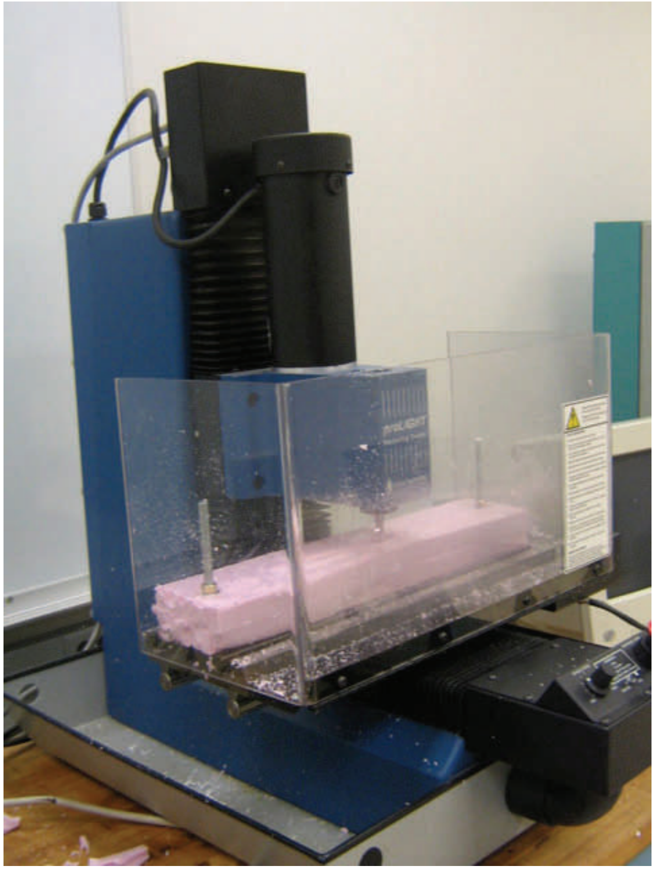
The College of New Jersey

School of Engineering

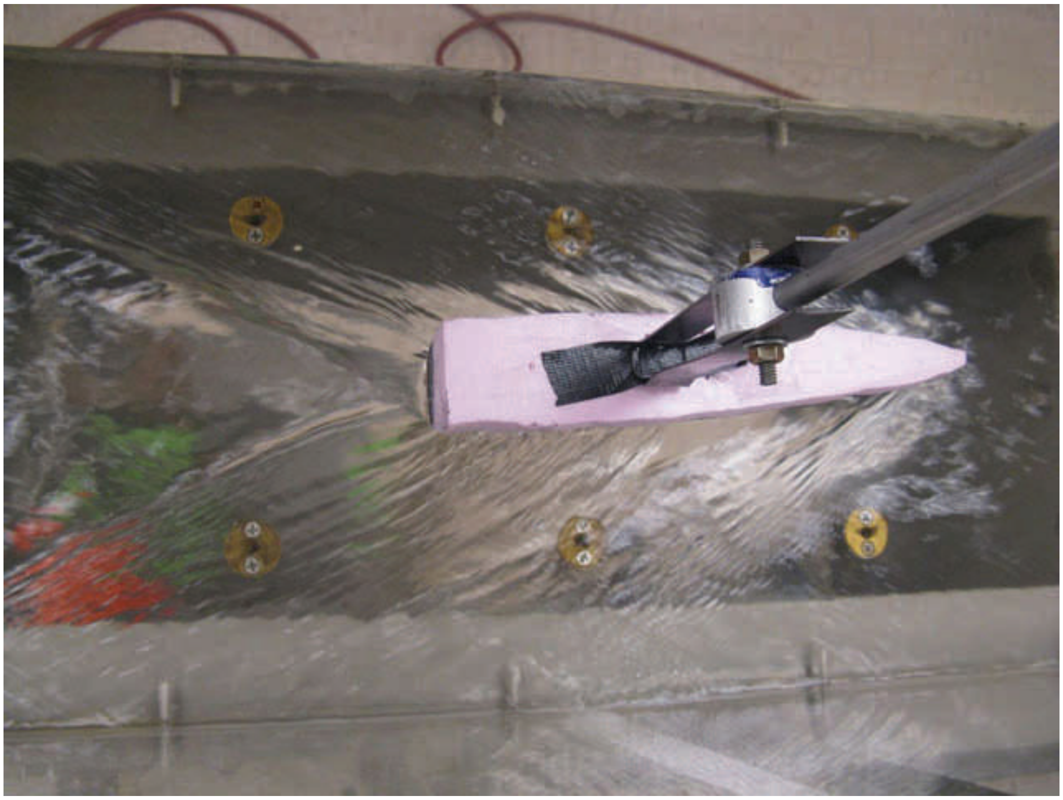
2009 Solar Electric Boat Project

The 2009 team from left to right, Dr. Karen Yan - Primary Advisor; Sean Anderson - Hull Design & Fabrication; Ryan VanAntwerp - Telemetry System/Digital Electronics; Russ Jones -Team Captain & Sprint Drive System; Jim Quigg - Project Management & Steering System; Brad Shensky - Solar Array, Peak Power Tracking & Electrical System; Chris Durando - Endurance Drive System; and Dr. Norm Asper - Secondary Mechanical Advisor. Not shown, Dr. Marv Kurland—Secondary Electrical Advisor

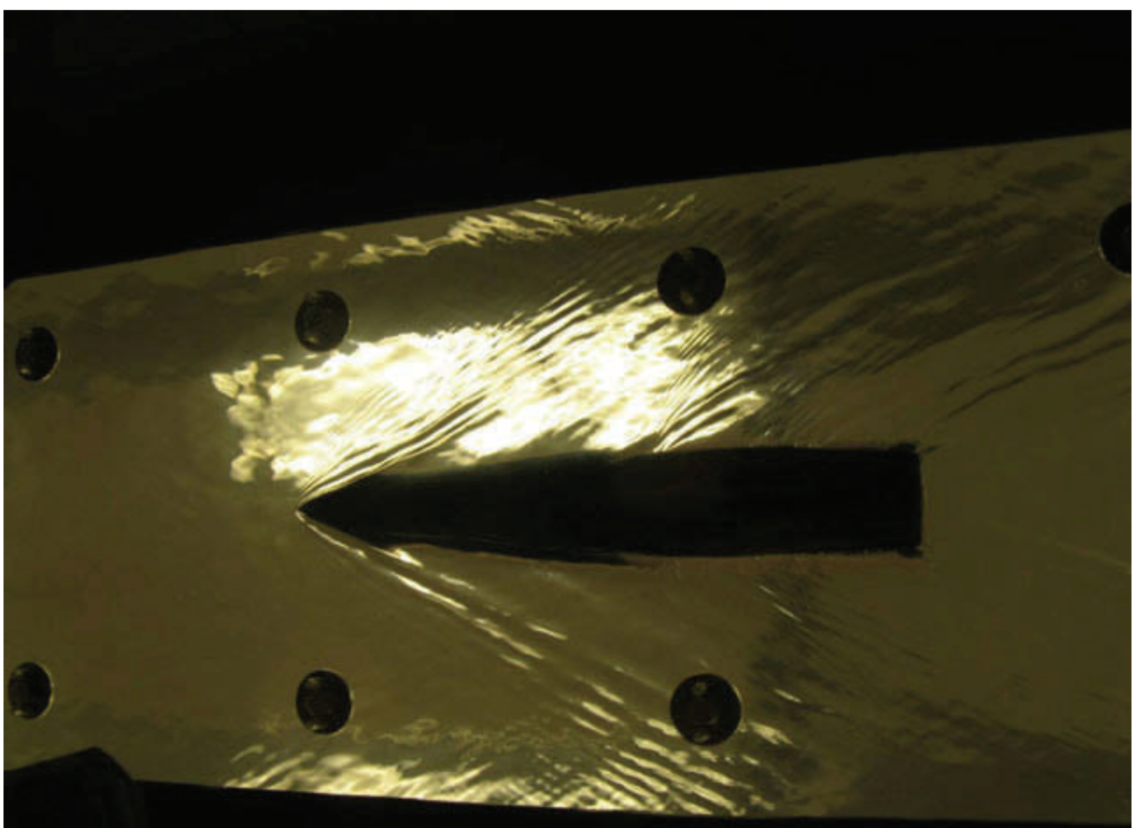
Before fall weather turned too cold, baseline data was confirmed through testing of the 2008 boat equipment.

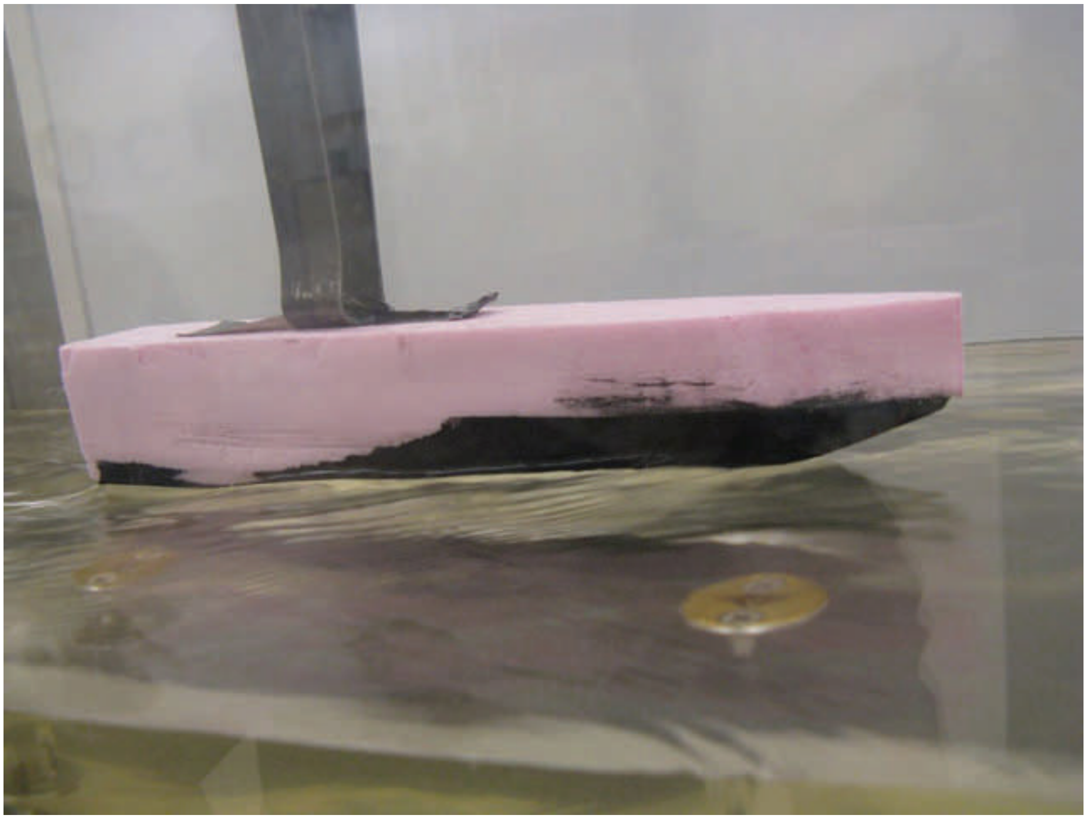


Russ took Sean's Solidworks hull models to the CNC 3-axis modeling milling machine and created polystyrene models of the three most promising hull shapes. The smallest model is a smaller scale of the final design.

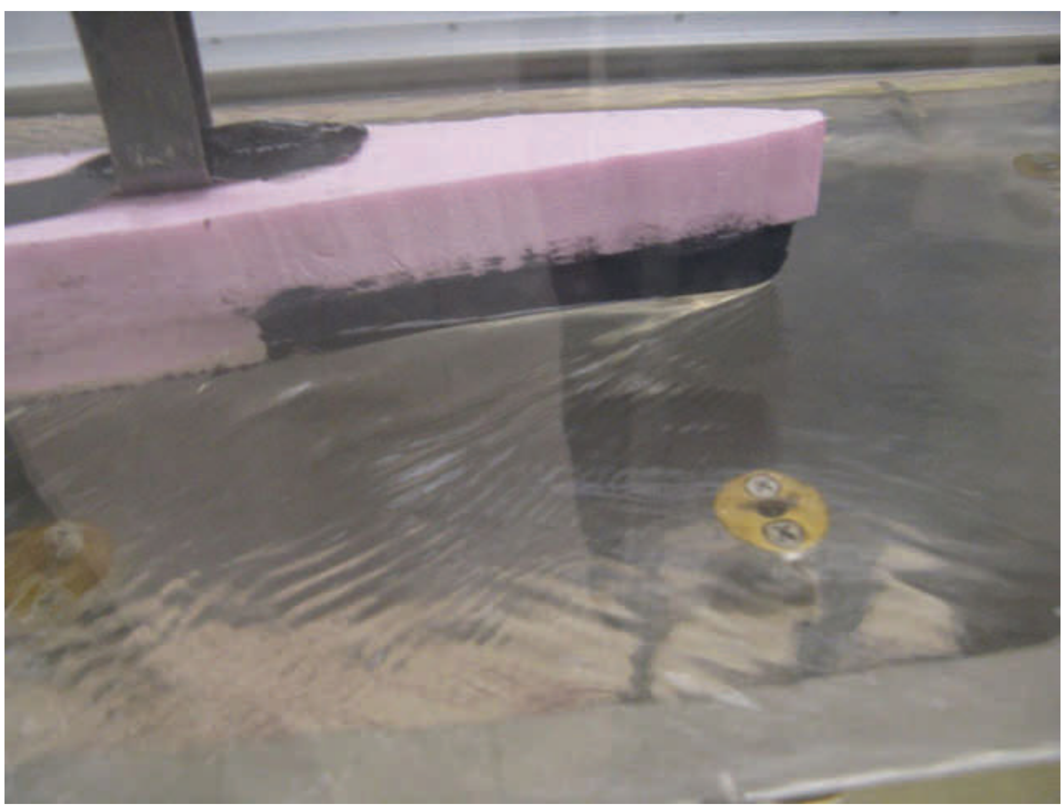


The hulls were tested in the Civil Engineering Flume with water velocity speeds determined using the Froude Number Correlation. These photos show bow and transom wakes from above and below the waterline.





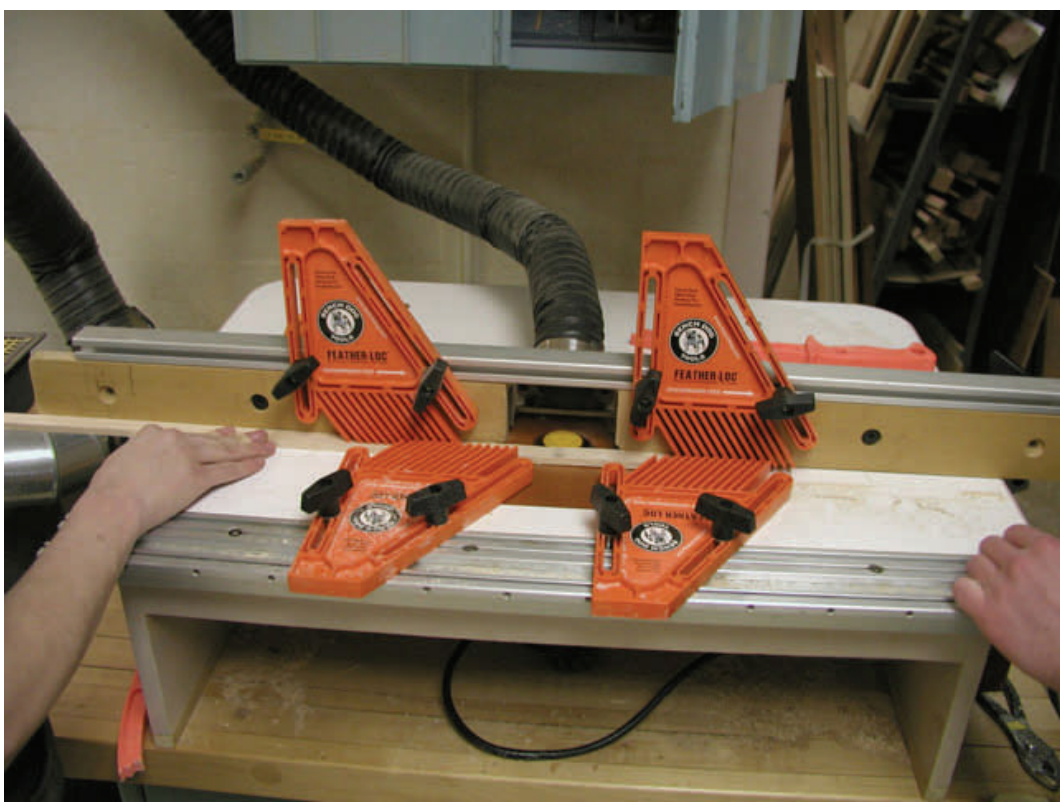
Each hull was tested at both the sprint and the endurance waterlines.
The paint was applied to smooth the surface of the Styrofoam.



The rough timber Balsa arrived, and the question became how to convert the timbers into Balsa strips to build the hull. The weight of these timbers is misleading; a 6” x 12” x 10’ timber is easily held in one hand. Either that or Sean is super strong.

A tall wooden fence was built for the Do-All vertical band saw and a new skip-tooth blade was used to re-saw the timbers into planks. This saw (actually metal cutting) in the manufacturing lab was selected because of the ample space around it for feeding the timber. It also was the only band saw with a variable speed adjustment. The planks were then sawed into strips. This soft wood makes for a great deal of dust.

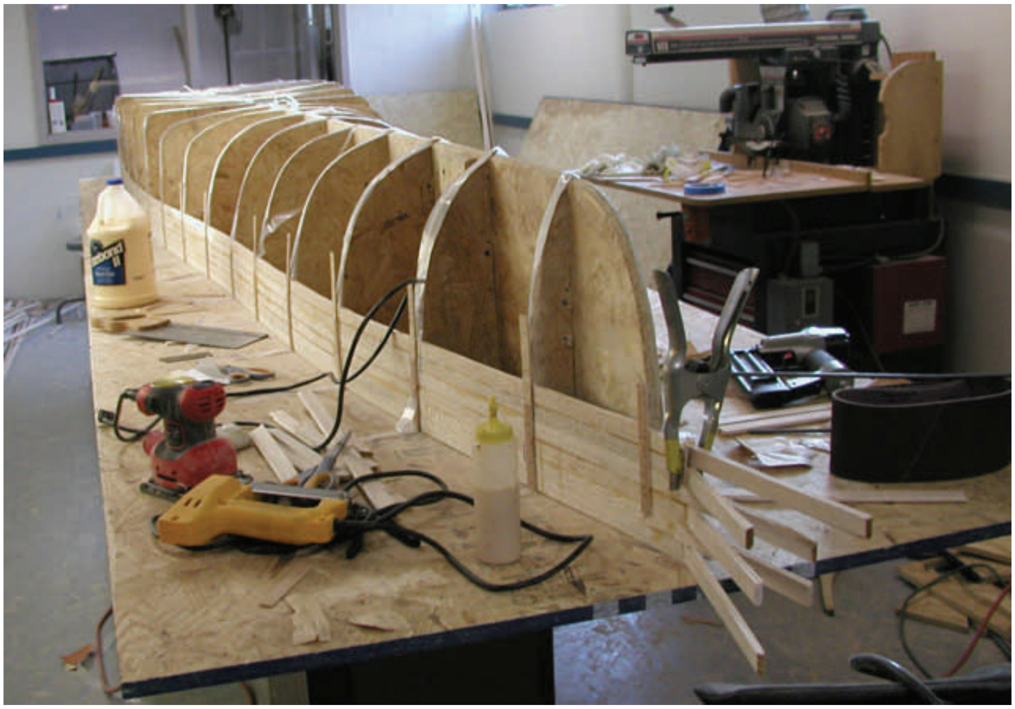
Back in the wood lab, Flute and Bead cutters were used on the edges of the strips to insure tight fitting joints during hull assembly.



While the Balsa strips were being produced, the plug was also being assembled. Full sized plots of the final design were marked out on flake board to make six inch rib stations for the plug. A 3/4 inch section was removed from the center of each rib to allow space for the flake board hardback center board, cut to represent the shape of the keel.

With all the ribs sectioned, wood cleats were attached to the bottom board and hardback center board to maintain square. Once we began mounting the balsa strips, the plug stiffened up considerably.

As the plug came together, the final shape of the hull became apparent. Notice some of the balsa strips piled on the floor at the rear of the room. Also notice the flute routed in the strip lying next to the plug. The bead on the back side of the strip is not as apparent. The final transom material was also fitted to the plug.



With the Flutes and Beads routed on each edge of the balsa strips, and the plug protected from the glue with Visqueen strips, the balsa strips could be applied to the plug. Brads are applied through a thin strip of plywood which makes the brads easier to remove after the glue dries.

The “basket weave” pattern of stripping at the bow should make for an exceptionally strong bow stem for the final hull. Both electric and pneumatic nailers were used to install the balsa strips.

As the stripping continued, the joinery got more complex where the strips meet at the ends. These final strips took some time.

With all of the Balsa strips glued into place, auto body hand sanders were used to smooth out the edges at the joints between the strips. The hand sanding process was a time consuming and tedious job. Luckily we had many hands to keep the job moving,

The soft chines of Sean’s multi-purpose hull design became evident as the sanding progressed. The honey-comb transom was also epoxied in place at this time. It will need to be reinforced on the inside.

The first coat of epoxy resin was applied to the hull in preparation for laying on the fiberglass cloth. The cloth was stretched to the bow to remove wrinkles and a second coat of resin was applied to saturate the cloth and bond it to the Balsa strips.

The final process was to squeegee the excess resin from the cloth and make sure that there were no bubbles between the cloth and the wood.

After the sanding and the application of the glass, the basket weave pattern at the bow stem proved to be an excellent choice.

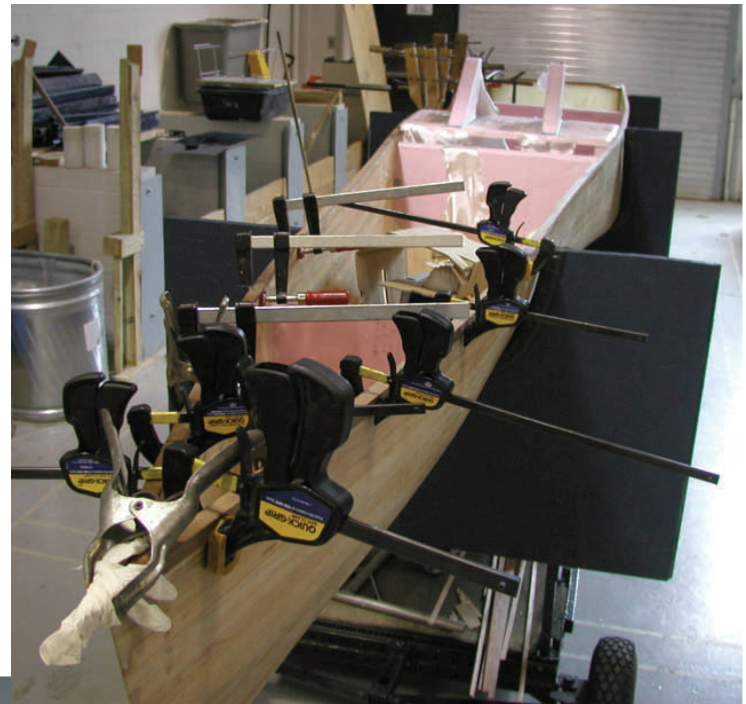
Sean’s forward displacement hull design, and its transition to the aft planning hull design show up well in this bow shot.

Once the hull was removed from the plug, the inside could be sanded and glassed. The bulkheads are also now being shaped from 2 inch extruded polystyrene foam. The bulkheads, the gunnel capping, and the helm are the next parts to be fabricated and applied to the hull. These foam parts also serve as part of the required flotation.

Wire chases and scuppers were cut into the bulkheads
before they were fiberglassed into place.

At this point, construction inside the hull would progress more smoothly if the hull were held in place within the launching dolly. Sean modified the 2008 dolly to accept the new hull shape, and the hull now rests in it’s new “roll-around bunk”.

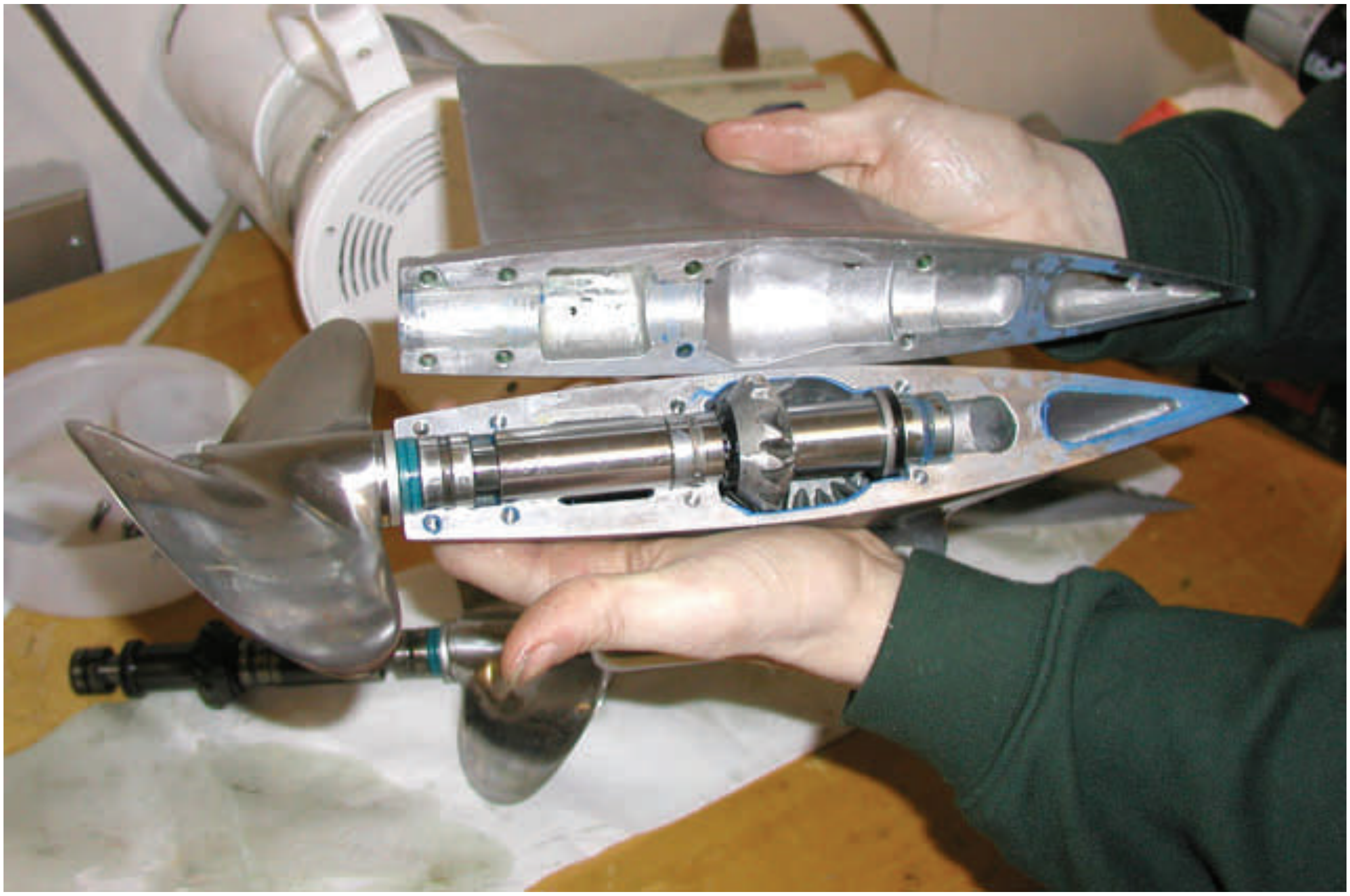
It took a number of clamps to form the gunnel capping to the complex curves of the gunnel shape.



It is also the time to form the helm to hold the steering components and house the electrical switches and electronic components. Again, two inch foam for structure and flotation.

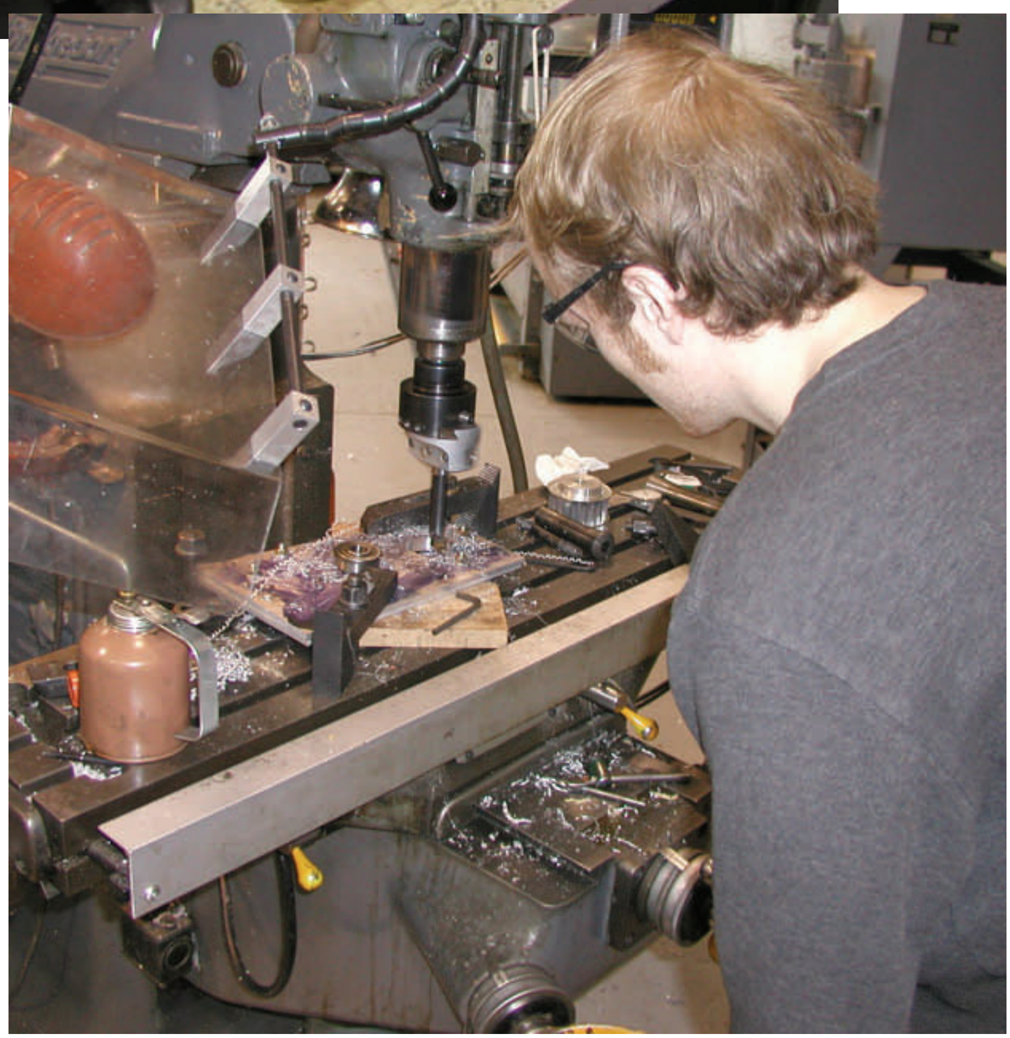
The aft section also gets the gunnel and transom capping as well as the transom knees.

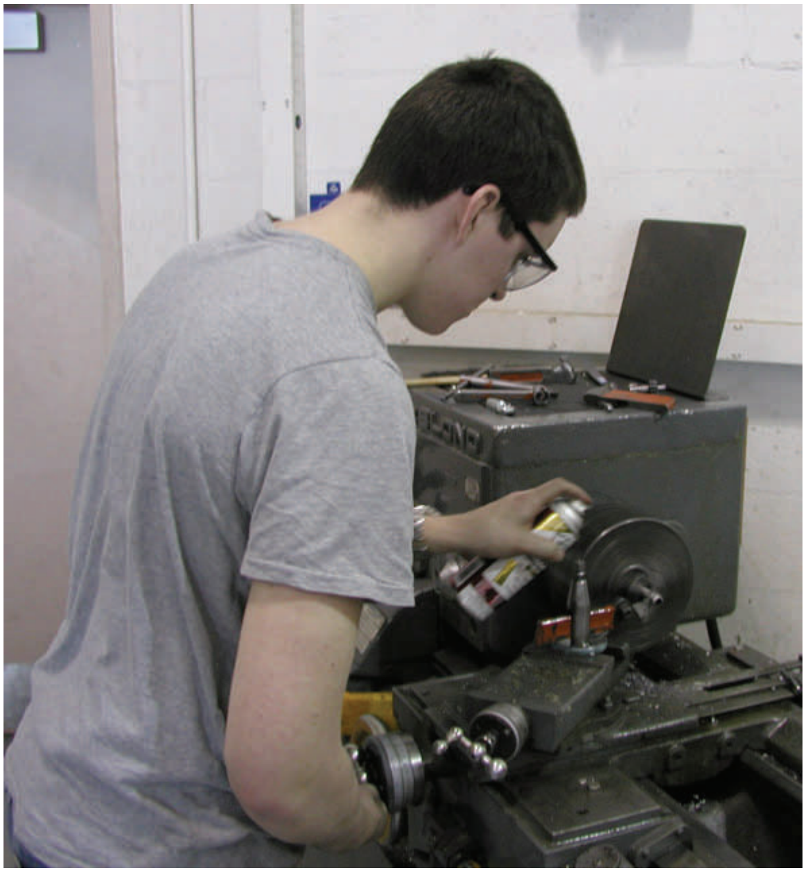
Now much of the interior can be mounted. The seating and steering assemblies are mounted, and the outboard motor brackets were also located at this time.



Meanwhile, It’s a good thing that Russ took apart the sprint lower units. One had leaked water into the gear case. Seals will need to be replaced, and bearings and tolerances will need to be checked. It is hoped that the unit is still serviceable.

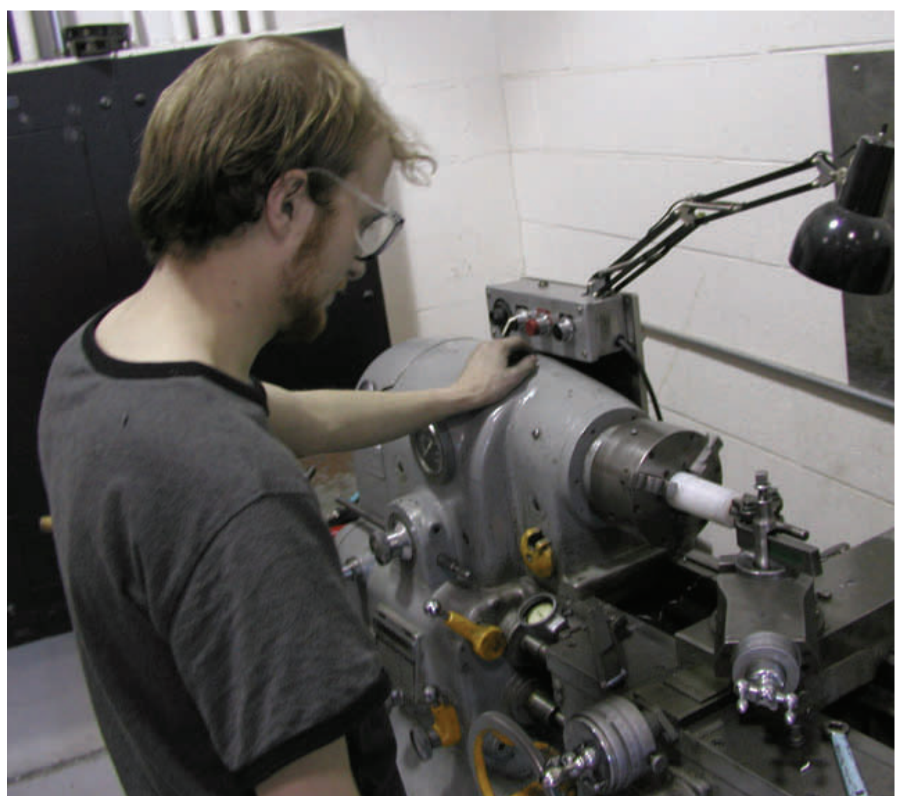
Russ also continued the construction of the sprint power heads. Although he was using the same sprint motors, everything else, down to the propellers, was changing.

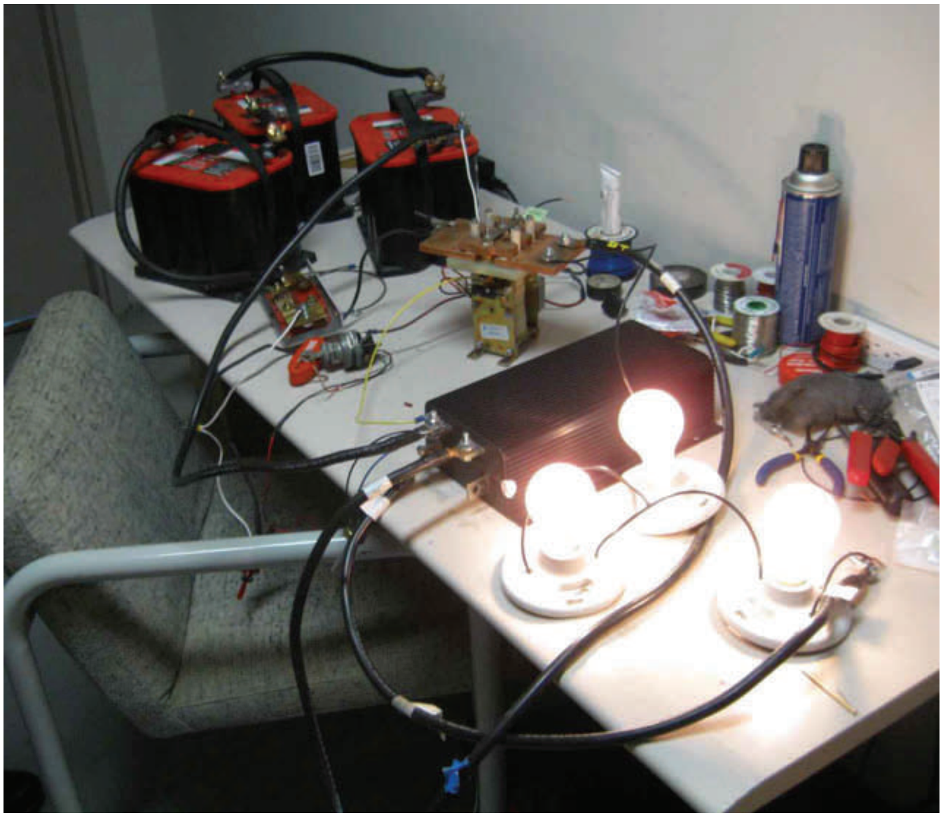




Jim busily machined “hundreds” of clearance washers for the rod end heim joints that make up his steering assembly.

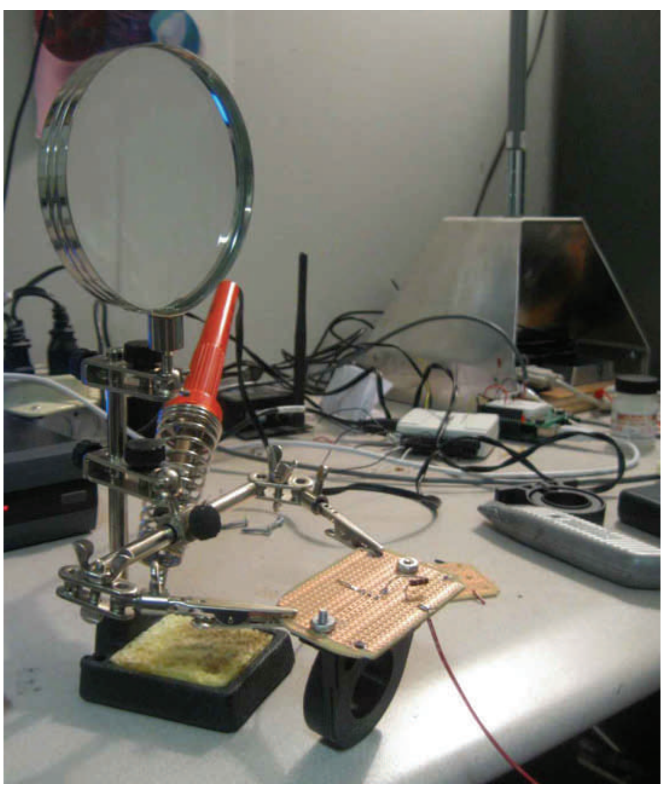
Russ also had to machine new nylon sleeves for the outboard power house tubes in order to increase ease of steering.

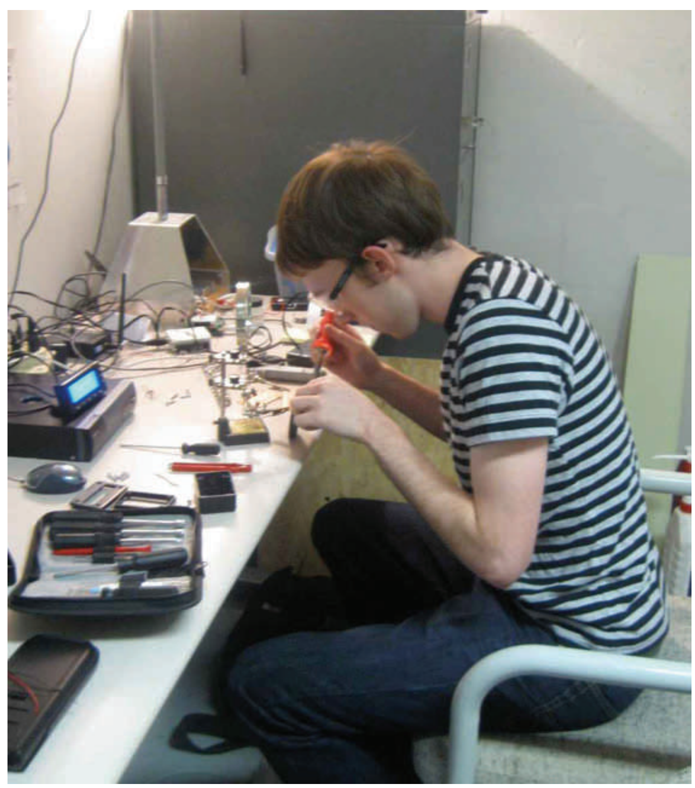


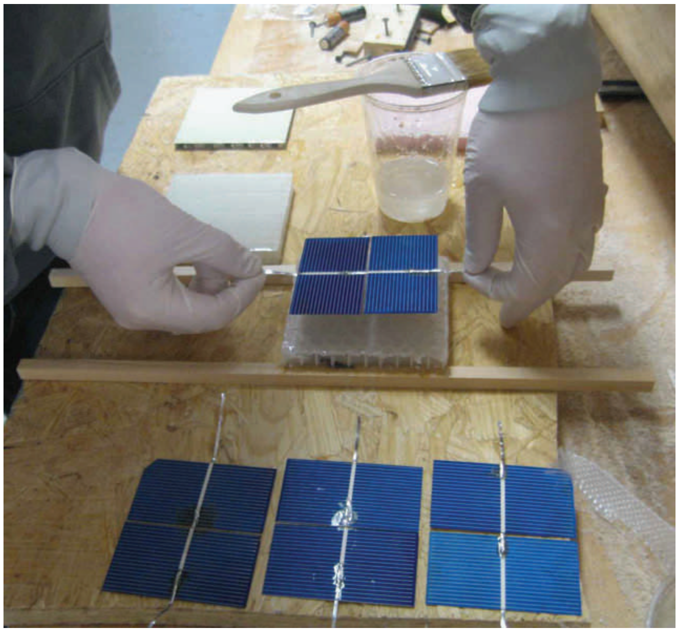


Brad did a mock-up of the sprint motor controllers. These new controllers were several steps beyond last year's sprint system. The test proved successful, but in reality the mock-up was nothing more than a $1,200 light dimmer switch.

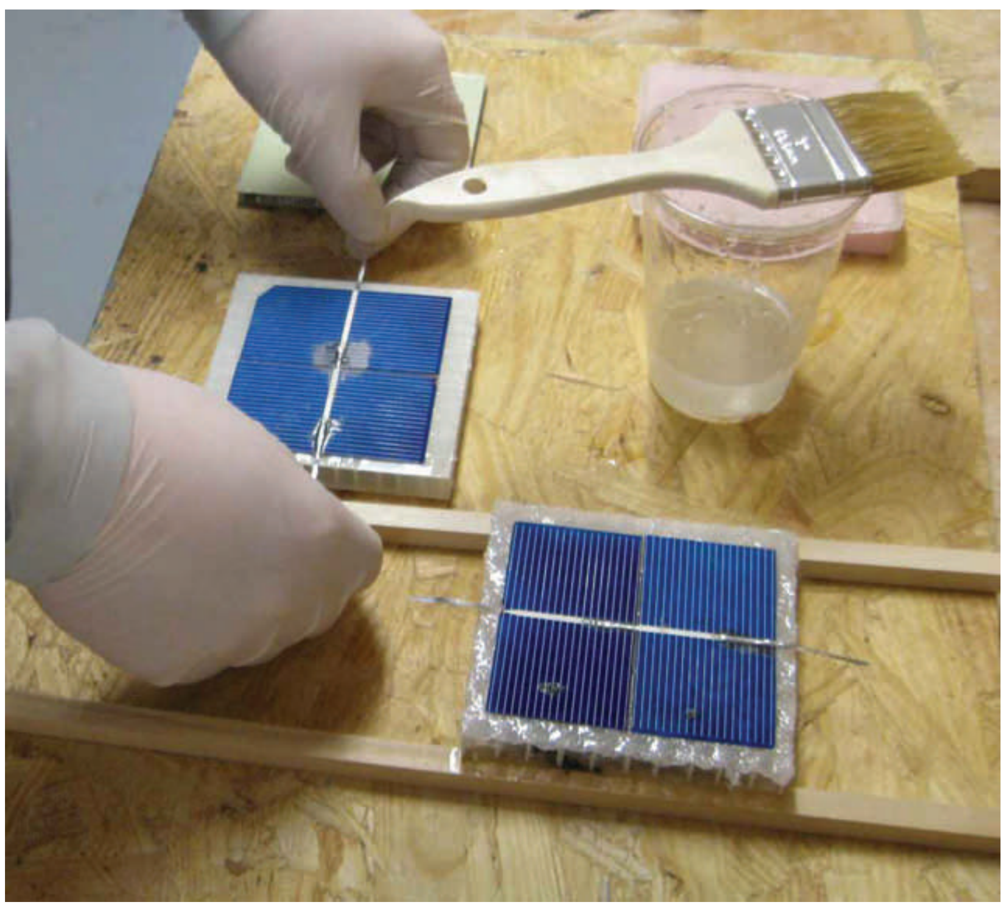
Ryan works out the programming for the computer to read the tachometer outputs for all three motors. Below he is seen manufacturing one of the induction ammeters.

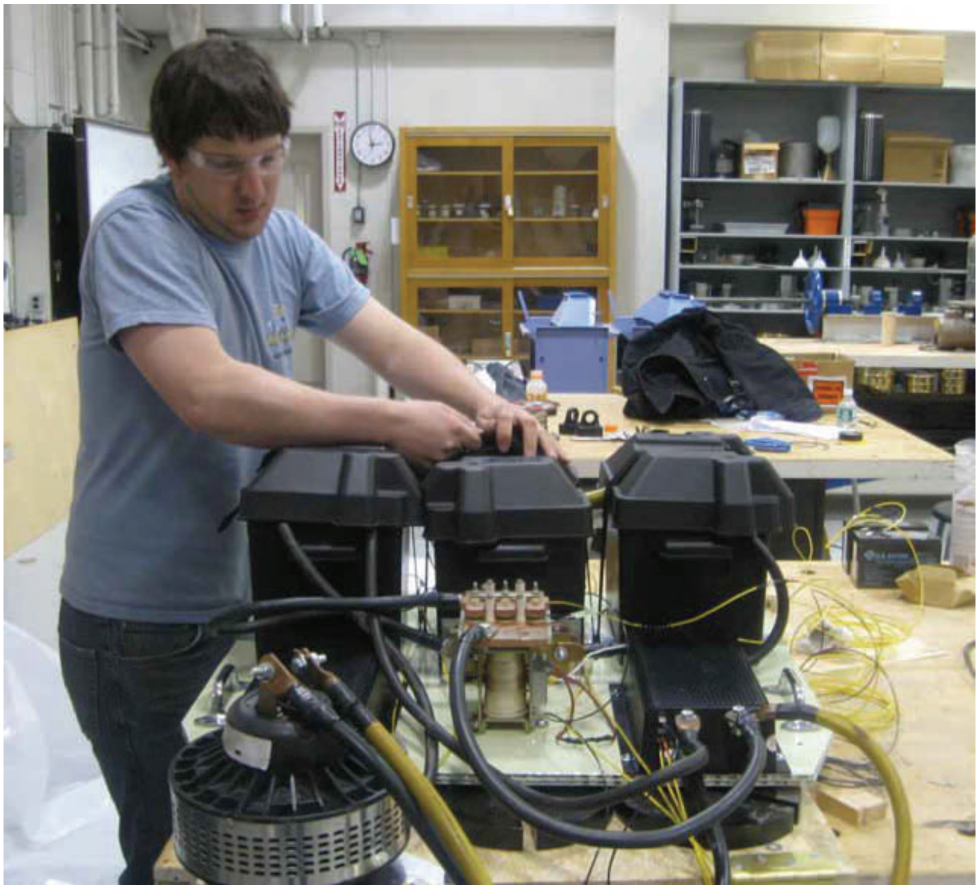




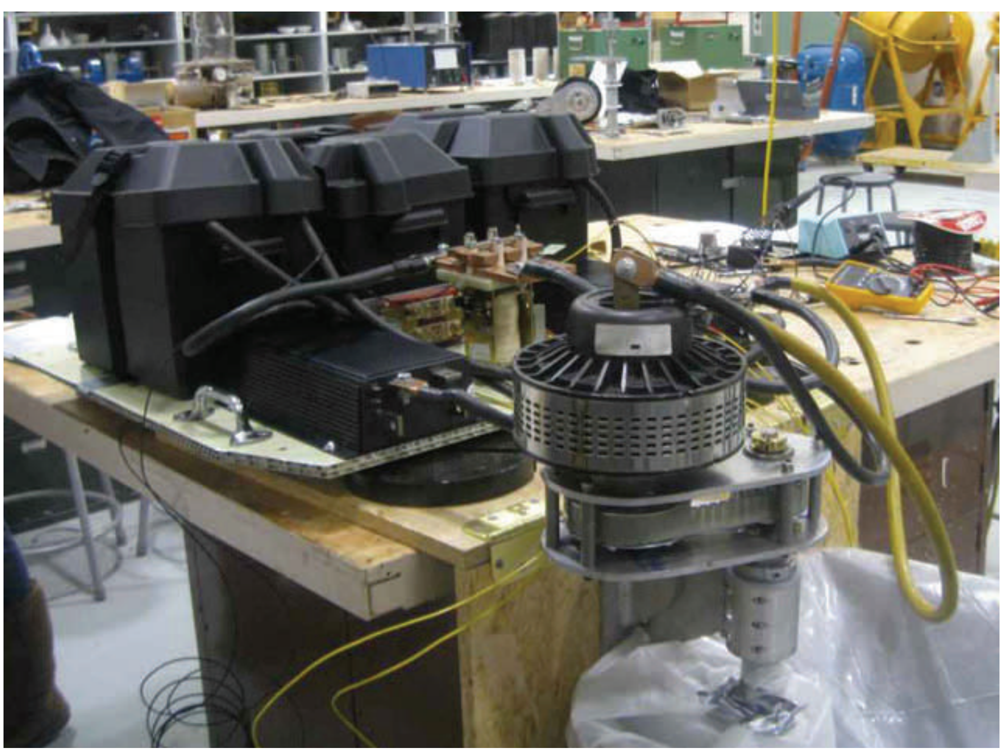


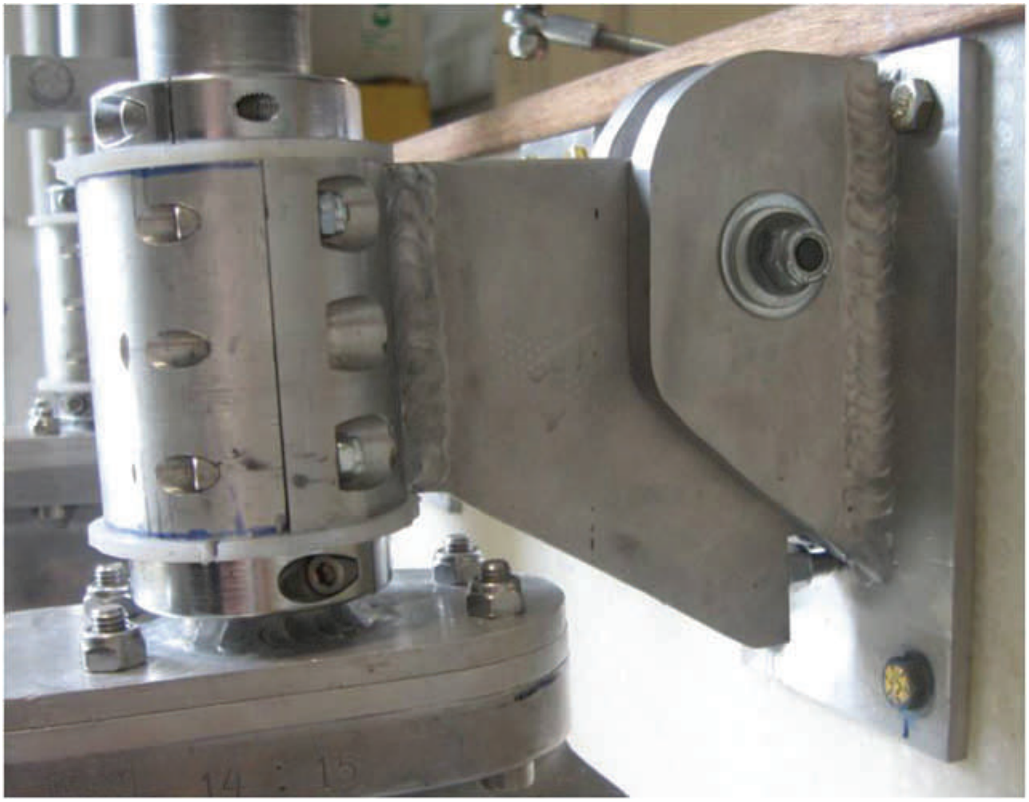
Meanwhile Brad was experimenting with alternate solar array backing and solar cell mounting materials.





Brad assembled a “late night wet’’ test of one of the sprint motors. This is always an exciting time, but no one will admit to whether the time on the clock says 11:15 pm or 3:00 am.





The new pintles were then mounted to the transom. The redesigned pintles moved the sprint outboards further back from the transom so that the sprint motors could be mounted as high as testing indicated. The pintles also offered an infinite (within reason) trim adjustment which was also based upon dynamic testing.

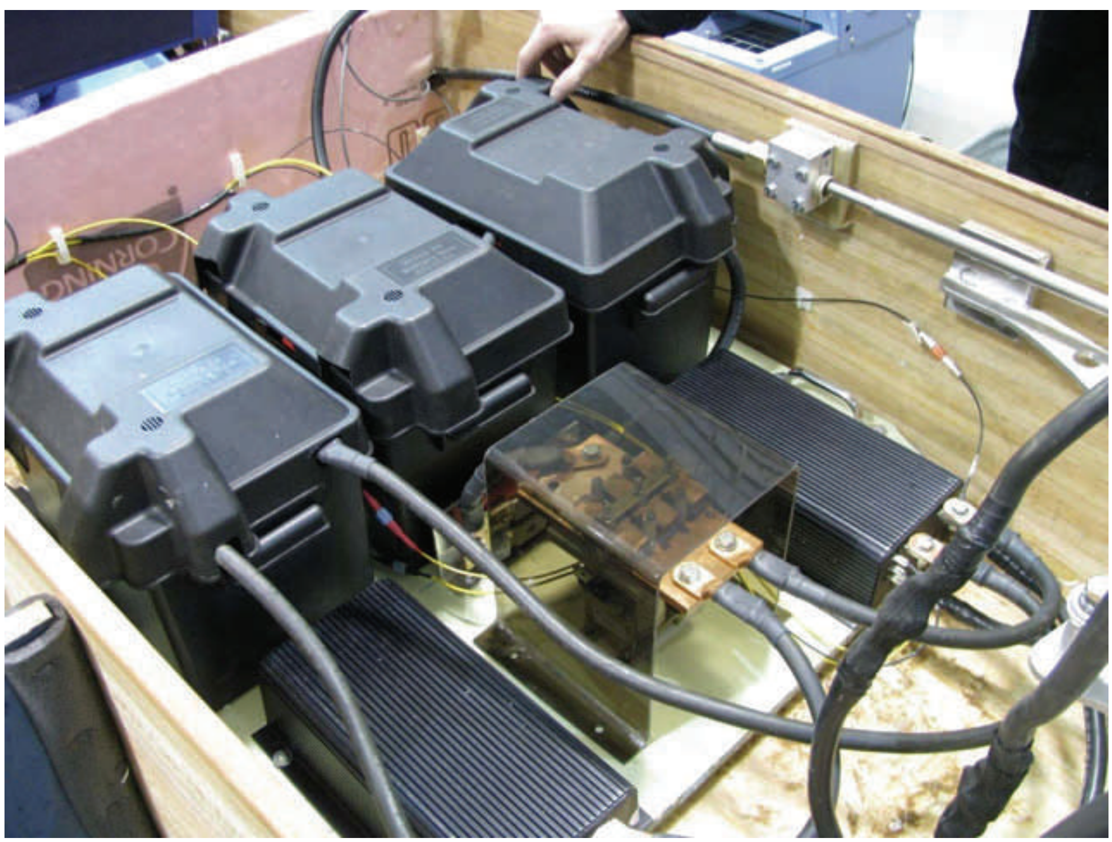
With the sprint motors complete, they could also be mounted to the transom in preparation for static waterline testing.

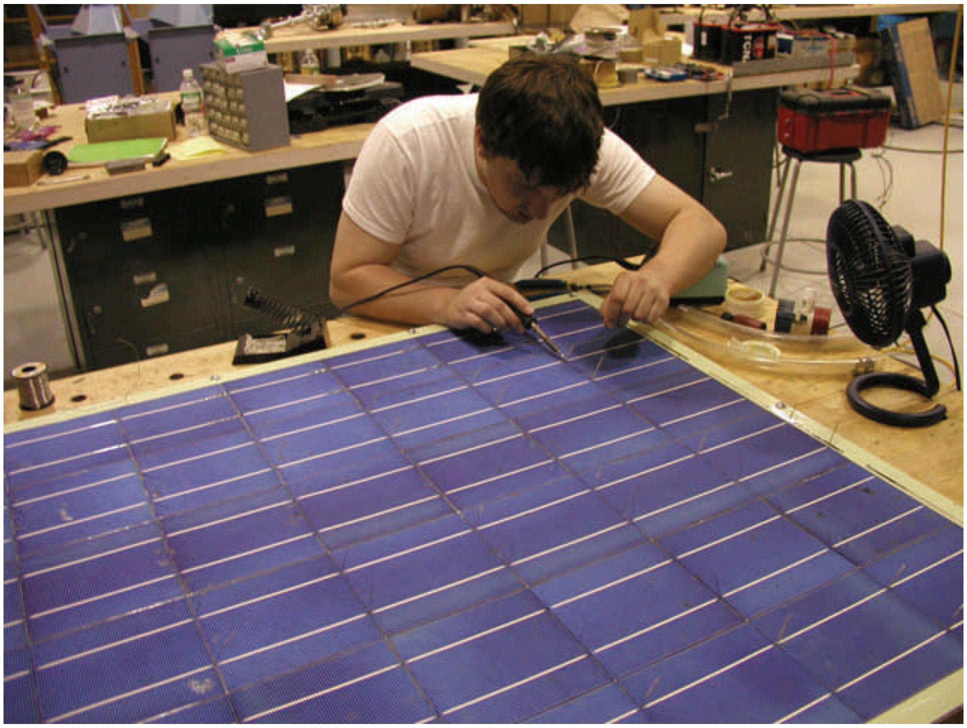
Once again the lake in front of the engineering building became the site for static testing. Just like previous years, it was raining—hence the plastic covering the electronics. It became quickly evident that the static waterline for the sprint configuration was not where the computer said it was going to be. Therefore the boat had to come out and go back to the lab for modifications.

Dynamic testing at Core Creek confirmed the conclusions made from the static testing. The center of gravity was too far aft. Back on campus, Sean is back in the boat with the helm and one bulkhead removed. The driver position was moved forward so that the motor controllers and batteries could remain in their original position.

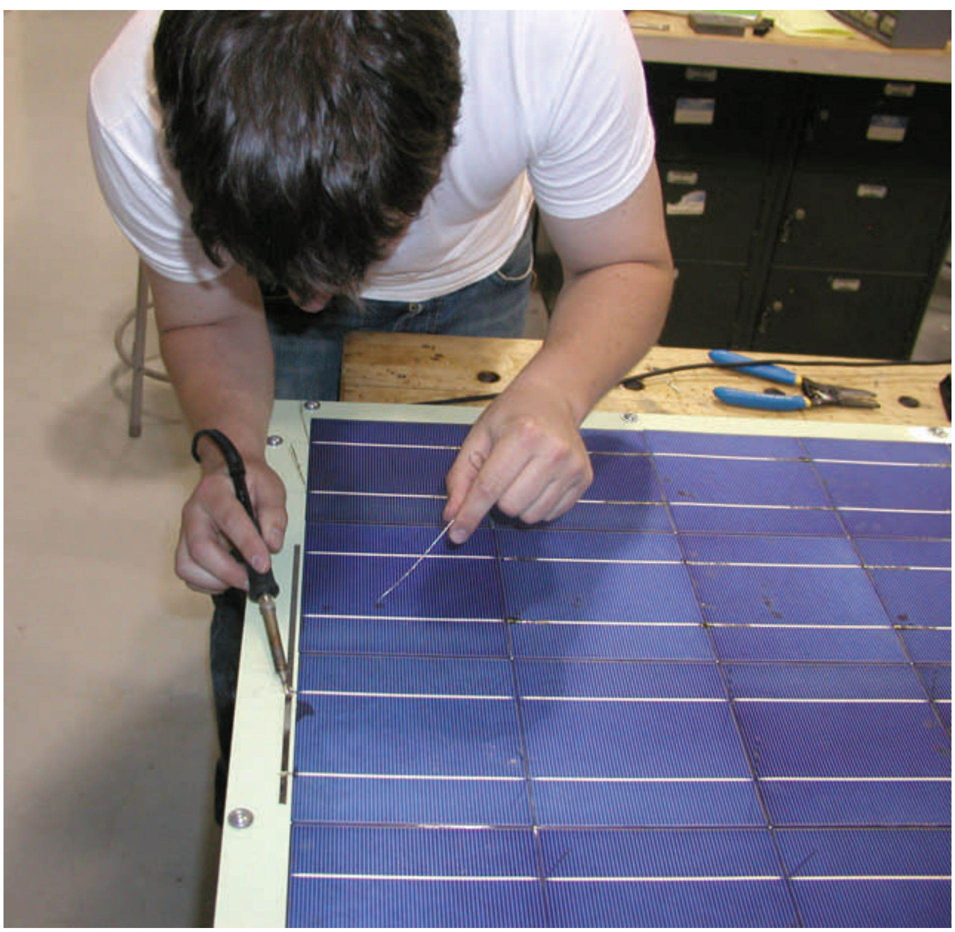
With the new helm position, the initial dynamic testing proved more promising. Here Russ gives the boat an initial acceleration test, but backed off the throttle when the steering reacted unexpectedly.

The sprint motor controllers and batteries remained in the aft section near the transom reducing the amount of high-current wiring required.

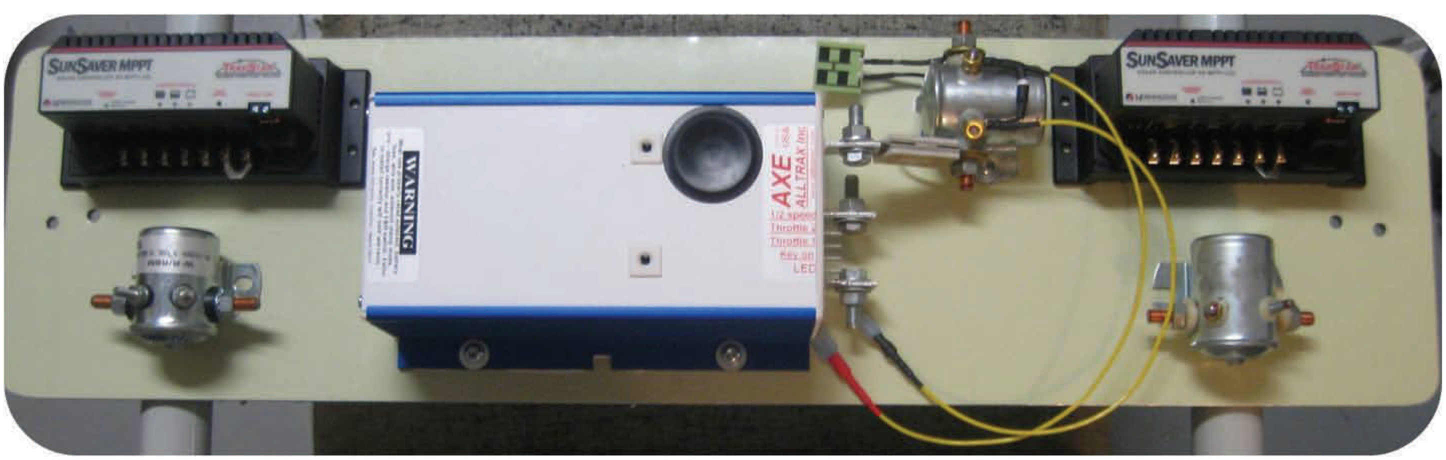




Brad endures the tedium of soldering the solar cells into an array.
It’s a relief to finally solder the cells to a bus bar.



The smaller of the three solar arrays was completed first and testing reaffirmed Brad's extensive testing of backing and mounting materials and processes. The endurance motor control system was coming together at this time with one motor controller, two Peak Power Trackers, and safety cutout solenoids.



After 26 hours of driving, we arrived at the competition site in Fayetteville, Arkansas on Wednesday morning May the 27th. After unloading the boat and all of the tools and materials, it was time to get the tent site ready for technical inspection and public display.

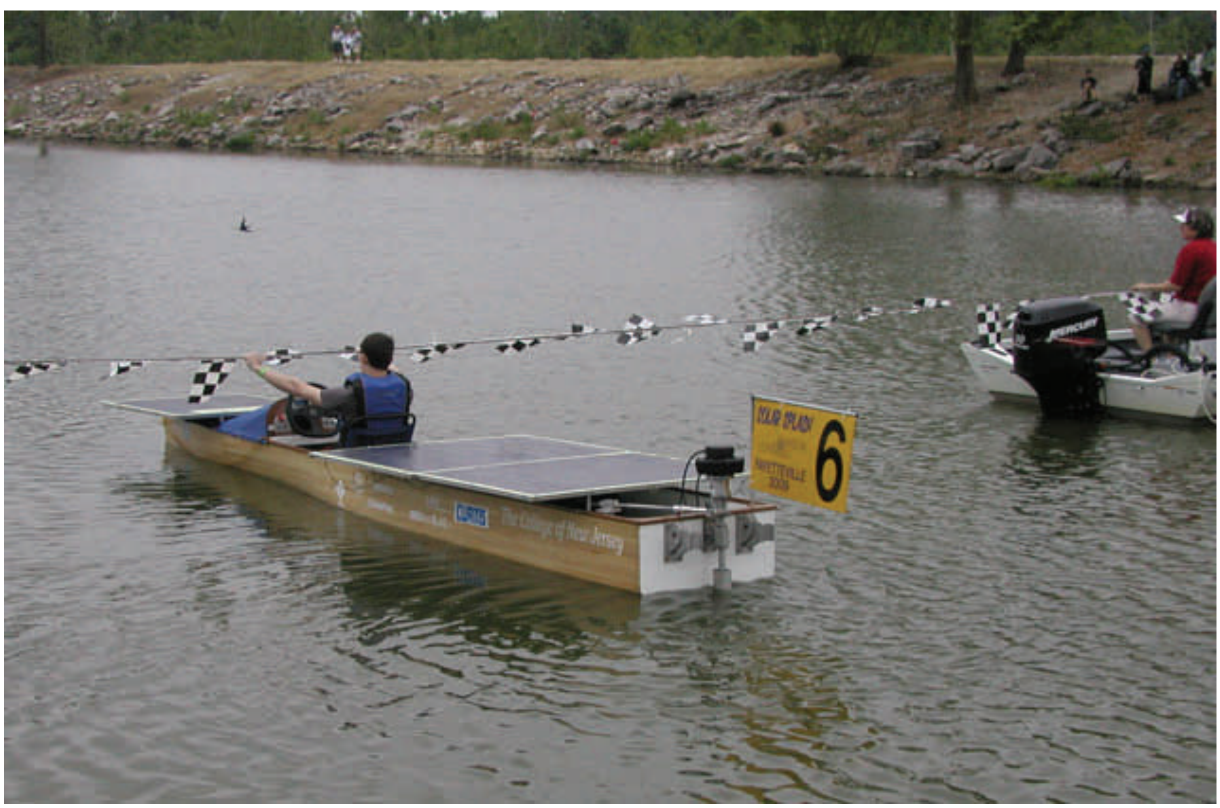
On this registration and inspection day, the boat also had to be set up for the Thursday qualifying events. Below, each day started with a 8:00 driver's meeting headed by Dr. Jeffrey Morehouse from the Mechanical Engineering Department at the University of South Carolina. Jeff has been coordinating the Solar Splash event since the retirement of the founder George Ettenheim.

The first qualifying event was the handling test done in the endurance configuration. This was a timed event designed to insure that boats could handle moderate speeds with solar arrays in place. Below, the carbon fiber endurance propeller was held in place by a tricky drive pin/compression collar.

Laurie Dann, the launch master (with clipboard), inspects each boat before each launch to insure adherence to safety and event requirements. Below, the boat is pulled past the giant screen television display which showed instant event images and results.

Being one of the first boats through technical inspection, we also became one of the first boats to launch for the qualifying events.

Sean was the driver for the handling event. The bag on the dock to Sean's left is a 10 kg bag of rocks which when placed on the boat's sheer, the boat will not heel more than 15°. Our boat heeled 0°.

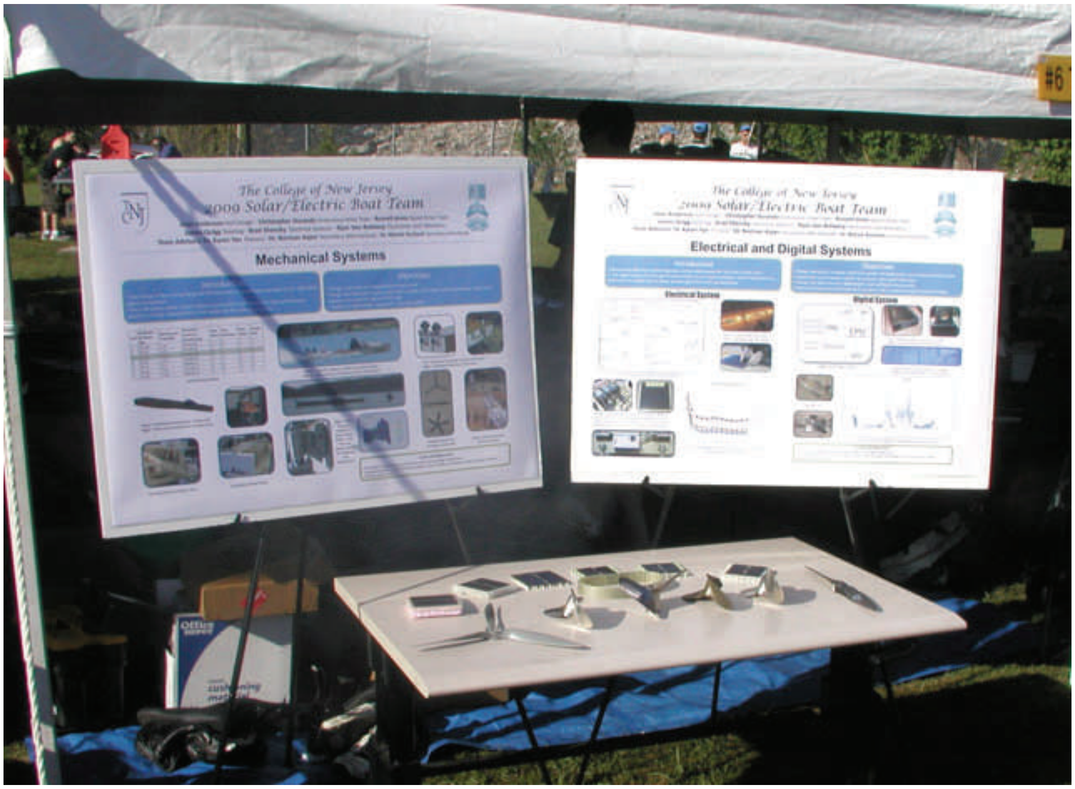


The boat was then converted to the sprint configuration for the slalom. Sean also took the helm for this event to prove that his hull design could also handle at high speeds. The boat handled perfectly as he took 2nd place in this event.

A short sprint event was used to determine seeding for the 300 meter sprint races to follow. Russ was not happy with the performance of his sprint motors, so he made some minor adjustments before the first sprint heat.

Because of the seeding from the qualifying sprint race, we were paired with the second fastest boat at the event. Below, Russ nosed out the Cedarville boat at the finish line. This finish put us into the championship sprint race on Sunday. Evidently those final adjustments were worthwhile.

Photo: © 2009 by Scott A. Miller



Our tent space in the paddock area was set up for public viewing. This was also a judged category. The judges awarded us 2nd place for this display. Our solar arrays, whether on the boat or on the charging stand were always charging batteries.

The two/two-hour endurance events on Saturday accounted for the largest number of points for any other single event at the competition. Chris took the helm for these two events. His endurance drive system was supported by Brad's solar energy charging system and energy management system.


(Photo: © 2009 by Scott A. Miller)

These photos show how the center of floatation was moved forward to take advantage of the displacement hull design of the forward half of the hull. Energy management proved perfect for our batteries and solar array, we were simply not as fast as some of the other boats, We came in 8th in the endurance. Below, we are passing the Tecnológico de Monterrey boat from Monterrey, Mexico.

The sprint championship finals pitted us against New Orleans (center), and Cedarville (right). We had beaten Cedarville in the earlier sprint heat, but no one had beaten New Orleans. Below, New Orleans was obviously faster than either of us, and at the finish line Cedarville nosed us out just as we did to them earlier. Therefore, we ended up taking 3rd in the sprint competition.

We ended up taking home more than our fair share of the trophies including the fourth place overall trophy shown below.

Another all new boat, for the College of New Jersey School of Engineering, designed and manufactured entirely by six graduating senior engineering students. The team was made up of three Mechanical Engineers, one Mechanical/Management Engineer, one Computer Engineer, and one Electrical Engineer. Primary advisement was provided by a Mechanical Engineering faculty member, while secondary advisement was provided by a Mechanical Engineering Emeritus faculty member, and an Electrical Engineering faculty member.

While the team did not achieve their original goal — winning the event or at least placing in the top three — they came very close with a 4th place overall finish. They also won the “Outstanding System Design Award”, won 2nd place in the “Solar Slalom” event, took 2nd place with their “Visual Display”, and won 3rd place in the “300 meter Sprint” event.

This is a great learning experience that I hope we can continue for future generations of students.

Return to Norm Asper’s web page.