Rogue Sub Works Presents

DIY RCABS

Foreword:

Before we get started with this "how to session" I would like to say a few words. First of all, this is by no means the only way to build a WTC (water tight compartment) for yourself. There are many types of systems out there all with their various pros and cons. This is merely a guide to constructing one type of WTC for your projects.

Secondly, this is in no way the ONLY way to construct this style WTC. There are many ways to improve upon this design or increase its efficiency. If you take it upon yourself to do so, then I applaud you and urge you to share your experiences with the rest. Additionally, there are many manufacturers out there and many places you can buy a good portion of these products. The ones I have listed here I either make myself (RSW) or are merely MY personal preference as a source for products. In the end you will have to decide what vendors and products work for you and I encourage you to do so.

Please note that I have done my best to ensure any links and prices were up to date at the time this article was written (2010). Some sources may no longer be available or have moved. A quick internet search can usually yield a new source.

It is also important to mention that this cylinder can be used for dynamic diving boats like the Dumas Akula. Simply omit the sections where the pump and bags are installed. This will give you a VERY cheap cylinder that will be highly effective in one of these boats.

If you have any questions about what has been covered here please feel free to ask questions on one of the boards or email me at:

Kevin@roguesubworks.com

I would like to thank the following people who helped me along the way so that I could bring you this guide.

Tim (subicman)

Chris (expfcwintergreen)

Tony (tony g)

Art (art broder)

Please feel free to distribute this to as many people as you like as it is FREE. If you paid for this you were scammed!

Kevin
(NukePower)

The Goal:

KISS.. Keep It Simple Stupid.
I plan to construct a 3" WTC using easily accessible parts for the lowest price possible. I also plan to show the simplest method I know to construct one of these cylinders.

The Build:

The first thing you are going to need to get this build under way is some parts. It may be beneficial to read through this once before designing your own cylinder or ordering parts. There is a list of the parts I used in this build at the end. This is just a starting point

The first thing on your list should be some Lexan tubing. For this build we will be using a 3" OD (outside diameter) tube with a 1/8" wall thickness. You will need to get 2 ft of it and your final size is up to your application. I found with my Dumas Akula 19" was plenty. This can be found at http://www.mcmaster.com Part Number: 8585K21

Price 12.85 per Ft.

You will also need a set of end caps for you project (or make them yourself). You can find these at a few places. One being at my place www.roguesubworks.com or www.mikessubworks.com they will run you ~29 dollars and come with the o-rings.

So far you have the makings of a very basic pressure hull. It is important to note that some resins will continue to shrink for up to 6 yrs after their cast date. What does this mean to you? It means that you may find your o-rings aren't sealing as well as they used to regardless of how many times you replace them or even grease them. This is because the o-ring groove has shrunk enough to allow a gap in your seal. This does not mean that it is junk though. One way to "fix" this problem is to wrap your groove with a few layers of lithium tape. Another method (the one I prefer) is to put down a couple layers of trim tape. Its thin fits in the groove and adhesive backed which helps it stay in place.

Another thing you may run into during your build is that you drilled the hole improperly and need to do it over. Not a problem. Most the stuff we work with is pretty forgiving. To fix this simple lay a piece of painters tape or duct tape over the hole and ensure you have a good seal. Then fill the hole with an epoxy resin or fill it with ca and sprinkle it with CA. Here is a picture of some end caps that needed major repair. They still worked in the end and had no leaks.

Your next purchase will be the motor and seals for the end cap. I am using a set of seals (16.95), one drive shaft seal ($8.00), and one 380 drive system ($37.00) all from www.mikessubworks.com.

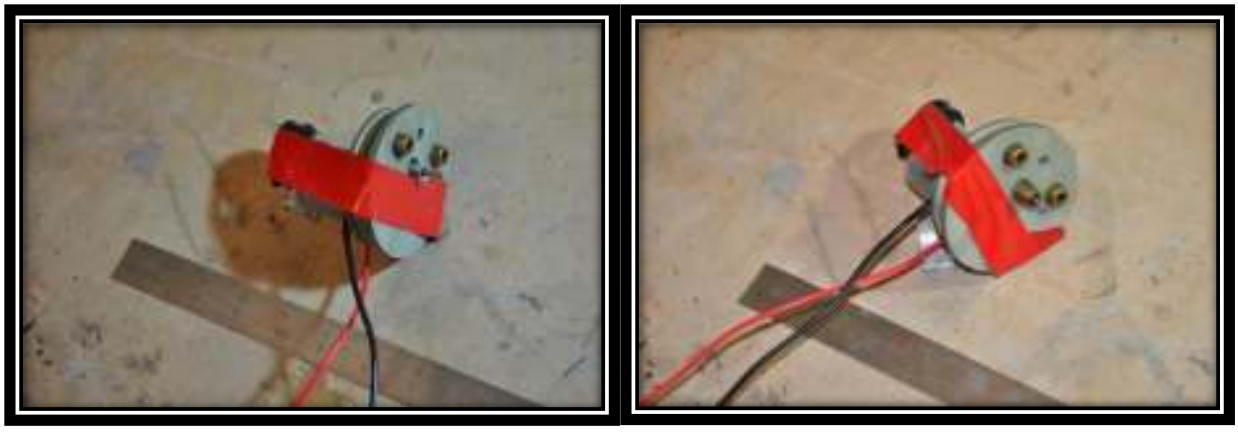
Once you have procured these items you will need to drill 3 holes in the end cap; one for the drive shaft and two for the push rod seals. The best way to determine what size hole you need is to get yourself a drill gauge and measure them. It is one of the best tools in my tool box.

The shaft seal needs a 3/8" dia hole and the push rod seals will need a ¼" hole drilled. You can recess the push rod seals into the cap to give them a tighter fit as well. It is also important to note that you should not drill a 3/8" hole all the way through the cap for the shaft seal. If you do so you will have nothing solid to mount the drive unit to. Instead drill that hole through using a ¼" bit and then drill half way through that with a 3/8" bit. Figuring out where to drill the holes is easy. Place the drive unit on the cap pulley side down. Arrange it on the cap so that there is some clearance between the motor and what will be the Lexan tube. Use a pencil and outline the big pulley as best you can. Your drive hole needs to be in the middle of that circle. The other holes for the push seals can be anywhere near the top. Equal spacing will make it look nicer. The above picture shows how I did it. Ignore the extra hole I have drilled as we will cover that later.

Now it is time to install the pushrod seals. Apply silicone around the base of the seal and press it firmly into place. You can use your finger or a wood stir stick to fillet the edges and ensure there is a good 360 degree seal and remove excess. Do this for both push rod seals.

Let's talk about silicone. What kind is best where do you get it etc. I have used quite a few different silicones and they have all held up no problem. The cheapest I have found was at Harbor Freight for 1 dollar. You can also use aquarium repair silicone from walmart or a pet supply store. I have even used the clear and blue stuff from an auto hobby store. My current favorite is from autozone. It is a very large container of pressurized silicon. All you do is squeeze the trigger and it comes out nice and steady. No cracked tubes, rolling pins, or prematurely dried silicone.

After the shaft seals have cured for a few hours it is time to install the motor. First run a bead of silicone around the shaft housing and push it into the hole. Then run a bead around the shaft seal and push that on from the other side. Next use a piece of tape to hold it all together while it cures. I like to place the motor as close to the cap as possible to save space and in the event it takes a hard hit the assembly will only band a little bit into the cap instead of all the way over. Use a small piece of plastic as a shim to ensure it does not cure touching the end cap though.



Your next task will be to construct the equipment tray. The equipment tray will be installed such that with the removal of a pin the entire thing will slide out. This is kind of like pulling out computer circuit boards. It is very simple and easy.

For this you will need two more items from www.mcmastercarr.com

Part number 8574K41 (12”x24” 1/8” thick polycarbonate sheet) $10.86

Part number 1753K61 (polycarbonate Channel, .235”WD (OD) X .300” Ht (OD), .050 thickness, 4’ L, Clear) $2.34

The first thing you will need to do is determine the size of your equipment tray. To determine the width of our tray I like to use a set of calipers to measure the inside of the Lexan tube. A ruler can be used for this or even some very simple math. Since we have a 3” tube with a wall thickness of 1/8”, you merely double the wall thickness and subtract that from your overall diameter of the pipe.


It is also important to subtract 1/16” from the width of your tray. This will help account for the thickness of the guide rails but will not do so completely. I usually bring it down the rest of the way using a file. A tight fit is important here.

Now that you have your width you will need to know how long to make it. To do this, install your fwd and aft end caps into the tube (make sure your motor cap has dried for at least 24hr you don’t want to ruin your silicone seals and make leaks). Then, measure from the back of the motor assembly to the fwd end cap. Subtract an inch from that number and you should have your length.

To cut your tray there are a few methods you can use. I like to use my band saw because it makes short work of this process. Of course, not everyone has a band saw. An alternate method would be to clamp the Lexan to a work table with a ruler along the desired cut line. Then, using a scribe, slowly remove material until you are through. Home depot also sells an acrylic knife that is very handy.

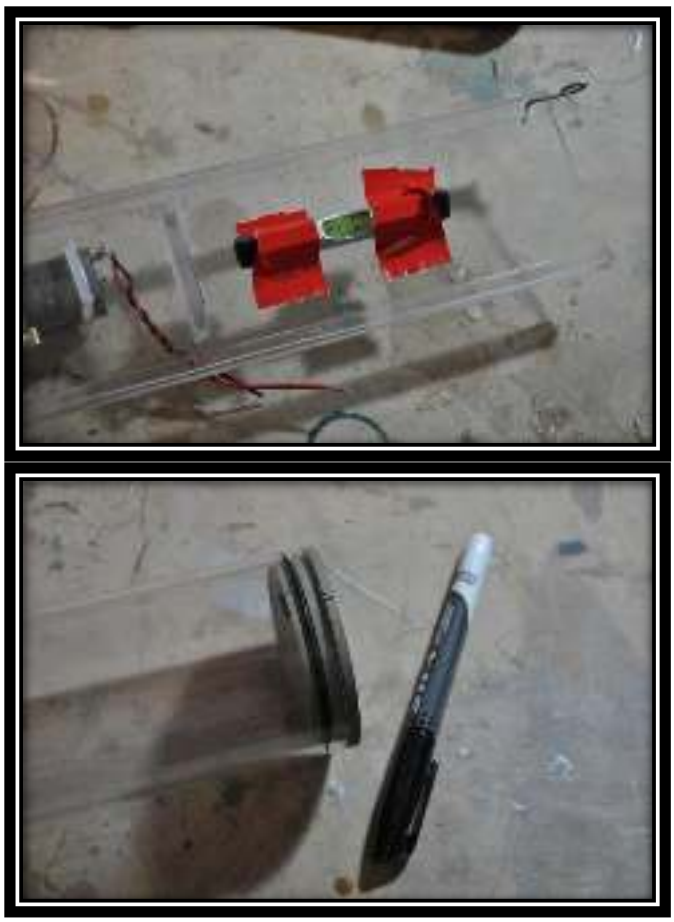

Now that the tray is cut to length you will need to trim it down to size so that it will fit inside with the rails attached. Cut two pieces of U channel to the length of your equipment tray. Place them on each side and try to insert the tray. Doesn't fit? File it down and try again. Rinse, lather and repeat until it goes in nicely. Make sure the fit is not so tight that it distorts the tube.

Now that the tray is fit to the tub it is time to make your retaining pin. To do this first tape the two u channel rails to the tray. Then using a 1/16" drill make a hole through the U channel into the tray and back through the U channel. It is best to make this hole at the end of the tray but make sure to leave enough material so there is strength. I would say .5" in would do the trick.

To make the pin use a piece of 1/16" rod and bend it into into an l shape with a little handle at the end. Test fit the assembly before you remove the tape for the U channels in case you need to resize the hole a bit to get the pin to fit easily.

First thing to do is to figure out where to place the tray in the WTC. To do this I stick an endcap on the end and using a dry erase marker I mark a location just aft of the endcap. I like to leave a small gap just incase I want to run some wires there; the gap should be approximately ½"

Now tape down a leveler to the equipment tray. This helps to make sure you get the tray in there nice and even. This it will help with the servos movement and pitch controller adjustment.



Once that is done it is time to put the tray into the WTC up to the mark that you made. It is also time to adjust the tray inside untill you get it level.

The next step is very important. Take your time and do not rush or you will be starting over!

Now that everything is in there it is time to Ca the tray in place. I dont like to keep either endcap on for this so that there is good ventilation for drying. It will also prevent you from gluing your endcap to the cylinder in the event of a mistake. Tip the endcap at an angle and using a needle nose applicator add a few drows of thin set CA to both sides of the rail. Let gravity and capillary action do its work until the drop stops moving. Get it to about half way and stop. Take a small time out and keep the WTC level. After a minute or two do the same thing starting on the other end of the WTC. After that set it down level and leave it. I like to use a fan to blow air through to prevent CA fumes from discoloring the tube.

Ok so why is this step so important? If you get too much on there you run the risk of the capillary getting in the U channel and making your equipment tray a permanent addition to you WTC. The excessive CA may also run all the way out of the cylinder ruining the o-ring seating surface of the WTC. So take your time.

After about an hour in front of the fan I like to take the tray out and let it set up over night just to make sure everything is dry in there and no longer fuming.

Alternately you can also use a product called Weldon #3. It is specifically formulated for bonding polycarbonate and will make a very strong bond. You must be very careful though as is it is as thin as water. I find that using a small hypodermic needle is effective for application. You can find this product by doing a quick internet search.

Next it is time to make the square hole for the servos in the equipment tray. To accomplish this use a rig. Since standard servos when placed together basically make a square you can use the same piece to make the lines for where you want to cut. The trick is to make sure the bends you make are at 90 degrees. A bend brake is perfect for this. If you don't have one and plan to me making your own stuff you might consider getting one. Othewise you can you a square to do this.

After you have made your simple template (mine is aluminum btw) merely place it on the Lexan sheet about .5" from the edge and make 2 lines one on each side. Then go to the side and repeat the process.

Once you have your lines take your dremel and some sort of cutting disk and make the cut.

Note: Yes I know my lines are crooked but this is just a sample for illustration

Ok next you make the bladder vent valve.

First thing to do is get the valves themselves. I get mine from Autozone for about $4 for two. Once you have them you will need to remove all that rubber on the valve. A lathe is the best way to do this but I am a realist. Not everyone has one. You can also chuck them up in a drill press or drill and try to remove the rubber with a rough cut file and a knife (not while the drill is on hopefully). Once you get it all off you should have something like in the picture bellow. Also shown in the picture is the valve removal tool offered at most auto hobby stores and the vent valve itself. You can also see the vent valve tool I made. I like mine better because it can reach just about any valve without those ridiculous arms on the other tool getting in the way.

Next step you want to remove the valve so you don't damage it. That is because you will need to file the top (threaded side) of the valve down to make the inner pin more accessible to the servo swing arm for actuation. This is simple and I did it with a file. Just make sure you take it slow and don't take too much off. If you do you won't be able to thread the valve back in.

Ok now to make the bracket.

For this you will need a drill bit, silversolder, soldering iron, hole punch, and 3/4" wide and 1/16" thick brass stock.

When ever drilling in metal it is always a good idea to use a drill punch to keep the bit from walking. Not everyone has a punch though. They are not that expensive and can be purchased from HarborFreight fairly cheaply.

To determine what size hole needed use a drill gauge and place the bottom part of the scharder valve in it till you find the right size. Then punch an indent near the top in the center of your brass and drill the hole.

Clean the area with some sand paper and alcohol and apply some flux. Then wrap the bottom of the valve with a small ring of solder and placed it in the hole. While ensuring gravity is working for you hit it with a blowtorch till it melts and sinks into place.

Now bend the new piece to a 90 degree angle about an inch down and trim the piece off about 2-3" back from that.

Also, you will need to drill 2 holes to mount the thing. The size will depend on what size screw you use. I like to use stainless steel 4-40 screws with an Allen head.

Now that you are getting close to mounting stuff on your equipment tray it is a good idea to make a basic layout of where things will go.

Here is a quick shot of a basic layout.

With nothing mounted, indicate where items will be put underneath the board. It is always good to keep a distance between the Rx and the power wires/esc. For example, looking at the photo below shows that the esc would more wisely be placed next to the 2 servos by swapping positions with the smaller servo. It is also a GOOD idea to keep the heavy stuff near the bottom. It will affect the center of gravity / roll stability of the sub.

Now is also a good time to talk about the electrical equipment required to complete this cylinder.

Just remember that an APC and failsafe are purchases worth EVERY penny but, not necessary to get it in the water. Hey we are in a "recession" right?

Technical Note: What is an APC?

APC stands for Automatic Pitch Controller. This is a device that is generally hooked up between the dive plane servo and the receiver. It allow for the autonomous control of the boats angle allowing it to operate in a level plane. Without this you may experience porpoising or an up and down motion of the boat, because it can be difficult to judge the angle of your boat under water or due to user over corrections of the stern planes.
Parts:

-Sport Pack Battery
(depending on the mah) ~$20 for a 1500mah

-ESC or Electronic Speed Controller w/ BEC (Battery Eliminator Circuit).
You can choose whatever you want as an esc. In this picture you will see a micro viper speed controller

from MTroniks. I like them a lot. They are rated for 10amps, have programmable fwd/rev/braking and they are waterproof. They will run you about $40. Also of note is their customer service is top notch!

-Receiver
A minimum of 4 channels is needed to run this WTC. What you use will depend on your radio so, it's best to ask on a case per case bases. In the picture you will see a Sombra Labs RX. They are nice because they can adapt to what ever radio channel you want to use with them and have 8 channels. $69

-S.P.D.T. MINI-SNAP-ACTION SWITCH
This will be used to actuate the air pump.

-Micro servo
There alot out there but I prefer the Hitec HS-81. For its small size it still packs the same torque output as a standard sized servo. This is perfect because you will need that torque to depress the vent valve. Also of note is that I have found no name servos on ebay with the same specs as this little unit for about $10. The choice is yours.

-2 Standard servos
These are obviously for left, right, up, and down. No need to get fancy here. Sure ball bearings are great and digital servos are sweet but, this is not a helicopter! Standard cheapo bushing servos work fine for us at $9.99 a piece

-Micro air pump
these can be found on ebay or a few other vendors

-Air Bladder

Size will depend on your boat. Can't go wrong with a #2 to start.

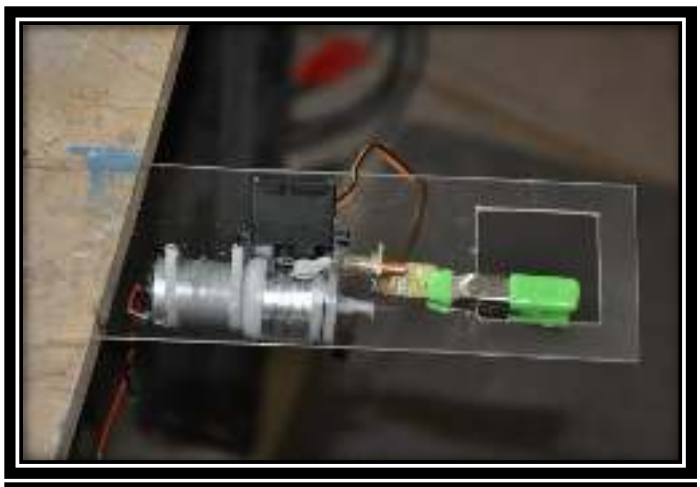
Ok now that you know exactly what you need it is time to mount the pump onto the equipment tray. This is a fairly easy thing. Just pick a spot drill 4 holes and zip tie it on the under side of the tray. Alternately, you can attach the pump by applying a thick bead of silicone to the bottom of the pump and smooshing it on the tray and letting it cure undisturbed. Keep in mind that you need some space between the pump outlet and the servos. If you use the zip ties make sure to run one of the ties around the midpoint because it will prevent the pump from slipping around.

The next step is one of the most crucial in the build; placement of the vent valve and servo alignment.

First pick a place on the tray near the front but not to close to the servos to mount the valve assembly. Make a mark for the holes and trace one corner of the valve assembly as a reference. You can see this in the picture above. Drill the appropriate size hole for the screws in the equipment tray and tap them. Now screw the valve assembly in. If you don't have a tap, you can always drill a through hole and use an appropriate size nut and lockwasher.

Note: Never screw directly into Lexan without tapping first; doing so is an excellent way to crack the Lexan.

Now you need to determine where the servo will go. Place the servo on the board and clamp it to the board. Then hook up the servo to a receiver on channel 3. Use the throttle stick so that you can swing the servo arm all the way and have it stay in position. Now you can check to see if you have the space to align the arm to the valve pin. The valve needs to be near the end of the servo arms travel so that it can depress the valve without placing unneeded stress on the servo gears. If you don't have the spacing properly the servo will either strip the gears or slip right off the valve pin. Of course if your transmitter has an adjustable throw this makes the job easier. Return the servo to the neutral postion and mark where it needs to go.



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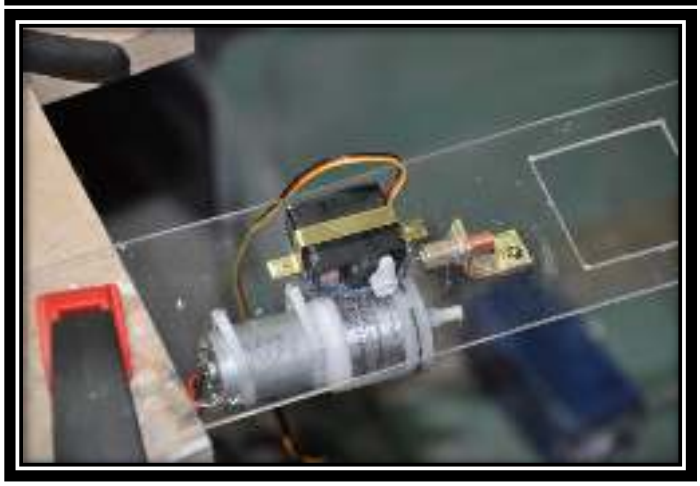
Next is to installed the servo (the micro servo)

To do this put a glob of silicone on the bottom and stick it on the board at the marks made earlier. Then put a clamp on it to hold it in place. Connect the servo to the radio like before and lined it up so that the pin was depressed at the end of the throw and lined up properly. Take the servo to neutral and walk away. DO NOT TOUCH IT, BUMP IT, OR MOVE IT. You don't want to ruin your alignment or you'll be doing it all over. Give it at least 3 hours to set up most the way preferably 24hrs.
Now that the servo is secure in its position it is time to make sure it doesn't move. Take a thin strip of brass and make a bracket to screw in and hold down your servo. Use more silicone for this and after it all cures your servo should be very secure.

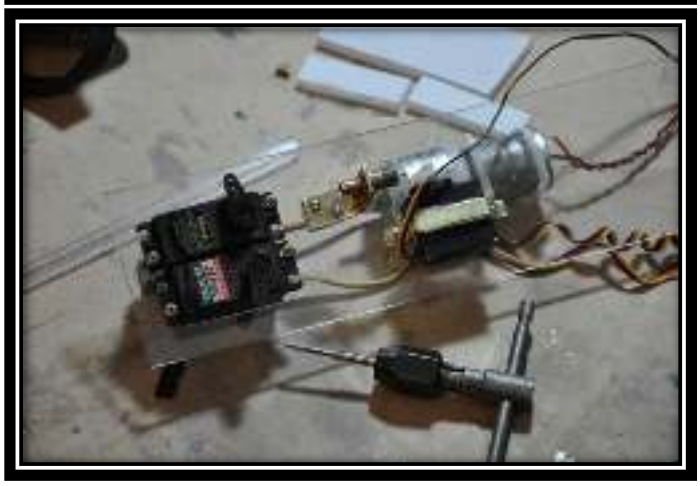
Note: It may be frustrating to get the servo horn to hit the pin. It happens sometimes. Do yourself a favor and thicken the servo arm by gluing strips of styrene to both sides of the servo horn.



Now we can install the standard size servos.

Simply put them in the equipment tray mark where the holes need to be. Remove the servos drill and tap the holes. Re-insert the servos and screw the servos in.

Note: Take the servos out to drill and tap. It is very easy to drill through the hole and then continue right down into the servo wires.



Next make a stop for the battery.

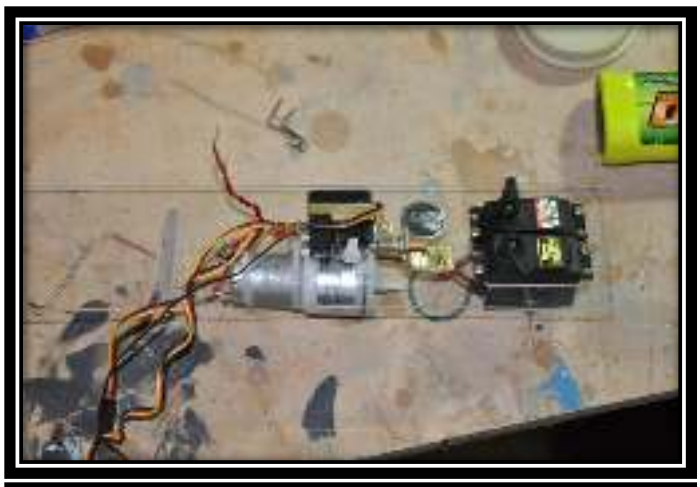
You want the battery to be as far fwd as possible and prevent the battery from slipping back and forth. Set the battery on the tray at the very end. Move it back about 1/8" to allow for the battery wires and make a mark at the end of the battery. Take a spare block of plastic and CA it where the line was to create a stop for the battery.

Next install the switch to actuate the pump. To do this, connect the servo to the Rx and reverse the throw all the way from before. Place the switch on the servo body to see if it is going to be able to actuate the switch with it mounted to the servo body. It should be able to. Now, CA the switch to the servo body in this position. Use CA instead of silicone this time since you do not want it to flex or come off ever. Worst case scenario the servo comes lose and you can't dive your boat but you'll always be able to surface! Also, it cost 1$ if anything breaks its going to be the servo not this simple switch. You can buy another switch.

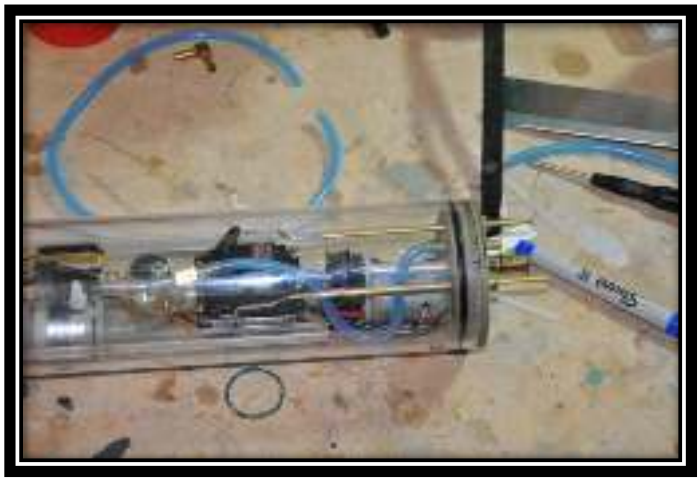
Note: It is very (very!) important to only use as much CA as necessary to get the job done. It is also best to use thick or medium CA. It is possible to put too much on and CA the dip switch in the position it is in permanently. In other words it will never actuate to start the pump. The most important area is the small spot under the metal rocker. You can put some petroleum jelly over it before you glue the switch on for added piece of mind.

Now you need to drill a hole large enough for the servo cables to come through the tray to reach the RX. Pretty simple stuff; just make sure you don't drill the hole in Prime real estate. Also, take your time and drill small first and vary till your final size. Would be a shame to crack that tray at this point!

Here is a picture of how everything is looking. All that is left is running some hose, wires, and control rods and well hit the tub!



Here you can see how to run the tubes for the bladder system.



For the air tubes buy some aquarium hosing at Petsmart. It just seems to fit perfect. I also went to Ace Hardware and bought a 1/8" brass T fitting. This was so that the vent and pump could be connected in the same line. I also drilled a small hole to feed the hose through the equipment tray to the top. Make

sure to leave enough line so that you can put it all together in the end. I have found i can do it with about 1.5" of slack fast the end of the WTC.

You will also need to drill a hole in the aft bulkhead and CA a brass tube in of appropriate size that the aquarium hose fits snugly over it.

Control rods for the servos:

The control rods are made of 1/8" brass so that they will fit the seals from Mikes Subworks properly. Unfortunately that won't fit in the servo control horns to well. Instead you need to drill a 1/16" hole in the end and inserted some 1/16" brass rod and soldered the 2 together. This also works nice because you get the strength of the 1/8" brass but it is much easier to bend 1/16" brass to line up to the servo arm. I usually use a z bend for my servos because it's cheap but you use what you like.

Note: Lining up the servos so that they have smooth operation can take time. Try to eyeball where they need to go and bent the rod appropriately. Then try them out and bend again. It can take time pulling the tray in and out for this process so I like to just leave the tray pin out. Take your time though no rush here, it is important.

Now for bag selection, I like to use a bigger bag then I need that way you get the same lifting power with less expansion of the bag. It is also a good idea, with external bag cylinders, to take a piece of plastic, such as a square piece cut from a 2 litter soda bottle, and place it over the bag on the WTC with some rubber band. This will assist the bag in deflating completely.

Operational Note:

With a RCAB system it is important that before you run, the bag is deflated and the cylinder is at atmospheric pressure. Installing a shrader valve in the fwd end to equalize internal pressure after end cap installation is a good idea. Additionally, leaks are bad for RCAB. If you ever think you have a leak you can remove the shrader valve and attach a hose and blow into it while submerged or inflate the bag with the cap off, then install the cap submerge the cylinder and vent the bag. Either will produce tell tale bubbles.

This is as far as I am taking this because you guys don't need to see me silicone the ESC down or anything like that. You are not stupid.

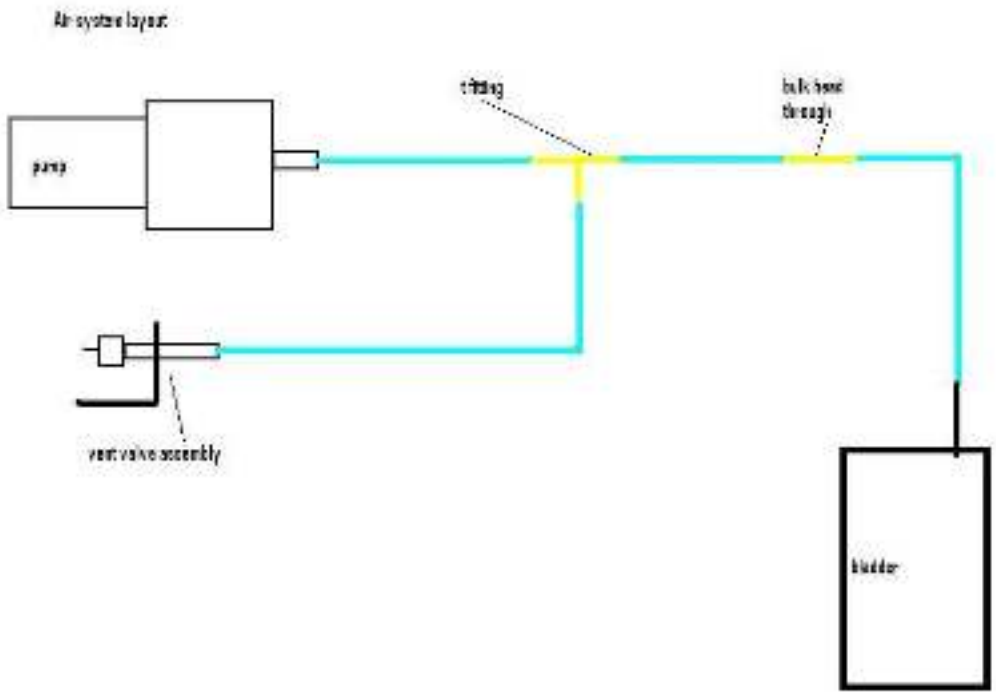
If there is any other questions just ask. Also if there are any other DIY or How-Tos you want to see let me know and I will see what I can do.

Parts/Tools List

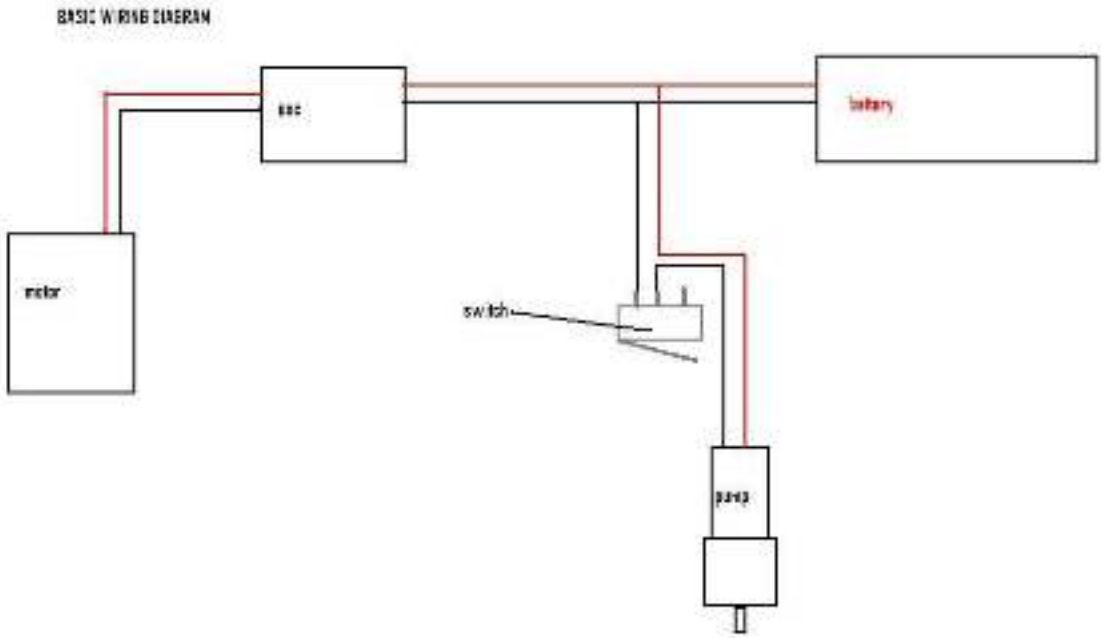
Part	Supplier	Contact Info
3" OD Lexan Tube, 1.8 wall	McMaster Carr P/N 8585K21	www.mcmastercarr.com
12"x24" 1/8" thick polycarbonate sheet	McMaster Carr P/N 8574K41	
Polycarbonate Channel, .235"Wd (OD) X .300" Ht (od), .050 thickness, 4' L, Clear	McMaster Carr P/N 1753K61	
1/16" thick Aluminum plate (servo template/optional)		
Brass Plate Stock	Local Hobby Store McMaster Carr P/N 8964K712	
Pushrod Seals	Mikes Sub Works	www.mikessubworks.com
Driveshaft Seal		
380 Drive System		
Air Bladder		
End Caps	Mike's SubWorks Rogue SubWorks	www.mikessubworks.com www.roguesubworks.com
Drill	Local Hardware Store	Lowes Home Depot Ace Hardware
Drill Bits (various)		
Dremel tool with cut off wheel		
Sandpaper various grits		
Propane Torch		
Vacuum hose fitting		
Zip Ties (small)		
1/16" Brass Wire (for retaining pin and control rods)	Local hobby Store	
2x standard size servos		
1/8" Brass rod		
CA (thin and medium)		
Weld-on #3	Internet	(I got mine on ebay)

1x Schrader Valve	Autozone Part number 20004	www.autozone.com
4 way tire valve tool	Autozone Part number 2044-a	
Center punch Part number 621	Harbor Freight	www.harborfreight.com
Silver solder	Radio Shack	www.radioshack.com
Soldering Iron		
Soldering flux		
Drill Gauge	Sears Item Number 00940747000	www.Sears.com
HS-81 Servo	Tower Hobbies	http://www3.towerhobbies.com/cgi-bin/wti0001p?&I=LXN676
2 Standard Servos		http://www3.towerhobbies.com/cgi-bin/wti0001p?&I=LXUK84&P=ML
Sport Pack Battery		www.towerhobbies.com
Micro viper ESC	M troniks	www.mtroniks.net
Sombra Labs Receiver	Sombra Labs	http://www.sombralabs.com/products.php
S.P.D.T. MINI-SNAP-ACTION SWITCH	All Electronics	http://www.allelectronics.com/make-a-store/item/SMS-227/S.P.D.T.-MINI-SNAP-ACTION-SWITCH/-/1.html
Pitch Controller Fail Safe	Mikes Sub Works Precision Pattern	www.mikessubworks.com http://precisionpattern.biz/subs/electronics.htm
Fine point Sharpie	Staples	www.staples.com
Air Pump	Ebay	www.ebay.com
Aquarium Hosing	Petsmart	www.petsmart.com
2 Liter bottle	Supermarket	

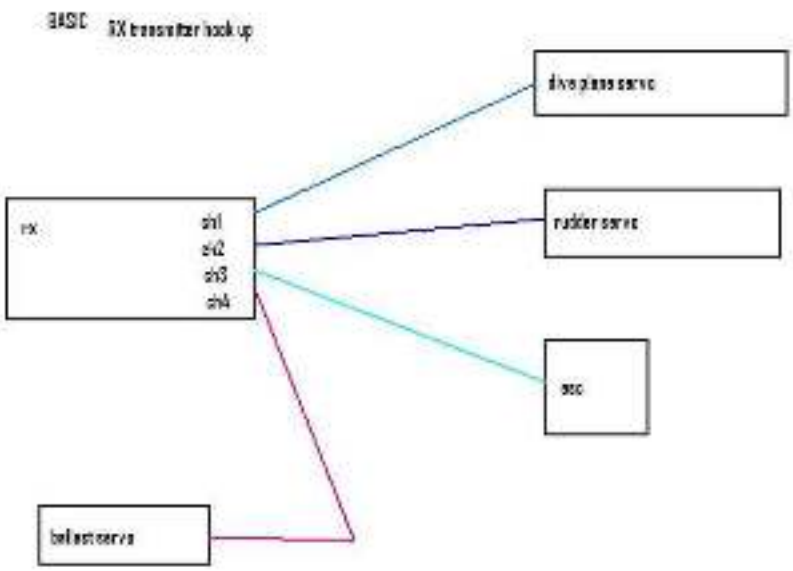
Diagrams



Air Piping Diagram



Basic Power Wire Diagram



Basic Reciever Layout