The College of New Jersey

Department of Engineering

2004 Solar/Electric Boat Project

The team at the launching area of Hoyte Lake, Delaware Park; adjacent to the campus of Buffalo State University. From the left: Sean Elmes, junior electrical, display designer; Brad Lynch, junior mechanical, hull modifications; Matt Pappalardo, senior mechanical, endurance drive system; Jim Giacchi, freshman mechanical, drive systems manufacturing; Erick Doyle, senior mechanical, steering designer; Tara Keohane, junior electrical, data acquisition and steering programming; Mike Current, junior electrical, data acquisition and processing; Mark Pabers, senior mechanical, sprint drive system designer; Tim Naples, alumni computer engineering, team manager and steering designer; and Dr. Norm Asper, advisor. Not shown, Mr. Jay Ross, President, Protocol Electronics, electrical advisor; Nick Ginga, junior mechanical, hull modifications; Allison Klotz, senior IT, web master; Rich Santillo, junior physics, GPS system designer.

For the "Solar Splash 2004" World Championship Solar/Electric Boat Regatta

Advisor, Dr. Norm Asper, Professor
Department of Engineering
The College of New Jersey
P.O. Box 7718
Ewing, NJ 08628-7718
Phone: (609) 771-2774
Fax: (609) 637-5148
E-mail: asper@TCNJ.edu
Web Site:
http://www.tcnj.edu/~asper/index.html

The first organizational meeting in September 2003 started with 17 interested students and two advisors. Three students were seniors, who wanted to use parts of the project as their Senior Design Project. The rest were juniors, sophomores, and freshmen who simply found the project interesting enough to volunteer their time and efforts to make the project a success.

Having come to the conclusion to reuse the 2003 hull, the team decided to redistribute the weight for better planing characteristics, and do drag testing in order to determine thrust forces required to attain the desired speeds for 2004.

It was a cold and windy day, not a fun day to be out on the Delaware River.

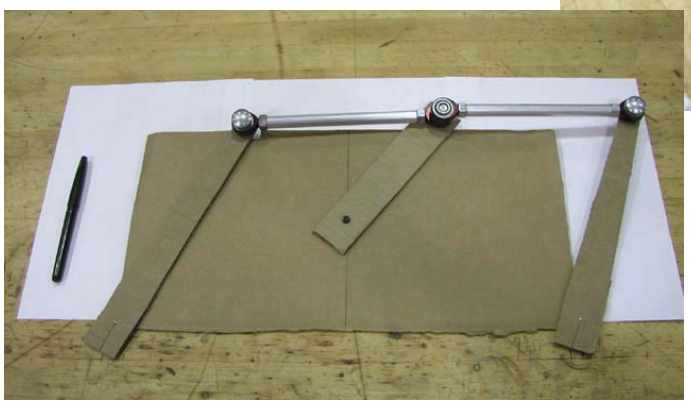
One of the first tasks in modifying the hull for the new weight distribution was to remove several of the original bulkheads.

A new position for the helm had to be located and prepared.

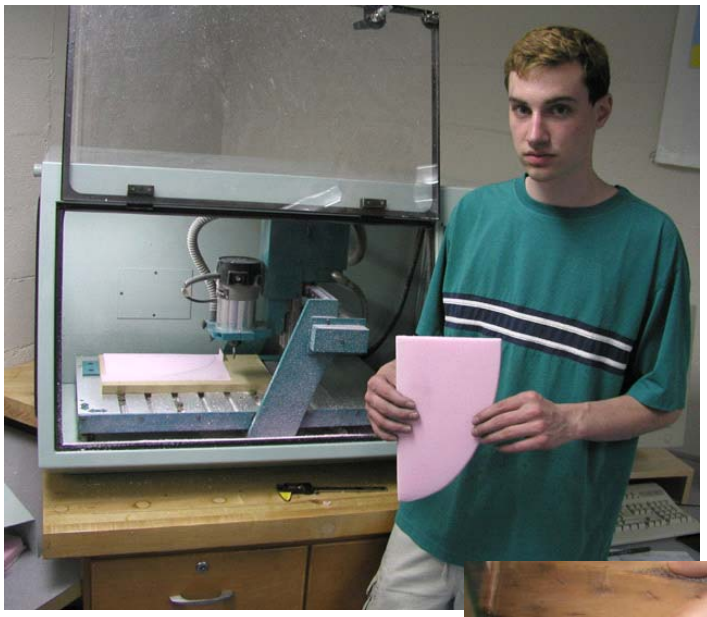
A new helm and new bulkheads had to be fabricated and fiber glassed into place.

New steering mechanics were designed to accommodate the electronic “fly-by-wire” steering.

A new, smaller steering motor and worm gear assembly were mated to drive the steering system.



New tiller arms and linkages were first plotted in “Working Model” then in full size as proof of concept.



New 1/4 ellipse rudders were designed using the NACA 0012 hydrofoil shape. Jim produced the pattern in Pro-E, and then Converted it into CNC code. Styrofoam patterns were then produced on a CNC router.

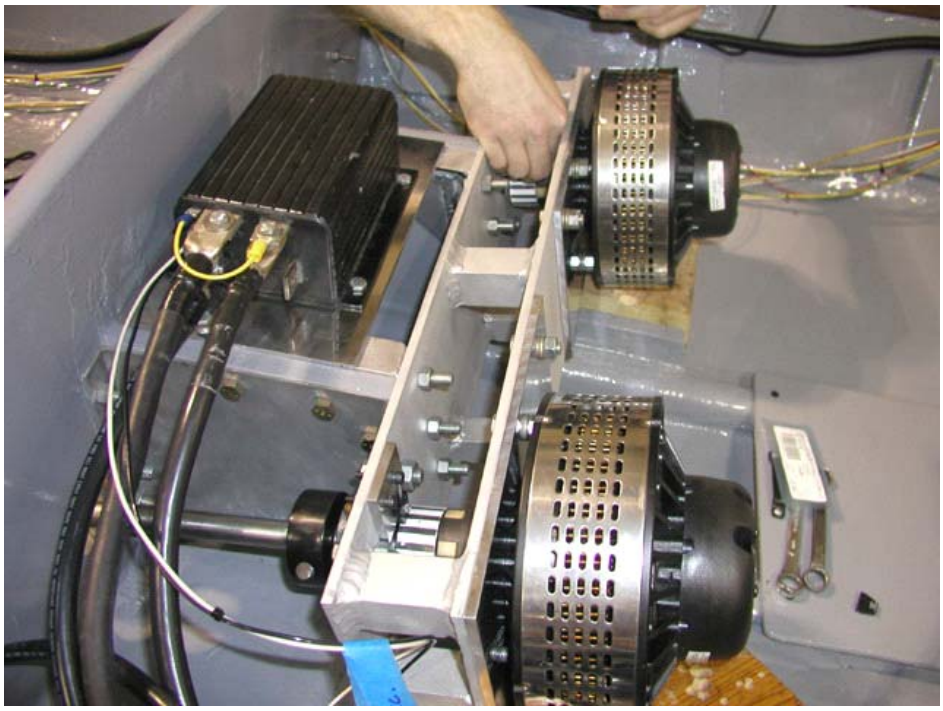
The Styrofoam patterns were then placed in a tall “flask” and then filled with foundry sand.

Erick packed the “Full Mold Patterns” in preparation for casting in aluminum.

Molten aluminum was removed from the furnace in preparation for pouring.

Molten aluminum was poured directly onto the Styrofoam pattern in the full-mold process. The process was repeated for the two-rudder system

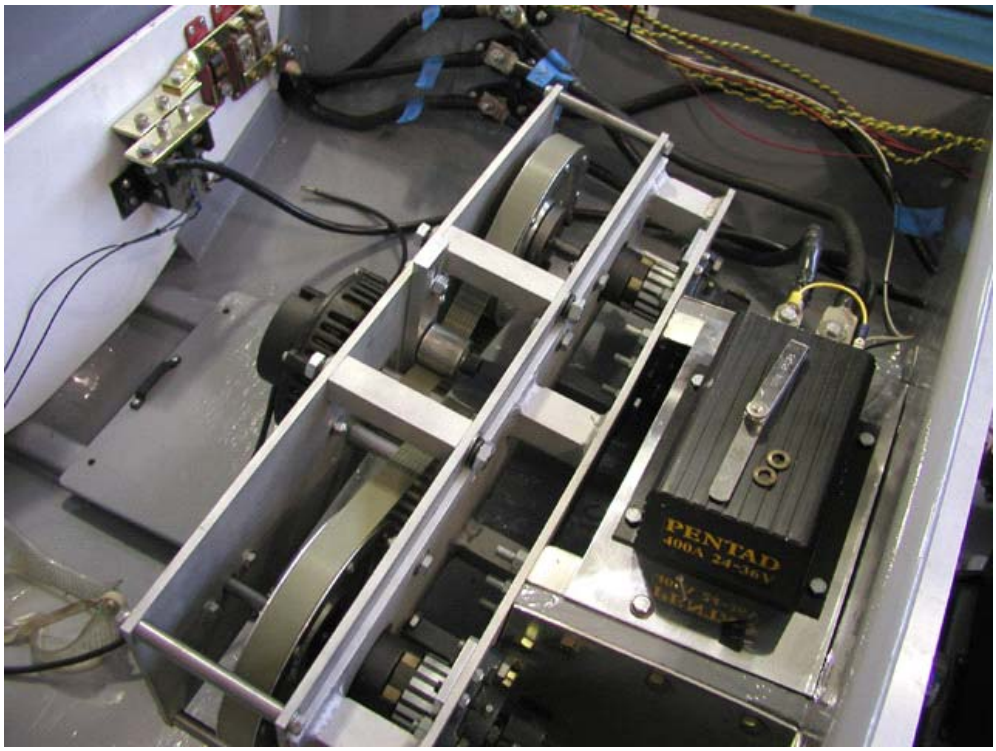
The rough casting was then broken out of the mold in preparation for the finishing processes.



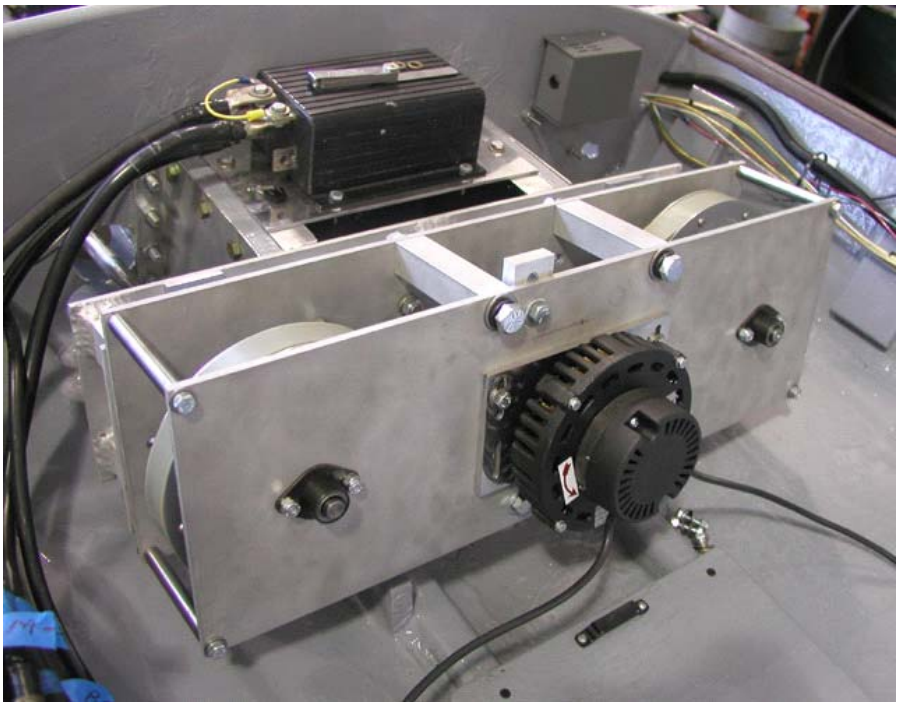
The Lynch LEM-126 sprint motors were the pride and joy of those members who wanted to go fast. The two motors produce a total of 22 hp with the 36 volt battery pack. Mounted directly to the propeller shafts, the motors turn at 3,400 rpm drawing approximately 275 amps. The commercial motor controller was used simply to protect the motors from the initial current surge. After three seconds, the controller was bypassed to offer full battery current to the motors.

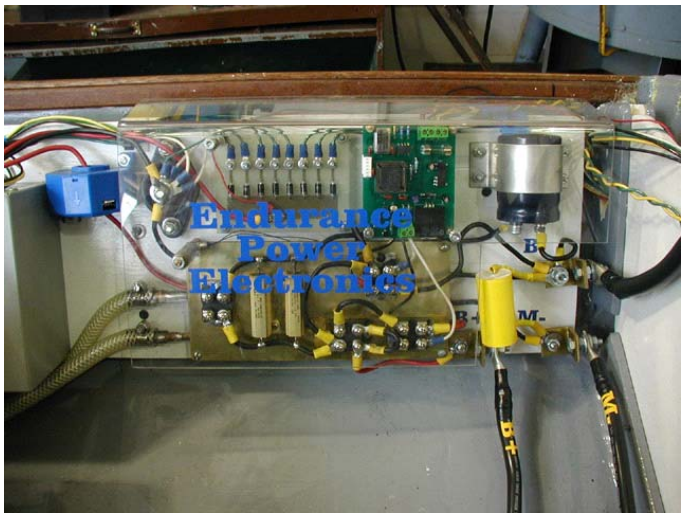
Mark mounts one of the Lynch sprint motors. Each motor had its individual adaptor plate which bolted to the motor mount assembly and engaged the propeller shafts through lovejoy connectors. The motor mount served both the sprint and the endurance configurations. The sprint motors were counter rotating.

After several days of testing, the team settled on the 7 inch, two bladed, ultra light-weight propellers provided by Hopkins.



The ultra light weight Permotor PM-080 was the heart of the endurance configuration. At just 7.5 lbs, it delivered 27 lb inches of torque at 3,000 rpm. After two hours of running, it was still cool to the touch. A 6:1 notched belt pulley system was manufactured to bring the propeller shaft speed down to 500 rpm. The propellers were specified accordingly.





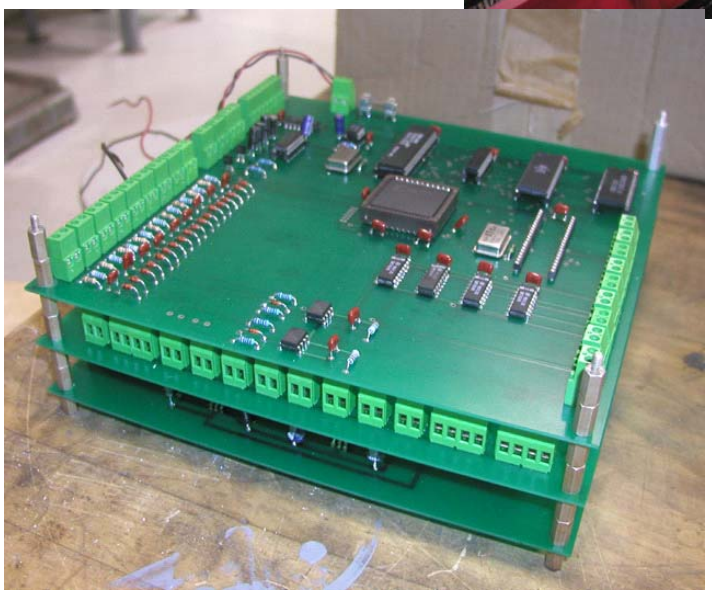
The team-built pulse width modulator used with the endurance configuration is paired with the Energy Management System, also used in the endurance event.

Tim uses the digital scope to measure the current spike created when the pulse width modulator switches the current off-and-on to the motor.

Also after considerable testing, the team settled on the 13 inch diameter by 18 inch pitch propellers provided by Hale. These propellers were not counter rotational due to the low power and rpm.

Tara mounted the electrical and electronic parts to removable panels for ease of servicing.

The “Super Cap” and “Energy Management Boards” were combined with the endurance Pulse Width Modulator board. Mike assembled the panel, and mounted it in the motor compartment.



The data management boards were stacked and mounted under the front deck. They could be unplugged and removed either as a unit or one board at a time. All of the electronics were designed and built by the team members under the guidance of Mr. Jay Ross, president of Protocol Electronics.

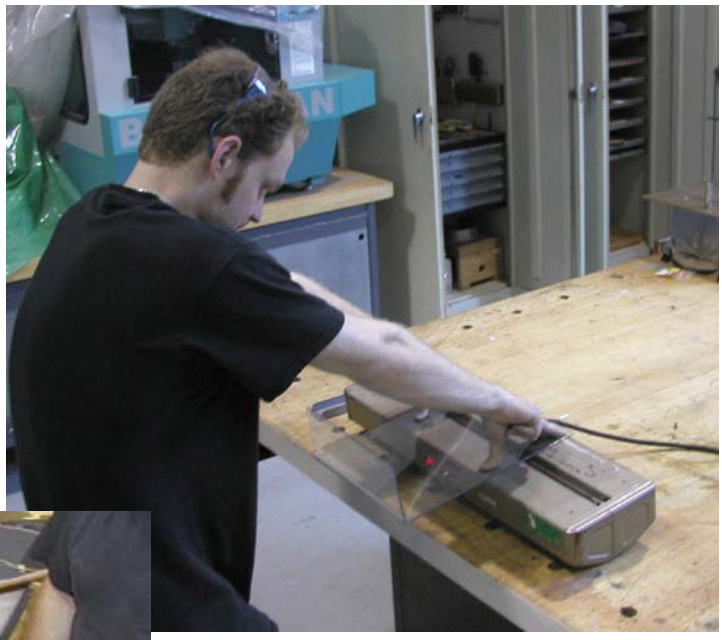
As the boat was coming together, the solar array was being designed and fabricated. Jim assembled the sixteen 30 watt panels that made up the array. They had to be fitted to the boat in an arrangement that would have as little adverse effect on stability as possible.

A charging stand also had to be designed to hold the array when it was not mounted on the boat. This stand served as a charging station, since all batteries had to be charged using solar energy through the competition. Jim and Brad laid out the legs for the stand.

When assembled, the charging stand provides 480 watts of energy to recharge batteries between events. It is fully rotational in order to follow the sun throughout the day.

In a project of this magnitude, the proof is in the details. From the spot-polishing of the dash panels —

— to bending Plexiglas panels to cover electronic boards —



- to water tank testing sprint motors for temperature change over a long period
- of high current draw.

Before on-the-water testing can take place, new wood and glass at the transom had to be primed and sealed. The first coat of “Ocean Blue” Bright-side Marine Enamel provided by Interlux Yacht Finishes is applied with fine foam rollers and brushed out with fine foam brushes.

Tim and Mark apply a second coat of finish in the same manner.

Mike and Nick are intent on attaining the highest quality finish. The hull finish sets the standard for the public’s first impression of the quality of the boat. We have used the Brightside finish for several years due to it’s excellent flow characteristics.

With the hull sealed and painted, the first series of on-the-water testing could start. The site is the Core Creek State Park in Newtown, PA.

The most pressing questions to be answered concerned the endurance configuration. Therefore the first tests included the solar array, endurance motor and gearing, and propellers.

Jim buttons the life vest for the first series of endurance tests. New questions arose from these tests, and it was decided that much more testing is needed for this configuration.

Then the solar arrays are removed. The motors, propellers, and batteries are changed for sprint testing.

Canvas covers replace the solar array, and Mark sets off to prove his sprint design. Everything works perfectly.

The team arrived in Buffalo Tuesday night the 15th, and were among the first to begin setting their paddock area on Wednesday morning.

One of the first tasks was to set up the charging stand for the solar arrays. This would make it possible to begin topping off our batteries.

It wasn't long before the paddock area was set up with the charging stand catching the early morning sun, and the poster and display ready for public viewing.

The first day of qualifying began with rain which continued throughout the day. Not a good day to start a solar event.

Mark takes the flag at the high line to start the solar qualifying event. At least all schools qualified under similar conditions.

The sprint qualifying continued in the afternoon under similar conditions. A technical inspection occurs before each event. New batteries are being installed just prior to inspection.

Above, Mark makes one of the fastest runs of the day, providing excellent seeding for the sprint runs of the next day. While in this configuration, he also ran the slalom event, finishing in fifth place.

Still another technical inspection prior to the first sprint heat. This was to see that the boat still conforms to the rules and was still a safe vessel.

Mark won handily the first heat. His competition isn't even in the picture at the quarter point of 300 meters.

"TSUNAMI" seems a perfect name for the boat "at speed". It definitely makes a "big wave".

If you drop a bolt off the dock, you go after it!

We won the second round just as handily.

The three fastest boats are in the championship round. Cal-Poly Pomona on the left won the event, our boat in the center came in third. Cedar-ville University is on the right.

Our poster and display explained how we changed solar energy into marine motion.

The team was happy with being awarded the maximum 90 points for the “Best Technical Report”. Here Tim receives the award from George Ettenheim, the retiring originator and director of the event.

It was a morning ritual to check the standings from the previous day. The team remained in third place until the last day and the endurance event.

Sunday dawned as the sunniest day of the event, and a perfect day for a solar race. The driving responsibilities for the two 2-hour events were shared between Mark above, and Jim below. One heat in the morning, and one in the afternoon. The unresolved questions remaining from testing were enough to move us down in the standings to fifth overall.

Jim passes under the bridge on the parade lap of his endurance heat. The parade lap was established for news media and photographers located on the steps of the museum, a good vantage point from which to photograph the boats.

In all, the team garnered four trophies. In addition to the **ASME "Best Technical Report"**, the team was also awarded the **IEEE "Outstanding Electrical System Design"** trophy. The other two trophies were awarded for **Third Place in the Sprint Event,** and **Fifth Place Overall.** They also received 2nd highest points awarded for workmanship.

The College of New Jersey

Department of Engineering

2004 Solar/Electric Boat

Technical Report

http://www.tcnj.edu/~solrboat/solbo04.html

#8

Team Members

- Tim Naples, Project Manager
- Ed Marion, Asst. Manager
- Mark Pabers, Sprint Drive System
- Matt Pappalardo, Endurance Drive System
- Erick Doyle, Steering System
- Mike Current, Data Transmission
- Dave Ullman, Hull Modifications
- Sean Elms, Helm Display
- Tara Keohane, Steer-by-Wire Software
- Nick Ginga, Weight & Hull Modifications
- Brad Lynch, Weight & Hull Modifications
- Jim Giacchi, Solar Array Structure
- Rich Santillo, GPS System
- Nick Vertucci, Software Development
- Allison Klotz, Web Master

Advisor, Dr. Norm Asper
Department of Engineering
The College of New Jersey
P.O. Box 7718
Ewing, NJ 08628-7718
asper@TCNJ.edu

Solar Splash 2004
Date, June 16-20
Buffalo, NY

Return to Norm Asper's Web Site