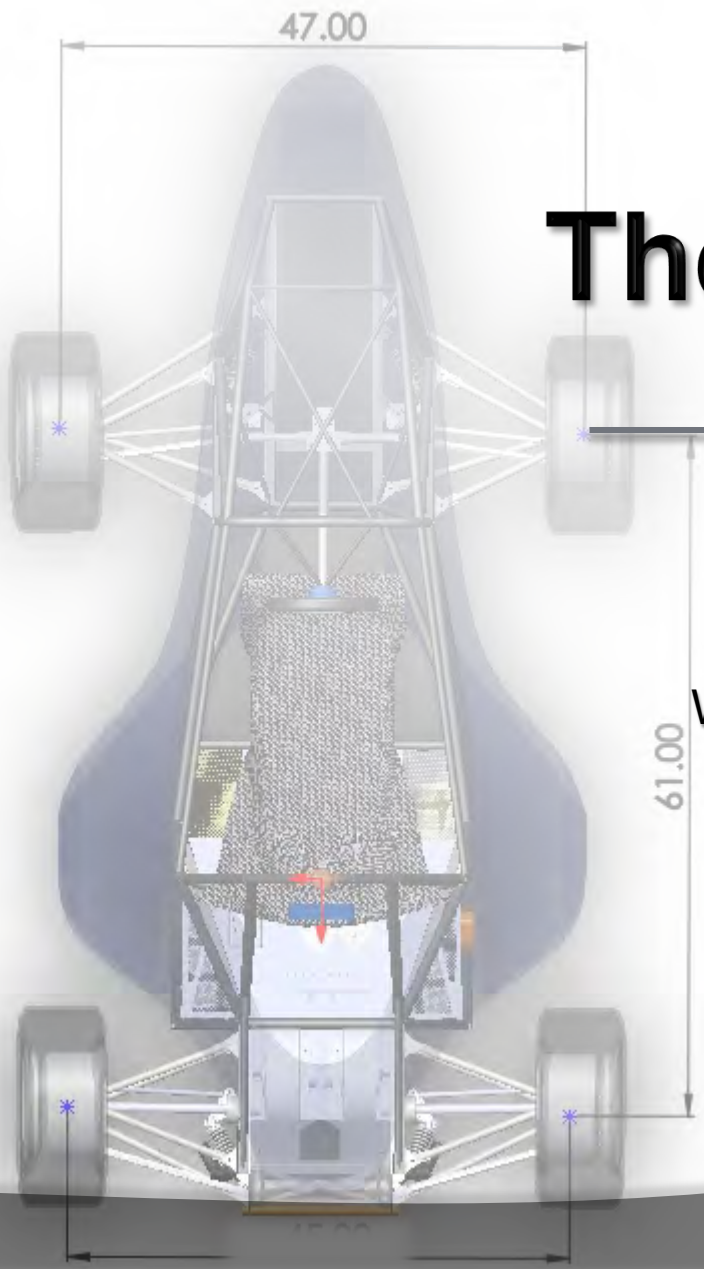
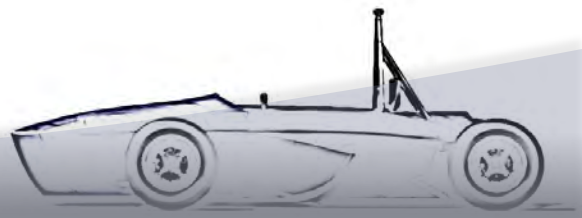


The Design Process

Suzanne & Michael Royce
Albion Associates, LLC
With material from Anthony Lyscio, GM/SpaceX

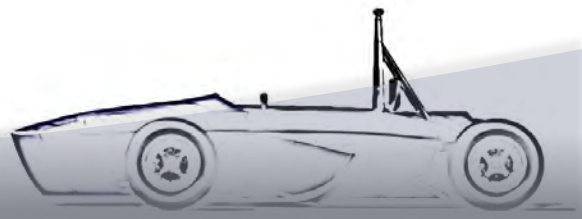
General Design Process

- Before you start the design, you MUST have already established:
  - The team organization
  - Your internal team processes
  - The Design Evaluation Process



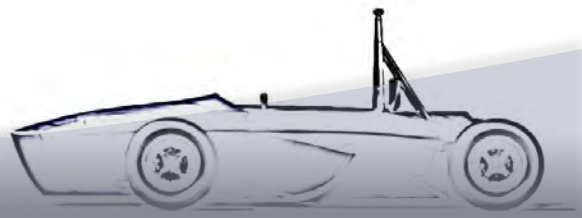
General Design Process

- Starting point?
  - Rules
  - Lessons Learned
- What are your goals for the Competition?
- On a per event basis, what are your goals?
- What performance specs will meet those goals?
- What resources are available to you?



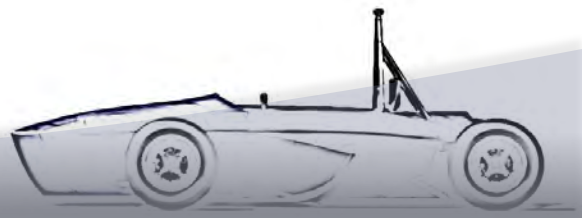
Resources Available

- Some basic design decisions must be based on the availability of some key components
- What components are actually available?
  - Engines
    - What engines (and spare engine parts) are readily available?
  - Tyres
    - What tyres are readily available?



Basic Design Decisions

- Simple versus complex? K.I.S.S. versus “high tech”
- Tube frame versus monocoque?
- Wings versus none?
- Supercharged or turbocharged versus naturally aspirated?



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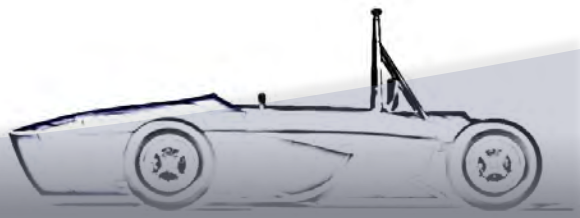


Design Complexity

Both do the same job…

What are the performance gains vs. cost, effort, and mass trade-offs?

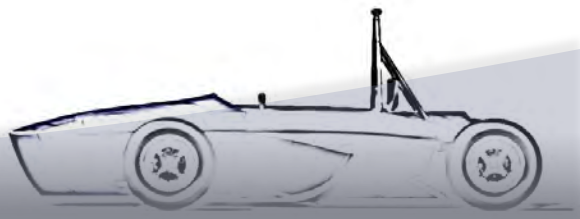
Can the same job be done more simply? Occam's Razor

Occam’s Razor

Occam's razor (also written as Ockham's razor and in Latin lex parsimoniae) is a problem-solving principle devised by William of Ockham (c. 1287-1347), who was an English Franciscan friar and scholastic philosopher and theologian.

The principle states that among competing hypotheses, the one with the fewest assumptions should be selected.

Other, more complicated solutions may ultimately prove correct, but—in the absence of certainty—the fewer assumptions that are made, the better.



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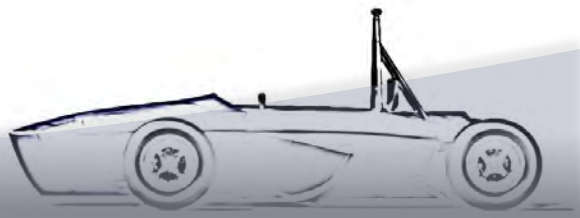
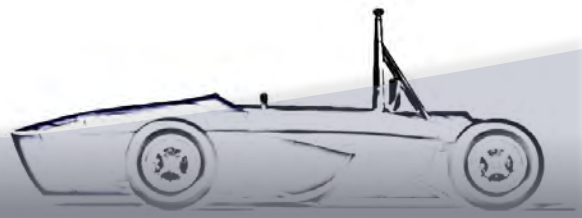


Basic Design Considerations
Chassis-Frame

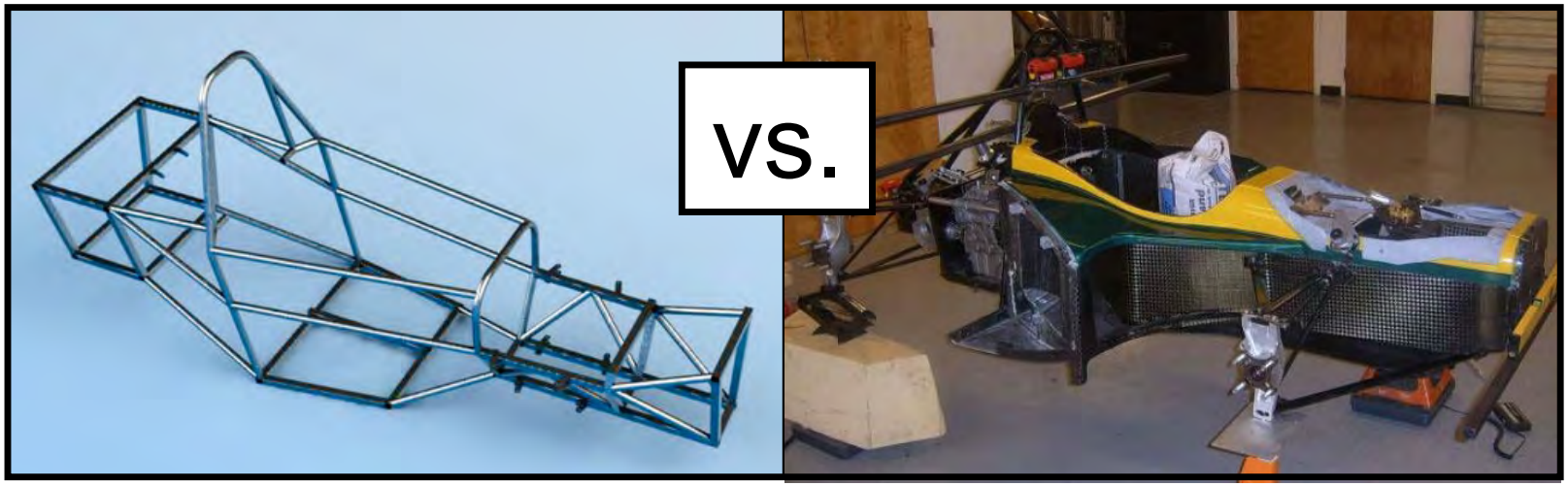
- K.I.S.S. vs. High Tech
- Materials
  - Carbon = cool, but is it the right choice?
  - Different materials may want different shapes



Tube Frame vs Composites

You must consider:

- **Time** and expense to design and build vs. REAL benefits
- Analysis capability, can you predict your performance?
- Development **time, cost & mass effects**
- Composites are ***very*** process sensitive, allow time to build it twice
- When problems are found in tech, what is plan B? **Upfront integration.**



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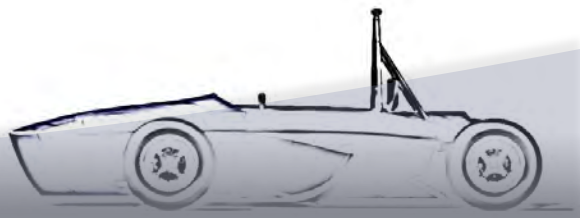
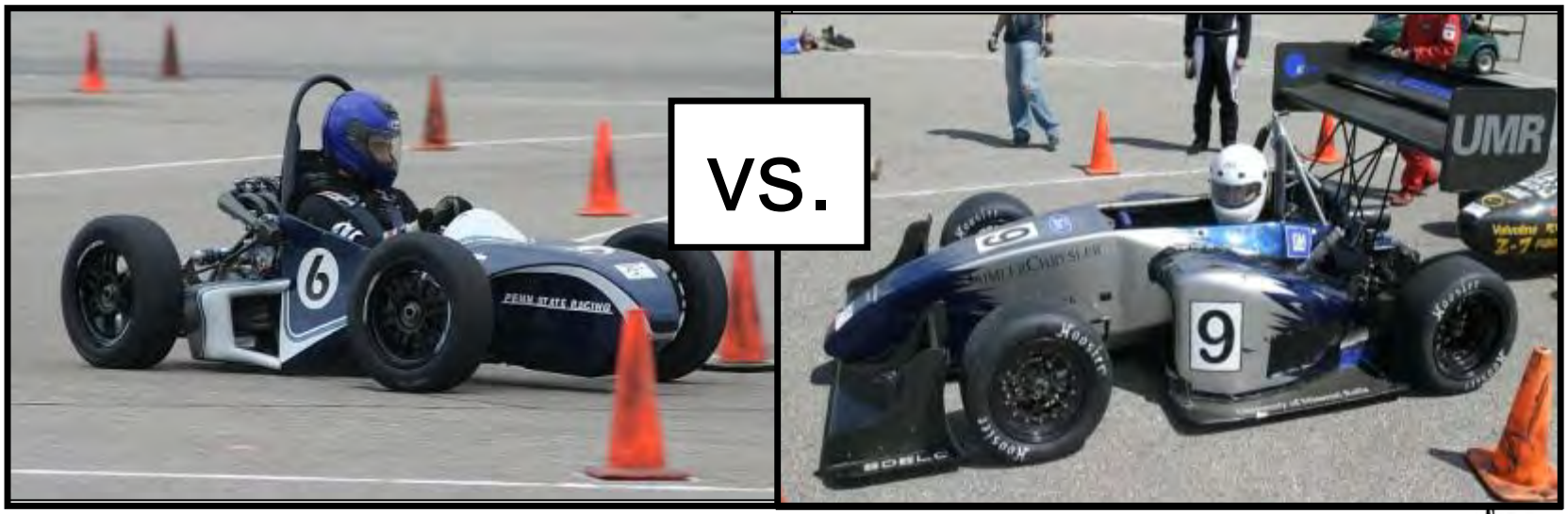


Aerodynamics

You must consider:

- **NEW Rules for 2015 – More stringent rules on aero = less potential benefit**
- Time and expense to design, build, and develop vs. predicted benefits
- Impact on other vehicle systems- must integrate into overall system
- Actual competition benefits (stopwatch **and the Design Judges**)



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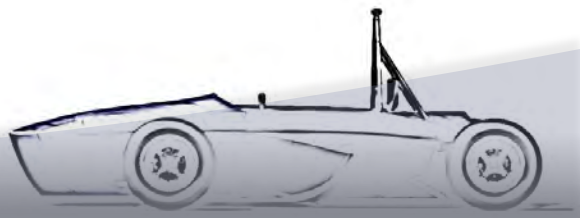
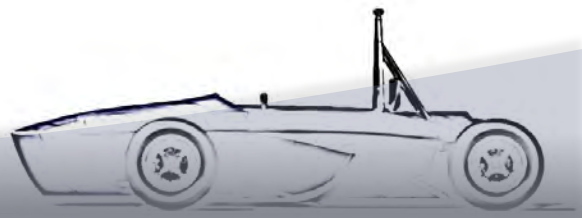


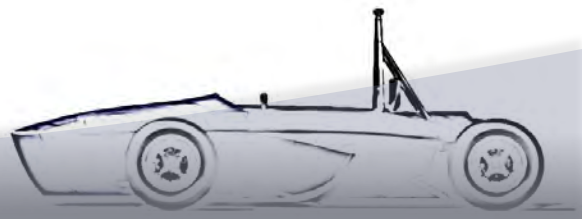
Boosted or NA?

- Supercharging or turbocharging:
  - Will add cost and weight
  - Will increase the engine calibration work an order of magnitude
  - Will increase the design work
  - Will NOT increase peak power
  - MAY improve the torque curve



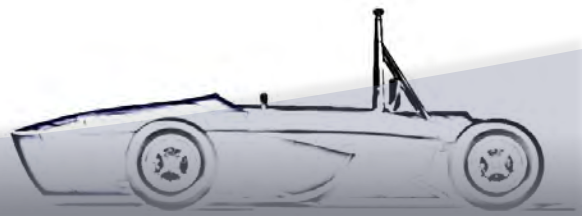
General Design Process

- Break the car into systems and work down (system to sub-system)
- Start with where the “rubber meets the road”
- Start with the tyres
  - The FSAE Tire Test Consortium
- Then suspension geometry
- Then the Frame
- Synthesis - every component, it’s interactions with other components
- Iterate to get through systems integration issues
- The packaging layout– the mass & 3D C of G and location of every little bit, must be on-going



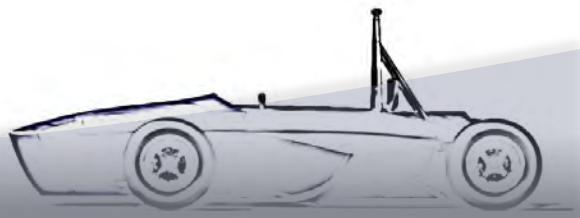
Packaging

- Packaging is how everything fits together
- Is vital to know:
  - That there are no interferences between parts
  - That there is space for everything
  - The location of the C of G



Important Considerations

- Tire Data – FSAE Tire Test Consortium
- Mass vs. Stiffness - A balancing act
- Itty bitty parts – mass vs. reliability
- Modeling and analysis vs. physical testing
  - Plan early!
  - Validate the models early and then interate
- Weight distribution (3D – C of G) Frnt/Rear, Left/Right and height, is more than specifications
- Data Acquisition is an engineering and driver tool
  - Need development plans for both car and drivers

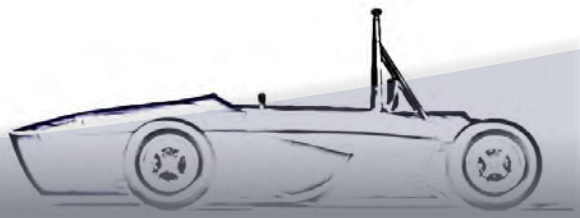


Qualitative Design "Rules" to keep in mind

- Good design → If it looks right it usually is
  - Corollary → If it looks wrong, well…
- Good load paths are your friend
  - Triangles (really tetrahedrons) = good load paths
- The part not on the car has zero mass, no cost and can't fail
  - The reward in performance must outweigh the risk and penalty
- Systems Engineering → Know it, Live it
- Engine calibration → Not just about air/fuel… Spark it right, always.
- Mass → ***Mass begets mass***. There is no minimum weight.
  - Make it ***light***. But stiffness matters and broken parts rarely win races

Things to Ask During All Project Phases

- Does the car look like it was designed with a systems focus?
- What parts look like after thoughts? Were they?
- Is the packaging tidy and looks planned?
- Are items such as wiring exposed or neatly routed in looms?
- Are components adequately protected from their environment
    - Heat, chaffing, impact, vibration
- Is the car reasonable to maintain and adjust?
- Is the car on track to mass, CG and packaging expectations? If not "Why not?"
- Tuning? Can discrete adjustments be made?



Good Packaging Examples

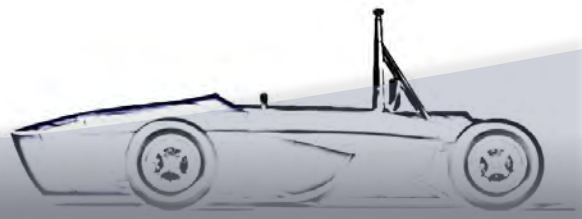
Well thought out,

Well integrated, and

Few surprises.

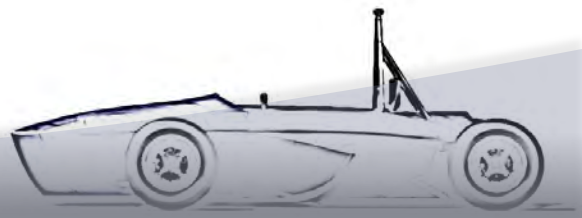
This is where the

Upfront work pays off!!



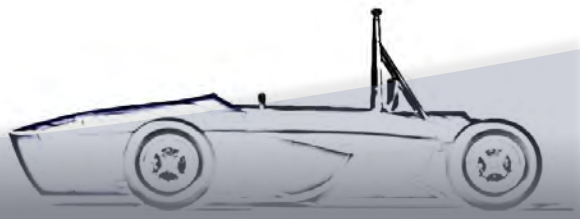
Often Overlooked Design Details

- Fasteners - quality, grip lengths, commonization…
- Welding quality
- Engine Design / Calibration - part throttle
- Cooling system - heat rejection
- Wiring - neat looms, proper gauge, shielding
- Safety wiring – well done



Resources

- The Rules… KEY: know them inside and out
- SAE Website - links to papers, guides, etc…
- Carroll Smith Books - cheap, practical, good reads
- Race Car Vehicle Dynamics - Milliken
- Learn & Complete - A Primer for FSAE- Royce & others
- FSAE Tire Test Consortium - www.millikenresearch.com/fsaettc.html
- Claude Rouelle Seminars
- www.fsae.com – book list (search the forums)
- Numerous FSAE specific papers out there



Questions ?