

A Joint Commonality Submersible (JCS)

Field

5 The present invention relates to a Joint Commonality Submersible (JCS) particularly though not solely to an underwater propulsion device for attachment to a scuba diver.

Background

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US patent number 6823813 ("Mazin") discloses a leg mounted propulsion device for swimmers and divers. Propulsion units are attached to the diver's legs. A battery pack is either attached as a weight belt or as a cylinder beside the air tank. A controller is attached to the belt beside the buckle on the stomach of the diver.

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Mazin may suffer from a number of disadvantages including lack of adequate sealing for the battery pack, lack of modularity, difficulty of access to the controller (especially when the diver's hands are already holding other equipment), lack of flexibility in control, and/or lack of user friendliness and difficulty of user servicing.

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There are also a range of other propulsion devices known in the art. For example tow type designs disclosed in US patent numbers 4996938 and 5469803; different kinds of body strap designs disclosed in International patent publication numbers 02072382 and 2004062744, French patent numbers 2608441 and 2763512, and
25 US patent numbers 3635188 and 4700654; push type designs strapped between

the knees; and tank mounted designs disclosed in International patent publication numbers 8602613, 2004050473 and 2005080194, US patent number 5365868, US patent publication number 2006243188 and Australian patent number 8070794.

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It would be desirable to provide a submersible or underwater propulsion device which overcomes one or more of these disadvantages and/or which at least provides the public with a useful choice.

10 Summary

In general terms the invention proposes a propulsion device with:

- motion-sensing capabilities, from the user wrist or any parts of the body that can attach motion sensor(s);
- 15 - modularity, so that the user can easily select between a plurality of user attachment configurations;
- quick-release connectors for the thrusters;
- underwater reconfigurability;
- modularity, for variable methods of propulsion; and/or
- 20 - effective battery sealing and/or underwater battery replacement.

Such a propulsion device may have the advantage that sealing of the battery pack may be improved even if the outer casing is opened while the diver is still wet; additional modules may be easily added; a much wider range of control options and user interactivity may be possible; user friendliness may be improved; users
25 may easily service or upgrade the device anywhere; the device may be attached

via a tow/pull type scooter, via a thigh strap, via a calf strap, between the thighs as a push-type, or to the tank or a rebreather unit; more intuitive and/or reduced fatigue control effort; a user can pre-fix the mounting before fixing the thrusters on in the water; a user can remove the thrusters in an emergency; a user can change the system from one form to another underwater without surfacing (e.g. diver using a conventional underwater scooter form, needs to go through a small port hole of a ship wreck, can dismantle the scooter into small parts, push through the port hole and calve mount it); propulsion can be via propeller, jet or pump; and/or the user may be able to change batteries underwater to extend travel distance without surfacing.

In a first particular expression of the invention there is provided an underwater propulsion device as claimed in claim 1.

Example implementations of the invention are provided in any one of claims 2 to 13 and 16.

In a second particular expression of the invention there is provided a controller as claimed in claim 14.

In a second particular expression of the invention there is provided a headlight module as claimed in claim 15.

Brief Description of Drawings

One or more example embodiments of the invention will now be described, with reference to the following figures, in which:

Figure 1 is a schematic view of various embodiments of a propulsion device according to an example embodiment;

5 Figure 2 is a schematic view of the parts used in the embodiments in Figure 1;

Figure 3 is a perspective view of the tow/pull type scooter in Figure 1;

Figure 4 is an exploded view of the tow/pull type scooter in Figure 3;

Figure 5 is an exploded view of the battery canister in Figure 3;

Figure 6 is a perspective view of the battery canister top cover in Figure 5;

10 Figure 7 is a perspective view of the thigh strap configuration in Figure 1;

Figure 8 is an exploded view of the thruster in Figure 7;

Figure 9 is a perspective view of the ECM module configuration in Figure 7;

Figure 10 is a perspective view of the hand controller in Figure 2;

Figure 11 is a perspective view of the calf strap configuration in Figure 1;

15 Figure 12 is a perspective view of the push configuration in Figure 1;

Figure 13 is a perspective view of the tank mount configuration in Figure 1;

Figure 14 is an exploded view of the head light module in Figure 2;

Figure 15 is a section view of the head light module in Figure 14;

Figure 16 is a perspective view of the underwater changeable battery canister in

20 Figure 1;

Figure 17 is a section view of the underwater changeable battery canister in Figure 16;

Figure 18 is a section view of the battery in Figure 16;

Figure 19 is a flow diagram of the control strategy for recreational applications;

25 Figure 20 is a flow diagram of the control strategy for technical applications;

Figure 21 is a flow diagram of the control strategy for military applications;

Figure 22 is a perspective view of the quick release mechanism in Figure 8; and

Figure 23 is a schematic diagram of the directional control using the hand controller in Figure 10.

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Detailed Description

Figure 1 shows a range of different embodiments for an underwater propulsion device. In a first embodiment the device is configured in as a tow/pull type scooter
10 300. In a second embodiment the device is attached to the user with a thigh strap configuration 700. In a third embodiment the device is attached to the user with a calf strap configuration 1100. In a forth embodiment the device is attached between the thighs of the user in a push configuration 1200. In a fifth embodiment the device is attached tank mount configuration 1300. In a sixth embodiment the
15 device includes an underwater changeable battery canister 1600.

All of the embodiments can be configured using a complete set of parts shown in Figure 2. The parts include a canister head 200, a body adapter 202, a hand bar 204, a tow converter 206, a battery canister 208, an ECM module or driver casing
20 210, a thruster 212 with quick release adapter 214, a hand controller 216, cables 218, push converter 220, a headlight canister 224, the underwater changeable battery canister 1600 and a waterproof battery pack 226.

If the user has the complete set of parts shown in Figure 2, they have the ability to
25 easily configure the device into any of the embodiments mentioned above. This

can either occur prior to a dive, or in some cases, the user can reconfigure the device underwater. For example, if the diver is using the thigh strap configuration 700, and becomes entangled underwater e.g fishing net, the diver can dismantle the thigh strap configuration 700 into parts, get out of the net and reattach to
5 whichever configuration suitable for safe travelling afterwards. This design also allows more situation control by the diver.

Tow/pull type scooter

The tow/pull type scooter 300 according to the first embodiment is shown in
10 Figures 3 to 6. In the first embodiment the diver holds onto the hand bar 204 and is towed by the tow/pull type scooter 300. The hand bar 204 is mounted using locking mechanism 400 to the tow converter 206. An on/off switch 402 and/or speed control knob 403 (on/off switch can also be incorporated into the speed control knob) is provided on the hand bar 204, which is connected via the cables
15 218 to the ECM module 210. On either side slots 406 are provided to house each quick release adapter 214, to which in turn each thruster 212 is attached to. The ECM module 210 slots into the side of the tow converter 206. An LCD panel 302 may also be provided on the hand bar 204.

20 The tow converter 206 can be pivoted open about a hinge 404 to allow the battery canister 208 to be inserted in place. A series of stainless steel latches 408 are used to clamp and secure the tow converter 206.

The cables 218 connecting the thrusters 212, ECM 210 and handle bar 204 may
25 be packed into a compartment within the tow converter 206. Alternatively the tow

converter 206 may include internal connectivity so that the user can snap the pins together.

The end of the battery canister 208 protrudes from the tow converter 206. The body adapter 202 fits onto the end of the battery canister 208, and the canister head 200 fits onto the end of the body adapter 202. The body adapter's 202 main purpose is to maintain the neutral or provide additional buoyant lift. The size of the body adapter 202 can be customised to carry additional loads attached on the outer rim of the adapter. For example an underwater video/camera may be strapped on top of the body adapter 202. An extended or multiple body adapters may be used for carrying heavy loads.

The canister head 200 is rounded for hydrodynamic efficiency.

Picatinny rail (also known as MIL-STD-1913 rail or STANAG 2324 rail or Tactical Rail) or NATO Accessory Rail (or NAR) can be used to replace tow converter 206 and thrusters can be slotted into these tactical rails and released via spring-loaded knobs or screws for military applications (not shown).

Battery Canister

The battery canister 208 is shown in more detail in Figures 5 and 6. The internal configuration of the in-water battery pack, consists of batteries 520 that may be alkaline, metal hydrides (NiMH), Li-Class families, Lead Acid etc.

The batteries 520 are sealed within the internal compartment by a battery canister top cover 500 to provide first and second level sealing. A secondary sealing cover 502 provides third level sealing. The secondary sealing cover 502 includes O-ring 504 at the top of battery pack to seal against the inner wall 506 of the outer casing

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When deliberately opening the top cover 500, a diver hands can be dripping wet. The secondary sealing cover 502 prevents water from entering into the battery compartment 510.

10 When inserting or removing the batteries 520 into the battery compartment 510, air must be able to escape/enter. A port plug 512 is installed on the secondary sealing cover 502, serves two functions.

1) To remove excessive gas build up from the batteries chemicals, if left over long period of time in an enclosed compartment. The port plug 512 enables the
15 releasing hydrogen gas by controlling the gas release, a special thread enables the gas to be released without any damage to the battery pack or user.

2) To allow excessive air flow - at times when diver seals the compartment 510 too tight or dives too deep, air contracts more than it expands after the diver ascend to the surface, so it may be hard to pull out the battery pack. By removing
20 the port plug 512, this allows outside air to fill up the battery compartment for easy removal.

The battery canister 208 may have independent application from the rest of the equipment. For example the battery canister 208 may be used to extend power
25 tools in hazardous areas on land or to provide power for other marine applications.

Thigh strap configuration

The thigh strap configuration 700 according to the second embodiment is shown in Figures 7 to 10. Each thruster 212 is attached to each quick release adapter 214. Each quick release adapter 214 has straps 810 to attach to the thigh of a diver. Each thruster 212 is electrically connected to the ECM module 210 via cables 218. The cables 218 also electrically connect the battery canister 208 and the hand controller 216 to the ECM module 210. The ECM module 210 and the battery canister 208 are mounted on a waist belt 702.

Thrusters

The thruster 212 is shown in more detail in Figure 8. Thrust is provided by a plastic composite or metallic alloy material driven propeller 800, turbine, jet or pump system. A safety barrier 802 made of high impact plastic composite surrounds the propeller 800. The cables 218 may be underwater releasably connected to the thruster 212 via a female connector 804.

Each thruster 212 slots into a slot 806 in the quick release adapter 214. A quick release button 808 allows the diver to quickly release the thruster 212 in an emergency. Figure 22 shows the quick release works by having at least two spring mechanisms. One spring 2200 latches the thruster 212, while another spring 2200 pushes the thruster's hinge 2204 from the bottom. For immediate release, once the button 808 is depressed, the latch 2200 will release, and the bottom mechanism 2202 will push the thruster's latching gap out of the latching mechanism. In an emergency, the diver may also unplug the cable to cut off the

power. The cable is attached even when quick released, as a precaution reduce the chances of thrusters 212 being lost completely and sinking to the ocean bottom.

- 5 Straps 810 are threaded through the quick release adapter 214 to attach around the divers thigh. The straps 810 are made of fabric materials which may include Kelvar, Nylon and/or Neoprene. They are an ergonomic design to support the thrusters on the thigh muscles. The straps 810 are wear and tear, heat and corrosion resistant.

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ECM Module

- The ECM module 210 is shown in more detail in Figure 9. The ECM module 210 is internally oil filled and includes a metal outer surface 900 for heat dissipation. The cables 218 connect to 5 I/O connectors 902. The inner surface 904 is curved for
15 attached to the waist belt 702 or can be secured to the thigh. A reset switch 906 serves two functions on the ECM, primarily to reboot the JCS computer when battery pack 1600 is changed underwater or any connections is removed and replace underwater. It also serves as a second level of safety switch.

- 20 The ECM module 210 is electrically connected with the battery canister 208 by electrical splash-proof connectors as shown in Figure 6. Independent power isolators 600, 602 are provided for individual battery or power source. As the battery is capable of highly discharge electric current at very fast rate, individual power switches depressed by water-proof push buttons 604, 606, preventing user
25 from touching high power switches 600, 602 with wet fingers within the top cover,

provides additional safety in addition to having a on/off switch 402/1004 on the hand bar 204 or hand controller 216. When the high power switches 600, 602 are turned on this will provide power to the ECM module 210. However, only when the on/off switch 402/1004 is turned on, will the ECM module 210 activate the
5 thrusters 212. This provides further safety against accidental powering the device by children or dropping from heights, and to reduce the risks of having electric shock.

Hands free motion control

10 Figure 10 shows the hand controller 216 in more detail. The hand controller includes guide 1000 for the divers hand, and a hole 1002 in the guide for the diver's thumb. An on/off switch 1004, manual/auto switch (not shown) and speed control switch (not shown) can be provided within reach of the diver's thumb.

15 The switches are US Military approved and the internal components are pressure sealed by resin.

The guide 1000 is fabric material and is curved to follow the shape of the diver's wrist and includes strap(s) to attach firmly around the diver's wrist. Alternatively it
20 may have a hand strap(s) to dangle loosely around the palm. User fingers will extend from the end of the guide, while thumb will exit from the hole 1002.

In auto mode a control module 1006 including an inertia measurement unit (IMU) senses movement of the diver's arm, translates this into speed and direction
25 requests and send control signals to each thruster 212 accordingly. The IMU is

placed approximately above, along the side or parallel of the radius bone of the diver or being installed on a flat surface area parallel to the act of motion, permitting the arm to perform like a joystick or any parts of the user's body (e.g. on a dive helmet). The location of the IMU is based on the ergonomics and anatomy of average adult hand wrist and bone structure, including the angle of wrist to hand and thickness of the hands & thumb.

Various different hand movements can be used to translate to control the thrusters 212. For example a left rotation of the wrist translates to a left turn and a right rotation of the wrist translates to a right turn. A double forward knocking motion can translate to emergency stop. Each thruster 212 power can then be adjusted or preset by the computer to rotate clockwise (CW) and counter clockwise (CCW) at independent speeds accordingly.

For normal forward motion, the two propeller blades are counter-rotating to each other, which cancels out thruster torque for travelling in a "straight" line only. If the power delivered to each thruster is adjusted independently, various different directions may be achieved. This is achieved by preset speeds and programmed into the ECM module 210. For example 8 different directions are shown in Figure 23:

2301 Forward thrust: two thrusters turning in the opposite directions (counter-rotating to each propeller) to "push" user (diver and/or swimmer) forward

2302 Right thrust: Left-side thruster will "push" the user forward, while Right-side thruster will either "pull" backward or stop – no power (act as pivot)

2303 **Forward-Right thrust: By combining Right (as mentioned in 2302) motion with speed adjustment and user body-twisting motion to the angle of flow, resulting banking motion (like an aircraft banking right).

2304 Left thrust: Right-side thruster will "push" the user forward, while Left-side thruster will either "pull" backward or stop (act as pivot)

2305 **Forward-Left thrust: By combining Left (as mentioned in 2204) motion with speed adjustment and user body-twisting motion to the angle of flow, resulting banking motion (like an aircraft banking left)

2306 *Backward thrust: two thrusters turning in reverse directions to "pull" swimmer backward.

2307 *Backward-Right thrust: Reverse direction of Forward-Left

2308 *Backward-Left thrust: Reverse direction of Forward-Right

*Applicable only to swimmer, as diver's fins can cause a lot of drag and eventually damage the ECM module and thrusters

** In order for the user to turn in a certain angle, a preset power will be programmed into the computer to command individual thruster to drive in a preset power – e.g. to turn forward right, the "push" thruster will deliver 100% power while the "pull" thruster will deliver lower power than the "push" thrusters so as to act like a pivot (much like a bull dozer steering) while the user's body twists with the angle of flow (motor biker needs to lower the body when turning at a sharper angle) and speed will then propel the user to the direction.

The user must also control the speed in order to determine the direction of travel, else user will circle on a dead spot.

The automatic mode may greatly reduce diver's fatigue load, permit confined space manoeuvres or during restricted fining of the legs when strapped with other equipment.

- 5 Because the hand controller 216 straps to the wrist of the diver, the diver's fingers are still free. Thus the diver can still hold or operate other dive equipment in that hand.

For recreational applications, the on/off switch 402/1004 is turned on in a
10 backward position (towards the diver), which is slightly more difficult than the turn off forward position (away from the diver). This allows the diver the more natural actuation of pushing forward, for an immediate stop or emergency brake.

The ECM module 210 may include sensors, for example water speed sensors or
15 depth sensors. The hand controller 216 may include an LCD panel with GUI (Graphic User Interface) and/or touch interactivity. Information can then be packaged and transmit through the ECM module 210 via wireless transmission (Radio-Frequency) and decoded by control module 1006 at the diver's wrist. The system can also relay a power signal (RF may be limited in water up to 1m) by
20 transmitting information from the ECM module 210 to the hand controller 216 and/or display information on a diver's mask (like head-up display). Depending on the application eg: sports, technical, commercial, military, different information may be gathered and/or displayed.

Hand controller 216 including motion-sensing can also be used as a manipulator for human-like movement, for any turret system mounting equipment (like apache attack helicopter pilot's helmet controlling the machine gun, the machine gun mounted will follow the direction where the pilot is looking). The equipment can be controlled by motion sensing, joystick-controlled, both wired or wire-less. This might be used in fire-fighting or rescue operations, or deep sea remote operated vehicle where the situation is hazardous. The motors that provide "CW" and "CCW" directions, can also be combined with or switched to actuators for "Pushing" and "Pulling" motions.

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Calf strap configuration

In the calf strap configuration 1100 shown in Figure 11, the straps 810 are attached to the calf of the diver instead of the thigh. In that case the quick release adapter 214 includes a hinged mechanism 1102 to angle the propeller backwash away from the divers calf and the fin attached to the diver's foot. The angle may for example be between 3-45°. The hinged mechanism 1102 is released by a button (not shown). Otherwise this is similar to the thigh strap configuration 700.

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Push configuration

The push configuration 1200 is shown in Figure 12. The push converter 220 (also called a saddle bar, scooter saddle or simply a saddle) has channels 1202 either side to accommodate the diver's thighs, and straps 1204 attach over the outside to secure the push converter 220 to the thighs. The battery canister 208, body adapter 202 and the canister head 200 fits into a channel 1206 on top of the push converter 220. On either side of the channel 206 slots 1208 are provided to house

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each quick release adapter 214, to which in turn each thruster 212 is attached to. The ECM module 210 is attached to the diver's waist belt 702. The ECM module 210 and hand controller 216 are connected to the battery canister 208 and each thruster 212 via the cables 218.

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Tank mount configuration

The tank mount configuration 1300 shown in figure 13 is similar to the thigh strap configuration 700, except that that straps 810 are used to strap to the tank 1302, to a double tank system 1304 or a rebreather unit. Also customised attachments
10 can be designed to accommodate different apparatus.

Headlight canister

Figures 14 and 15 show a headlight canister 224 that can be used for the tow/pull type scooter. The body adapter 202 and the canister head 200, are substituted for
15 the headlight canister 224.

The headlight canister 224 is independent similar to a dive torch except it must be neutral or positive buoyant, or to be compensated by other means to balance the buoyancy.

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The headlight canister 224 includes transparent plastic faceplate 1501, a bulb 1502 in its front section 1504, circuitry on a PCB 1506, first seal 1508, a second seal 1510, and underwater water pluggable connector 1512 from the PCB 1506 into a battery compartment 1514, a separate underwater changeable battery 226,

a waterproof switch 1518 and an end cover 1520 to seal the battery compartment

1514. The bulb 1502 may be H.I.D, Halogen, LEDs etc.

A reduced space gap 1522 is designed between the waterproof switch 1518 and
5 the end cover. The end cover 1520 also includes small holes 1524 for funnelling
seawater out when the end cover 1520 is being secured. As sea water is being
compressed and funnelled out of the holes 1524, the reduced space gap 1522 is
so small that sunlight and seawater will not be able to get / flow in. This removes
the chances of marine growth. Also, the small holes 1524 do not allows seawater
10 to flow in easily as the battery compartment and outside ambient pressure remains
the same, therefore seawater is not being compressed to flow into the small holes
1524.

This method reduces the chances of marine growth (e.g. barnacles) within the
battery compartment 1514 where the underwater switch 1518 and battery 226 is.
15 The reduced space gap 1522 cuts off sunlight, reduces oxygen and nutrient in the
water, and prevents marine growth.

The headlight canister 224 can be applied for any marine application that requires
power and submersion in sea water for prolong period of time.

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Underwater changeable battery

The underwater changeable battery canister 1600 shown in Figures 16 to 18, can
be used in place of the battery canister 208 mentioned above. In this case, two or
more waterproof battery packs 226 may be changed under water to allow the diver
25 to extend bottom travel distance without having spare scooters or surfacing.

To change the battery:

- 1) Turn off power – by pressing on the water-proof push-button 1604 (flip the underwater switch 1518 for front mount headlight 224). Power must be cut
5 off before changing battery, as it can damage circuitry and/or electric shock to user.
- 2) Unclip the end cover 1602 for underwater changeable battery (or unscrew the end cover 1520 for front mount headlight 224).
- 3) After turning off power, use the index finger to pull the In-water changeable
10 battery pack 226 out (both In-water changeable battery canister & front mount headlight uses the same waterproof battery pack(s) 226)
- 4) The In-water changeable battery pack 226 has a female connector 1606 which is self-sealing, once pulled out from the male connector 1608.
- 5) A new in-water battery 226 is inserted using a slot 1610 in guide the battery
15 pack(s) in place. Only a correct slot position will the male connector's 1608 pins be match exactly to the female connector 1606 of the battery pack 226.
- 6) Secure back the end cover 1602 / 1520 to prevent battery pack 226 from falling off.
- 7) Once connected, user can turn the power button 1604 / 1518 back on.

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Control Strategy

Different control strategies may be employed depending on the application and user requirements. For example, for recreation applications (up to 40m depth rating) the ECM module 210 might be programmed as shown in Figure 19. The
25 main controller 1900 receives power from the battery canister 208, via a voltage

regulator 1901, which may also power other electronics 1902. In turn the main controller 1900 is connected to the on/off switch 402/1004 and the speed control knob 403, and provides control signals to a motor driver ESC 1904. Each motor driver ESC 1904 receives power from a respective battery canister 208, and sends
5 an appropriate drive signal to each thruster 212.

For technical diving or advanced applications (up to 120m depth rating), the ECM module 210 might be programmed as shown in Figure 20. The control is similar to Figure 19, except that the main controller 1900 receives speed control signals
10 from the control module 1006. Control module 1006 includes motion sensing capabilities from the integrated IMU. Speed control 2000 and mode switching 2002 are also input to control module 1006.

The IMU uses a combination of accelerometers and gyroscopes to measure the
15 changes of angle in which the user turns the wrist or movement of the body. Thus angle motion produces analog signals to the control module 1006. The control module 1006 will then convert the differential analog signals to digital signals, compile and relay the information to the speed controller 2004. The main controller 1900 will decode, analyse the digital signals and transmit to the motor driver / ESC
20 1904. The ESC 1904 converts the decoded digital signals to digital frequency and generates pulse width modulated power waveforms for the BLDC motor in the thruster 212. The refresh rate is performed in milliseconds.

The speed control 2000 is analog, the control module 1006 adjusts the voltage
25 difference and computes the difference. The input speed is measured in the

difference of the voltage range, e.g. 0 Vdc to 5 Vdc, the speed controller 2004 will calculate this difference voltage range and convert this into binary and send it back to main control module 1900. As the speed control must be constantly monitor by control module 1006, therefore this function is taken off from main control module 1900 to reduce traffic) The main controller 1900 will then compile the voltage difference (for speed) and decoded signal (for motion signal) to the motor driver/ ESC 1904. The ESC 1904 will finalise the results, convert them into the digital frequency and generate the required pulse signals for the BLDC motor in the thruster 212.

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Control module 1006 includes an analog-to-digital converter, which converts the analog signals from the IMU to digital signals. Main controller 1900 performs multiple tasks, analysing and monitoring the entire system. Having two control modules reduces the work load and reduces the chances of total malfunction due to overload.

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For military applications (customised depth rating), the ECM module 210 might be programmed as shown in Figure 21. The control is similar to Figure 20, with the addition of a vector thrust system 2100, underwater navigation system 2102, an underwater HUD unit 2104, flow meters 2106, water detectors 2108.and user input waypoints 2110.

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With the introduction of motion-sensing control in Technical / Advanced applications, it creates wide applications such as:

- 1) Flow meters 2106 – used to provide reading of the thruster when water flows through the sensor(s) mounted on each thrusters
- 2) Water detectors 2108 – used to monitor any leakage within the JCS system. When water is detected, LED and/or buzzer will activate. In the event the safety switch is activated, or any errors conditions occur (eg: cable unplugged, short circuit, over temperature, water detected etc) the thrusters are immediately deactivated by main control module 1900 and/or control module 1006.
- 3) Underwater navigation system 2102 – a new methodology to by pass accelerometer in a Global Positioning System (GPS) and applying dead-reckoning methodology by using other measuring devices (e.g. flow meters) to provide acceleration readings. This application if successful, can also be used in land / underground areas where GPS signal is not available at all.
- 4) Diver Head-Up-Display (HUD) 2104 – a projected view of information shown to the user by projecting information through a prism installed on a water-proof diver's helmet. User can flip side way or up the projector away from normal viewing to reduce glazing from the projector (much like the apache helicopter pilot's HUD)
- 5) Vector thrust system 2100 – a set of gimbal thrusters controlled by several pulse-read motors, creates the vector thrust system through pulse generated from control module. From motion-sensing, whichever the user indicates by the motion, the thrusters will react and move according to the direction indicated by the user motion. This allows the thrusters to perform the "pitch, row and yaw" vectors in all directions (much like a rocket using its booster adjusting its flight). Together with motion sensing, this

applications can be apply / transfer for autonomous vehicles, robotics or remote sensing equipment, turret and/or weaponry etc

- 5 6) User input waypoints 2110 – Once all the above functions are achieved, the user input waypoints is like indicating the coordinates required to travel to a certain distance and bearing, the vector thrust system will follow the waypoints, while the main control module #1 controls the motor system requires for vector thrust and monitor the speed from the flow meter to constantly checking the speed of the thrusters. This allows a fully functioning “Auto-Pilot” control of the JCS, which can be apply for an
10 advanced autonomous vehicles or self navigation capabilities.
- 7) A cellular telephone module can be installed in the battery canister compartment or handheld waterproof compartment with remote/wired access capabilities. The diver can then speak though a full face mask to connect to the above water telephone network via a surface buoy. Voice
15 commands may be used to call preset numbers, or if the device detects an emergency condition an emergency number might be called with a pre-recorded emergency message.
- 8) A different type of power switch can be used to detect diver awareness, by means of hand or jaws depression. A diver can press on a spring loaded
20 hand switch or a force sensor installed in the diver regulator's mouth piece, which senses the amount of force the diver's jaws holds the mouth piece. Through these two methods, any sudden reduction in forces will trigger the control module to deactivate the thrusters- immediately.

Once in the water, when the diver is oriented in the desired direction, the on/off switch is actuated to energise the thrusters. The thrusters 212 are then controlled as described above. Any further control(s) (non-critical) can be communicated wirelessly between the Hand Controller and the ECM and other devices such as a
5 Head-Up-Display (HUD) in the diver's mask. An acoustic modem with a hydrophone, can be installed in the ECM to exchange information with other diver teams in the water. Information received by other divers, can in turn be displayed on their mask, allowing networking in the water.

10 To charge the batteries an electronic controlled charger may be connected to the batteries and ensures all the cells within the battery are charged evenly.

For upgrading, additional software modules the ECM module by connecting any spare ports to a computer. Additionally an ECM module with upgraded firmware
15 may be used to replace the existing ECM module in a plug and play manner. Individual parts of the JCS can be dismantled and replaced or upgraded accordingly by skilled user.

Whilst exemplary embodiments of the invention have been described in detail,
20 many variations are possible within the scope of the invention as will be clear to a skilled reader.

REFERENCE NUMERALS

25 200 canister head
202 body adapter

	204	hand bar
	206	tow converter
	208	battery canister
	210	ECM module
5	212	thruster
	214	quick release adapter
	216	hand controller
	218	cables
	220	push converter
10	224	headlight canister
	226	waterproof battery pack
	300	tow/pull type scooter
	302	LCD panel
15	400	pin lock mechanism
	402	on/off switch
	403	speed control knob
	404	hinge
20	406	slots
	408	latches
	500	battery canister top
	502	secondary sealing cover
25	504	O-ring
	506	inner wall
	508	outer casing
	510	battery compartment
	512	port plug
30	520	battery pack
	600, 602	individual power switches
	604, 606	water-proof push buttons

	700	thigh strap configuration
	702	waist belt
5	800	propeller
	802	safety barrier
	804	female connector
	806	slot
	808	release button
10	810	straps
	900	outer surface
	902	I/O connectors
	904	inner surface
15	906	reset switch
	1000	guide
	1002	hole
	1004	on/off switch
20	1006	control module
	1100	calf strap configuration
	1102	hinged mechanism
25	1200	push configuration
	1202	channels
	1204	straps
	1206	channel
	1208	slots
30		
	1300	tank mount configuration
	1302	tank
	1304	double tank system

	1501	transparent plastic faceplate
	1502	a bulb
	1504	front section
5	1506	PCB,
	1508	first seal
	1510	second seal
	1512	underwater water pluggable connector
	1514	battery compartment
10	1518	waterproof switch
	1520	end cover
	1522	reduced space gap
	1524	small holes
15	1600	underwater changeable battery canister
	1602	end cover
	1604	water-proof push-button
	1606	female connector
	1608	male connector
20		
	1610	slot
	1900	main control module
	1901	voltage regulator
25	1902	other electronics
	1904	motor driver ESC
	2000	speed control
	2002	mode switching
30	2004	speed controller
	2100	vector thrust system
	2102	underwater navigation system

	2104	underwater HUD unit
	2106	flow meters
	2108	water detectors
	2110	user input waypoints
5		
	2200	latch
	2202	spring
	2204	hinge
10	2301	Forward thrust
	2302	Right-side thrust
	2303	Forward-Right thrust
	2304	Left-side thrust
	2305	Forward-Left thrust
15	2306	Backward thrust
	2307	Backward-Right thrust
	2308	Backward-Left thrust

CLAIMS

1. An underwater propulsion device comprising:
at least one propulsion unit capable of attachment to two or more of a user,
5 a tank, a scooter and a saddle.
a controller configured to receive the user's input, and
a battery compartment capable of attachment to two of more of a user, a
scooter and a saddle.
- 10 2. The device in claim 1 wherein the propulsion unit comprises a thruster and
a quick release adapter, the quick release adapter including a button configured to
eject the thruster.
3. The device in any one of the preceding claims wherein the propulsion unit,
15 the controller and the battery compartment are configured to be connected by
cables that may be removed and reconnected underwater.
4. The device in claim 4 wherein each cable including a wet connector at each
end.
- 20 5. The device in claim 2 wherein the thruster may include a propeller, turbine,
jet or pump.

6. The device in any one of the preceding claims wherein the controller includes a motion sensor configured to strap to the user approximately above a radius bone or any parts of the user body.

5 7. The device in claim 6 wherein controller is configured to translate movements of the wrist as detected by the motion sensor into left or right turn and/or speed control signals to the propulsion unit.

8. The device in any of claim 1 to 5 wherein the controller includes a speed
10 control switch or a speed control knob to control the speed of the propulsion unit.

9. The device in claim 2 wherein the quick release adapter includes a hinge configured to direct backwash from the thruster substantially away from the user's leg.

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10. The device in any one of the preceding claims wherein battery compartment is configured to allow a battery to be removed and to be replaced underwater.

11. The device in any one of the preceding claims wherein the propulsion unit
20 includes a motor.

12. The device in any one of the preceding claims wherein the controller is configured to shutdown depending on the output of a water detector.

13. The device in claim 8 further comprising a navigation module configured to vary the left and right and/or speed control signals depending on the output of a flow detector, a location and one or more way points.

5 14. The device in any one of the preceding claims further comprising an image projection unit and/or an LCD panels configured to display control information received from the controller.

15. A controller for an underwater propulsion device comprising:

10 a motion sensor configured to strap to a user approximately above a radius bone or any parts of the user's body, and

a processor configured to translate movements of the wrist detected by the motion sensor into direction and/or speed control signals to energise the underwater propulsion device.

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16. The device in claim 15 wherein the speed control signals are translated to independent dive signals to at least two thrusters attached to the user.

17. A headlight module comprising:

20 an internal battery compartment,

a power switch within the internal battery compartment, and

an end cover configured to minimise a gap to the power switch.

18. The device in claim 17 further comprising a plurality of holes in the end cover configured to funnel seawater from the internal battery compartment to restrict seawater flow.