



Solar Cup 101

Planning and Building your Solar Cup Boat

October 2019

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and Lab Supervisor, Department of Physics Occidental College**

Presented by the Metropolitan Water District of Southern California

A BEGINNERS GUIDE TO TURNING YOUR GOOD INTENTIONS INTO A SOLAR CUP BOAT

Building a Solar Cup Boat is a difficult task. It requires a dedicated team effort over many months to guarantee a successful season. Most new teams do not know where to start or where to concentrate their efforts. What parts should be purchased at what price and where? What should be done first and how does it all fit together?

We have created the following guide to help new teams to get a good start on their first boat. The following is our suggested way of building a solar boat. There are other ways that might be better, but this one works and will give you a good beginning.

As a rookie team your goals might be:

- 1. Have a fun and safe year.**
- 2. Don't focus on trying to win the event (you probably won't).**
- 3. Instead focus on learning and applying what you learn in the workshops to building as seaworthy a boat as you can.**
- 4. If possible, finish your boat early to give yourself time for on-the-water testing.**
- 5. Make some effort to learn the rules & regulations.**

First Year Suggestions for building your Solar Cup Boat

- Find out how you can get access to the money you will be given by the sponsoring water district so you can start ordering parts.
- Use the boat building workshop as a learning experience. Ask lots of questions, you will be amazed by how eager everyone is to help you.
- Order a motor mount, drive train, and rudder from Patrick Donovan.
- Have your team look at the pictures in this report and on the MWD Website to get an idea of what the boats look like and how the parts all fit together.
- Don't wait until the last minute to ask for help.

Solar Cup 2019-20 Timeline

The following is a list of tasks do by the date listed. These guidelines are not absolutes. Try to follow them if you can, or if you get behind catch up as soon as possible. The order and timing do matter for saving money and time.

September 2019 Organize your Solar Cup team

October-November 2019

Read all you can from the 2019 Solar Cup Program website:

<http://www.mwdh2o.com/inthecommunity/education-programs/Pages/Solar-Cup.aspx>

- a. Timeline
- b. Rules of Participation
- c. Solar Cup Technical Manual
- d. Scoring results for 2019 teams
- e. Videos; PSA winners, Take a Ride

October 28

- a) Preview the boat building instructions

November – December 2019

November 2 **Boat Building Workshop**

November 16 **New Teachers ½ Day Workshop - Solar Cup Basics**

November 18 Read the Rule Book and review this [Solar Cup 101 Guide](#)

November 23 **First Technical Workshop – Mandatory for Rookie Teams**

- a. Finish sealing the hull against water absorption; sand, prime and paint inside and out.
- b. Re-read the rulebook, this planning, and building guide and the Tech manual. These will help you with decisions that follow.
- c. Research and make choices about your drivetrain design, motor, motor mount, motor controller, batteries and solar panels.
- d. Research and purchase the materials for your motor mount, strut, drive shaft, shaft log, thrust bearing, throttle and steering. We recommend the Patrick Donovan kit.
- e. Motor selection and purchase
- f. Propeller selection and purchase (see Ron Hill)
- g. Purchase your solar panels (lightweight, 13 lb each or less if possible)

January 2020 – Focus on Mechanical Systems

January 9 **First Technical Report due – Topic: Drivetrain/Steering**

- a. Design and purchase the hinges, metal and bolts for your motor mount.
- b. Install the strut, line up and cut the hole for the drive shaft. ***This is a critical part of the process. Read all you can and get advice for this procedure. See Donovan Kit instructions.***
- c. Make and install your motor mount at a 90-degree angle to the drive shaft.
- d. Drill elongated holes in the motor mounting plate for the thrust bearing bolts so it can adjust up or down to align with the shaft.
- e. Align the shaft and connect it to the thrust bearing on the motor mount.
- f. Adjust the thrust bearing so the shaft spins easily by hand.
- g. Install the motor.
- h. Install the sprockets on the drive shaft and motor shaft. Install the idler sprocket on the motor mount. All sprockets should be in the same plane.
- i. Measure and install the chain around the sprockets.
- j. Seal and bolt or glue down the shaft log and shaft seal. Make sure the shaft still spins easily. You may have to shim the shaft log if it doesn't line up.

Electrical Equipment—Purchase all your electrical equipment. See list of vendors and prices listed in this booklet and the Solar Cup Check List.

Controller and more electrical

- a. Decide where to put the Motor Controller, contactor, shunt resistor, batteries, and high amp fuse. Put the Master switch in front of the bulkhead.
- b. Measure and purchase your high amperage cables (0 - 2 AWG) (9 cables) with lug ends for the motor, motor controller, contactor, high amp fuse, shunt resistor, master switch and batteries.

February 1 **Second Technical Workshop – Mandatory for all teams**

February 2020 – Focus on Electrical System

February 13 **Second Technical Report due – Electrical/Solar Array**

Follow the electrical schematic and watch our [YouTube video](#) for step by step instructions.

Solar Cup Electrical System

<https://www.youtube.com/watch?v=FH1mkwaJuOk>

Solar Cup Electrical System Detailed Instructions

<https://www.youtube.com/watch?v=ky7t3IGaZws>

Electrical system installation - Following your electrical schematic drawing, layout your electrical system on a table. Make all the connections and see if it works.

- a. Following your schematic to install the electrical system in your boat: Motor controller, 350 amp fuse, master switch, cables, throttle. etc. Make sure the cables are color coded for polarity. (+ and -)
- c. Install the dead-man switch with proper wiring.
- d. Install the batteries with the master A/B switch turned off.
- e. After checking the wiring for proper connections, turn the master A/B switch on and start the system with the throttle slowly. See if the motor runs and the driveshaft turns. Make sure the prop is turning in the right direction for forward thrust. If it turns in the opposite direction reverse the cables connecting to the motor.
- f. Make final adjustments.
- g. Build and seal the dashboard if you are using one. Or build a bracket for your steering handle.
- h. Design and build your Rudder System: the rudder, rudder tube, support beam, rudder shaft arm. (these are provided in the Donovan kit.
- i. Order a push-pull steering cable with front and back brackets
- j. Purchase or make a steering arm for the cable. See pictures below.

February 20 Draft Public Service Message due

March 2020 – Finishing Touches

March 5 Boat expenditure submission

March 16 School Site Visits begin (progress check and troubleshooting)

March 26 Liability forms for entire team due

Buoyancy

- a. Calculate the size needed for your buoyancy bags or foam. (see manual)
- b. Construct and install your buoyancy device.
- c. Install your bilge pump system including the separate battery.
- d. Design and make a safety cover for the transmission (chain & gears)
- e. Install the flag holder in the stern.
- f. Design and construct a plug-in system for your solar panels. (see your electrical schematic) Use shielded and polarized terminals to prevent an accidental short circuit. Install a 20-amp fuse and a cut-off switch between the solar panels and batteries.
- g. Purchase and install an MPPT charge controller in the solar circuit.

- h. Make a mounting system for your panels.
- i. Learn how to charge your batteries using your solar panels.
- j. Learn how to use a multi-meter to test your panels, batteries and electrical system.
- k. Make sure you have a secure system to transport your boat to, from practice runs, inspections, and to Lake Skinner.

April 2020 – Practice, Practice, Practice

- a. Practice driving the boat.
- b. Select two people to drive the boat. (always have a back up)
- c. Use a walkie-talkie system to communicate with the driver.
- d. Use a waterproof GPS unit to measure speed or just time them on a length of water with a known distance.
- e. Ideally, you should get at least five sprint test runs and two endurance runs before coming to the contest. Take a picture of one of your tests for proof to the officials that your boat works

April 9 **Final Public Service Message Due**

April 16 **School Site Visits End**

April 23 **Boat Expenditure Submission**

May 2020 - Race Preparation

- a. Assemble tools and spares to take to the races
- b. Stage camping supplies

May 2 **Technical Inspection Workshop – Mandatory for all teams**

May 15 -17 **Solar Cup Races**

COST OF BOAT PARTS (ESTIMATED)

Wood Sealers	Epoxy, Bondo, primer and finish paint	\$150
Bow Eye Bolt	Provided by MWD	
Bilge Pump / Battery for bilge pump	Seaflo Automatic Submersible Boat Bilge Water Pump 12v 750gph Auto with Float Switch-12V	\$26.99
	Battery - SLA-12V5-F1 battery.com	\$11.95
Secured battery boxes	Make you own (water proof)	
Paddle	Plastic - collapsible ~3ft long	18.99
Marine Fire extinguisher	1lb - shop around for best buy	\$20.00
Air horn or whistle and red signal flag	1.4 oz (Seasense)	\$6.55
	Make your own flag	
Contactor / Solenoids	***MZJ-200 24V (evdrives.com) Comes extra with Alltrax controller	\$42.00
Pre charge resistor	***220 OHM 10-watt (evdrives.com)	\$5.00
Diode	***3 Amp diode (evdrives.com)	\$3.00
Sierra Emergency Cut-Off Switch MP40970	Provided by MWD Tech Team – must use provided switch	
Cole Hersee M750BP Master Disconnect Switch	https://www.amazon.com/Cole-Hersee-M750-Battery-Selector/dp/B000XBCPD6	\$44.00
Motor	<u>Motor:</u> http://www.evdrives.com ME 0708 brush type, 28 lbs, 70 rpm/V, \$449 ME0909, brush type, 24 lbs, 83 rpm/V, \$374 * ME 1004 brush type, 32 lbs, 70rpm/V, \$525 ME0907, brushless, 22 lbs, 69 rpm/V, \$383	\$383-\$525
Motor Controller	***Alltrax SR 48400 *** http://www.evdrives.com 250 Amp Fuse included (older SPM and AXE models available on eBay)	\$437.00
***Cables for batteries and motor (Measure these after you place your electrical parts on the boat)	Flexible high amp #0 - #2 (multi-strand) Cables with lugs for batteries and motor	\$40
**350 amp fuse	McMaster-Carr 70635K412	\$45.30

*Trailer	(can use donated funds) Find the best deal on a safe, legal trailer or find way to transport your boat.	
Transmission	McMaster-Carr (sprockets and chain)	\$100
Propeller	Call Hill Marine, Ask for Solar Boat prop and price	~\$175
Drive shaft, strut, shaft log, stuffing box and rudder assembly. Purchase entire package from Patrick Donovan donovanbrothers@gmail.com 714-504-8631		\$450 With motor mount ~\$500
Motor mount metal and bolts	Can make your own metal mount, braces, bolts	\$75
Push-Pull Steering cable Teleflex CC179 Control Cable http://www.wholesalemarine.com/control-cables-for-1965-and-newer-mercruiser-mercury-38087.html You can get a 10' to 11' cable Look at the Teleflex cable connectors at this site		\$26.95
Batteries	One pair (Two sets preferred) (4 Odyssey PC1100) \$184.52 each from West Coast Batteries 888-379-2555 (<u>\$369.04/pair</u>) Tell them you are from Solar Cup http://www.westcoastbatteriesinc.com BCSC 10 AMP Charger (dealer cost—tell them you are with Solar Cup)	\$369.04 pr \$128.18
2 Solar Panels	160 watts each: 320 total watts maximum allowed, 100 watts minimum https://www.ebay.com/itm/Monocrystalline-18V-160WATT-Solar-Panel-Flexible-Charge-Car-RV-Boat-Home-Camp-v1/163845780755?hash=item2625f83513:g:EXQAAOSwKENdbnvt Search on eBay for 160 watt solar panels. There are many choices. Buy flexible lightweight ones.	\$125.99 each 251.98 for pair

MPPT Solar Charge Controller	Charge controller <i>Here is a good one:</i> https://www.amazon.com/dp/B0794RCDYJ/ref=twister_B0794X8QN1?encoding=UTF8&th=1	\$108
Steering handle	Make your own	
Throttle	*** PB-6 Curtis *** Can be made into a foot or hand throttle https://www.evdrives.com/product_p/thr-pb6.htm	\$95
Multifunction DC Voltmeter	https://www.amazon.com/Signstek-Manual-Digital-Multimeter-Ammeter/dp/B00FFYPUTM/ref=sr_1_4?keywords=victor+multimeter&qid=1571514307&s=automotive&sr=1-4	\$37.20
Ammeter	#IN2510 (0-60 AMP DC, build in shunt) (optional)	(\$17.95)
Shunt Resistor	https://www.amazon.com/AMMETER-SHUNT-500-AMP-MILLIVOLT/dp/B005BHPG6K/ref=sr_1_2?keywords=500+amp+shunt&qid=1571514548&s=automotive&sr=1-2	29.50
**Boat Cart	Very useful; make your own	
Miscellaneous wires, wire connectors, screws, bolts, clips for steering, cable, motor cover material, solar panel brackets, buoyancy material		\$250
TOTALS FOR ESSENTIALS (approximate)		~\$3,354

*Money can come from donations **Optional ***<http://www.evdrives.com/>

Tools:

Circular power saw (7.5") with metal cutting blade
Power drill and an assortment of drill bits
Saber jig saw with metal cutting blade
Sawzall
Flathead and Philips screw drivers
Needle Nose Pliers
Socket set with metric and standard sockets
Clamps
Saw horses
Wire cutter, stripper, crimper combo tool
Multimeter
Battery Charger
Work table with Vise

Some things to Consider:

Trailer or some means of moving the boat legally and safely

It is important to get a trailer soon so you can modify it for the boat with a drive shaft coming through the bottom. You will need a trailer license.

Harbor Freight has a 1195 lb. Capacity 48 in. x 96 in. Heavy Duty Trailer \$280
<http://www.harborfreight.com/1195-lb-Capacity-48-in-x-96-in-Heavy-Duty-Folding-Trailer-62648.html>

Try to get someone to donate this item so you can save your money for the boat.

Transmission or Direct drive?

After choosing a motor you need to decide if you want to have a direct drive (the motor connects directly to the drive shaft with the aid of a Lovejoy connector) or use a chain with sprockets to turn the drive shaft (transmission type). Direct drive gives you a 1:1 turning ratio. The chain/sprocket driven shaft can change the transmission ratio by altering the size of the sprockets on the motor and the drive shaft. If you want direct drive you need to measure the diameter of the motor and calculate its position in the boat so it will meet the drive shaft directly. Some motors require the front end of the shaft to move higher to meet the motor shaft. This may affect the angle of the strut and shaft log you choose. You can compensate the angle with a **flexible coupler** if you do not want the angle of your shaft too steep.

If you use a chain/sprocket transmission system you can lower the front end of the drive shaft and get a strut and shaft log with a 12 degree angle. This system requires that you purchase sprockets for the chain. The size of each will alter the speed of the drive shaft. Example: A #35 40 tooth sprocket on the motor and a 30 tooth sprocket on the drive shaft will increase the speed of the drive shaft. When the motor sprocket turns once the drive shaft sprocket will turn 1.5 times.

I like this arrangement. We used the 35 series roller sprocket and chain.

The 5/8" bore sprocket and 5/8" drive shaft insert on the anterior end of the drive shaft should have a groove for brass "key" to prevent slippage.

Sprockets, wheels, chains and belts can be purchased at McMaster-Carr

<http://www.mcmaster.com> The bore on the motor sprocket must match the motor shaft diameter. The bore on the drive shaft sprocket must match the drive shaft diameter. This system requires a **standard flange mount bearing** to support the front end of the drive shaft, which **can also be purchased at McMaster-Carr. \$100. Or it is included with the Donovan kit.**

I recommend a transmission drive and the Donovan Kit.

Drive Shaft, Strut and propeller (some of the most important parts you will buy)

I recommend that you purchase the strut and drive shaft from Patrick Donovan.

He makes the parts specifically for the Solar Cup boat. (714) 974-3768 phone or cell (714) 504-8631 Donovanbrothers@gmail.com

He uses a 3/4" hollow chromoly drive shaft and tailor makes the ends to fit your propeller.

Patrick has a package deal that includes the drive shaft, strut, thrust bearing, shaft log, shaft seal and rudder assembly. **We highly recommend this package.**



Patrick Donovan
 135 Circlulo Robel
 Anaheim, CA. 92807-2328, USA
 email: donovanbrothers@gmail.com
 phone: (714) 974-3768
 cell: (714) 504-8631

Invoice

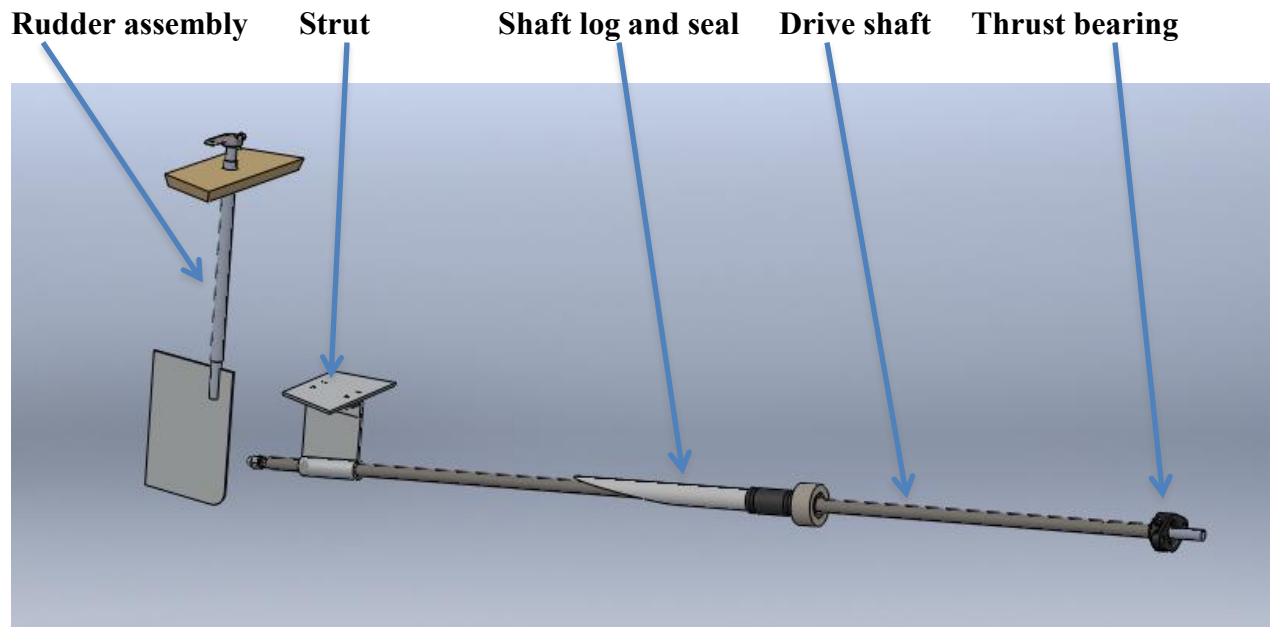
Client Information		Date 10/19/2015	
Name		Rep. <u>Patrick Donovan</u>	
Address			
Contact	Cell		

Qty	Description	Unit Price	TOTAL
1	3/4 " Hollow 4130 Chromoly Drive shaft stepped to 5/8" on motor side Pin drive propeller side	\$145.00	145.00
1	3/4" Rulon LR Strut Set up and 5/8" motor mount bearing	\$130.00	130.00
1	3/4" shaft seal assembly	\$30.00	30.00
1	Rudder set up	\$120.00	120.00
1	Motor Mount	\$75.00	75.00
Total			\$ 500.00

Payment Details	Office Use Only

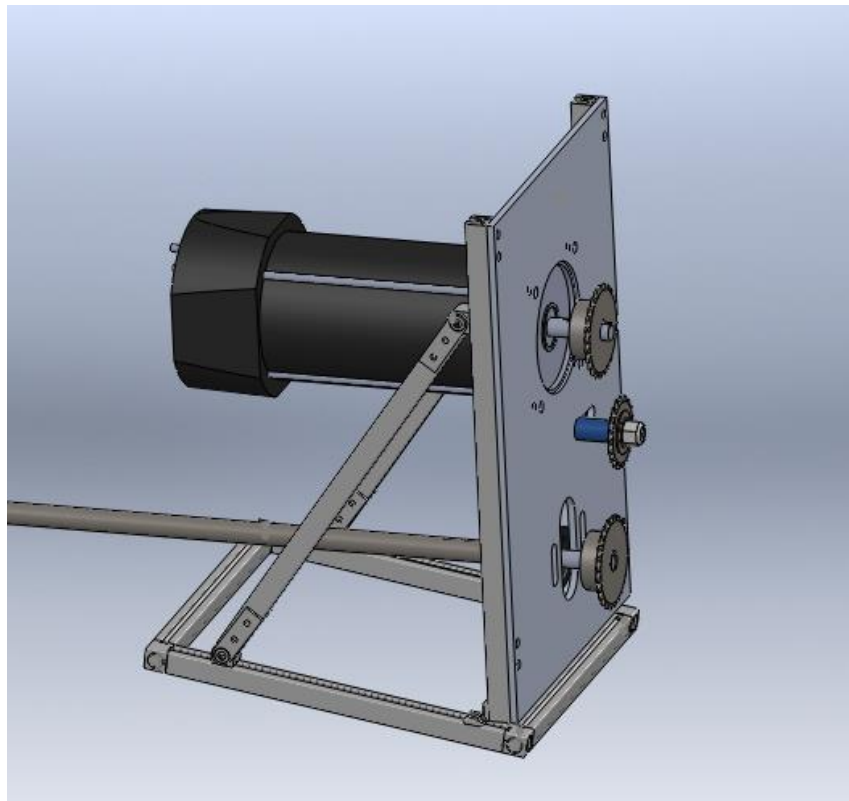
Prices subject to change

Aluminum strut and chromoly drive shaft. Made by Patrick Donovan (see Patrick Donovan for purchase) 714.504.8631 cell donovanbrothers@gmail.com



Above: rudder assembly, strut, drive shaft, shaft log and thrust bearing.
 Patrick Donovan's Drive shaft and Rudder kit (above \$450)

Motor Mount Plate only (below \$75) (sprockets are shown below)



MOTOR MOUNT (one option)

Shaft Log and Stuffing box installation:

If you are buying Patrick Donovan's system, he will give you instructions on how to fasten the PVC shaft log and stuffing box.

If you purchase the aluminum shaft log follow these instructions:

- After lining up the shaft and flange bearing you can line up and install the shaft log and stuffing box.
- Slide the shaft back so you can slip on the shaft log. If you are lucky the shaft should sit right in the middle of the shaft log opening when it is place flat over the hole in the bottom of the boat.
- Mark where the bolt holes should be and drill these holes and bevel the bottom of the holes so the bolts sit flush when put in place.
- Use Marine 5200 glue and beveled bolts with lock nuts to secure the shaft log to the bottom of the boat.
- If the shaft log needs a little adjustment to center the shaft you may need to put in a washer or two so that it aligns.
- Add a little 5200 around the edges of the shaft log after it is secured in place to seal any leaky areas.

Note the PVC shaft log provided in the Donovan Kit is fiber glassed to the floor of the boat. An instruction sheet is included.

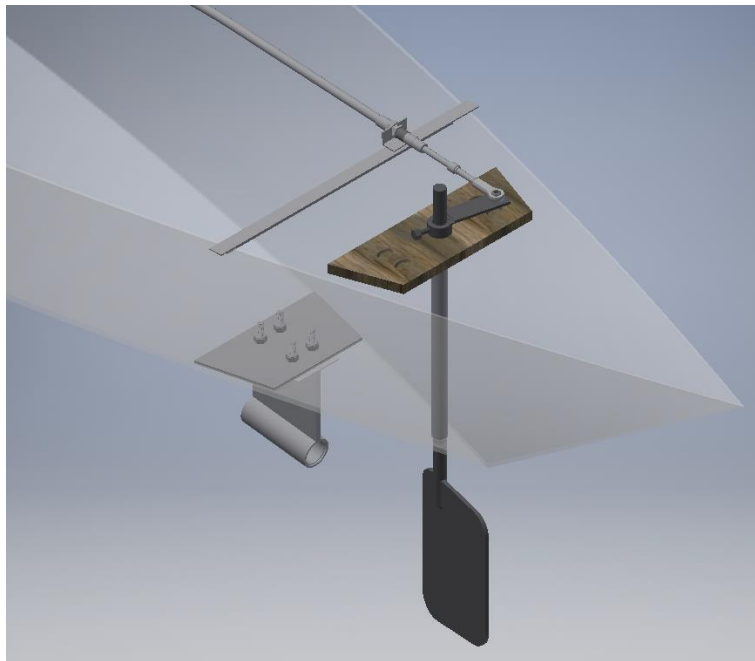




Note that the prop is about 1" to 3" from the strut. This cuts down on drive shaft damaging vibration.

After calculating the position of the strut, install a 1/2" X 5" wide board across the bottom inside the boat from chine to chine. Secure with Epoxy or glue and metal plates that tie into the chines. This will give you a strong support for the Strut.

Install the strut with bolts through the hull. Use a backing plate or large washers inside the boat for stability.



Propeller

Hill Marine (800)762-0309, chad.hill@hillmarine.com Ask for Ron or Chad Hill 2709 Orange Ave Suite A, Santa Ana, CA 92707-3746

They have the best choice for good props.

They have straight 3/4" inch bores that can match up with the Donovan drive shafts. **You need to order a notch cut into the distal end so a pin can be inserted to hold the prop to the shaft when purchasing.** It is too difficult to cut the notch yourself. They have the proper equipment.

I recommend an 8" to 12" two blade, variable pitch inboard prop. ~\$175-\$200

Avoid getting an outboard motor prop. They are cheaper and easier to find but they have a large central exhaust hub that creates a lot of drag.

Take your prop to Patrick Donovan's when ordering your drive shaft system so he can match it to the drive shaft prop insert.



This is a Hill Marine Prop that works very well for Solar Cup (Stainless steel, variable pitch, racing prop)

Placing the strut and cutting a hole in your boat for the shaft to enter the boat.

(SEE STRUT PLATE WITH RUDDER INSTALLATION INSTRUCTIONS HAND OUT)

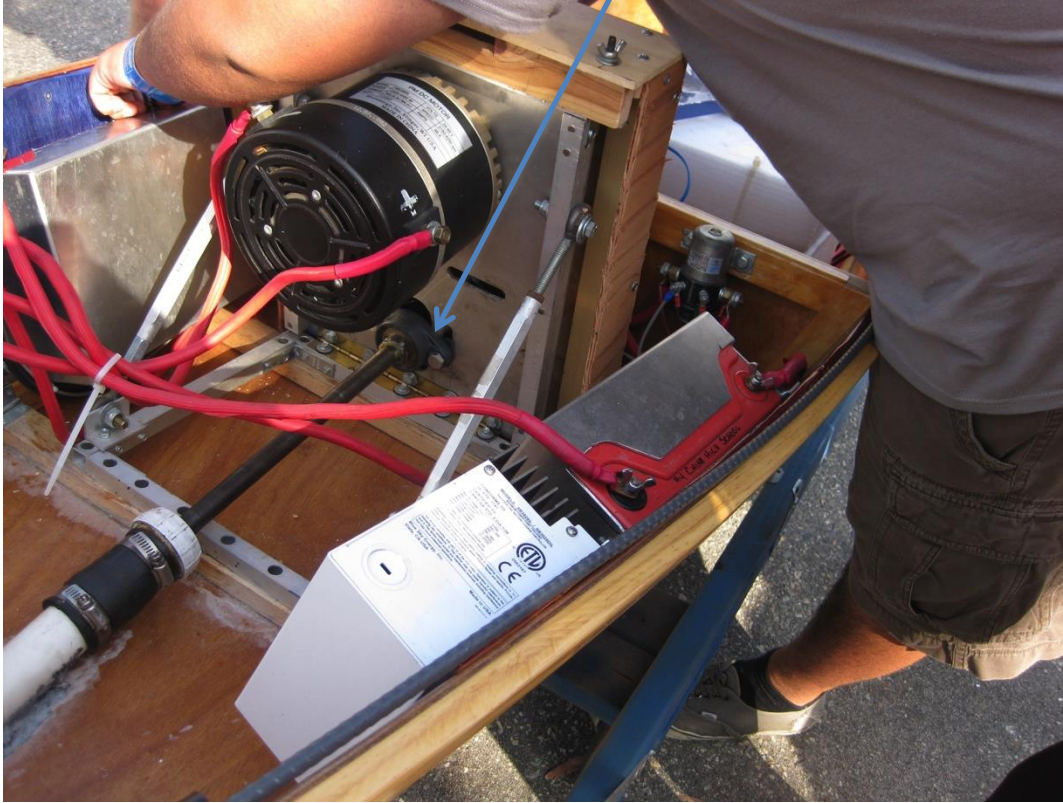
- a. Turn the boat upside down. Snap a chalk line along the middle of the boat from the bow point to the stern point.
- b. Put your shaft through the strut and place it on the bottom. Position the strut as far back as possible (at least 12 inches from the rudder) so you can drill the four holes in the bottom that will hold the strut. **Note: The rudder tube will be in the stern corner of the bottom.**

- c. Move the shaft forward through the strut until it touches the bottom on the chalk line. If everything is lined up mark the position of the strut and mark where the shaft touches the bottom on the chalk line.
- d. **Install the strut** with stainless steel bolts and lock nuts through the bottom of the boat. You must reinforce the 1/4 inch plywood bottom with at least 1/2 " board inside the boat so the bolts do not rip through the thin bottom. Make sure it is lined up before snugly tightening the nuts. **Note: before you secure the strut make sure it is lined up perpendicular to the motor mount** Put some 5200 marine glue under the strut and in the holes to seal for water leaks **after the motor mount is installed and lined up with the drive shaft.**
- e. Again move the shaft forward through the strut until it touches the bottom on the chalk line. Project where the center of the shaft would hit if it extended forward to the boat bottom. That should be the center of the hole you will cut. Mark lines parallel to the center line 1" wide (for a 3/4" shaft) about 3" forward and 3" back from the center point. So the hole will be about 6" long and 1" wide. Drill 1" holes at each end. Use a saber saw to cut out the remaining rectangular piece. Check to see if the shaft fits through the hole in the boat after going through the strut. If it touches you may have to file or saw some more. Use a round file to slant the front and back curved edges of the hole so the shaft clears the wood.

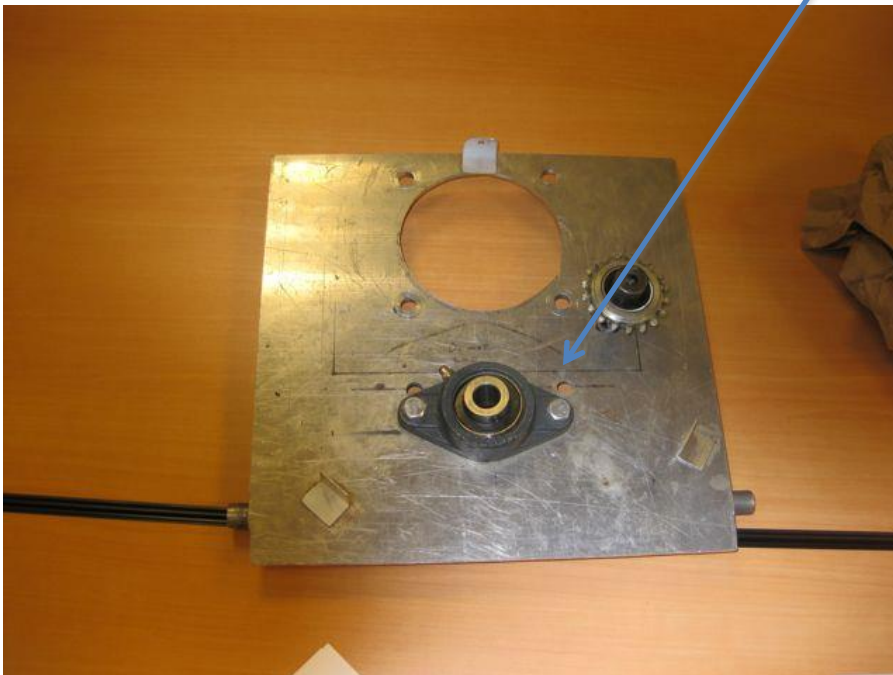
Installing a Flange or Thrust bearing to hold the front end of the drive shaft (assuming you are using a gear system)

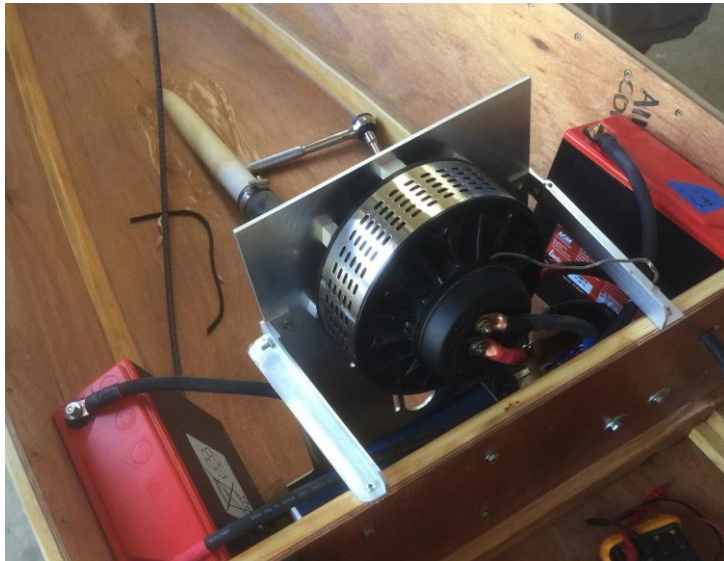
- a. **Purchase the Donovan Kit which includes the flange/thrust bearing or purchase a standard thrust bearing with a bore that matches the step-down on your drive shaft. McMaster-Carr has some for \$33 to \$72 <http://www.mcmaster.com/#mounted-bearings/=1rwtmo>.**
 - The Donovan shafts have a step-down on the front end that fits nicely into the flange bearing for forward thrust.
 - Mount the flange bearing on the motor mount with slotted openings for up and down adjustments.
 - This adjustment is critical for lining up the drive shaft with the strut and avoiding speed killing and energy consuming friction. The end coming through the motor mount can be used for the sprocket attachment.
- b. You should be able to turn the shaft easily with two fingers if it is aligned correctly.

Thrust/Flange bearing mounted on the motor mount



Thrust bearing on the motor mount with slotted holes for adjusting up and down. The chain idler is also adjustable to take up slack in the chain.



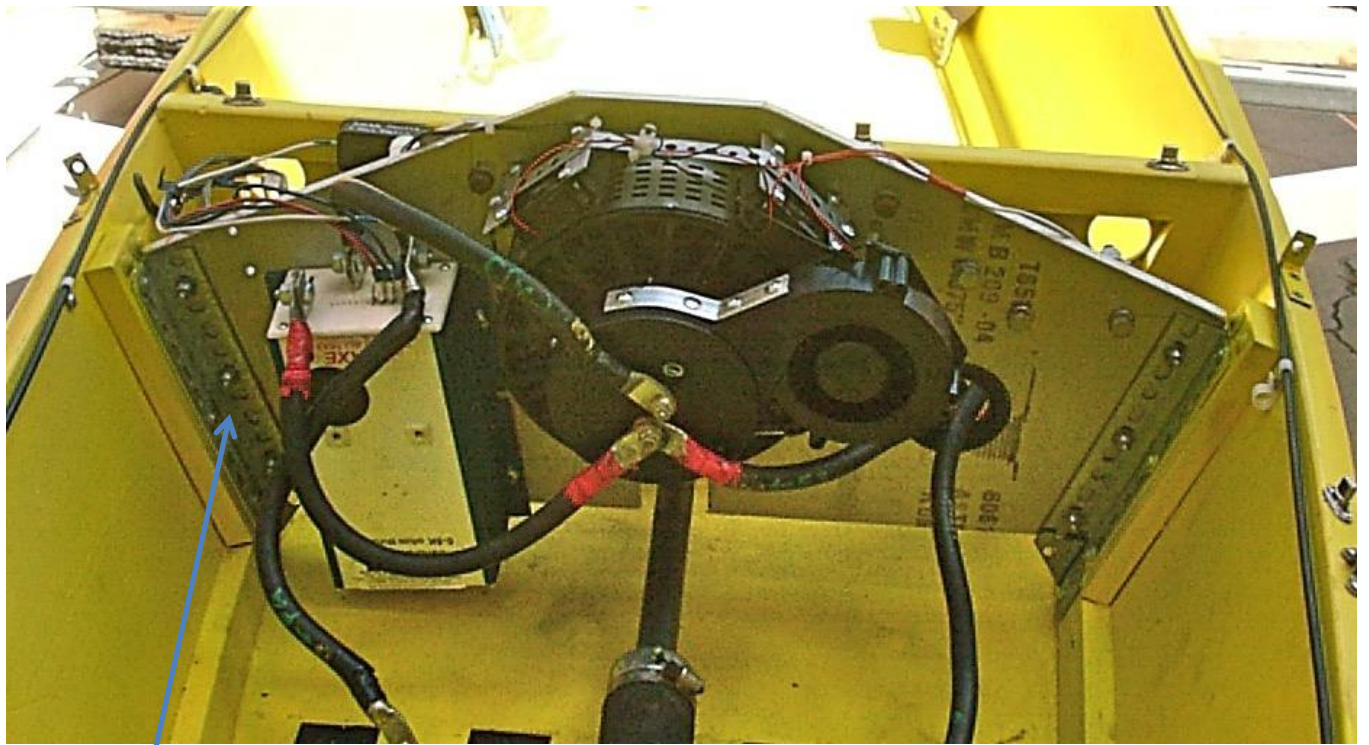


Mounting the motor

There are several ways to mount the motor. Some are shown in the pictures. The motor mount and sleeve bearing must be fastened very securely so the vibrations do not cause the bolts to come loose.

1. I suggest that you make a 1/4 or 5/16ths inch plate aluminum motor mount that can be bolted to the holes on the motor. Have it overlap at least 1" on the sides, top and bottom of the motor.
2. Reinforce the sides of the boat with 3/4 X 3" boards that extend from the top of the gunwale down to the chine slanted on a 12 degree angle. These boards will be placed behind the bulkhead about 7 inches. They will be the mounting boards for the motor frame.
3. Install a right angle metal strip (galvanized steel with multiple holes from Lowe's works good) over the reinforcing boards. Overlap the chine at the bottom. Put two screws into the chine at the bottom of the metal angle iron. Put two bolts at the top through the metal and gunwale. This will provide a strong place to mount the motor frame.
4. Make a motor frame that will stretch across the bottom and top of the aluminum motor mount you made. 1/8 steel angle iron with holes is a good material for this that can also be obtained at Lowe's. Connect all the pieces so you have the motor is above and tilting at the same angle as the drive shaft.

For beginners I suggest you call or email me or one of the experienced boat builders and share the pros and cons of different motor mount configurations. (Woody's contact info is on last page)



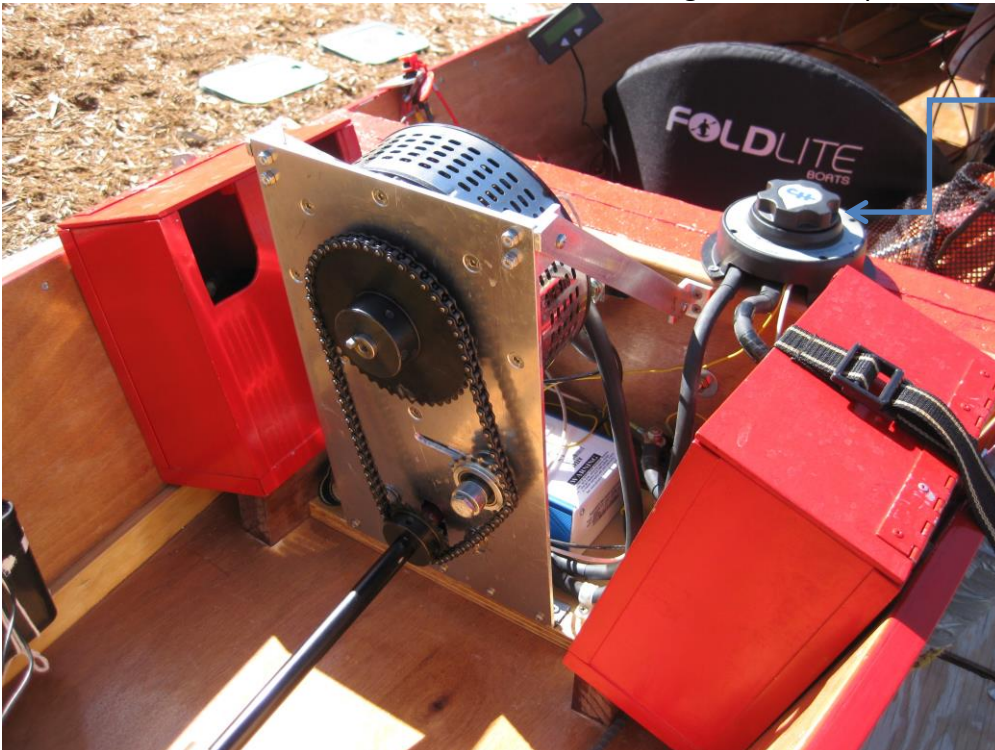
Another way to build a motor mount



Motor mount and Lovejoy coupler for direct drive (no transmission)

Installing a transmission: (if you want the driveshaft to go faster than the motor).

- A. Purchase three roller chain steel sprockets (ANSI # 35) from McMaster-Carr. <http://www.mcmaster.com/#6236k251/=4w0lib>.
- B. I used a 40 tooth sprocket (part # 6236K252, \$29) for the sprint race and a 30 tooth sprocket (# 6236K232, \$23) for the endurance race with a bore size to match the motor shaft. (3/4" for me)
- C. I had to make a brass key to fit the motor shaft and the sprocket key way. Allen bolts held it in place.
- D. Then purchase a 30 tooth sprocket for the drive shaft (#6236K233, \$23) with a bore size to match. (3/4")
- E. Again you will have to fashion a brass key for the shaft and sprocket.
- F. Then buy a roller chain (approx..two feet) of #35 single strand steel with a couple of connecting links. (#6261K292, about \$ 8)
- G. Put the 40 on the motor and the 30 on the drive shaft gives you a faster turning prop with a one to one and a half ratio which is good for the sprint race.



Do not mount the master A/B switch as shown in this picture. It must be in front of the driver.

We have only included this picture because it shows the motor mount and battery boxes so well!

SPROCKETS AND CHAIN DRIVE:

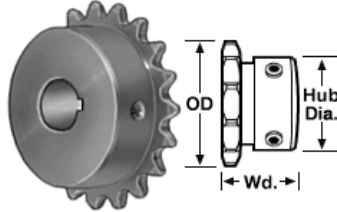
TRANSMISSION (parts from McMASTER=CARR)

<http://www.mcmaster.com/#6236k251/=4w0lib>

Part Number: 6236K251

\$28.51 Each

Type Drive	ANSI 35
For Chain Number	Inch
System of Measurement	Pitch 3/8"
	Bore Finished
Finished-Bore Type	Includes ANSI Keyway and 2 Set Screws
Bore Size	5/8"
Shape	Single Strand With Hub
Number of Teeth	40
ANSI Keyway Size (Width x Depth)	3/16" x 3/32"
Outside Diameter	4.99"
	Width 1"
Hub Diameter	2-1/4"
Material	Steel



ANSI Chain Number	35
	Style Single Strand
System of Measurement	Inch
	Pitch 3/8"
	Material Steel
Connecting Link	ANSI 35



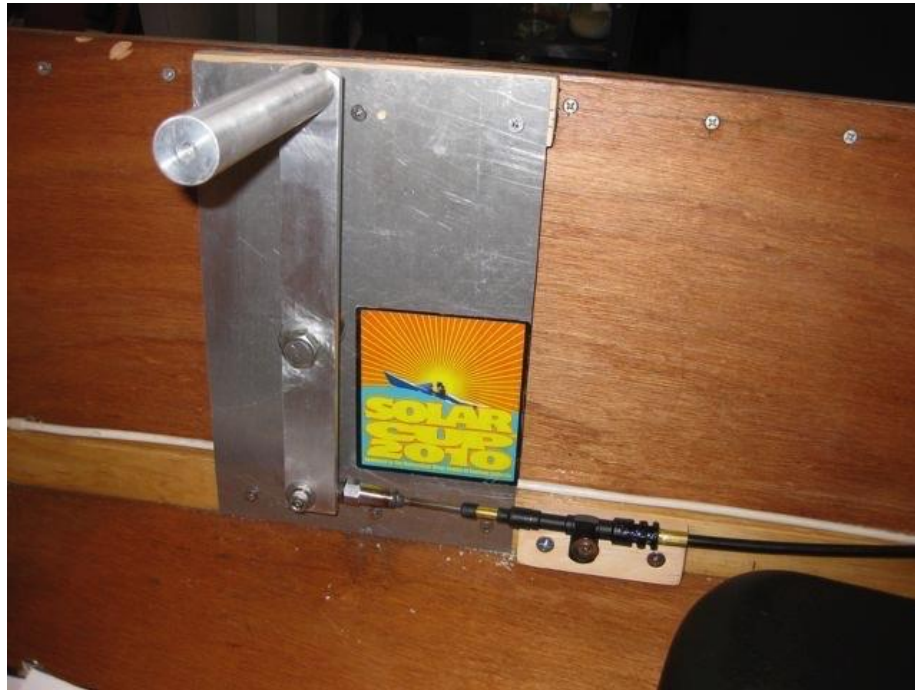
<http://www.mcmaster.com/#steel-roller-chain-links/=4w0gmn>

FLOATATION



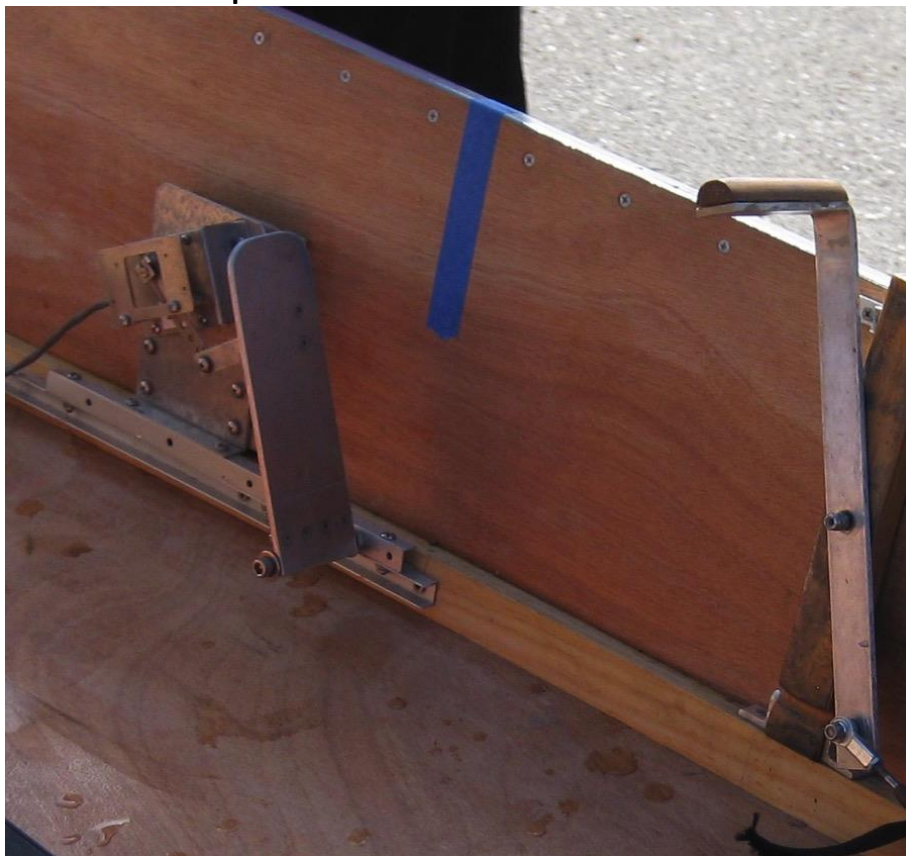
Buoyancy Bags held in place with netting, hooks and bungees
 You will need approximately 3 cubic feet of buoyancy bags or Styrofoam.

STEERING:

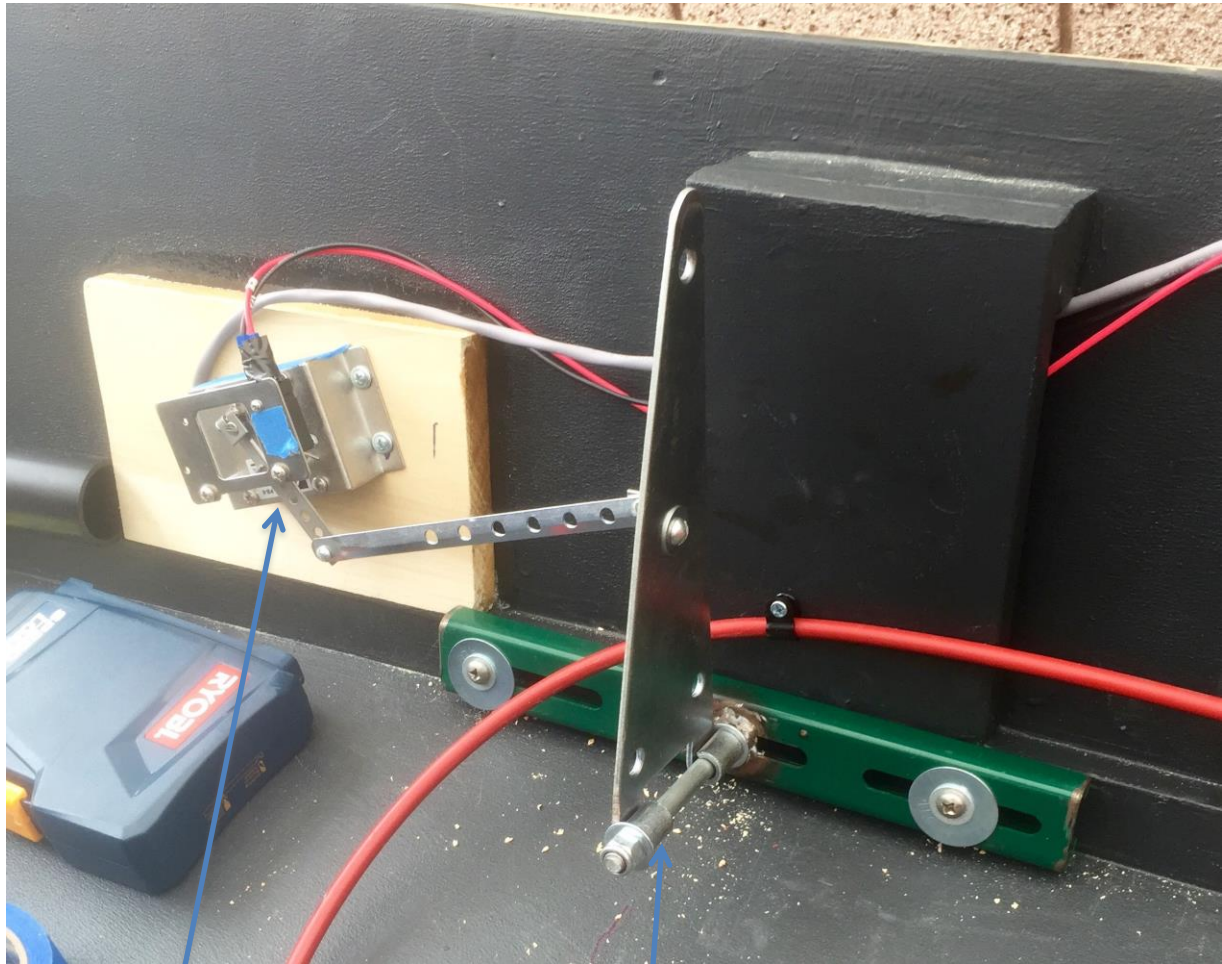


Push-Pull single cable steering. Dash not needed This is probably the best steering system. (see [Donovan's Installrudder/strut #30224C pdf](#))

Here is an excellent example of a homemade foot throttle attached to the Curtis PB-6



Push Pull steering arm and foot throttle system frees up a hand for Walkie-Talkie use.



Curtis PB-6 Throttle

Door hinge





STEERING CONTROL

Control Cables

562 949-0455 will sell you one of these Arens C72 Friction Levers along with a push pull cable

OR Push-Pull Steering cable Teleflex CC179 Control Cable

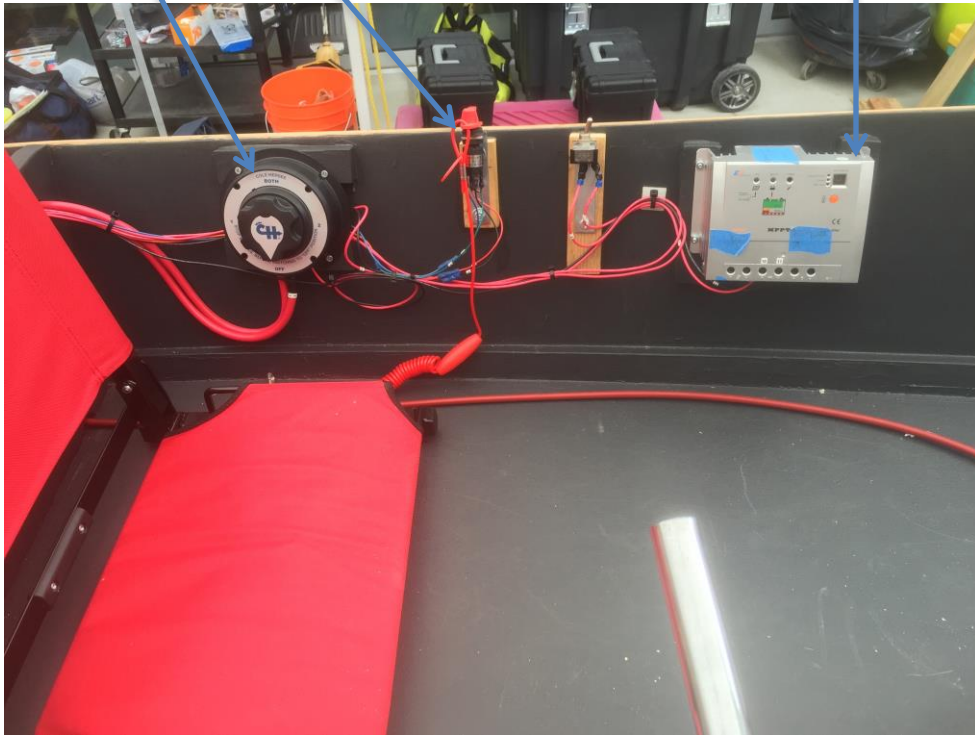
<http://www.wholesalemarine.com/control-cables-for-1965-and-newer-mercruiser-mercury-38087.html> You can get a 10' to 11' cable

Look at the Teleflex cable connectors at this site

Master Switch

Kill Switch

MPPT Solar Charge Controller



Electrical system installation:

NOTE: We will be providing a complete electrical schematic at this workshop.

Master Switch

The Cole Hersee 750 Master switch (recommended) is shown below, although other switches are available. **This required switch must be in front of and within easy reach of the driver inside the driver's cockpit. Do not mount it behind the driver, as might be shown on older pictures you may come across, like the one on page 20 above.** This picture is intended to show the motor and gears, and was taken before the rules were changed which required that this switch be in front of the driver.



MOTOR CONTROLLER

Purchase a motor controller. Alltrax makes a good one, their model SR48300 (recommended) is shown below. Older and somewhat cheaper models may be available from a distributor or on eBay. If you want to save money by buying an older model don't hesitate to contact me for a recommendation. Install the motor controller behind the bulkhead where the cables and wires can be easily attached. For efficiency, and to save money, keep the high current wires as short as possible.



BATTERIES:

West Coast Batteries (888) 379-2555, sells the Odyssey PC 1100, the one we recommend. It weighs 27.5 lbs. They said they would sell this battery to Solar Cup teams for \$185 ea. This good buy will last you 3-4 years with proper care.



Batteries play a big roll in the success of your boat and these are about the best on the market. Your electrical system requires 2 x 12 volt Batteries wired in series so you have a 24 V system: Read the rules on the batteries. Purchase these soon and strap them down in battery containers (they sell these as well).

Solenoid

The purpose of the solenoid is to form an interface between the low current side of the circuit and the high current side. It is essentially an electronic switch which will turn on the motor when you close the electrical circuit by applying the throttle. If you purchase an Alltrax motor controller as shown above, it will come with a solenoid and high current fuse (below).

DC CONTACTOR SOLENOID
200amps, 24volts



High Current Fuse:

Use the 250 amp fuse that came with the motor controller or get a 350 amp **fuse**. Part # 70635K412, \$36, <http://www.mcmaster.com> Make sure to purchase a holder (shown in the picture below) for the fuse, it will make mounting it much easier.



HIGH AMP CABLE: Purchase # 0-2 AWG size cables for the high amp connections.

Put several wraps of black electrical tape over the cable/lug connection down to the flattened end of the lug. This will help prevent accidental contact with other connections. Wrap a strip of red electrical tape on the ends of your positive cables.

I went to **Sims Welding Supply, 2445 South Street, Long Beach, CA, 90805 (562) 728 5500 Mike Arellano, Branch Manager** was very helpful. He cut the cable to my specifications and crimped the copper lugs on the ends. **It cost me about \$30 for all the cables.**

Install the cables. Make sure the connections are secure. (use lock washers) and do not let them touch other metal connections. Connect the final battery cable last, then turn on the master switch and set the kill switch when you are ready to start the motor.

Purchasing and installing photovoltaic solar panels

The panels you purchase cannot add up to more than 320 watts. A starting point is to compare different panels and then after you have picked a couple of possible choices look for the best buys. Try not to spend over \$300 and keep your weight below 30 lbs. Some teams made their own light weight panels without glass. This is a time consuming and difficult task and is not recommended for a new team.

There are many different panels available on Ebay. They are all made in China and just about any you can purchase will be good enough for the races.



Solar Charge Controller

There are many different solar charge controllers available. Try to buy an MPPT controller, they are more efficient. Any MPPT controller you can buy on Amazon or eBay in the \$75- \$100 price range should work OK.



Bilge Pump:

See the price chart for the two bilge pumps that we recommend, purchase one of them. Also purchase a battery for the bilge pump. The bilge pump cannot get its power from the main batteries which drive the boat.

The pump must be automatic when the water gets to 3/4" in the boat bottom. Put the 12 volt battery up off the bottom so it cannot get submerged.



Kill Switch

The kill switch is the most important safety item in the boat. **The switch you are required to use will be handed out at the second technical workshop at Oxy in February.** The terminals on the bottom of the switch have been waterproofed to prevent a short circuit in the event your boat takes on water. Refer to the pictures on page 26 for mounting suggestions. **For simplicity, the wires coming from the switch are color-coded to match the schematic diagram.**

