Specialty Workshop

Aerodynamics, Weight, & Friction

Triton Shoup, Chief Technical Director

Go Faster on Less!

- Intro to Aerodynamics
- Weight Matters - Reducing the weight of your car
- Friction - Rolling resistance (tires and bearings)
- Implementation
  - Simple body aerodynamics (fairings and coverings)
  - Complex body aerodynamics (full-size bodies)

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Aerodynamics is Not Essential to Race

First Year (2017) – Third Year (2019)

Your cars will evolve through the years

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To Give Credit Where Credit is Due

Most of these slides are courtesy of:

Mark Westlake
Saint Thomas Academy

Saint Thomas Academy Experimental Vehicle Team (St. Paul Minnesota)

- Facebook: https://www.facebook.com/staEVT
- Instagram: https://www.instagram.com/sta_evt/

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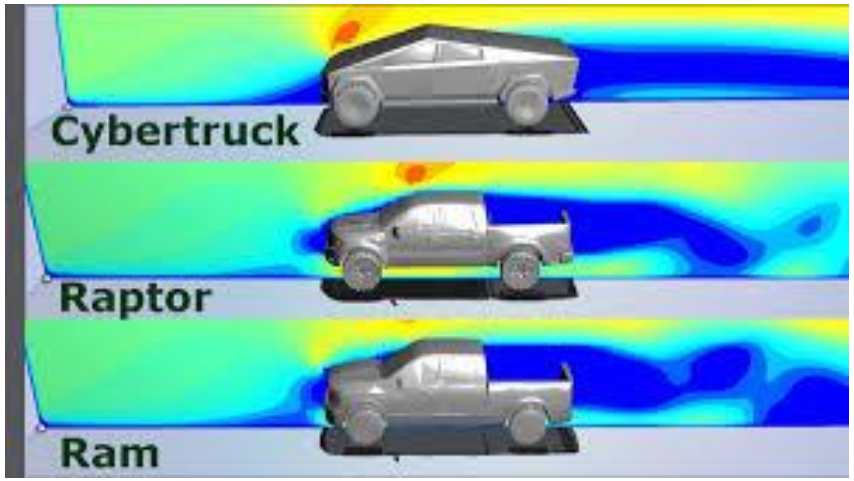
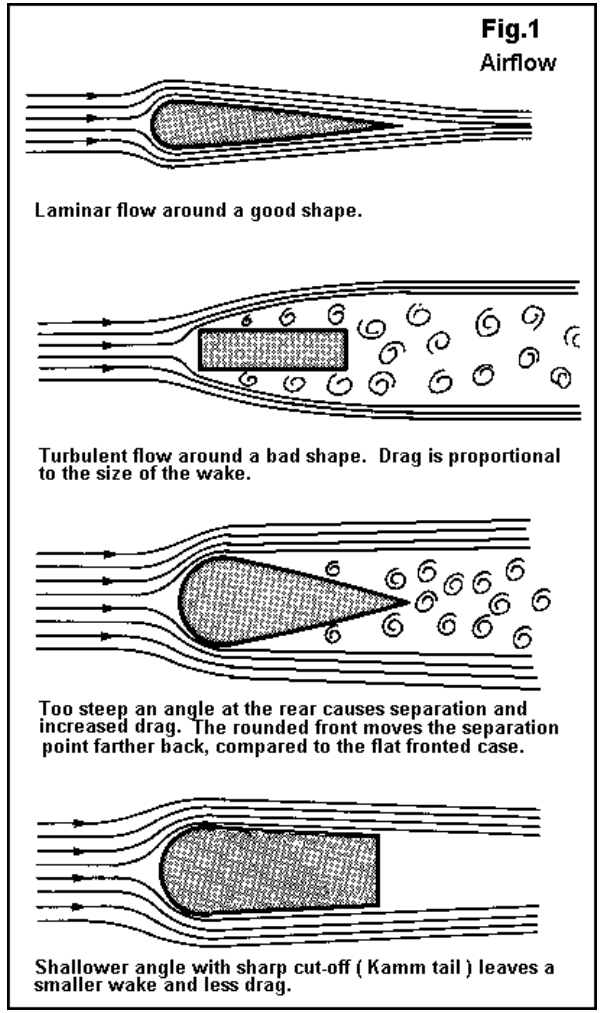
Aerodynamic Drag Basics

- Drag starts at the back of the vehicle, not the front. Hence the name “drag”.
- Different shapes have unique airflow patterns
- Easy modifications such as fairings or shields can be made to help reduce this.





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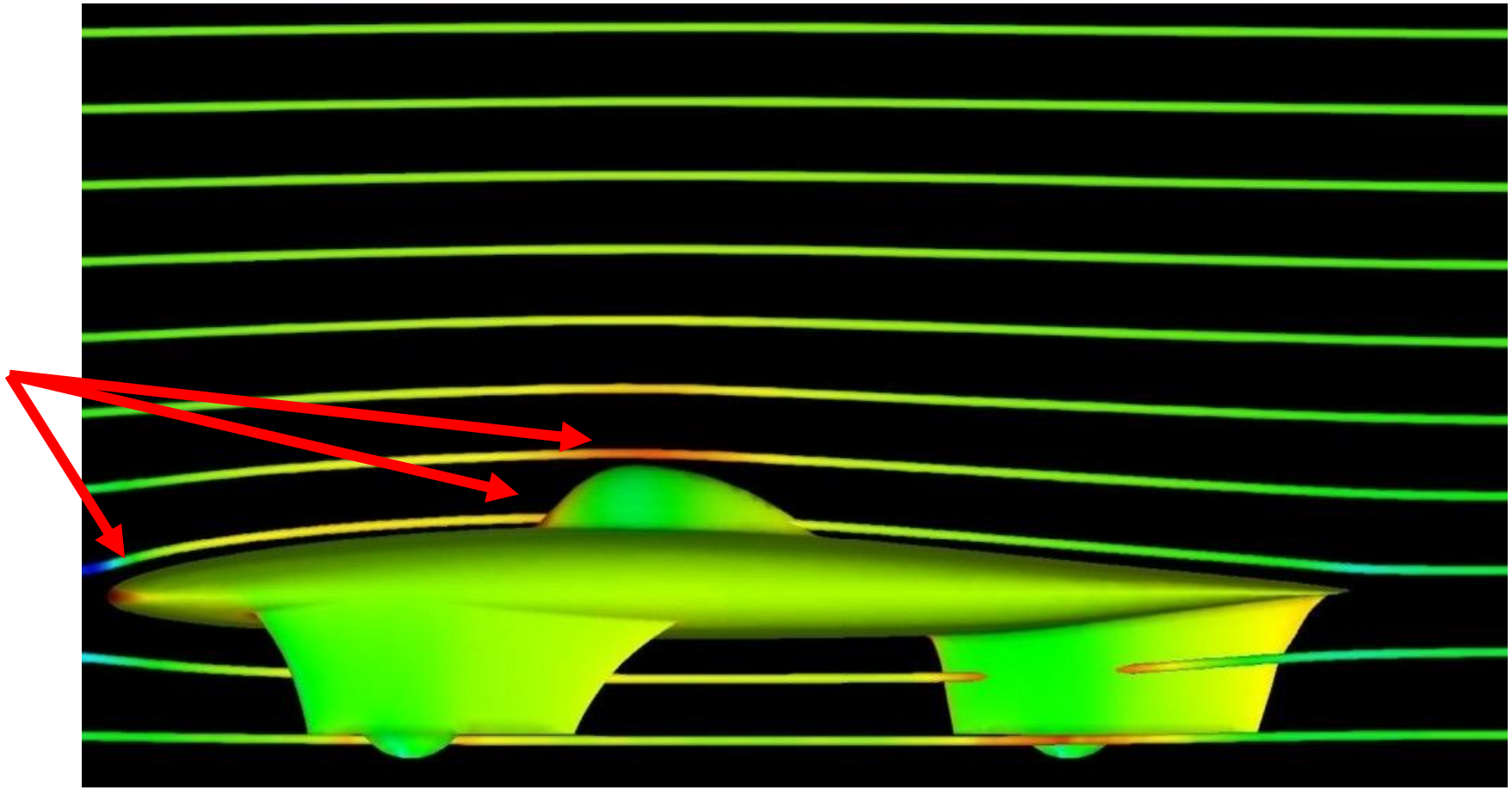
Aerodynamic Drag in a Wind Tunnel

Very little deformation in the flow lines.

Notice areas of deformation in red, but a very subtle showing a good airflow design.



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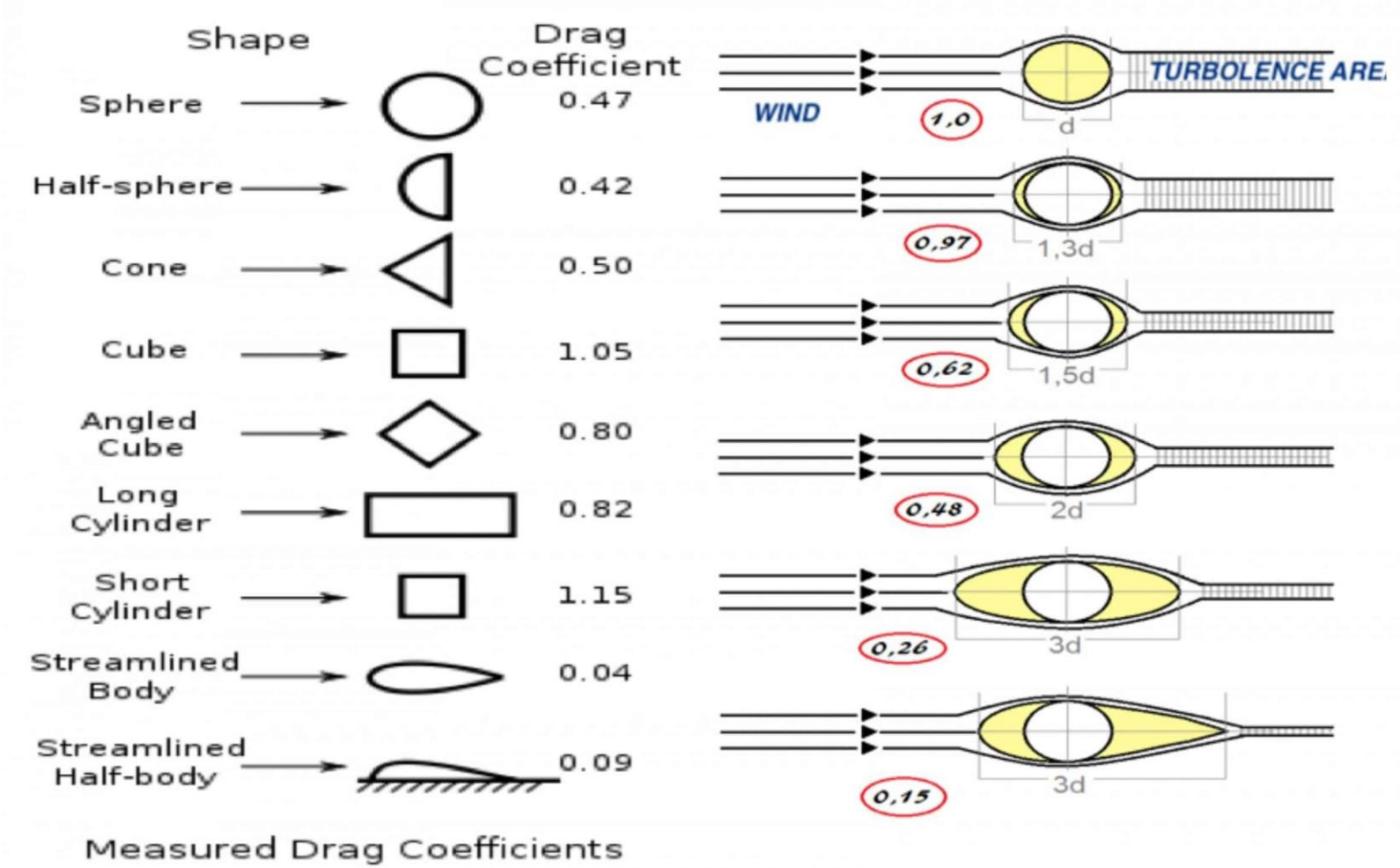
Aerodynamic Drag Coefficients



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Real World Examples of Cars Handling Drag

General Motors EV1

Cd = 0.195

Tesla Model S

Cd = 0.208

Cadillac Escalade

Cd = 0.38

C8 Z06 Track Package

Cd = 0.50

- Some drag on commercial cars is not a bad or significant factor to their performance
- Sports cars require this to provide down force to help with turning and keeping the car from launching
- **However… for solar cars it is bad**

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Aerodynamic Drag Calculation

- **Doubling your speed, the force on your car is 4 times greater!**

- **For example: at speeds of 55 mph, ~50% of the average car's energy is used for pushing air out of the way for a full sized vehicle.**

$$F_D = C_D A \frac{\rho V^2}{2}$$

where

F_D is the drag force — Final Calculation

C_D is the drag coefficient — Table value / wind tunnel

A is the reference area — Calculated based on solar car's frontal area

ρ is the density of the fluid — Given Value

V is the flow velocity relative to the object — Given Value

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Why Care about Drag?

Reducing drag is the least expensive way to improve your solar car.

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Aerodynamics vs. Weight

- If I were to choose one thing, what would I focus on?
  - Dependent on speed
  - Track vs. road race
    - “Uphills/Downhills” on turns
    - Heavier cars have more rolling resistance and take more energy to accelerate. (Much bigger problem in a road race.)

- Reliability while perusing the ideal solar car…
  - A note of caution about taking things too far when trying to be as efficient as possible
  - Do not reduce weight at the cost of safety

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Weight

- **Reduction Methods:**
  - **Lighter batteries**
  - **Switching frame material to composites**
  - **Removing metal frame from solar panels**
- **Do not reduce weight at the cost of safety.**
  - **Example: Do not take out a single structural bar of the frame to reduce 2 lbs**
- **Making things too light will force you to find an expert welder because <u>things WILL break.</u>**

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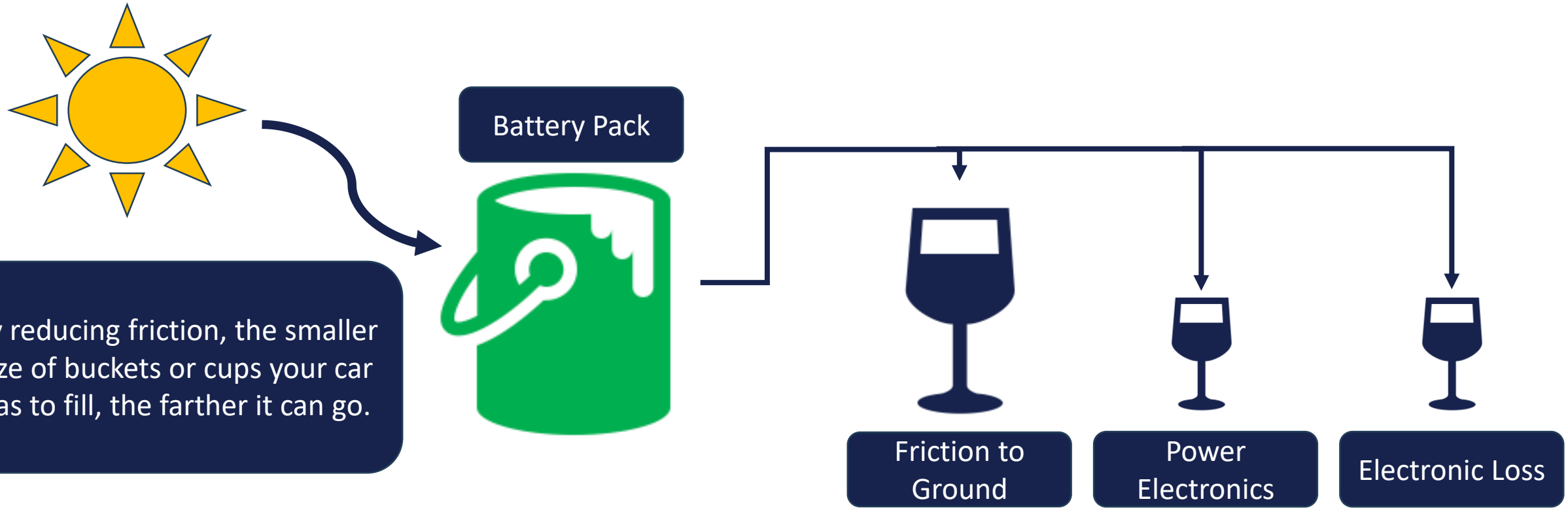
Friction is a Solar Car's Worst Enemy

Think of your car as a bucket of water that has to fill out smaller buckets….



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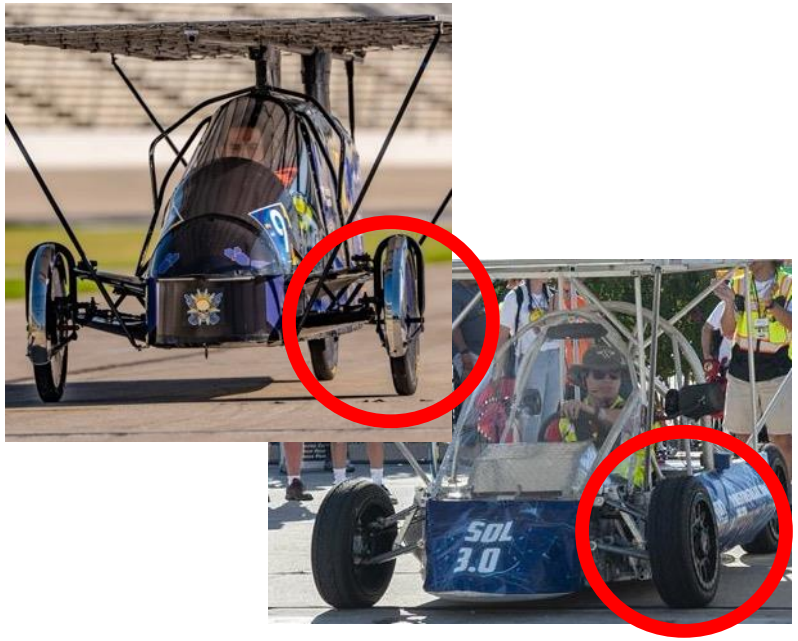
Friction: Reduction methods

Brake caliper rubbing



Tire diameter/ contact patch

Excess mechanical connection

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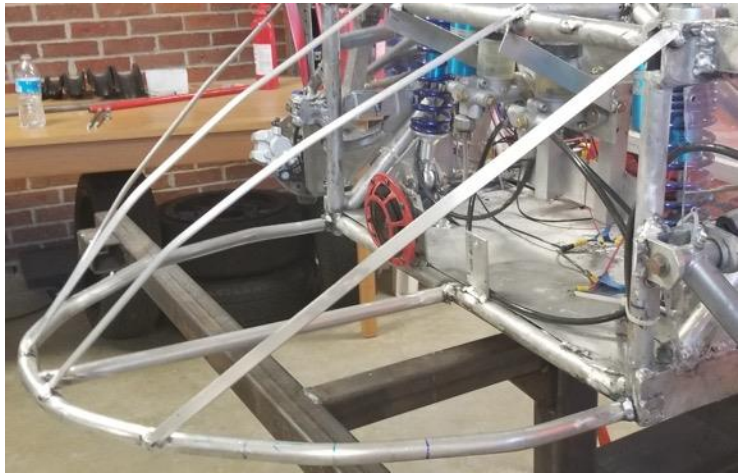
Inexpensive Aerodynamic Solutions

- Things you need:
  - Foam core board
  - Razor Blade
  - Hot glue
  - Carbon fiber or Fiberglass reinforcement
  - Epoxy resin
  - Creativity
  - Body filler



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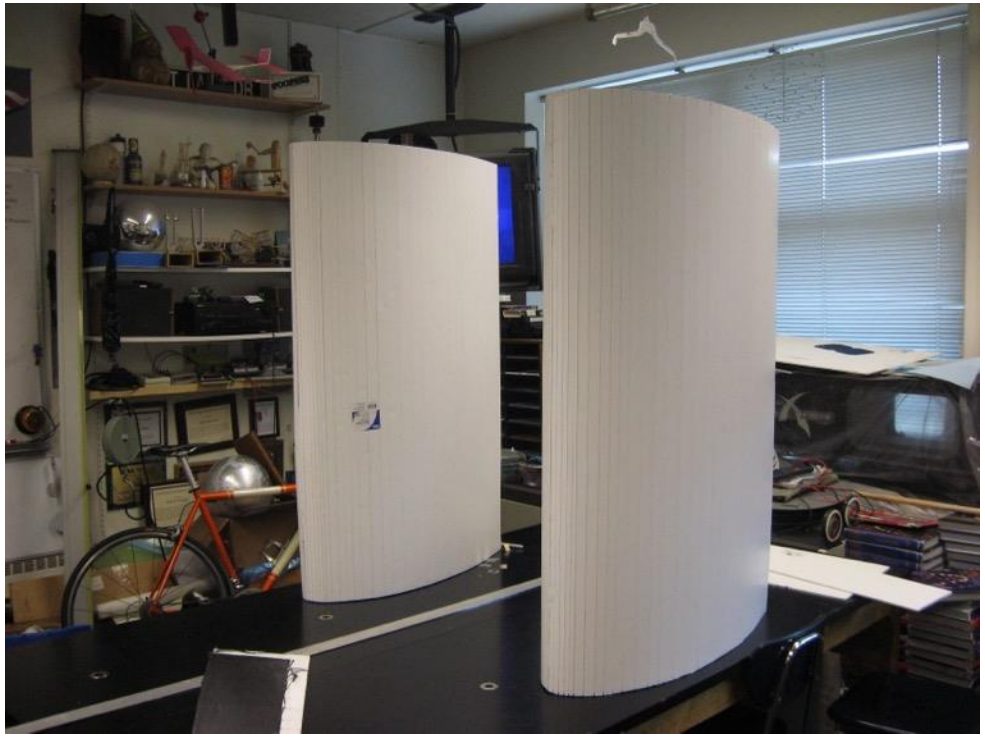
Wheel Fairings



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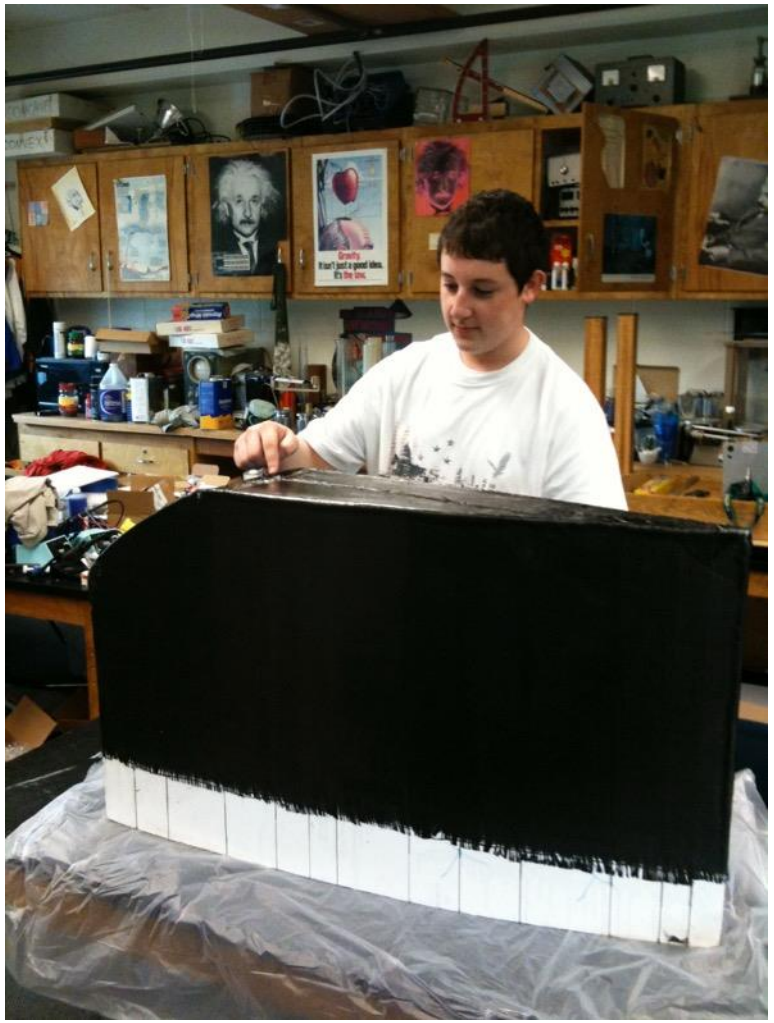
Adding Reinforcement

- One or two layers of Carbon or Fiberglass cloth is enough.
- Epoxy resin won't eat through the foam core.
- Squeegee excess resin from fabric, no need to vacuum seal the carbon fiber



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Adding Reinforcement

- Add some carbon fiber squares on the inside at attachment points to strengthen foam core board.
- Trim with a common jigsaw to fit.

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Simple Implementation

- A fulling enclosed wind shield can help with any drag points being the driver compartment
- Simple faring can help increase efficiency
- Note: these type of components can increase the maximum dimensions off the car

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Intermediate Implementation

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Intermediate Implementation

- When designing your crush zone keep Aero in mind to help with overall look and structural integrity

- Don’t use heavy materials for this to keep weight down

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Complex Implementation – Composites

Pros

- Lightest and stiffest
- Can be formed to any shape

Cons

- Expensive
- Needs careful planning
- Learning curve is steep
- Very hard to repair on the side of the road
- **NOTE: Need professional engineer certification if used for safety cell, roll bar, or crush zone**

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Finishing Touches

- Reinforcement is covered with a light-weight body filler and sanded smooth.
- Prime and paint
- (A good painter can cover a lot of flaws!)

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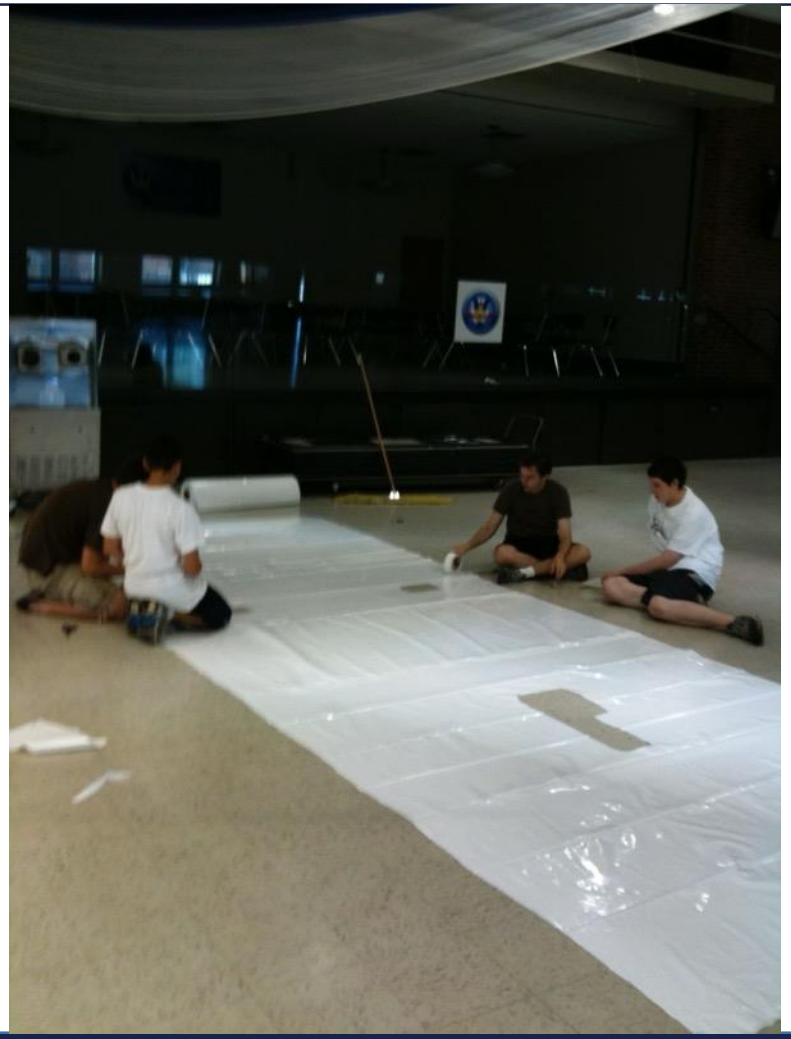
Complex – Heat Shrink Wrap



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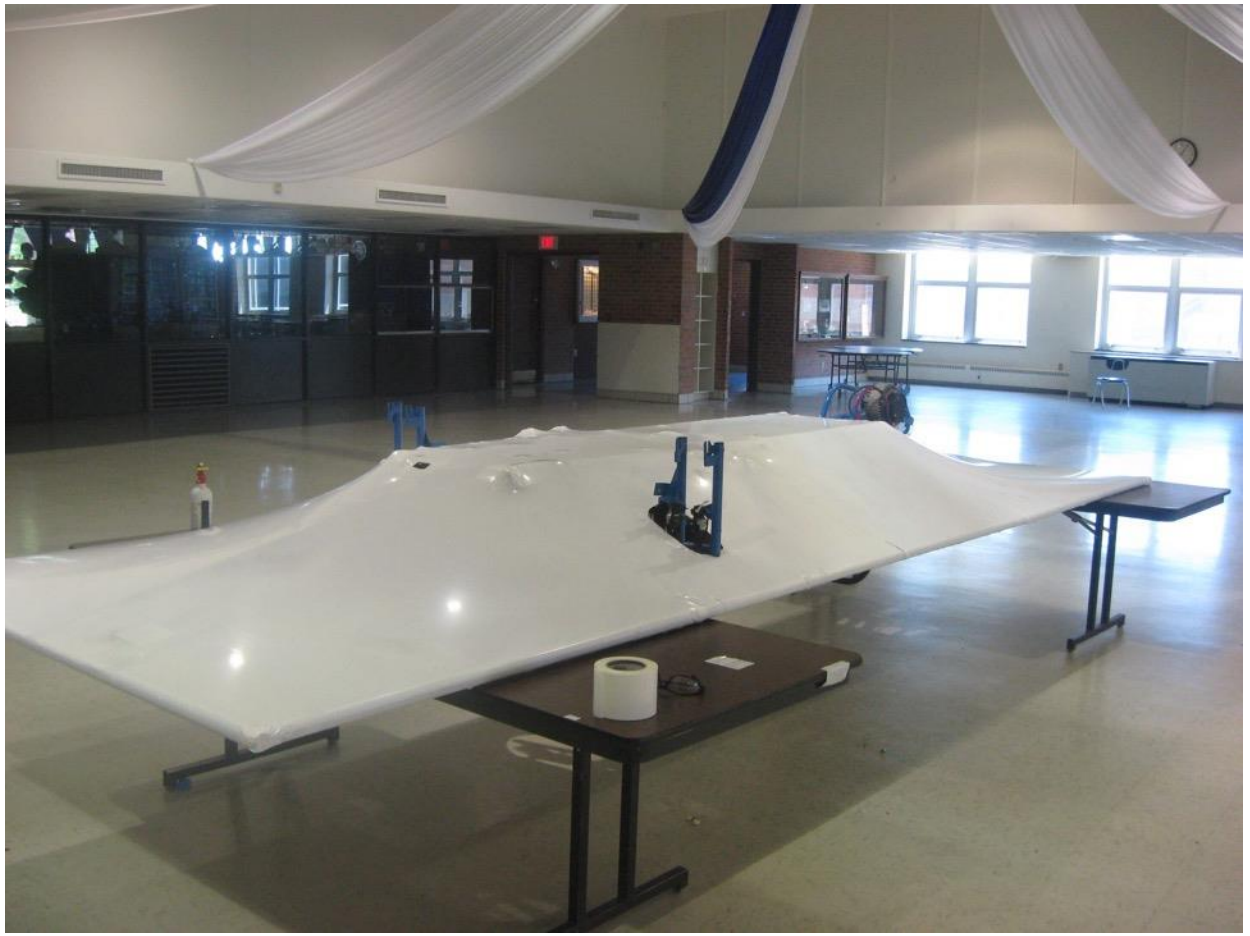
Complex – Heat Shrink Wrap



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Final product – Heat Shrink

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MTEEA Supermileage Body Parts

- Cut foam core board to shape
- Score with a razor blade
- Bend to shape
- Hot Glue

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MTEEA Supermileage Body Parts

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MTEEA Supermileage Body Parts

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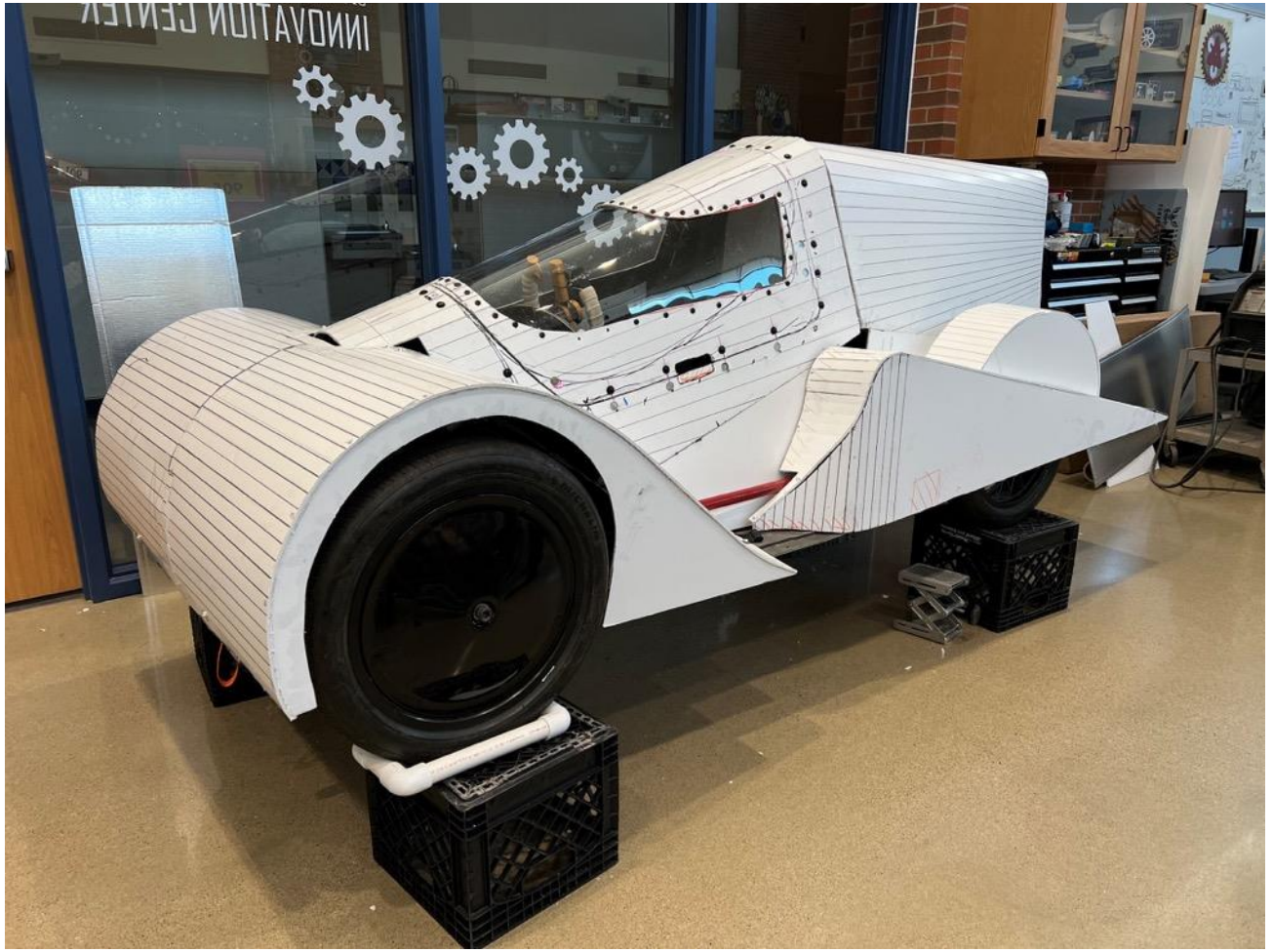
MTEEA Supermileage Foam Core Body Example



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Adding Vinyl Decals

Allows for teams to add branding to their vehicle and add recognition to the year's sponsors

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Brainerd International Raceway

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Tips for Success in Scrutineering

READ the rule book… and read it again…

Look at the scrutineering booklet on the website

Think of this as an open-book test, where the review is the test questions – but only a 99-100% score is allowed to race

Go over your car with that booklet to check if it will pass inspection two to three weeks before Scrutineering

Bring as many tools and parts as possible to fix the car or make changes during Scrutineering – a lot of time is lost when teams have to go find parts

Do stations 1 and 2 on Day 1, even if you know you'll fail one the first time going

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Kahoot QR code: