral movement and clockwise torque is produced on said watercraft by increasing the vector angle between said propulsion units until the extended thrust vectors of the propulsion units intersect aft of the center of mass of the watercraft.

**12**. The position management system according to claim **11**, wherein:

the magnitude of thrust from said first and second propulsion units is substantially equal.

**13**. The position management system according to claim **11**, wherein:

the magnitude of thrust from said first and second propulsion units is unequal to cause lateral oblique angle movement of the craft.

**14**. The position management system according to claim **10**, further comprising:

a movement sensor in communication with said control unit and generating a movement signal indicative of movement of said watercraft; and

wherein said control unit generates a propulsion angle command responsive to said movement signal.

**15**. The position management system according to claim **14**, wherein:

said movement sensor is selected from a group consisting of:

an accelerometer;

a directional sensor;

a compass unit;

a yaw sensor; and

a gyroscope unit.

**16**. The position management system according to claim **15**, wherein:

said operator command includes an on-station command; and

said control unit generates a propulsion angle command responsive to said on-station command.

**17**. A method of controlling movement of a watercraft comprising the steps of:

providing a first propulsion unit attached to the aft portion of said watercraft;

providing a second propulsion unit attached to the aft portion of said watercraft;

providing a steering mechanism coupled to said first and second propulsion units;

causing said first propulsion unit to produce reverse thrust;

causing said second propulsion unit to produce forward thrust;

controlling the propulsion angles of said propulsion units such that the angles are equiangular and opposite thereby defining a vector angle between the thrust vectors of said first and second propulsion units; and

controlling said propulsion angles to perform precision maneuvers of said watercraft.

**18**. The method of controlling according to claim **17**, wherein:

said precision maneuver comprises lateral movement of said watercraft while the forward velocity and the rotational speed of said watercraft are essentially zero.

**19**. The method of controlling according to claim **18**, wherein:

said precision maneuver comprises lateral and rotational movement of said watercraft while the forward velocity of said watercraft is essentially zero.

**20**. The method of controlling according to claim **18**, wherein:

said precision maneuver comprises lateral movement at an oblique angle.

**21**. The method of controlling movement according to claim **18**, further comprising the steps of:

providing an operator interface in communication with said steering mechanism; and

changing the propulsion angles responsive to operator commands.

**22**. The method of controlling movement according to claim **21**, wherein:

the step of controlling said propulsion angles comprises using a variable length draglink connected between said first and second propulsion units.

**23**. The method of controlling movement according to claim **22**, further comprising the step of:

providing a draglink position sensor coupled to said draglink and generating a signal indicative of the length of said draglink.

**24**. The method of controlling movement according to claim **23**, further comprising the steps of:

providing an engine control unit in communication with said steering mechanism; and

generating a propulsion angle command responsive to said operator command from said operator interface.

**25**. The method of controlling movement according to claim **24**, wherein:

the magnitude of thrust from said first propulsion unit is substantially equal to the magnitude of thrust from said second propulsion unit for lateral movement.

**26**. The method of controlling movement according to claim **17**, wherein:

said first propulsion unit is attached to the port side of said aft portion;

said second propulsion unit is attached to the starboard side of said aft portion; and

further comprising the step of causing the thrust vector intersection point to be aft of the center of mass of the watercraft to induce port lateral motion and clockwise torque on said watercraft.

**27**. The method of controlling movement according to claim **26**, further comprising the step of:

causing the thrust vector intersection point to be forward of the center of mass of the watercraft to induce port lateral movement and counter-clockwise torque on said watercraft.

**28**. The method of controlling movement according to claim **27**, further comprising the step of:

causing the thrust vector intersection point to be at the center of mass of the watercraft to induce lateral or oblique movement of said watercraft in the port direction.

**29**. The method of controlling movement according to claim **28**, further comprising the steps of:

providing a movement sensor in communication with said control unit;

generating a movement signal indicative of movement of said watercraft; and generating a propulsion angle command responsive to said movement signal.

**30**. The method of controlling movement according to claim **17**, wherein:

said first propulsion unit is attached to the starboard side of said aft portion;

said second propulsion unit is attached to the port side of said aft portion; and

further comprising the step of causing the thrust vector intersection point to be aft of the center of mass of the watercraft to induce starboard lateral motion and counter clockwise torque on said watercraft.

**31**. The method of controlling movement according to claim **30**, further comprising the step of:

causing the thrust vector intersection point to be forward of the center of mass of the watercraft to induce starboard lateral movement and clockwise torque on said watercraft.

**32**. The method of controlling movement according to claim **31**, further comprising the step of:

causing the thrust vector intersection point to be at the center of mass of the watercraft to induce lateral or oblique movement of said watercraft in the starboard direction.

**33**. A propulsion control system for a vehicle comprising:

a first propulsion unit attached to the aft portion of said vehicle and generating a first reverse thrust;

a second propulsion unit attached to the aft portion of said vehicle and generating a second forward thrust substantially equal in magnitude to said first reverse thrust;

a steering mechanism coupled to said first propulsion unit; and

wherein said steering mechanism controls the propulsion angle of said first propulsion unit to a toe-in angle relative to the propulsion angle of said second propulsion unit to perform a precision maneuver.

**34**. The propulsion system of claim **33**, wherein:

said steering mechanism is in communication with said second propulsion unit: and

said steering mechanism controls the propulsion angles of said first and second propulsion units to he substantially equiangular but opposite in direction for lateral motion.

**35**. The propulsion system of claim **34**, wherein:

said steering mechanism comprises a variable length draglink connected between said first and second propulsion units.

**36**. The propulsion system of claim **35**, further comprising:

an operator interface in communication with said steering mechanism, said interface generating a propulsion angle command representative of a desired propulsion angle for said first propulsion unit angle.

**37**. The propulsion system of claim **36**, further comprising:

a control unit in communication with said steering mechanism, said control unit generating a propulsion angle command to affect a precision maneuver of said vehicle.

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