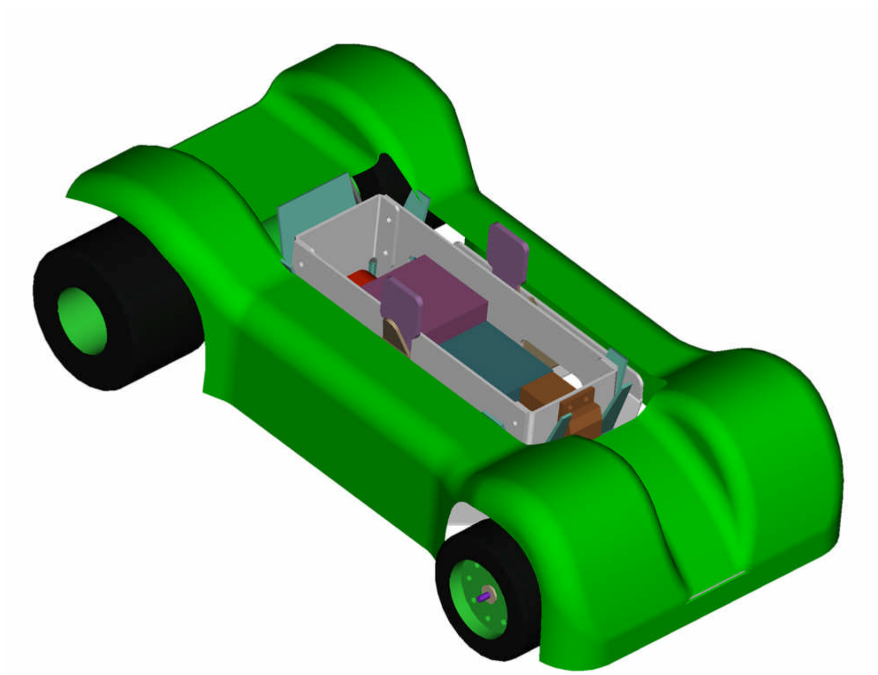
2.810 Final Report

12/8/1999

Group F

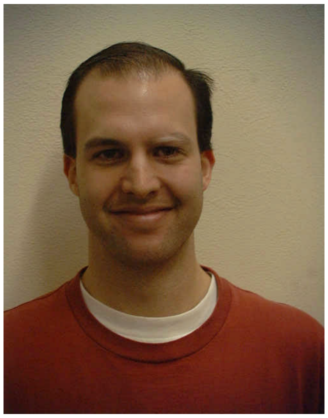
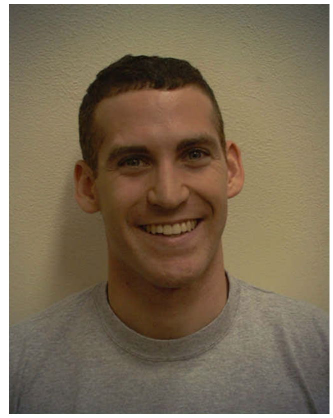
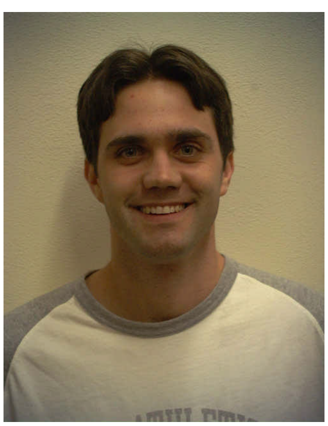
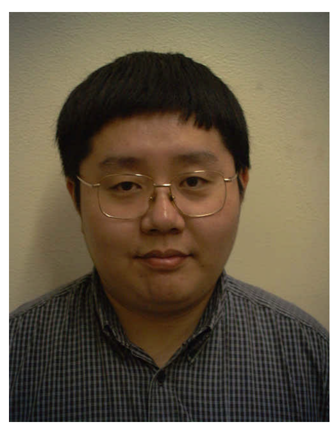
FUZZBUSTER



The RC Car Manufacturing Project

Team F Members

The Fuzzbuster team has worked with a great amount of determination and skill to design the fastest, most efficient car for the end-of-term race.

 Darin Spain	 Jeff Freedman
 Jongyoon Kim	 Luke Sosnowski
 Anthony T. Chobot	 Yu Qiao

Introduction

In the process of designing and building a series of remotely controlled cars for the 2.810 contest, our group's primary objective has been the creation of a design that would stand a good chance of winning the race. In view of our primary objective, we set and accomplished several intermediate design objectives. These included quick control box changeover times, high car speed and good acceleration, rugged design, and good maneuverability. To keep the team sane, the design also needed to be relatively simple with few and uncomplicated parts. We believe that the Fuzzbuster RC car accomplishes these goals. What follows is a description of our design along with relevant information on the manufacturing process and people of the team.

Time Estimate for the Project

The whole project involves lots of individual tasks, starting with preliminary design and brainstorming, and ending with debugging and fine tuning of final production cars. In the process, team members learned and perform tasks such as drawing and making DXF files, injection molding plastic wheels, preparing and gluing tires, thermal forming shells, machining Delrin steering components, clips, and other small parts, cutting chassis parts by water jet, bending chassis and other parts, riveting small parts onto chassis, assembling the prototype, etc.

Each member of the group devoted lots of time on the project. Every car is the result of hard work of all members. The following is a rough estimate of time spent on the project of each member.

Table 1. Individual task and time sheet.

Task (all times are given in hours)	Jeff	Tony	Luke	Yu	Darin	Jongyoon	Task Time
Preliminary design meetings	20	20	20	20	20	20	120
Designing and drawing (Pro/E)	5		40				45
Thermoforming shells	2	2	2	2	2	2	12
Bending chassis and parts	4	4	4	2	4		18
Various machining		5	8				13
Machining clips				5			5
Cutting chassis and parts by water jet	10		2	4	5		21
Injection molding of wheels				1	1	1	3
Machining Delrin steering components		15			7		22
Preparing and gluing tires			1	8		12	21
Cutting shells			1			5	6
Riveting parts onto chassis				4	2		6
Making prototype and final assembly	15	15	8	10	15	12	75
Testing and trouble shooting	12	12	12	10	12	10	68
Total Team Member Time Input	68	73	98	66	68	62	435

Total man-hours spent on Project: 435

Car Photos

The photos below show the Fuzzbuster remote control (RC) car designed and built by Group F. The car is built for maximum acceleration and good handling combined with a sub-three-second control box changeover. Secondary priority is placed on aesthetics.

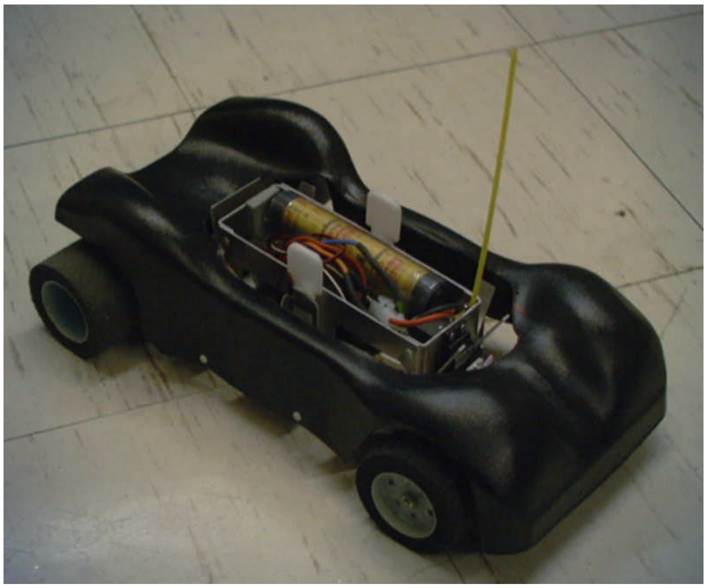


Figure 1. Fuzzbuster RC car ready to race

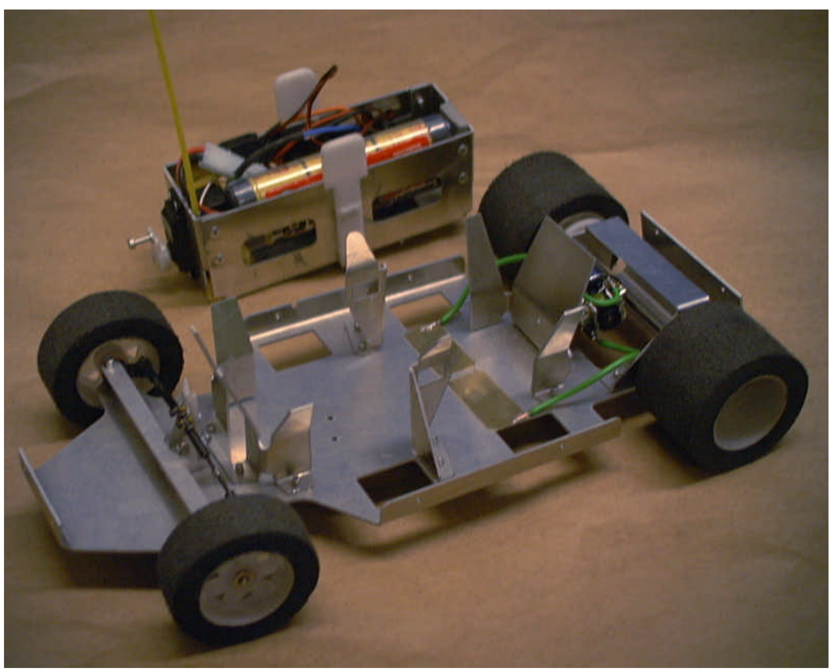


Figure 2. The chassis of the car shows full sheet metal construction with minimum use of machined components. The riveted chassis is simple and to make and rugged. The control box visible in the background and features drop-in loading from the top for quick pit stops.

Pit-Stop Time Estimate

The control box for team F is a top loading module. Removing the module from a car and inserting it in another takes three seconds. Well-versed users only need one hand to remove the module from a car and insert it into another. This design is quite simple and easy to use. We decided at the beginning of the design to go with a top loading control box to keep the pit time to a minimum. An estimated assembly time analysis from Boothroyd and Dewhurst[1] for the removal and insertion of the control box is shown below.

Taking the control box out of one car:

Time: 1.95 seconds Handling code: 30

Parts can be grasped with one hand, with only one orientation of control box possible (3). The control box is larger than 15mm. (0)

Time to transfer box from one car to another after removing the control box from the first car.

Time: 1 second

Inserting the control box into another new car:

Time: 5 seconds Insertion code: 31

Addition of part where part is finally secured immediately. (3)

No plastic deformation after insertion, and has resistance to insertion. (1)

Total estimated time to remove the control box and insert it into another car is 7.95 seconds. The actual time pit stop time for team F is about 3 seconds because we have practiced the pit stop numerous times.

Group Strategy

Our group took a rather different strategy compared to most other groups, who based on their mid-term progress reports seemed to break up into smaller teams to work on sub-components of the car. We all felt that we would each get the most out of the project by getting involved in every aspect of the design, manufacture, assembly, and testing of the car. Furthermore, we felt that working together would make the project more fun and interesting.

Therefore, in the design stage we arranged weekly meetings that everyone would attend and considered inputs from each team member. This generated a lot of initial design concepts and we had a lot of discussion before we settled onto our final design. We all agreed on a few aspects of the design right away and then took some time going over the concepts that were more intricate, like the control module and steering assembly. Typically we found that it was easiest to make some rough concept sketches or solid models of our ideas so the other group members could visualize the idea. In the end we tried to combine the best ideas into our final design and everyone was in agreement on the final decisions.

[1] From 2.810 class notes on Assembly. Notes complied from Boothroyd and Dewhurst

When it came time to start manufacturing the prototype we all took part in each of the different process as much as possible. This way we all learned the basics of each operation rather than have each of us do one process for the entire group and only get exposure to that specific process. Since each of us had slightly different knowledge about the various processes we were able to share that knowledge with each other. With six of us working together there was very little chance of having to do any major re-work on a component since potential mistakes in the manufacturing were easily caught. Once the prototype was complete we made a few minor changes and divided up the tasks for fabricating the final cars. Although each of us concentrated our efforts on one process at this point, we still did not have distinct sub-component responsibility and continued to work together for the most part. Finally, the assembly and testing was also a group effort. We did not divide up the parts and assemble our own cars, but, rather everyone worked on each others car until the very end when we all put the finishing touches and tweaked our individual cars. Overall this strategy led to a group that functioned well and produced a competitive car.

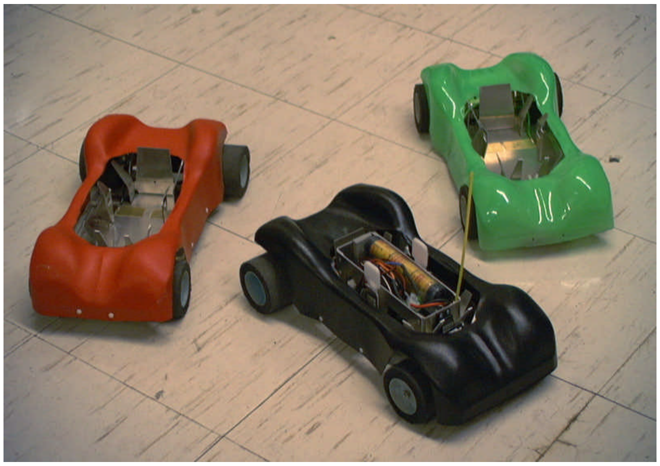


Figure 3. Three Fuzzbusters ready to race.

Design and Manufacturing

The design of the car started from several meeting discussions, quick-and-dirty notes and lots of bad drawings on a blackboard. Early in the design process, we transferred as much of the design to a solid modeling system, and improved upon the model throughout the design process. The solid model was used to check some of our ideas, and finally to output files of finished parts for manufacturing.

There was a cycle of iterations between water jet manufacturing and the design on Pro/Engineer, and it took a few tries to obtain DXF files that would produce components of proper dimensions. The feedback loop cycled several times before acceptable parts were produced. In addition, shop experience revealed limitations in tooling and quickly highlighted features that were difficult to make with the processes available.

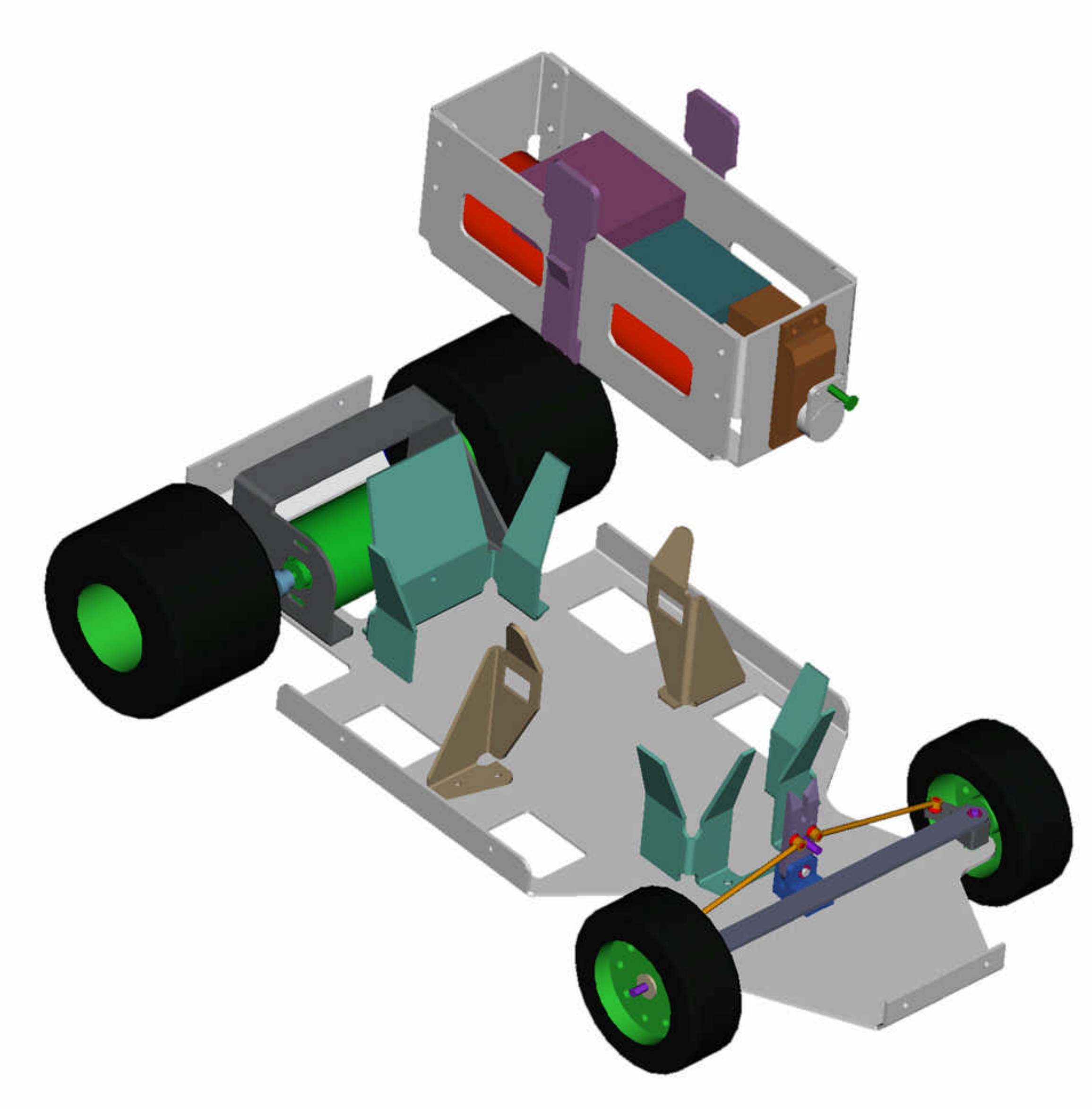


Figure 4. Top loading car assembly. Note clips and steering assembly.

To conserve weight, we decided to use thin sheet metal for our chassis as opposed to casting. After several iterations, we settled for a basic chassis design based on the stock car and began to refine it to suit our needs. Sheet metal components were used because of ease of design, manufacture, and assembly. The chassis is simply riveted together. The control box is aligned and held in place by a series of sheet metal brackets. Care was taken to not over-constrain the control box, which could have resulted in uneven and difficult fit.

We decided on a top-loading design to minimize the pit-stop time, and designed a plastic clip system to secure the control box, as well as a spring loaded contact system for transferring the power to the motor. The electrical connections are springs taken from a Radio Shack battery pack augmented with a section of braided copper to prevent meltdown at the two hundred watt peak power output of the motor. Only two of these connectors needed to be made for the control box, and the receptacle on the car side is a set of simple 0.25 mm brass plates.

Figure 5. Electrical contacts with augmenting copper wires

The final part of the interface of the control box is a steering linkage. Our design features a rotating link whose slot engages a pin on the steering servo. Ball links on threaded bars transfer the motion of this coupling link to the steering blocks on the wheels. The unique steering system is self centering, meaning that a spring keeps the wheels in the centered position when the control box is removed. This feature eliminates misalignment problems during insertion of the control box.

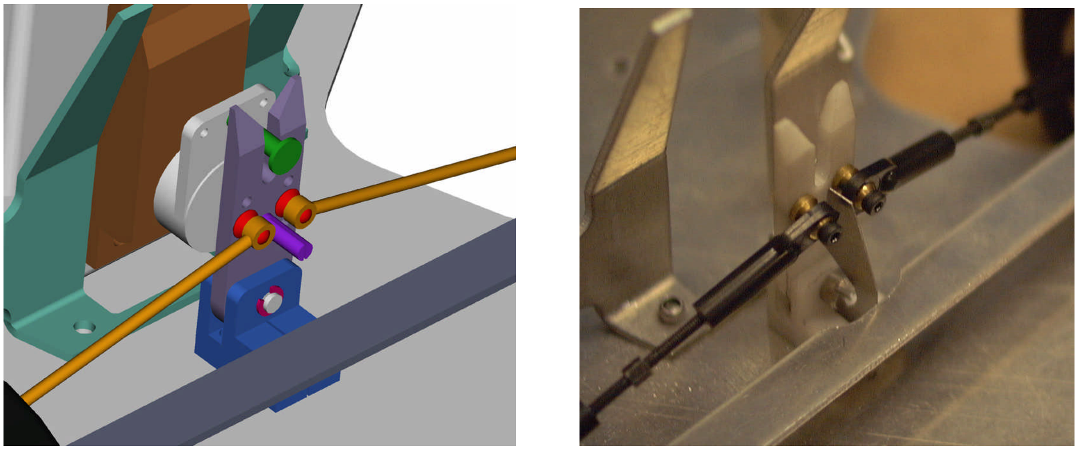


Figure 6. The steering assembly in ProE and reality. Note the self-centering mechanism.

We used Delrin for the moving parts of the steering components. Multiple parts translating in various degrees of freedom (rotation and translation) were used to increase the mobility of the steering instead of using a single piece that would only translate as the servo rotates. All Delrin parts were machined on a vertical mill. A fly cutter used to face the edges, end mills and drills were used to make profiles and necessary holes, and a slitting saw was used to make the slots. A few hours was needed to make a part for the first time (steering coupler, pillow block and control box retaining clips). As with the majority of machining, the learning curve is quite high. We found that using a single blank to make the majority of parts (six of each, one for each car) reduced the machining time significantly. For example, making the first steering pillow block took just over two hours, making the next five from a single piece of Delrin stock took three hours. The picture below shows a rough outline of the steering pillow block and how multiple pieces were made from stock Delrin.

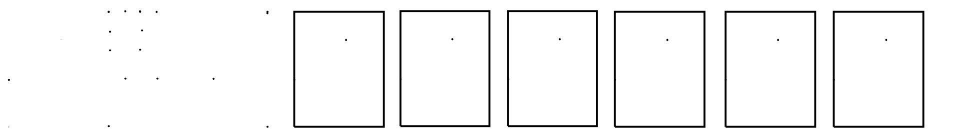


Figure 7. Shows five steering pillow blocks in Delrin stock.

The final challenge of the manufacturing process was putting all of the components together. Despite our best efforts, the parts did exhibit variations that made for a somewhat unpredictable fit, and necessitated 'tweaking' operation such as additional bending or sanding of corners or edges. Yet overall, the cars were assembled and tuned with relative ease.

Summary

The car has been constructed with the 'light, simple, and fast' strategy in mind, and fulfills all the initial design goals. The handling of the car is good, acceleration and top speeds are excellent, the changeover time is comparable to the best times from previous years, and the design is relatively rugged. We feel our car turned out better than originally anticipated and think our team will be very competitive on race day.