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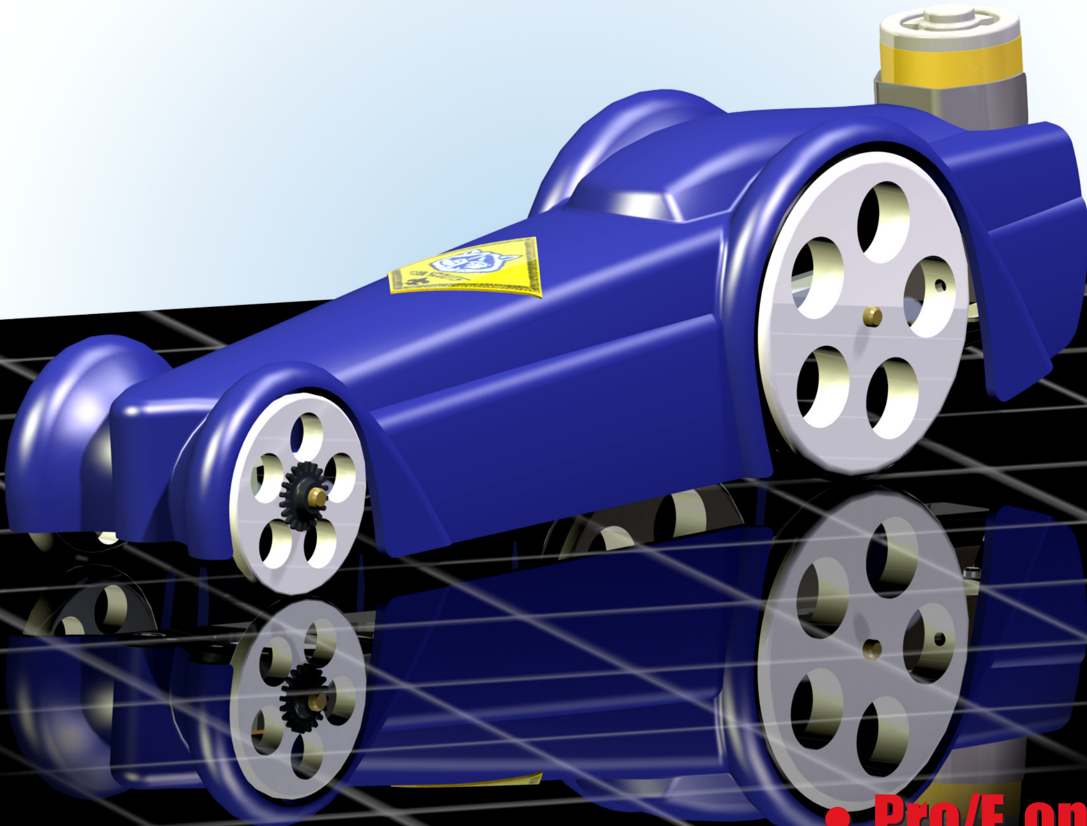
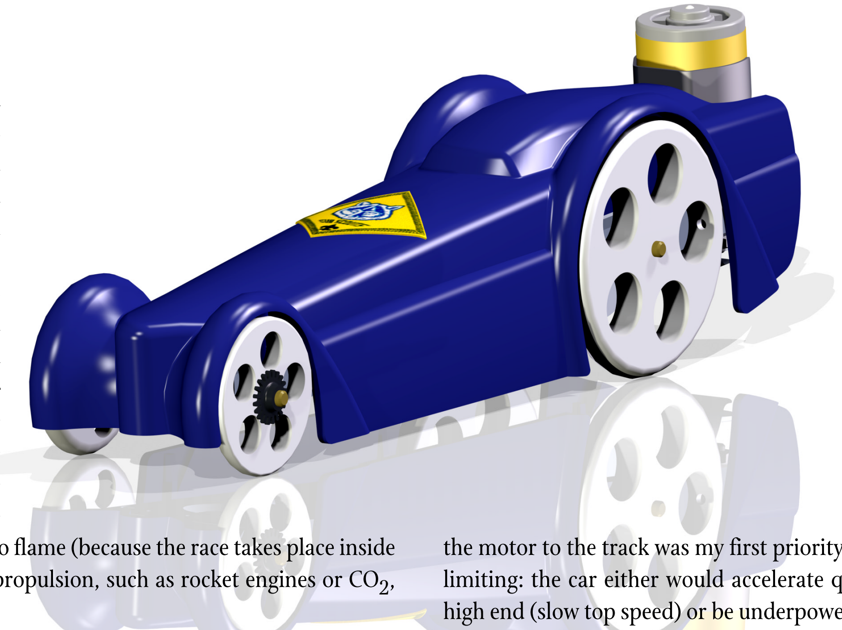


- Pro/E on Linux
- UI Scripting in Pro/INTRALINK 3.2

Going Pro/Extreme at the Pinewood Derby

Designing a racecar with verve

by Eldon Goates



Many Cub Scouts, Cub leaders and Cub Scout parents have dreamed of creating a screaming fast racecar for a Pinewood Derby. Last March in Colorado Springs, CO, Cub Scout leaders, older scouts and parents carried out a variation of the well-known race in a lighthearted competition. The race took place immediately following the official Pinewood Derby race of Cub Scout Pack 503. The only rules that applied were no flame (because the race takes place inside a church) and no projecting propulsion, such as rocket engines or CO_2, for obvious safety reasons.

Because I am a dedicated Cub Scout veteran who participated in the Derby as a child and am an active Scout leader (and love a technical competition), I was compelled to build a car. The mechanical engineer inside me took over and it wasn't long before I utilized Pro/ENGINEER. Although my design started simply, talk of electric motors and drive fans among other participants stimulated the perfect idea—an electric vehicle with a three-speed automatic transmission. With the race only two weeks away, I pulled an all-night session with Pro/E. I believe my fanatic determination yielded a fun design that surpassed the typical spirit of the Pinewood Derby. There was no doubt in my mind that my car, christened *The Extreme*, would be quick—but would it stay on the track?

Engineering considerations

An official Pinewood Derby is a gravity-accelerated race. This means that cars start at the top of a long ramp. When released, they roll down the ramp and across a flat to the finish. Our particular track had four sections, each eight feet long: one ramp section, one transition and two sections of flat. Cars are kept on the track by straddling a raised segment between the wheels. The most important factors that affect speed are weight distribution, aerodynamics, wheel alignment and rolling resistance. Winning cars are typically those that best sustain momentum from the ramp across the flat. However, with added power, a car could accelerate to the end.

To make *The Extreme* move quickly, solid axles and bearings were used to minimize rolling resistance and assure alignment. Careful measurements were taken to optimize fit to the track. The motor, battery and weight distribution were considered for stability, center of gravity (CG) and to put power to the track.

Design execution

Transferring power from the motor to the track was my first priority. A fixed ratio drive would be limiting: the car either would accelerate quickly and be limited on the high end (slow top speed) or be underpowered to start and finish strong. As in drag racing, more acceleration early yields a shorter time to finish. So, for fun, I incorporated a three-speed transmission into the design to accelerate quickly and to produce a high top speed.

The transmission was a simple three-diameter spool mounted on the rear axle with thread wound around it. As the motor turned, it pulled thread from the largest diameter, then the second largest diameter and then the smallest. The trick was to know how many turns for each diameter would optimize performance. Another challenge was that the design of the transmission conflicted with stability of the racecar. For ratio, the large diameter (first gear) wanted to grow. But to clear the raised track guide, the rear wheels also had to grow—raising the center of gravity. The compromise was to use large rear wheels, with battery placement low for stability.

Aluminum wheels carried the car and featured rounded inner edges for tracking and lightening holes for reduced inertia (and heightened aesthetic value). The rear wheels also used an o-ring "tire" for traction. Power was supplied by an 18-volt, 2-amp, 12,000-rpm direct current motor and a pair of 9-volt batteries. The batteries were placed in a recess in the machined aluminum chassis with space to adjust for dynamics—forward for lower CG or aft for traction.

The car was not complete without a body, so a body was modeled with Pro/E and sent for rapid prototyping by Protogenics, a professional service bureau that manufacturers prototypes and conceptual models using stereolithography (SLA) technology.

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Going Pro/Extreme

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The tools

Pro/ENGINEER was used to design elements such as the chassis, wheels, sheet metal brackets and more. Pro/E also was used to assemble the components to ensure proper clearances both over the track and among moving parts. Wheel, pulley and spool sizes were calculated in Excel with velocity predictions based on CG, inertia and mass properties from Pro/E. A few iterations yielded a well-balanced design. Finally, and perhaps most significantly, the body was designed with the surfacing capabilities of Pro/E, with proper fits assured.

The body is an SLA (rapid prototype) made from a new ABS-like resin, Vantico SL5260, which is easy to work with and finishes beautifully. This resin proved tough throughout the rigors of racing—even with high speeds and abrupt stops. Older resin types certainly would not have survived.

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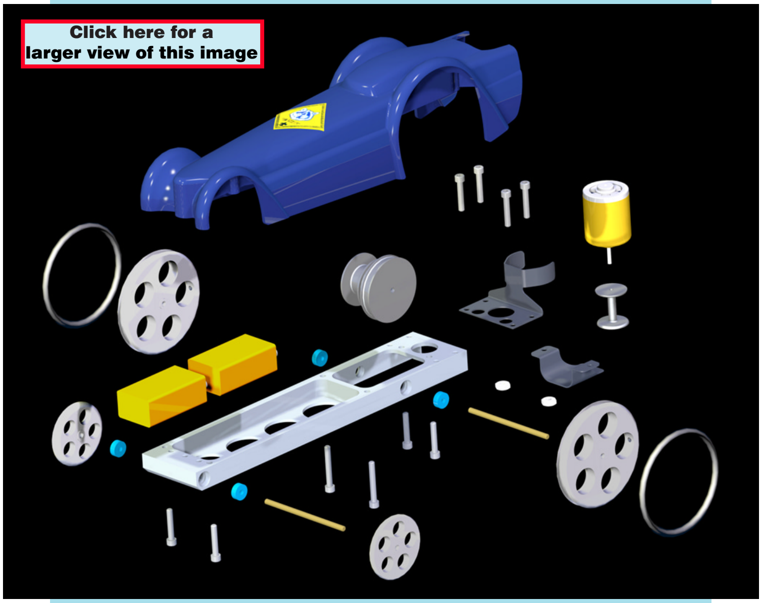

Rendered parts in Pro/ENGINEER.

Going Pro/Extreme

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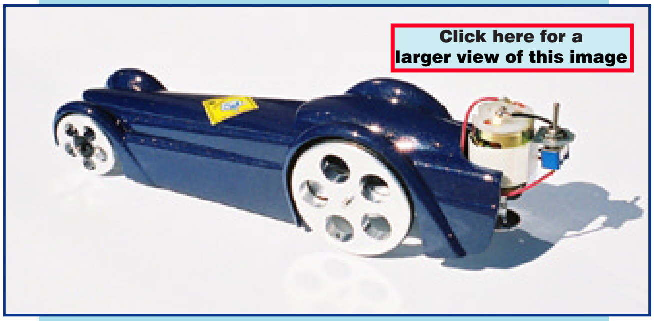

The final product.

The value of using Pro/E was evident when the parts arrived. The wheels, axles, bearings, chassis, etc. all came together perfectly, and the body fit snugly without alteration. The only change necessary involved the front micro-switch. Because the body was sent out for build before I selected the switch, the plan was to cut a hole for the switch later. But the body was so beautiful, I just could not cut it. Instead, I taped the switch onto the body. (What racecar shouldn't sport 200-mph tape?)

Race day

The last pieces arrived the morning of race day. After assembly, the car was tested on a flat court floor and performed superbly. But testing prompted two changes. First, wires were rerouted inside the chassis to prevent rubbing. Second, a heavier drive cord was fitted because the motor kept breaking the string.

That evening as racers arrived, it was terrific to see the creativity of the entrants. There were electric cars, propellers powered by electric motors or rubber bands, a balloon-powered car and one even used a mousetrap! Others preferred designs with snazzy lights and side pipes.

When it came our turn to race, I could tell there was some doubt in the ability of *The Extreme*. But the moment of truth came—the gate fell and the cars were off. There was an audible gasp from the crowd as *The Extreme* launched from the starting line and blurred to a memory as it disappeared into the fabric bag at the finish line. Other cars had barely cleared the main ramp. The speed was inspiring.

More races followed with similar results. Although these competitions were more spectacle than race, *The Extreme*'s design demonstrated engineering in action: time and effort combined with the right tools go a long way.

Reflections

The Extreme showcased the capabilities of Synthesis Engineering Services, a small design company. The design was completed from start to finish in just a few days using Pro/E. And in just two weeks, the car was designed, built, tested and raced with flawless performance. Michael Cowan of CNC Technical Solutions (www.cnctechsolutions.com) was responsible for the machining, directly from the models, and Protogenics (www.protogenics.com) produced the body (with the awesome paint job).

The Extreme *in all its glory.*

Eldon Goates is the owner of Synthesis Engineering Services (www.synthx.com) in Colorado Springs, CO. Synthesis specializes in creative ideas for product development and engineering consulting. Goates can be reached at egoates@sythx.com.

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