INTRODUCTION:

This project is designed for the beginner. Anyone can build this in his own basement, garage or living room. Even if you never built an R/C model before you can tackle this one with confidence.

The hull can be adapted to incorporate a wide variety of components. Dimensions are left out intentionally, purchase all your items and don't start cutting the hull sections until you've assembled the internal framework.

TECHNICAL DATA:

Dimension: 15-16”/ 38-40 cm long, 9.5”/ 24 cm wide, 7”/ 18 cm high
Weight: ca 9 Lb/ 4-5 kg
Range: 40 minutes continuous operation
Test Dive: 6 feet/ 1.70 m. Can be extended using an umbilical.

HULL PARTS LIST

The type of drain pipe used isn't sold by Home Depot or Lowes. You can find these at industrial suppliers! Look in your phone book for a seller near you. You can easily substitute PVC for ABS which is available at the two retailers mentioned. Stick to thinner pipe typically used for French drains, the thicker stock intended for pressure applications is costlier, harder to machine and the inner dimensions may be too restrictive.

<table>
<thead>
<tr>
<th>Shell</th>
<th>Motors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ABS, PVC Rain Pipe End Caps 4”/ 100mm</td>
<td>4 ABS, PVC Rain Pipe end caps 2”/ 50mm</td>
</tr>
<tr>
<td>1 ABS, PVC Rain Pipe T-junction 4”/ 100mm with gasket and screw cap</td>
<td>2 ABS, PVC Rain Pipe 2”/ 50mm</td>
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<tr>
<td>1 half sphere Christmas ball</td>
<td>2 ABS, PVC Rain Pipe double junction tube 2”/ 50mm</td>
</tr>
<tr>
<td>2 Rain Pipe wall mounting ring 4”/ 100 mm</td>
<td>2 half sphere Christmas ball 2”/ 50mm</td>
</tr>
<tr>
<td>4 Rain Pipe wall mounting ring 2”/ 50 mm</td>
<td>4 Air compressor male-male connector 2”/ 6mm</td>
</tr>
<tr>
<td>Tube of Aquarium Silicone</td>
<td>1 aluminium Channel/ U shape bar</td>
</tr>
<tr>
<td>2 Air compressor male-male connectors 1/4”/ 6mm</td>
<td>2 motor Grupner 400 7.2 V</td>
</tr>
<tr>
<td>Bolts &amp; nuts</td>
<td>2 Electric cables 40”/ 100cm</td>
</tr>
<tr>
<td></td>
<td>2 Shaft with propeller</td>
</tr>
<tr>
<td></td>
<td>2 couples and transmission for motor to propeller shaft</td>
</tr>
</tbody>
</table>
Electronics:
1 RC receiver (3 channel) 27MHz
2 speed control (regulators) Navi Type or similar
1 Battery Pack 7.2 V 2000mA
Cables
Plugs, nuts, bi-adhesive 3M

Blow tank: (option):
1 Servo 8Kg/cm or more
1 Syringe Veterinary Type
Plastic Tube
Aluminium channel, U shape bars

Frame:
1 screw type bar, cut in 4 pieces
1 aluminium channel, U shape bar
4 plywood circles 3 1/8"/ 80 mm
Bolts & nuts

Fittings & others:
4.40 lb/ 2 KGs ca. Lead for trimming
1 Spray Paint Black
Stickers

SHELL
The shell can be constructed of a variety of materials, including PVC and ABS. Aside from the bonding agents recommended by manufacturers you can also use silicone and acrylic adhesive which will bond different types of plastics together including acryliics, it even bonds plastics to glass.

The hull is binded to the motors by strap used to fasten pipes to walls and ceilings. In case these are hard to find substitute them for aluminim strap, bend them over the hull sections and shape them using a pair of pliers or vise grips.

Holes are drilled for cables. This too is not terribly important to the design, but symmetry is critical as it may affect control and stability of the sub. Air line fittings used for compressed air tools were used for this, with gaskets to prevent any leaks.

A clear plastic hemisphere from a Christmas ornament was used to streamline the forward part shell, this greatly improves the handling of the sub. You may also install a second in the trailing side. Should you want to convert this sub to an ROV an acrylic dome is recommended. See section of suppliers at the end of this ebook. You may also create your own plastic bubble by making a frame with the acrylic sandwiched between sections, a hole is cut on top roughly the shape of your intended bubble. This is then heated in an oven to make the acrylic supple and compressed air is pumped in expanding the flat material into a bubble.

The sub is then sanded and painted with automotive paint, color is optional.
The frame is built of 4 threaded bars with nuts holding all the components together. A bit time consuming but highly adaptable to a wide variety of different R/C brands.

Bases and supports for fittings are made with transparent Lexan. The picture illustrate the result.

The two motors are very simple to make. A Grupner 400 with a coupling shaft/stuffing box combo. Almost any motor up to 12 volt will do but there will be some torque lost when using lower voltage power supply.

The system is framed in aluminium bracket and a cable connects it to the central shell.

Grease is used for watertight seal.
ELECTRONICS

The Electronic/electrical system is simple. If you do not install the Blow Tank you can use a two channel R/C Transmitter.

The diagram on the right shows the principle circuit: The regulators (speed control) are also a "battery eliminator" system for the receiver. The set up inside the shell is on the frame.

Battery was mounted in front and all the other electronics in the back leaving space in the middle for the ballast tank (optional). Look at other pictures...

There are many brands of motor controls. I recommend you purchase one like the one on the left.

These units plug right in to your receiver, and all you need do is solder or connect the motor
connections, and power source.

For less than $20 you can purchase one on eBay. Make sure there are english instructions with it.

Your Sub should look like this.

If you are not confident soldering all the electrical components together, use a bus terminal like the one in the picture below.
BALLAST TANK

A simple way to get the sub to dive is to trim your sub so that the front of the vehicle sinks a little deeper than the back end. When power is applied the sub will slip beneath beneath the waves, and to surface power is cut off to the motors.

If you want to better control the sub a Blow Tank is needed. In this case a 3 Channel RC controls the system. The principle is simple. A strong servo (8-10 Kg/cm) move back and forward a piston that sucks water inside the sub and it goes down! See drawing below.

To build your ballast tank remove the actuator from the servo, this is the cross shaped part in the picture above, yours may be different. Next insert a gear to drive the shaft which is attached to the piston.

The piston is used by plumbers to unclog sinks. They are sometimes sold as 'Kinetic Drain Openers' or 'Suction And Force Plungers' and there may be other designations. A veterinary syringe will also work, and with some ingenuity a pump used to extract resin from cans will work, with some modifications. The spring and ball valves must be removed. This will allow the piston to
move freely and allow the water to move in both directions.

A third alternative to all of this is to purchase a ballast system already made and tested from the supplier's list at the end of this ebook.

An untested method would be to sling a weight between two pulleys. The string holding up the weight loops over both pulleys like a clothes line, with the servo driving one of the pulleys. As the weight moves forward the front end will sink lower than the back, making the sub submerge when the motors are turning, the opposite happens when the weight is moved rearward. This way you can travel at full speed when surfaced.

**TRIMMING:**
Before deep test run you have to trim your boat.
Add some lead to balance the sub. If you do not use the ballast tank, the sub has to be a bit heavy in front in order to use the motor to go down. The ship in this case should be a bit "Positive".
If you are using the ballast tank the ship should be carefully balanced and neutrally buoyant or bit positive.

**OPERATION:**
Without the ballast tank just use the two motors to submerge and no power to surface.
Use alternatively one or the other to turn around. That's all.
In the sub version the hemisphere was painted and two holes were drilled on opposite sides. The plastic bubble was mounted so the holes were facing top and bottom. This lets the water in and the air out allowing the sub to submerge.

If you are planning to build an ROV do not drill holes in the plastic dome.

The external frame was built entirely of aluminum strap with nuts and bolts connecting all the parts.
If you run into trouble fabricating your own dome try this link:
http://www.globalplastics.ca/default.asp?mn=1.179.188
You can get a nearly perfect dome for $30
A Cheaper Alternative

The next generation model submarine. There's no ballast tanks, frame or motors to assemble. By eliminating the ballast tank we've made the sub much smaller without the need for frame work. All components were held together using wire ties. Instead of motors driving propellers we employed submersible pumps, these are already water proof.

This sub's dimensions are similar to the above example, but much slimmer. Without the ballast tank this craft relies solely on impulse to dive.
Building An ROV
Underwater Radio

Many have thought of using radio equipment underwater. I've often been asked of the possibility to adapt wireless devices to underwater use. Unfortunately it's not feasible to use most wireless gadgets underwater. The conductivity of the Sea is sufficiently high (1.6 mho per foot) to diminish a radio wave at very short distances.

For example a metal detector operating in the one meter range or less loses 99.9% of its radiated energy within four inches of water. As wavelengths increase (lower frequencies) the performance improves. 1000 meter waves will travel 5 feet losing 99.9% in the process, and 10,000 meter will travel 33 feet, making it practical for rudimentary communication. A quarter wave antenna used to project such a long wave needs to be a mile and a half long.

Submarine's radio use long cables attached to a Para vane which maintains the cable at a desired depth to communicate with their base.

Use of wireless devices underwater is impractical, our model sub works in fresh water at shallow depths such as in pools because of its low frequency wavelength. Video transmission occurs in the narrow bands and reception would be cease once the sub dove. To overcome this ROV designers incorporate an umbilical, either a copper wire or in some high tech models a fiber optic cable is used to control the ROV and recieve telemetry from the vehicle.

The following are excerpts from my underwater video camera project.

**Starter Project**
This is perhaps the easiest, and least expensive camera projects to build. It involves encasing a spy camera in a polymer inside a clear plastic box, that doubles as a mold, lens and housing.

**Materials Needed**
- One camera. Try getting supercircuits.com PC 166XS, or these less expensive models; PC 33XP, PC 300XS both $11.95; PC 302XP, PC 302XS both are good quality CCD units and a bit more expensive.
- 50 feet of video cable with RCA connectors, they vary, get one that matches your unit. Supercircuits' Model # EXT-POW-50 matches PC 166XS camera. An alternative is to purchase the cable on your own and solder the plugs yourself. Shielded cable can be purchased at Home Depot, and the plugs are available at Radio Shack, both at very reasonable prices. This type of cable is too stiff for our ROV, it will hinder the sub from maneuvering freely. Communication cable is recomended for the Sub project. You need 2 conductor if you intend to use a 9 Volt supply and 4 if a 12 volt surface supply is used. The ones I use are of the General Cable brand.
- A clear plastic box at least 1 1/2” (3.8 cm) X 1 1/2” X 1 1/2”. A suitable box is a display case used to house expensive collectibles such as Beenie Babies, rare Matchbox cars... Try hobby shops, or arts and crafts stores.
- One monitor, or any TV with RCA receptacles. Due to the popularity of video games these are common on many portable DVD players. If you have a portable TV with a coaxial cable connection RFU unit costing $7 can be adapted to it. If you choose the latter you don't need RCA plug. More on this later.
- A 12 volt battery.

**Supplies**
- One 8 oz (228 ml) epoxy compound or polyurethane compound kit. Found at hobby shops, hardware stores, or fiberglass supply outlets.
- One small tube of clear silicone sealant.
- Heat shrinking tubing.
- Roll of electrical tape.
- Pair of latex gloves.
- Dozen toothpicks.
- Old newspapers.
- Rags or paper towels, and cleaning solution.

**Fabrication**

Always test your camera prior to casing it in polymer. Read the manufacturer's instructions and follow the guidelines. Not all spy cameras will work off a 12 volt power supply, some are rated for 9 volts. Next read the section on adjusting the focus on your camera model. You want the focus to be sharp when objects are 6” (15 cm) from the lens. Once you have completed these steps you are then ready to cast the polymer.

Spread the newspapers over your work area. Wear your latex gloves. Dispose of excess compound after it hardens.

First strip the ends of wires. Then cut off the sections of heat shrinking tubing and insert them in the wires. Next twist the two ends together so they lay flat, clip ends off, and solder the splices. Last slip the heat shrinking tubing over the splices and apply heat using a blow dryer, heat gun or other source.

To begin the waterproofing process, insert the camera inside the plastic case, and make sure the spliced wires fit inside the box. If the case is too small and the splices hang out, then you need to solder the wires directly to the camera.

Practice positioning the camera inside the box prior to casting the compound. The box should have no beads on the side used as a window. Usually display cases are well made of clear plastic without any beads, cheap containers will have have beads and other imperfections. Then apply a small bead of silicone on the flat ring around the camera lens. If you apply too much silicone it may smear on to the lens and diminish your viewing area. Best results if you use toothpicks dipped in silicone for this application.

Next insert the camera in the box pressing the camera lens against the bottom, making sure not to move it in any direction as this will smear the silicone, and wait for the silicone to dry. This may take an hour. The Silicone bead will not only fix the camera to the box but will also prevent the compound from flowing into the lens.

While you are waiting for the silicone to dry out, read the instructions on the compound package. Start mixing the polymer only after the silicone has cured. Immerse the camera and spliced wires thoroughly. Leave the project to cure at room temperature overnight.

If you did everything according to plan your camera should perform like the expensive models. Always slip the case inside a cloth bag as it will scratch easy.

You'll need to fabricate a bracket for this camera see the next section for more details.

To use this camera at night strap on a waterproof flashlight.

### Using A Cheap Color B/W TV

**B/W CRT TV**

Instead of LCD screen, you can get cheap CRT portable 12V B/W TV from Wal Mart or other discount retailer. However, most of them don’t come with RCA Video Input, but you can purchase an RFU adapter to convert to video signal.

**RFU Adapter**

Play Station 2 RFU Adapter. Connect green and orange wires to the camera (see photos below), then step down the battery from 12v to 6V using an auto power adapter (does not need be exact 5V) by connecting the power to the black and white wires. Switch your TV to channel 3 or 4 depending on your setup. The Pelican 7020 is less expensive and easier to work with, instructions for wiring the 7020 follow the power options section. I'm not going to go into details on hooking the Play Station 2 RFU unit.

**Power Options**

An alternative to buying an adapter is purchasing two 6 volt motorcycle batteries ($10 each). Attach them together so that both positive and negative terminals line up. Then connect the negative terminal of battery 1 to the positive terminal of battery 2. Battery one now Supplies + 12 volts from the positive terminal, to the camera and LED’s and battery 2 supplies with a ground to the same. The RFU power of 6 Volts comes solely from battery 2. Use the ground shared by the camera/ LED combo, and tap into battery 2’s positive terminal for + 6 volts.

<table>
<thead>
<tr>
<th>TO CAMERA</th>
<th>TO RFU</th>
<th>TO CAMERA AND RFU</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 12 volts</td>
<td>+ 6 Volts</td>
<td>Ground</td>
</tr>
</tbody>
</table>

Bridge
RFU Wiring Pelican 7020 unit

Caution the red wire is your ground, and the green your positive. To assemble this cut off the plug (do not cut off the ferrite) and strip off the insulation, exposing the conductors. drill a hole in your control unit (any electronics project box will do) and slip the wire through. secure the cable with a wire tie. solder the output from the adapter to the red and green wires, next solder the video cable to the yellow conductor. Don't forget to insulate all solder connections with heat shrink tubing. The powering options above apply to this model.

This is too much work for you and you want a simpler solution. Well 9 volt cmos cameras can be bought quite reasonably on eBay. I bought one color several years ago for $5 plus S&H from Singapore. Secure the camera to the forward bulkhead using 5 minute epoxy and attach the battery with a clip, this you can buy at Radio Shack.

The cameras usually have two RCA jacks unless they are intended for surveylance. The yellow jack is most often the video, but sometimes they may be white. Cut off the jack and strip 1/4 inch off the end exposing the wire do same to umbilical cord, pick the red for video, and use the black for the antenna.

Slip on heat shrinking tubing onto the wire and solder exposed wires, slide the heat shrinking tubing over the bare wire and apply heat.

The antenna wire (black) can be sodered right onto the reciever in most cases. or simply cut the ariel whip short and solder it to the umbilical.

Sealing the umbilical/ antenna
List of manufacturers suppliers:

**Acrylic domes:**
- UK
  - [http://www.applegate.co.uk/company/09/12/260.htm?clickedfrom=HOTLINK_29648](http://www.applegate.co.uk/company/09/12/260.htm?clickedfrom=HOTLINK_29648)
- USA
- $30 domes
  - [http://www.globalplastics.ca/micro.htm](http://www.globalplastics.ca/micro.htm)

**ABS PIPE**

**Marine Hardware**
- Ballast tanks
  - [http://www.mikessubworks.com](http://www.mikessubworks.com)
  - [http://www.rcboats.com](http://www.rcboats.com)
  - [http://www.dumasproducts.com](http://www.dumasproducts.com)

**Dumas**
- #3003 1/8 shaft 1.75" dia Nylon Prop $1.20
- #2603 Stainless Steel Shaft + stuffing box $6.00
- #2008 1/8 x 1/8 Shaft Coupling $6.25

For phone orders call **1-800-458-2828** toll free

**Electric Motors**
- [http://www.jameco.com](http://www.jameco.com)

Files like this one can be freely downloaded at:
- [www.underwaterprojects.741.com](http://www.underwaterprojects.741.com)

Check often as new files added regularly and old files are updated often.