Instructions for the SeaMATE PufferFish ROV Kit

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PufferFish ROV Systems

An ROV consists of many systems that are independently constructed and then assembled into a single ROV. The frame, power, controls, propulsion, and buoyancy are the major systems. In addition, your ROV may have a number of other systems depending on it purpose and mission. Mission tools such as grippers, hooks, temperature probes, or sampling devices may need to be constructed. Underwater lights and video monitoring may be needed to achieve your mission. How you approach constructing the needed systems and assembling them into a **single** vehicle largely depends on the size of the ROV team. A smaller team may choose to construct each system one at a time, fitting them together as each system is completed. This approach may help insure the pieces fit together since they are added one at a time, though the one system at a time approach is slow. While a larger team may choose to divide the systems up amongst the team members and build them simultaneously, assembling them together as each system is completed. The build all at once approach is faster, however it should follow an initial design outline, and requires more teamwork and coordination. There is always lots to do to construct the ROV so all team members should be busy with tasks at all times. The major systems listed below can be built concurrently, by separate sub teams, and then assembled into a single ROV vehicle.

Frame: A sturdy three dimensional structure that holds all the systems together.

Power: Provides the pathway for the electrical energy to get to the ROV while protecting the ROV from excess energy**.**

Control: Steers the ROV by sending electrical signals through the tether to the motors..

Tether: Transmits power between the vehicle and the controller on the surface.

Propulsion: Provides the force to move the ROV through the water while protecting fingers from propellers.

Buoyancy: Adjusts the weight to volume ratio of the ROV so it does not float or sink but remains neutrally buoyant.

Mission Tools: Grippers and sensors to achieve the mission tasks.

This document, **PufferFish Kit REV6**, covers the systems included with the REV 6 kit: Power, Control, Tether and Propulsion.

For **Frame and Buoyancy** instructions, please see the AngelFish Instructions
http://www.marinetech.org/files/marine/files/Store/AngelFish/AngelFish%20instructions%20V14.pdf

For **Mission Tools**: This depends upon the mission you choose. For mission ideas, please see the MATE ROV competition page OR to run you own mission, please see the Spanish Galleon page.

The Power System

Time required:	20 min
Tools needed:	Wire strippers, soldering iron, solder, hot glue gun and heat gun
Tools recommended:	Multimeter
Parts required:	Red/black power wire, in line blade fuse holder, power-pole connectors, hot glue and heat shrink

The power system delivers electricity to the control box, which is then delivered down the tether to the ROV. The 10 or 15 amp blade fuse protects the electronic systems. The powerpole connectors connect to a power source and help to prevent polarity mistakes (connecting red/positive wires to black/ground wires). The PufferFish Power Kit comes mostly assembled. The Powerpoles are already connected to the ground wire and the fuse wire. The fuse wire must be connected to the red power wire. Although this connection should never be underwater, it is a good idea to waterproof any solder joint you make on an ROV. The other end of the wire will be connected into the control box. To create your power system wires follow the instructions found here:

PRESENTATION LINK: **POWER SYSTEM: CREATING YOUR POWER WIRES**

Important note: Attaching Anderson Powerpole connectors to the wires **REQUIRES** a special crimping tool. If you are attaching your own powerpole connectors to the wires, **do not use a standard crimper** to make these connections. Standard crimping tools are not sufficient to make a proper connection on the Anderson powerpoles. In 2017 Anderson Powerpoles will be required for all teams competing in the MATE ROV competitions. To learn more about Anderson Powerpoles please go to: http://www.marinetech.org/anderson-powerpoles/

POWER NOTE:

The MATE PufferFish kit does not come with a power source. At this time, MATE does not sell any power sources. You will need to provide a power source to power your vehicle. Here are some suggestions:

Power pack with powerpole adapter:
Powerpacks are battery packs that will provide the power you need. They are often kept in vehicles to jumpstart a car battery if there is a problem. They will run down over time, but can be recharged

easily by plugging them into a wall socket. A standard power pack should be able to run a PufferFish ROV for 1 to 2 hours.
http://www.harborfreight.com/3-in-1-portable-power-pack-with-jump-starter-62306.html

The power packs will need an adapter for the powerpole connector to plug into. This adapter plugs into the cigarette lighter outlet found on the side of the powerpacks, and the Powerpole plugs into the adapter. You can find the adapter at:

https://powerwerx.com/cigbuddy-cigarette-lighter-powerpole-adapter or can be purchased from the SeaMATE Store.

AC to DC Power Supply:
PowerWerx provides an AC to DC, 30 amp power supply. This supply plugs into an AC outlet, and provides a constant source of 12 volt DC power that the ROV needs. This power supply can operate two PufferFish vehicles at once without issue.

https://powerwerx.com/ss30dv-desktop-dc-power-supply-powerpole

SAFETY NOTE: Since this converter is being used near water, you **MUST** plug this converter into a GFCI protected outlet, or have a GFCI plug on the end of the converter. DO NOT PLUG THIS INTO A STANDARD WALL SOCKET WITHOUT GFCI PROTECTION.

MATE also recommends keeping the AC to DC converter in a splash proof container or case. A small plastic tub turned upside down will work to keep splashes off the power supply.

12 volt Deep-Cycle Marine/RV car battery:
Large lead acid batteries are another way to power the ROV. MATE recommends the Deep-Cycle Marine / RV battery, as they are designed to be run down and recharged many times (a standard 12 volt car battery is not designed for this). The battery should be able to run a PufferFish ROV for 4 to 6 hours or you can run 3 ROVs at a time for an hour or more. The battery will need to be recharged after that. To recharge a car type battery, you will need to purchase a charger.
The battery will also need an adapter to for the powerpole connector to plug into. This adapter has Alligator clips that connect to the battery posts on one end and has powerpole connectors at the other end:

https://powerwerx.com/alligator-clips-inline-fuse-powerpole

Control System

Time required:	1 to 3 hours
Tools needed:	Soldering iron, solder (MATE recommends 60/40 rosin core solder in 0.32" [0.08mm] diameter), wire snips/flush cutters, wire cutters, wire strippers, utility knife, Phillips head screwdriver, ⅛ inch flat head screwdrivers, slotted jeweler screwdriver, ruler with metric scale.
Tools recommended:	Multimeter
Parts required:	Red/black power wire, in line blade fuse holder, Powerpole connectors, hot glue and heat shrink

The PufferFish control system links the power system and the propulsion system. The control system uses three double pole, double throw rocker switches. These switches allow the pilot to turn the electricity to each motor on and off, and also control which direction the motor turns in (forward and reverse).

To build the PufferFish control system, follow the Building the PufferFish Circuit Board instructions. There are a few different variations on the PufferFish control box, so know what version of controller you are building (the circuit board should have the Revision number (REV #) stamped on it). For REV 6, follow the instructions found here:

PRESENTATION LINK: **SOLDERING THE PUFFERFISH CIRCUIT BOARD REV 6**
If you bought your kit before September 15, 2016 you may have an earlier version of the kit. Please look at the green circuit board for the correct REV # (see the slide presentation it you don't understand where to look.)
PRESENTATION LINK: **SOLDERING THE PUFFERFISH CIRCUIT BOARD REV 5**

Soldering is a key skill for creating the PufferFish controller. MATE recommends reviewing the soldering presentations and improving your soldering skills before working on the PufferFish control board. Another way to practice soldering skills is with the MATE Practice board. The practice board consists of a small printed circuit board, one switch, one LED and resistor, power wires and tether wires. Installing these components onto a practice board will help to minimize mistakes on the PufferFish board. To review the soldering presentations, to download a soldering worksheet, or to purchase MATE practice boards, follow the links below:

SOLDERING WIRES AND WATERPROOFING CONNECTIONS
MATE SOLDERING WORKSHEET

HOW TO SOLDER COMPONENTS TO A PRINTED CIRCUIT BOARD (PCB)
MATE STORE - Purchase Practice Boards or View Practice Board instructions

The Tether System

Time required:	30 min
Tools needed:	Wire strippers, soldering iron, solder, hot glue gun and heat gun
Tools recommended:	Multimeter
Parts required:	Tether wire with six 18 gauge wires (black, white, green, red, blue, and brown)

The tether system connects the control box, which is on the surface, to the ROV, which will venture underwater. The tether should have two wires for each motor; one carrying power to the motor and one carrying it back to complete the circuit. Since the PufferFish has three switches controlling three motors, the tether providing power to the motors will have six wires. Your tether may include other wires, cords and cables as well. If a camera is used on your ROV, there will be an additional camera cable in the tether. The camera cable will have two wires to provide power to the camera, and additional wires for the data (video signal) coming from the camera. The camera wires are usually all wrapped into one cable. If you are building a hydraulic or pneumatic manipulator, the airline tubing will be part of the tether. Other systems, lights and sensors, may require additional cables as well. Remember, although it may be nice to have lots of systems on the ROV, each system needs wires or lines, and each wire adds thickness and mass to your tether. If there are too many systems on a small ROV, the motors may not be able to push the big thick tether through the water.

If you do have two or more lines running through the tether, it may be ideal to wrap your tether in a sheathing. The PufferFish kit does not come with this sheathing (it really isn't needed since the PufferFish only has one cable with six motor wires) but tether sheathing is available for purchase from MATE. The Tether presentation shows how to wrap your tether in sheathing. Remember! Wrap your tether BEFORE making the soldering connections on either end. It is very difficult to impossible to do afterwards.

PRESENTATION LINK: INSTALLING A SHEATH OVER YOUR MULTIPLE TETHER WIRES
MATE STORE - Tether casing

Length of tether: Why don't we build our small, 12 volt ROVs with 32 meters (100+ feet) of tether so we can explore in a greater area? Why not 150 meters (500 feet) of tether?

Longer tethers have issues. It takes a little bit of voltage to push electricity through every bit of wire you have. As you increase the length of wire, you decrease the amount of voltage that you are getting at your motor. This is called voltage drop. Since electricity must run through a circuit (from the battery to the motor and back to the battery) every 0.31 meters (1 foot) you increase your tether length, the electricity now has to travel 0.62 meters (2 feet) more in distance through the circuit. All that distance can add up. As your motor sees less voltage, it won't turn as fast. That means you have a lot less thrust. At 8 meters (25 feet) of tether, the motors work well and provide plenty of thrust. At (10 meters) 33 feet, they still work well, but don't provide quite as much thrust. At 13 meters to 16 meters (40 or 50 feet) you will really notice the drop in motor thrust. At 33 meters (100 feet) of tether, your motors will likely not provide enough thrust to move your vehicle through the water. There are many online tools to calculate voltage drop.

Check out the following online calculator.
http://www.calculator.net/voltage-drop-calculator.html
Wire is copper or aluminum wire.
Wire size is 18-gauge (AWG).
MATE ROVs use 12 volts DC.
MATE ROVs use single sets of conductors.
In water, our load current is approximately 2.5 amps.

Think about some of the things that could be done to increase the voltage at the bottom end of the tether.

Attaching your tether to the control box:
This section deals with attaching the top end of your tether into the control box. The next section, Propulsion, deals with attaching motors to the bottom end of your tether. To connect the top end of the tether, follow the instructions found here:

PRESENTATION LINK: **CONNECTING THE TETHER TO THE CONTROL BOX**

The Propulsion System

Time required:	1 hour
Tools needed:	Loctite thread lock, small hex wrench (included in kit), and Phillips screwdriver
Parts required:	PufferFish Motor and Propeller Kit

The propulsion system consists of the motors, propellers, motor couplings and the tether management cross. The wires from the three motors connect to the bottom end of the tether. There

are three sections to creating the propulsion system, each with its own instructions. Creating the tether management cross MUST be completed before connecting the motor wires to the tether.

Attaching propellers to the motor

Your PufferFish Motor and Propeller Kit comes with three bilge pump motors, three PVC motor mounts and three propellers with attachments for each. The propellers need to be secured to the motors at the end of the motor mount. Loctite (metal glue) will help to secure the propellers onto the motor and keep them from falling off when moving through the water. To attach your propellers to your motors, follow the instructions found here:

PRESENTATION LINK: **PROPULSION SYSTEM: MOTORS AND PROPELLERS**

Creating the tether management cross

Not having any strain relief on the bottom side tether can cause problems. Any tug on the tether will pull directly on solder joints and could cause issues. Having loose wires on the vehicle side near the might cause issues too. Loose wires can get pulled into propellers and be damaged, or damage the propellers. The MATE PVC strain relief allows the wires to be tightened and secured against strain damage. Using ½-inch PVC allows the strain relief to be incorporated into an ROV frame made from ½-inch PVC pipe.

Note: If you are using ½-inch PVC pipe for your frame, take into account the cross in the tether management system. If you are not using ½-inch PVC pipe, you will still need to take strain relief into account when building your ROV. To build your strain relief, follow the instructions found here:

PRESENTATION LINK: **PROPULSION SYSTEM: CREATING THE TETHER MANAGEMENT CROSS**

Connecting the tether to the motors

The final step in adding your propulsion system to the ROV is to attach your motors to the bottom end of the tether. Make sure the color combinations you used on the topside of the tether (tether wires going into the control box) match up with your bottom side tether (which color wires go to which motor). If you use the MATE color scheme (recommended), the red and green wires should go to MTR 1 in the control box and the left horizontal motor on the ROV. The black and white wires should go to MTR 2 in the control box and the right horizontal motor on the ROV. The blue and brown wires should go to MTR 3 in the control box and the vertical motor on the ROV.

Since these wire connections are going underwater, make sure to use hot glue and shrink wrap on every joint to ensure a waterproof seal. To connect your motors to your tether, follow the instructions found here:

PRESENTATION LINK: **PROPULSION SYSTEM: CONNECTING THE TETHER TO THE MOTORS**

When you have completed all of these steps, close up your control box and attach your motors to your frame.

Congratulations, you have a PufferFish ROV!