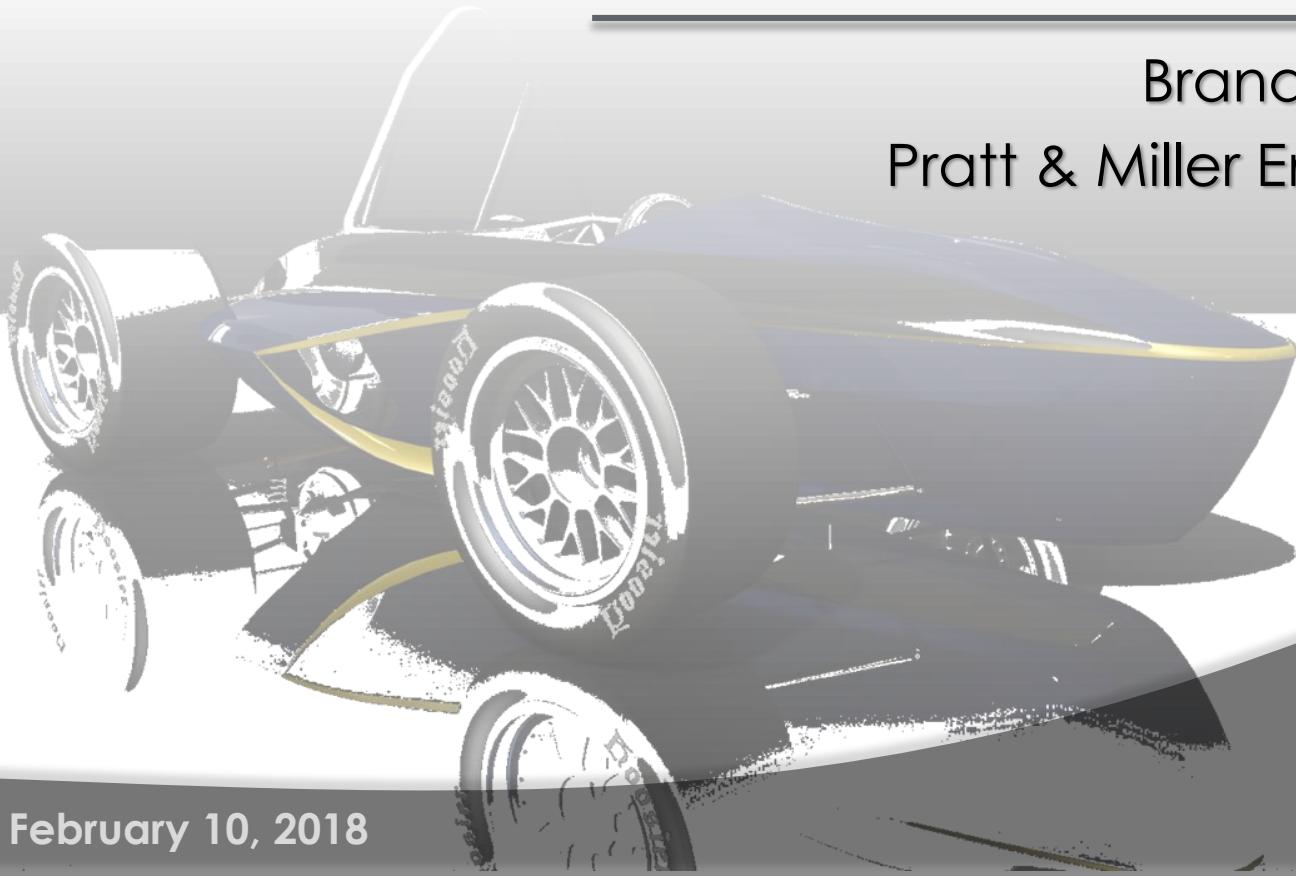


Three View Drawings

Brandon Horsch
Pratt & Miller Engineering

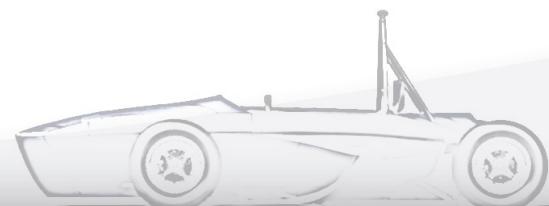


February 10, 2018

FSAE Workshop
Combustion - Electric - Hybrid

Contents

- Why you should care
- The rules
- Evaluation
- A good drawing
- A great drawing
- An outstanding drawing
- Examples and judge comments



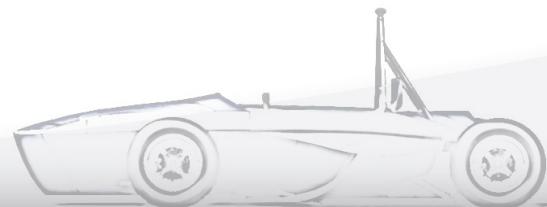
Why You Should Care

- The three view drawing is part of the design report and thus the first look design judges will have of your car.
- It's your chance to make a good impression before even getting to the event.
- A strong drawing can improve your design score.
- Oh yeah, there's also an award.



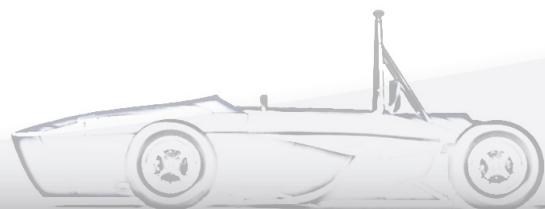
The Rules

- The first, perhaps obvious, step to a successful drawing is to know the rules.
- Every rule and guideline for this award is published on the SAE website for easy access and reference.
- “Three View Drawing Excellence” by Steve Fox



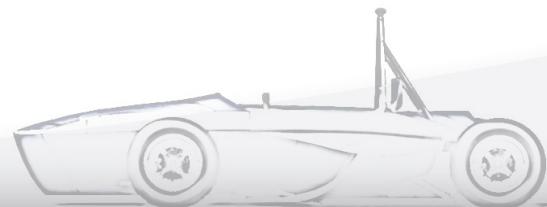
The Rules (Required)

- Must be a line drawing, no shaded, colored, or rendered images or photos will be accepted. (S6.4.3)
- Each view must be on a separate page (can have front and rear on front view) (S6.4.2)
- Must have a front view, side view, and top view (S6.4.1)



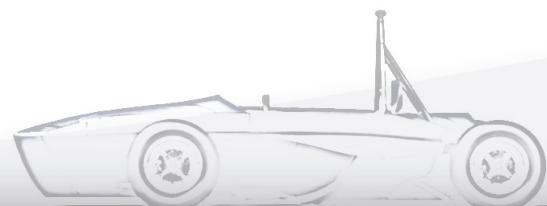
The Rules (Additional)

- Include important dimensions
- Include a useful title block
 - Include school name. Can have team logo, but school logo is preferable, school wordmark is best.
 - Include car number in a clear location.
 - Do not clutter title block. Car names, mascots, etc. are not necessary.
 - Include a scale for the drawing (11x17 page)



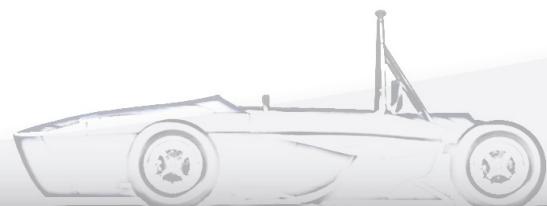
Evaluation

- The drawing is evaluated on-screen, and as a black and white print.
- Colors do not help your drawing.
- Judges will frequently evaluate the drawing before reading the design report.



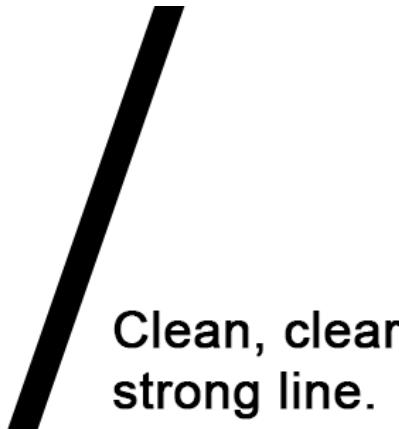
Evaluation

- Judges will go through all drawings and remove ones which don't make the cut.
- Judging gets progressively pickier.
- Tips are broken up to help give a sense of what a drawing of each “level” should include.

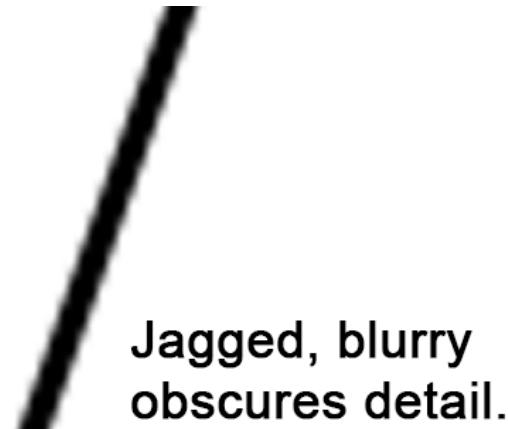


A Good Drawing

- No raster – lines look clean and sharp even when magnified.
 - Drawings should be vector format. A raster drawing will work if the resolution is high enough that it still looks crisp at 400% size.



Clean, clear
strong line.



Jagged, blurry
obscures detail.

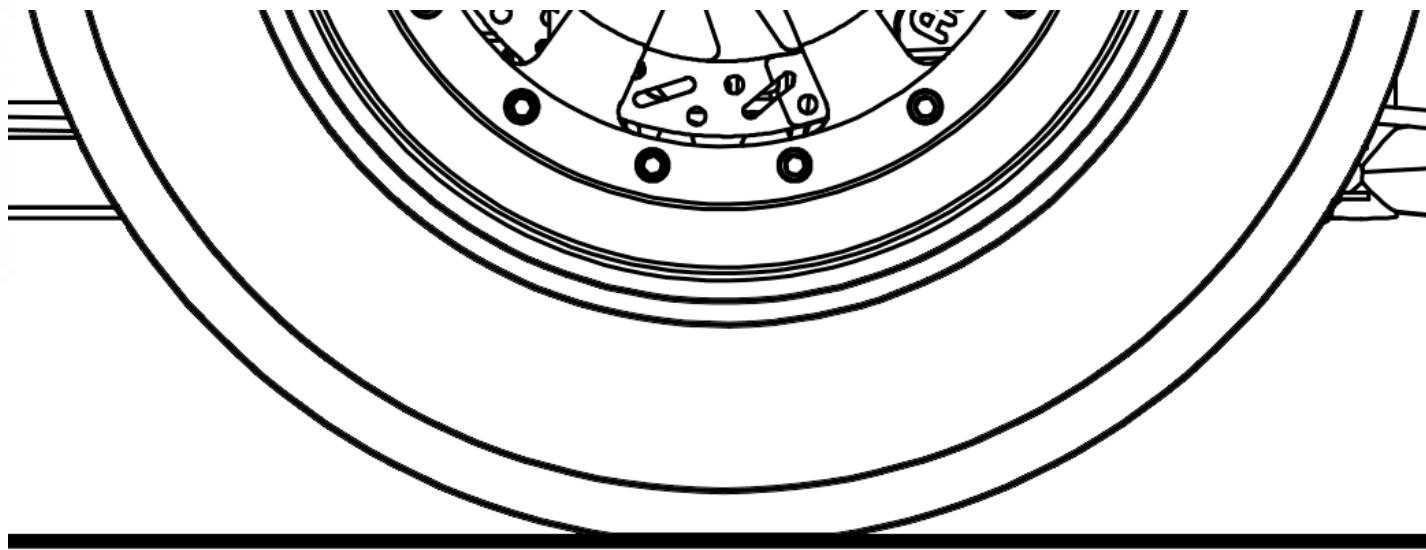


A Good Drawing

- Varied line weight
 - Use thick or thin lines to enhance the drawing
- Large, well-placed views
 - Is the view well-scaled, or is it a tiny image surrounded by empty space?
- Title block
 - Is the title block informative and non-intrusive?
 - It is not uncommon to have a specific title block for the three view drawing.



A Good Drawing



- Notice how line weight separates the ground, tire, and wheel just through varied thickness.
- Finely detailed parts can be clearer with thin lines.



A Good Drawing

Scale and sheet number are essential. Number your sheets 1,2,3

Include an area for notes, anything you wish to tell the judges.

Car number should be listed, in the title, in a separate box, or both.
Should be bigger than this

Drawing title should be descriptive and useful.

| | | | | | | | | |
|-------|--|---|---|---|---|---|---|---------------------------------------|
| NOTES | RACE CAR UNIVERSITY FSAE.SPEEEEEEED.EDU | | | UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE AS FOLLOWS: (mm) in | DRAWING TOLERANCES: | TITLE: CAR 321 SIDE VIEW | | REVISION: Q SCALE: SHEET 1 OF 3 |
| 5 | 1 | 4 | 3 | X.X ± .125 in X.XX ± .010 in X.XXX ± .005 in FRACTION ± 1/16 in MACH. ANGLE ± 0.5° BEND ANGLE ± 1.0° BREAK ANGLE ± 1.0° | X.X ± .125 in X.XX ± .010 in X.XXX ± .005 in FRACTION ± 1/16 in MACH. ANGLE ± 0.5° BEND ANGLE ± 1.0° BREAK ANGLE ± 1.0° | DRAWN BY: B.HORSCH DRAWN DATE: 2/1/2018 CAR NUMBER: 321 | MATERIAL: SEE COMPONENTS QUANTITY: 1 VEHICLE: SPRINTER GT18 | |

Wordmark is large and easy to see.
Team website address can be included

Units are essential.
Best to use dual units.

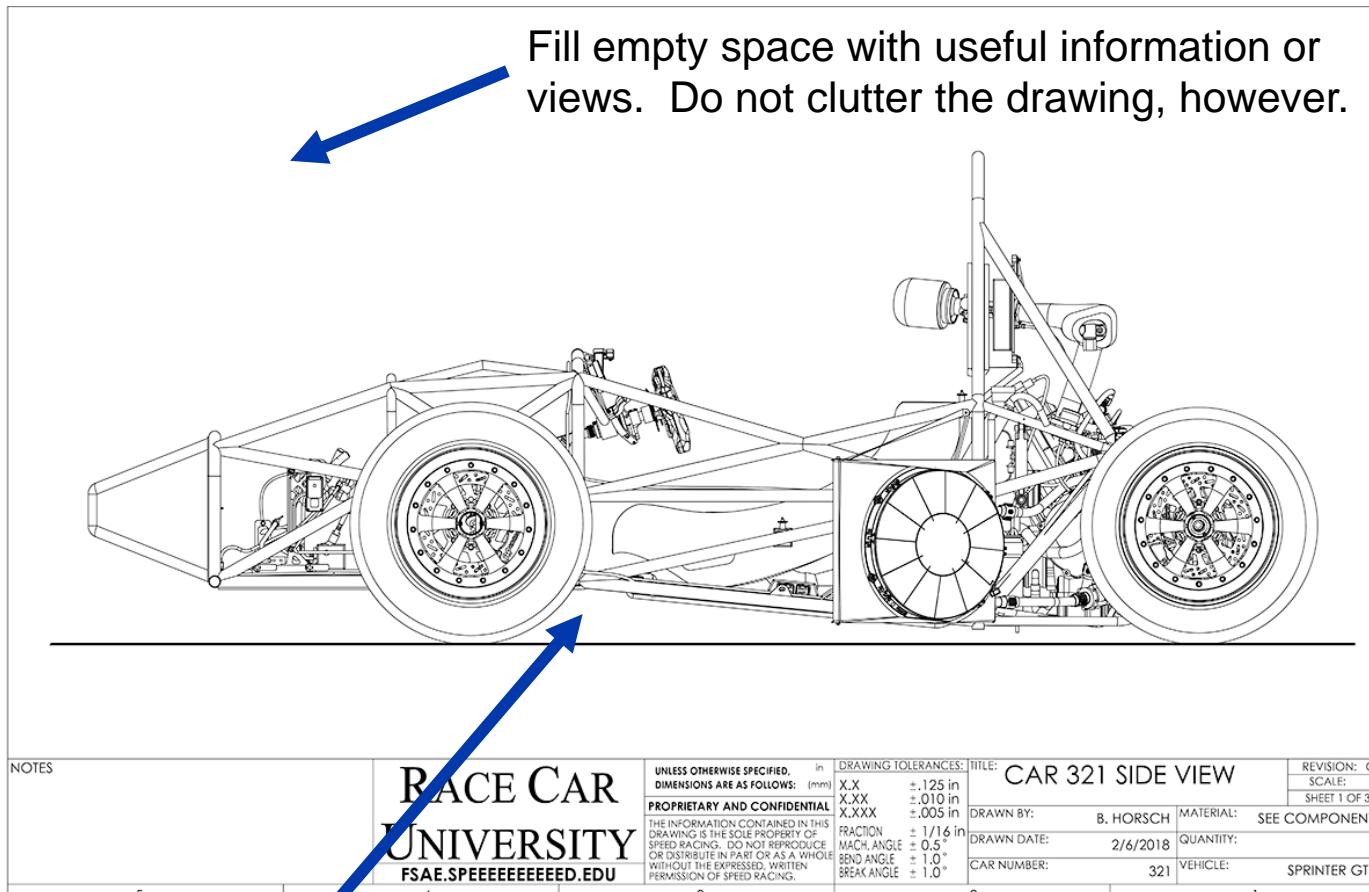
Confidentiality notice is standard practice in industry.
It is not required here, up to the team whether to include it.

Car name is not useful but is OK if small

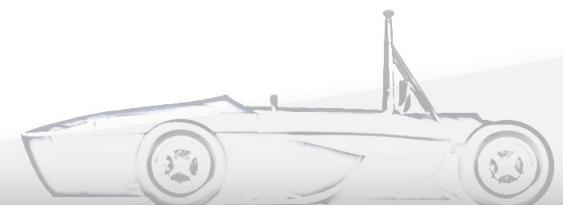
Block tolerances are useful.
These give a reasonable idea of the tolerances to which you build. Do not use individual tolerances on any dimensions.



A Good Drawing



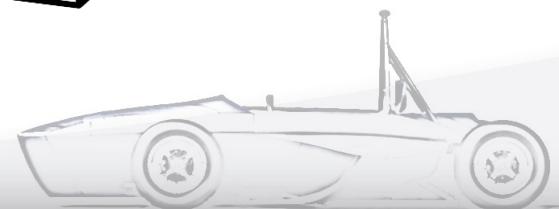
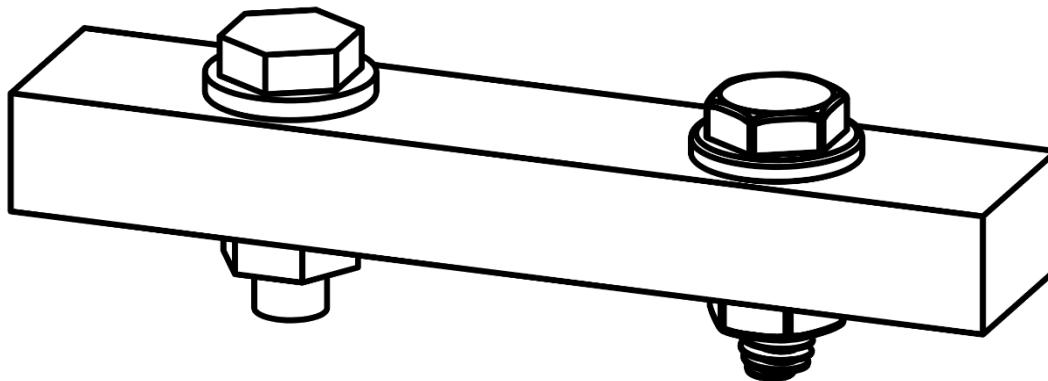
Make the view large and centered. The car is item #1. All else are secondary.



A Good Drawing

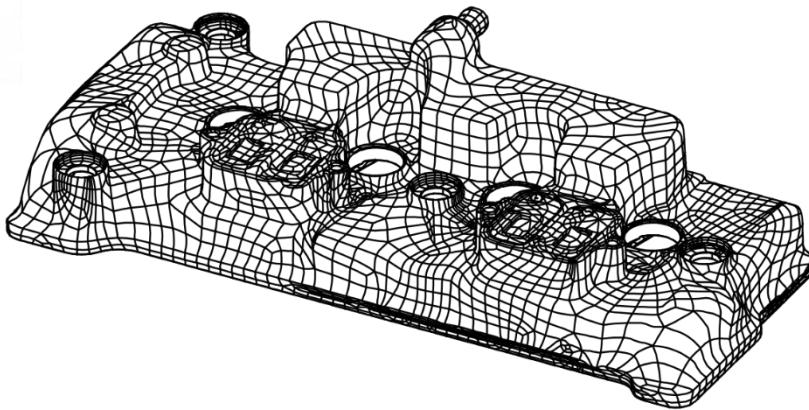
- Shows detail well

- It is not necessary to show every detail, and this can make a drawing cluttered or hard to read.
- Only detail so much as helps the drawing, include fasteners and other small features but don't go overboard.

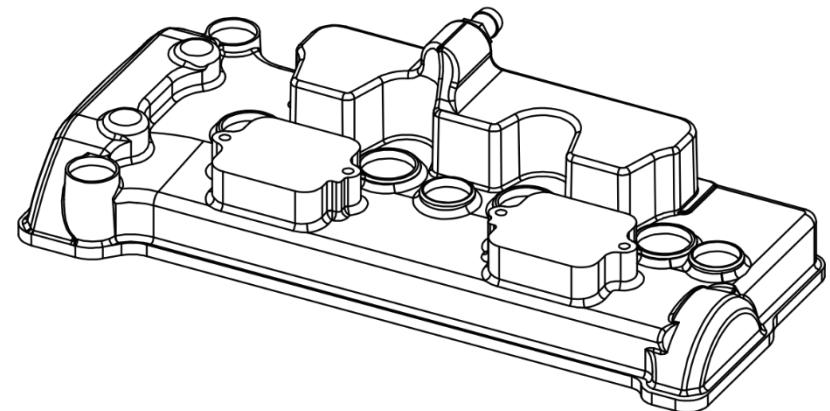


A Good Drawing

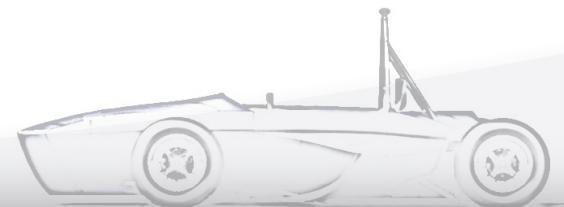
- Meshes do not show well in drawings



This valve cover is difficult to see or grasp details. It becomes a mess.



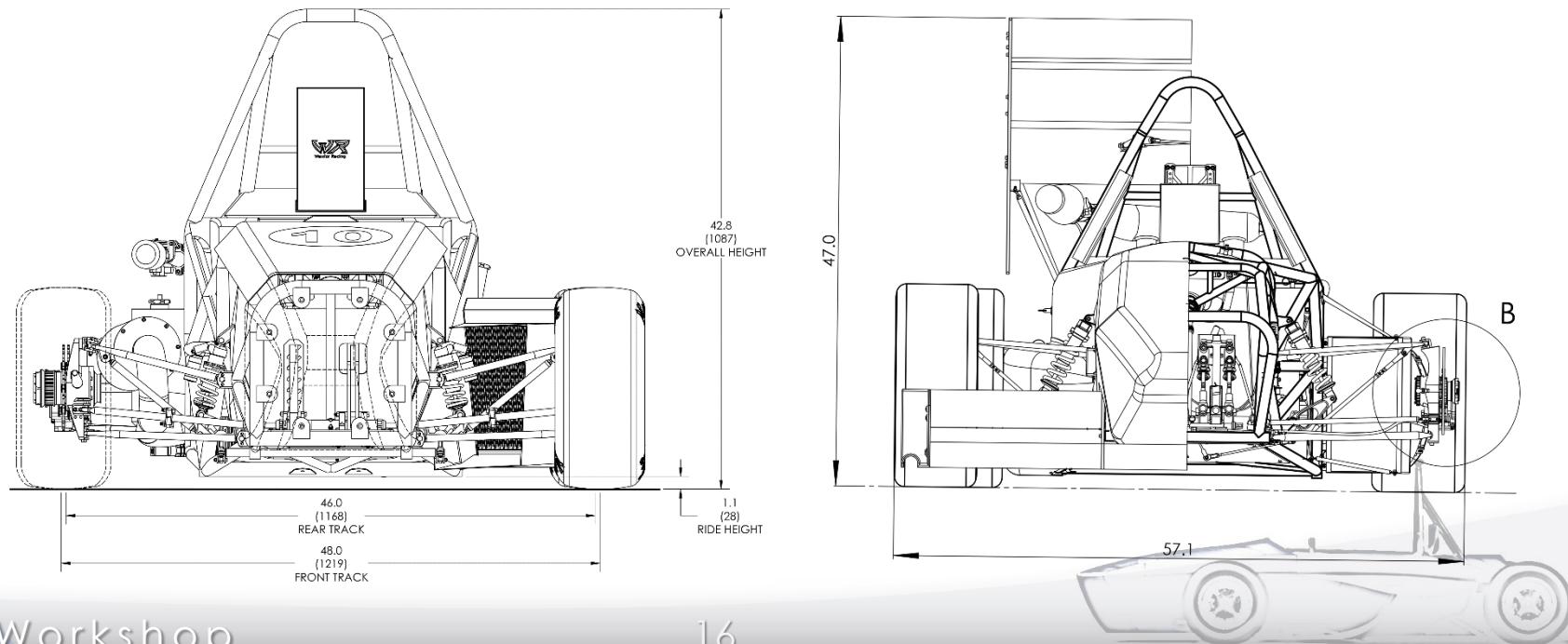
This valve cover conveys the important geometric shape and doesn't fret about perfect accuracy.



A Good Drawing

○ Give useful dimensions

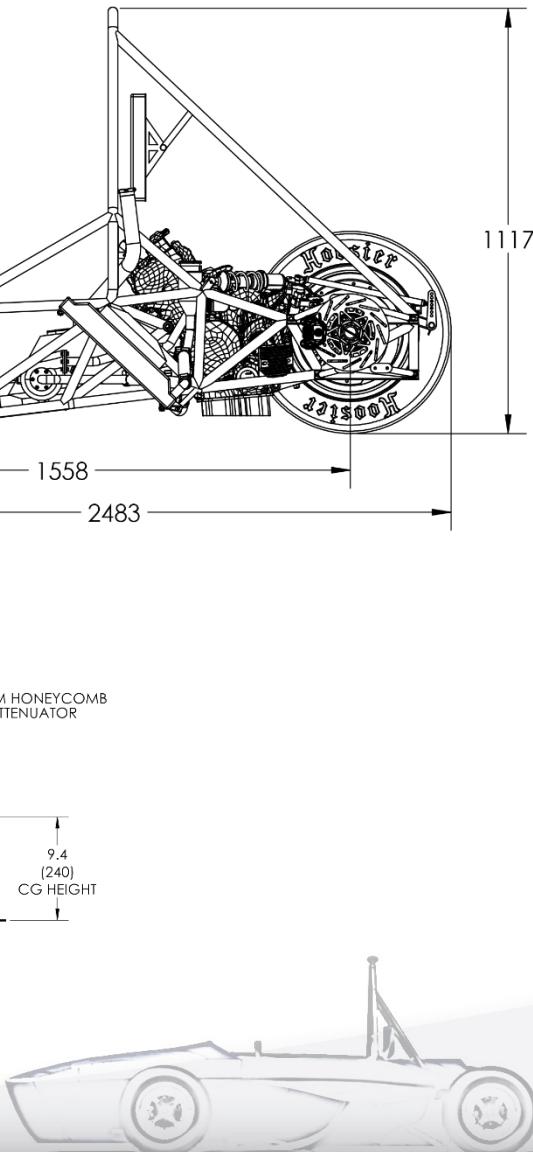
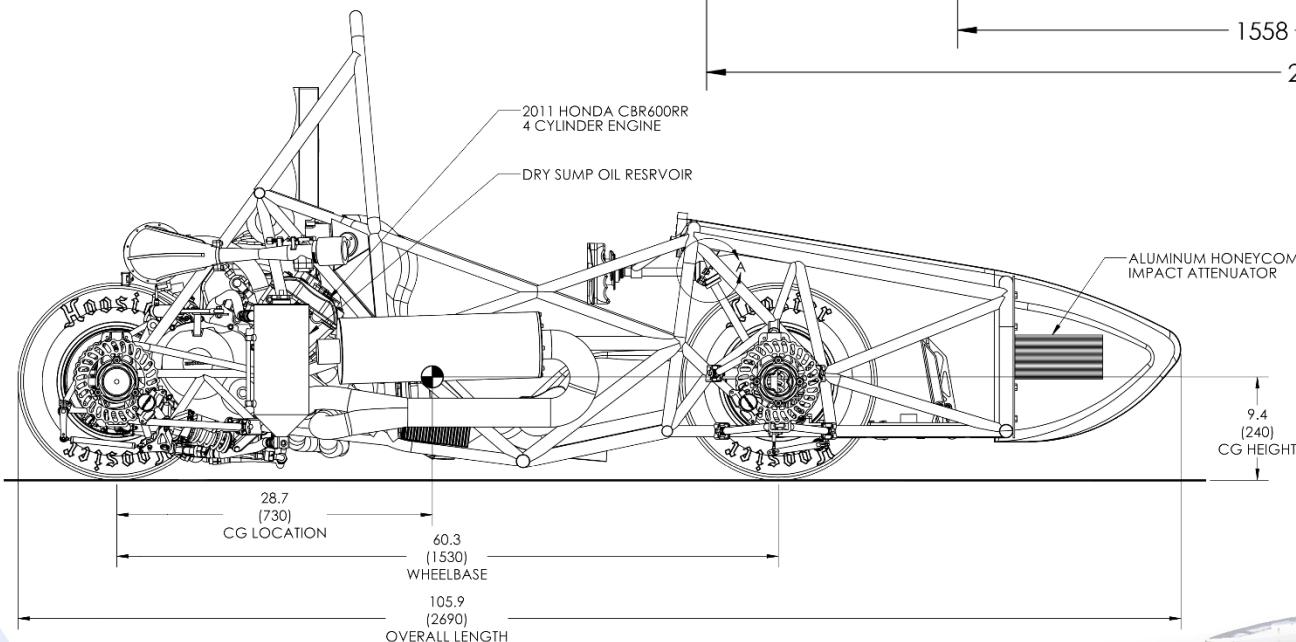
- Track width, wheelbase, overall length and width are a must.
- Remember that these are overall drawings. Dimensions of specific subassemblies are usually not useful.



A Good Drawing

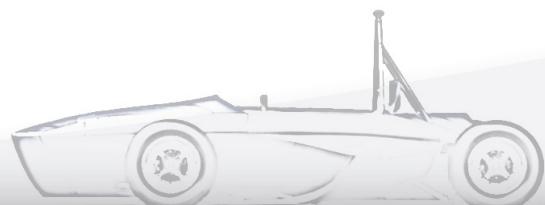
- >Show a full vehicle

- Which gives more information?
- Do not use a section view as the main view. The car should be represented in whole, not in part.



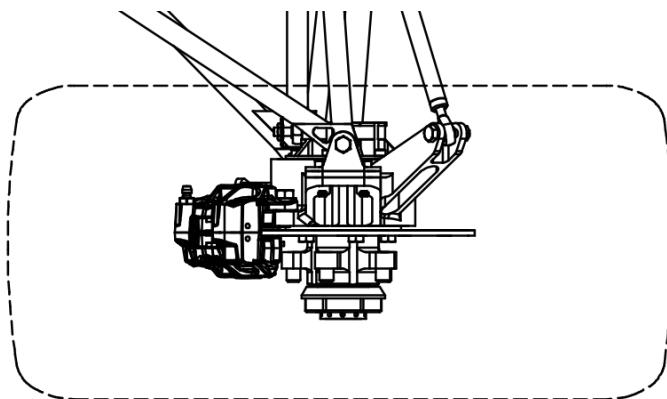
A Great Drawing

- This is where details get pickier.
- A good drawing will help you, but a great drawing will get you in the top 10.
 - Remember that top 10 drawings are posted publicly on-site. Take pictures, learn from all 10.



A Great Drawing

- Remove components for clarity
 - It is usually obvious why something is missing, forgetting to draw a part does not constitute a good drawing.
 - “XXX Removed for clarity” note doesn’t hurt.
 - Dashed lines to display where a hidden part *would* go is a plus.



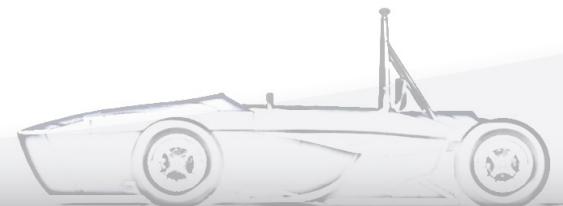
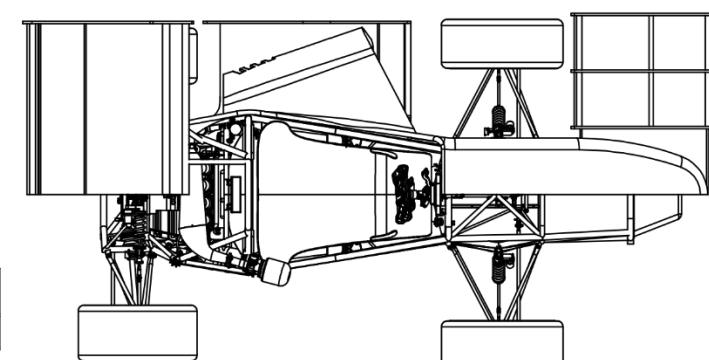
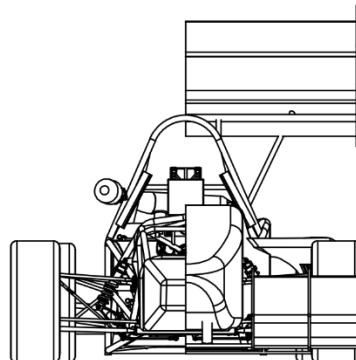
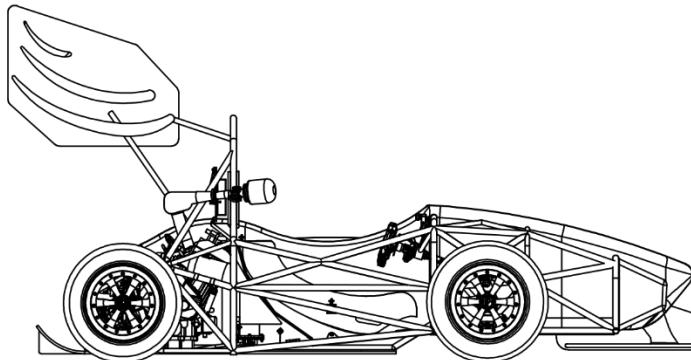
NOTES:

1. WHEELS HIDDEN FOR CLARITY
2. HALF OF BODY AND SEAT HIDDEN FOR CLARITY, TRANSPARENT PROFILE LEFT FOR REFERENCE.



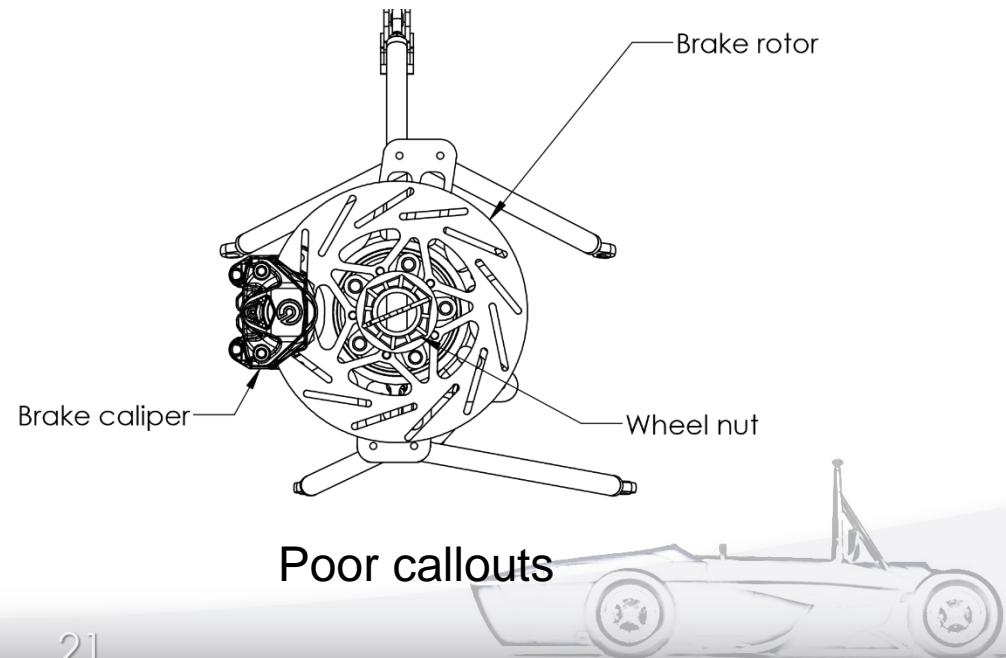
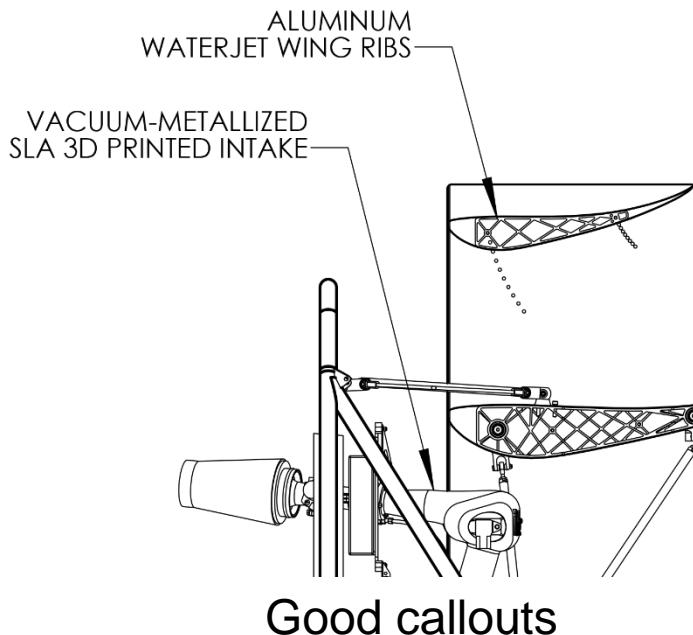
A Great Drawing

- Remove parts from the same side in every view.
 - It can be confusing to see components appear and disappear across views, adds a level of consistency and professionalism.



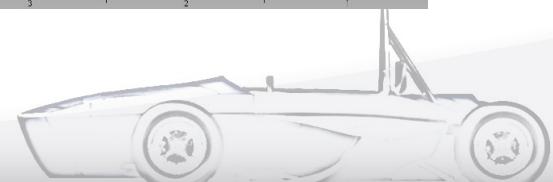
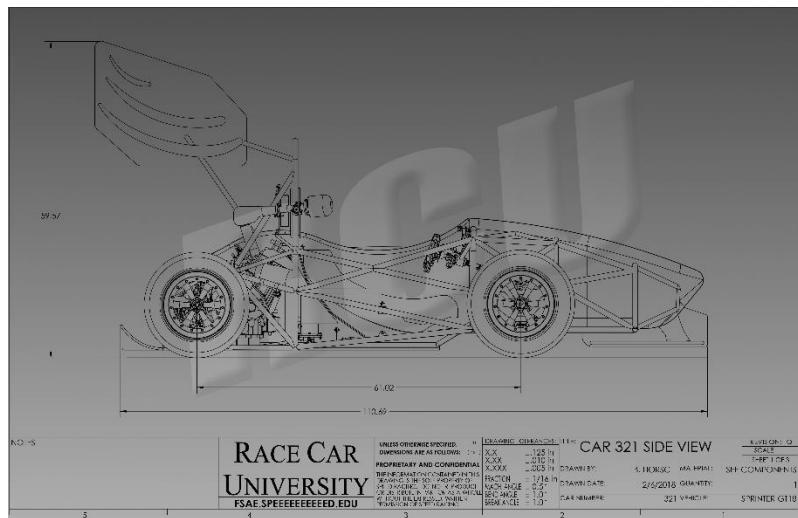
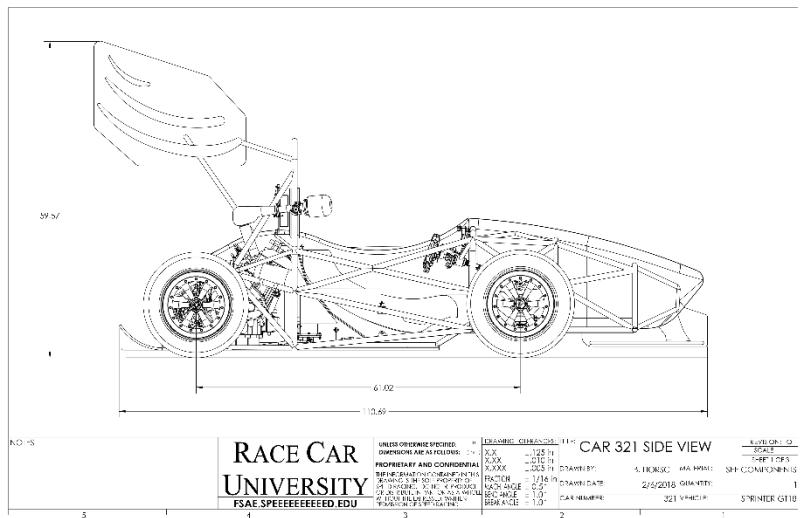
A Great Drawing

- Use descriptive callouts to draw attention to important components
 - Tie this to your design report. Anything which is mentioned in detail in the report should be called out in the drawing.
 - Do not litter the drawing with useless callouts.



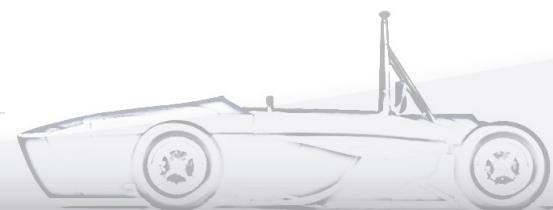
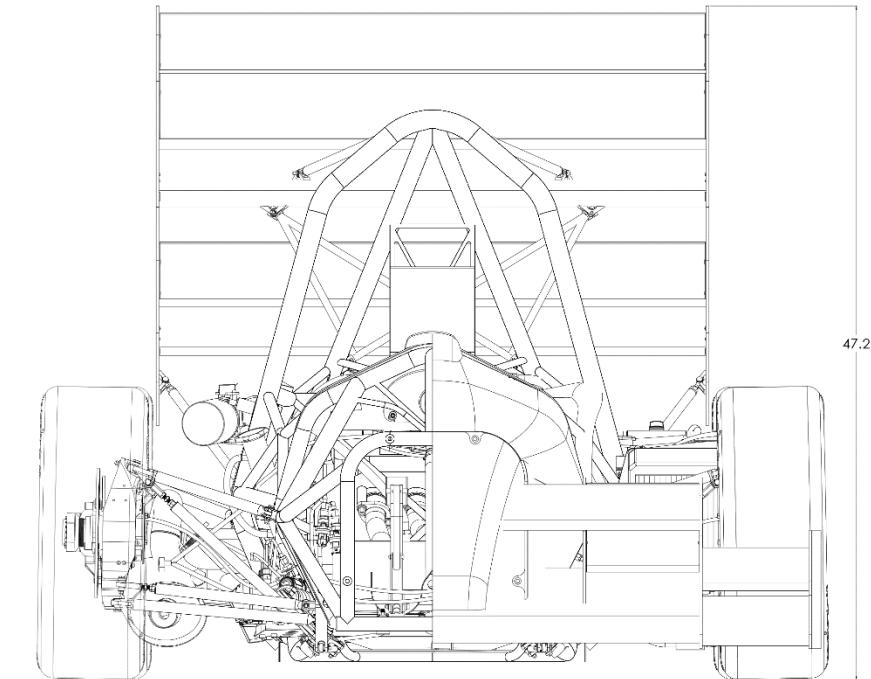
A Great Drawing

- Use a clean, blank background.
 - Logos, watermarks, and shaded backgrounds are detrimental to an overall drawing.



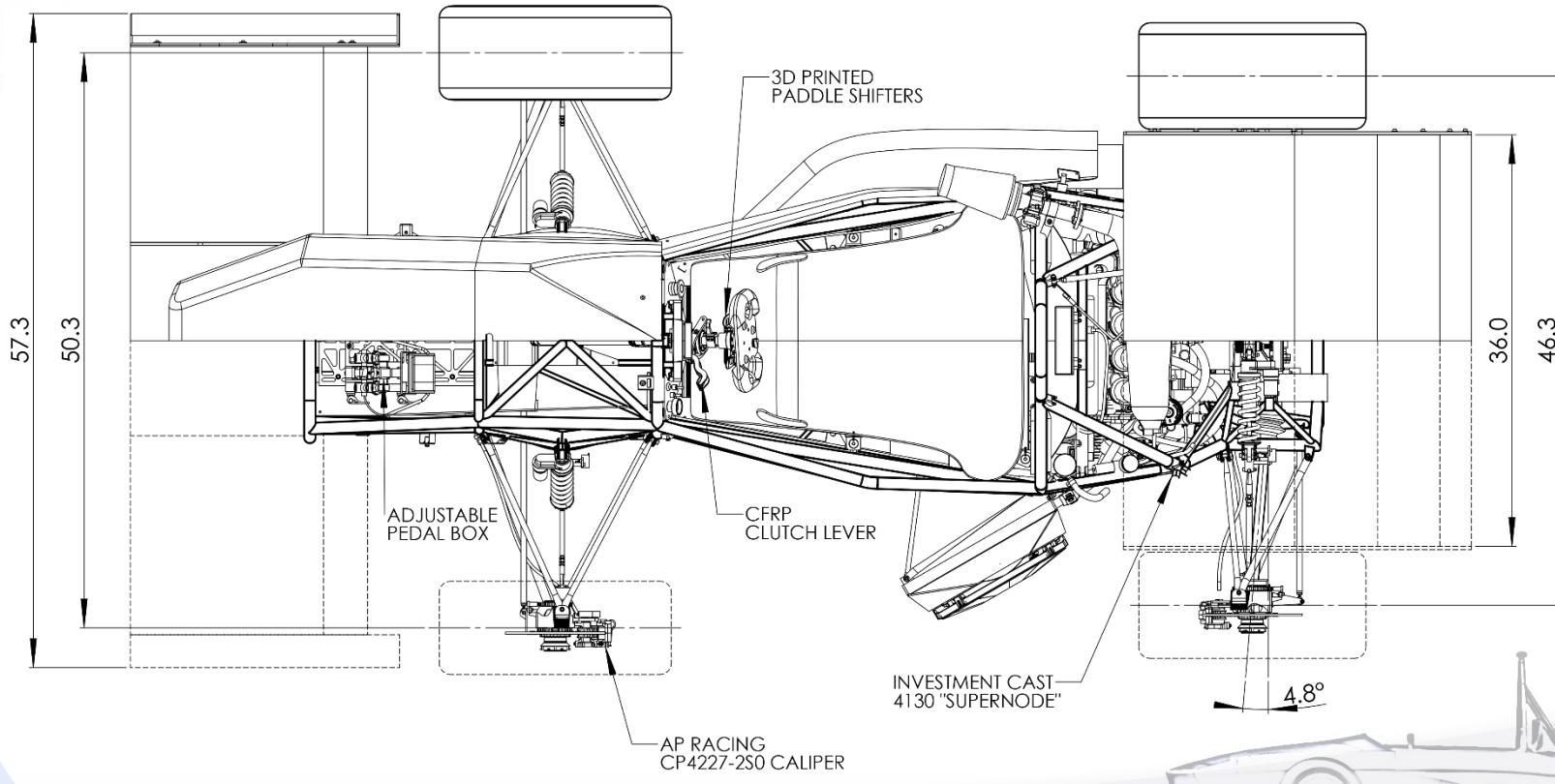
A Great Drawing

- Use a ground plane
 - Show how the car sits at ride height
 - Use a solid line, not a dashed line



A Great Drawing

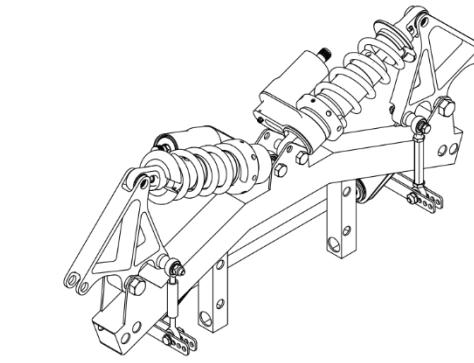
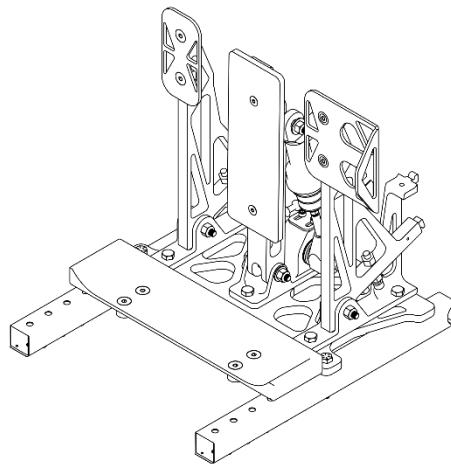
- Give reasonable dimensional accuracy
 - Usually whole millimeters and inches to 1 decimal.



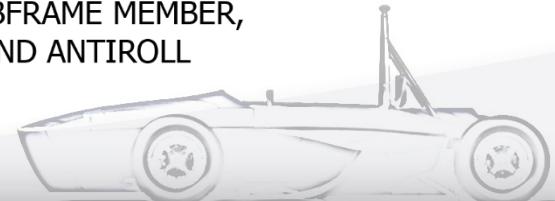
A Great Drawing

- Use detail and breakout views to clarify
 - Show off components which are difficult to see in the three main views
 - Don't bother with unhelpful views
 - Iso views of suspension corners, for example, are not helpful.

DETAIL F
SCALE 1:3
ADJUSTABLE
PEDAL BOX

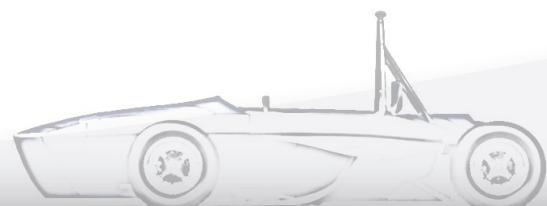


DETAIL D
REMOVABLE SUBFRAME MEMBER,
DAMPERS, AND ANTIROLL



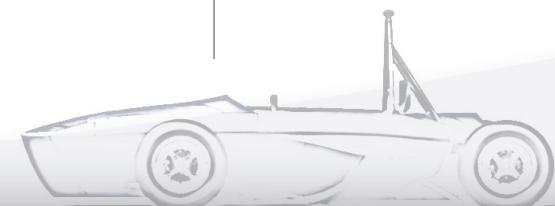
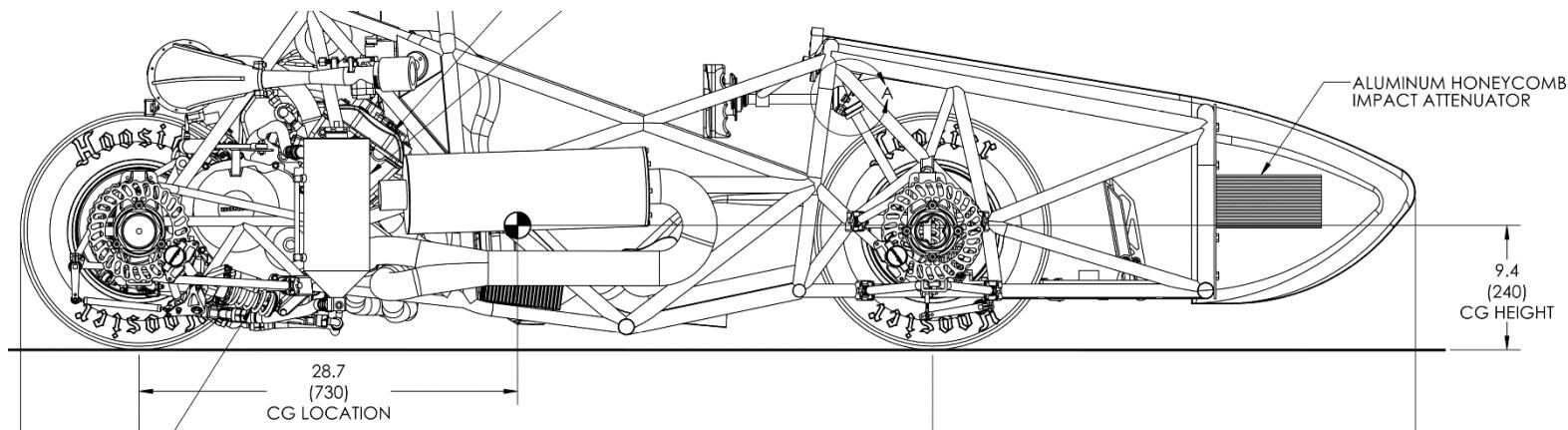
An Outstanding Drawing

- This is where things get VERY picky
- These are drawing features which are frequently featured in top 3 drawings
- These extra touches can be the difference between winning the award and sitting 4th or 5th



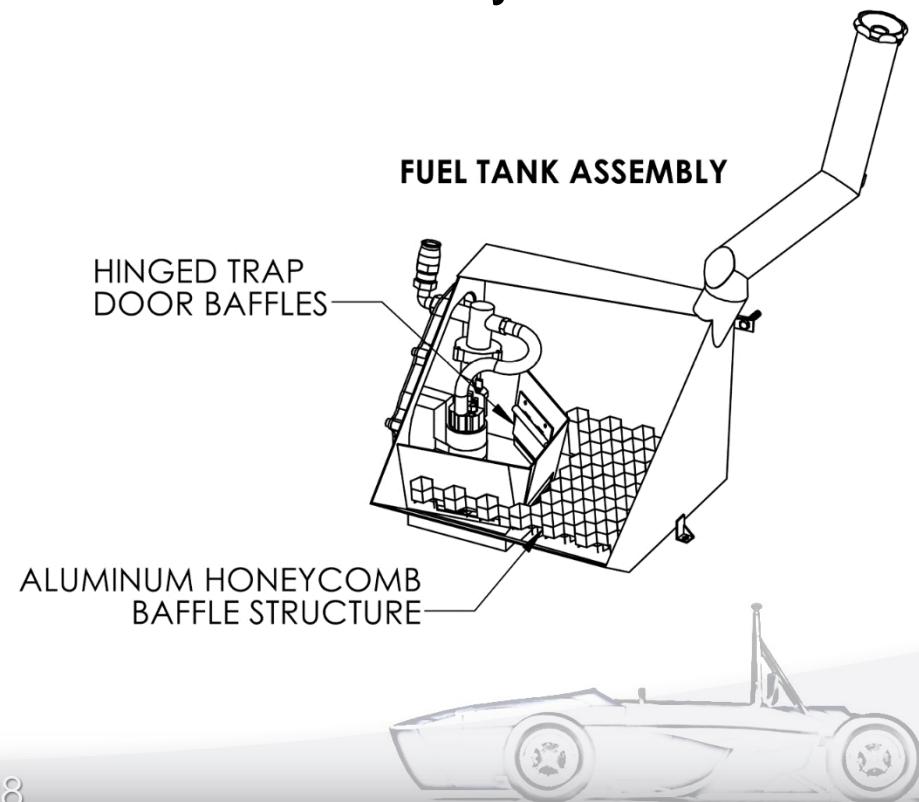
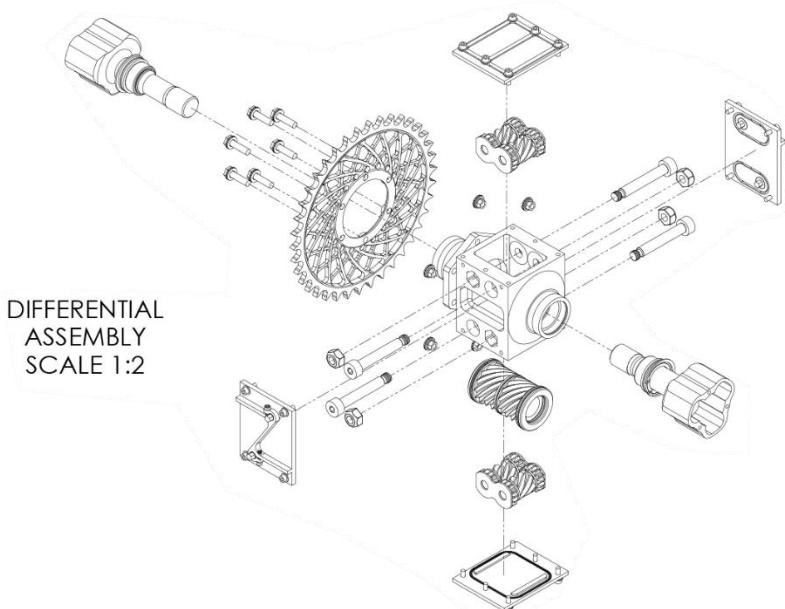
An Outstanding Drawing

- Show the CG location
 - CG is a useful metric for your car
 - Specify assumptions in the leader or notes
 - With/without driver
 - With/without fluids
 - How heavy is driver?



An Outstanding Drawing

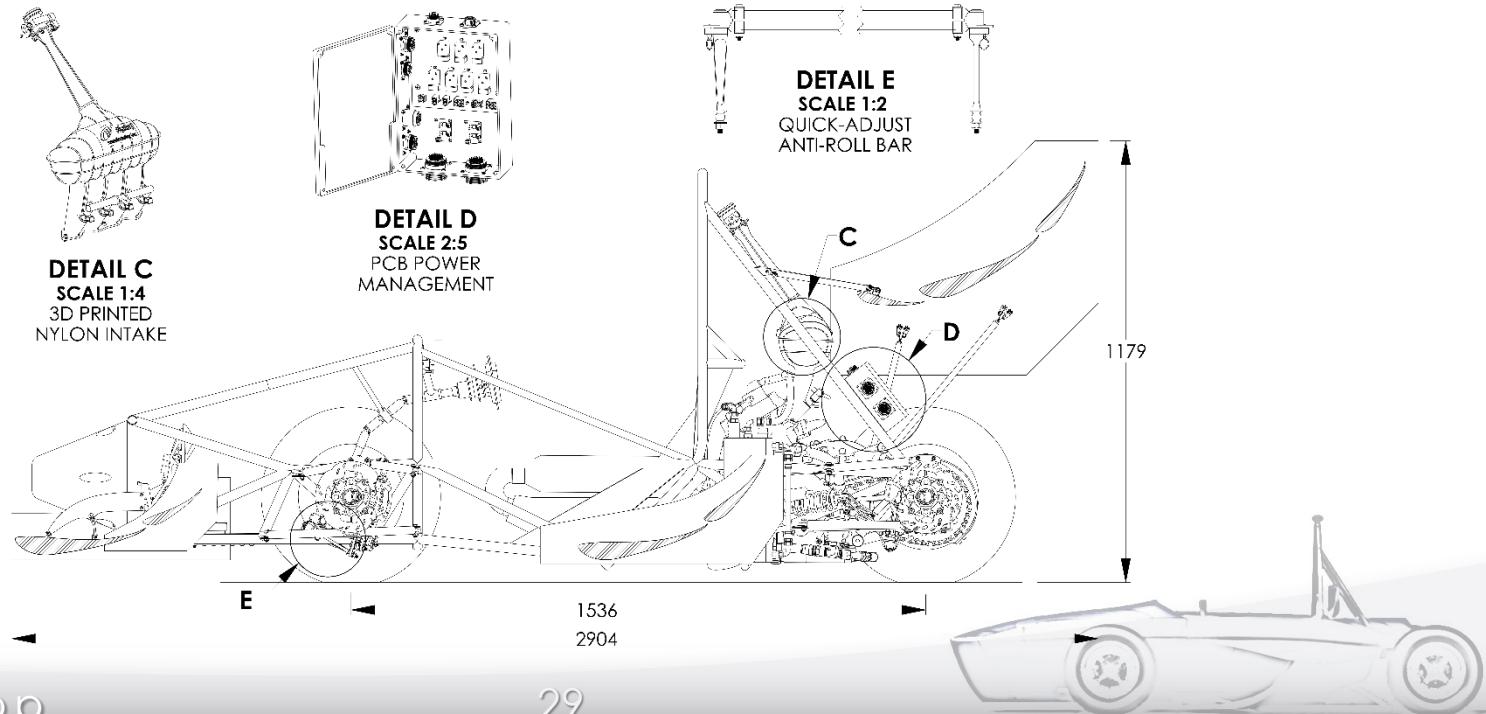
- Use section and exploded views
 - Show intricacies and supplement main drawing
 - Do not sacrifice main view size or clarity



An Outstanding Drawing

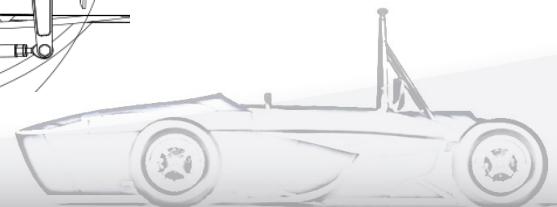
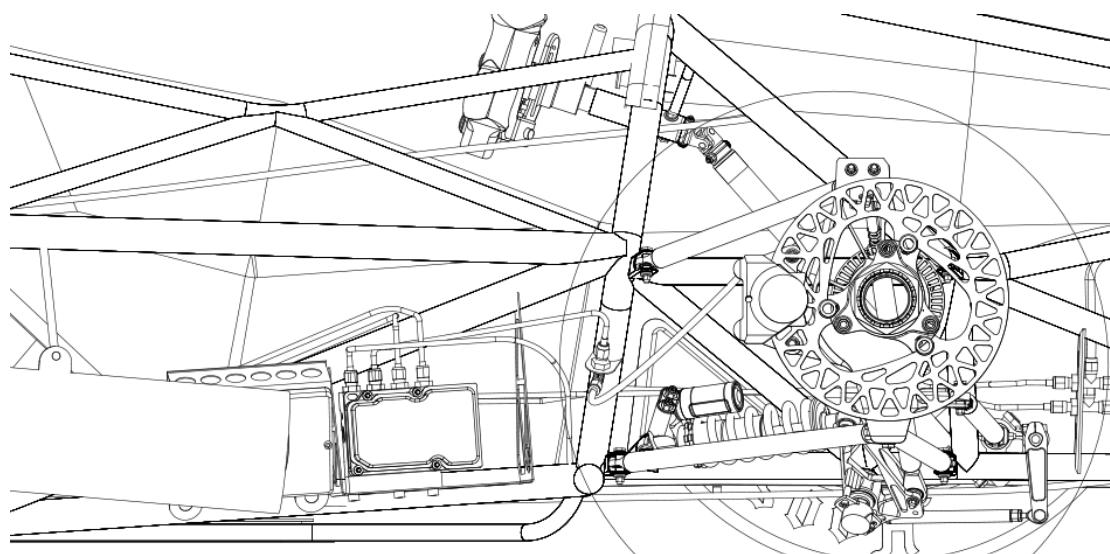
○ Be clean and elegant

- Drawings should be easy to read at a glance and pleasing to see.
- Cluttered or difficult to read areas hurt a judge's ability to gather information quickly and will harm a drawing.



An Outstanding Drawing

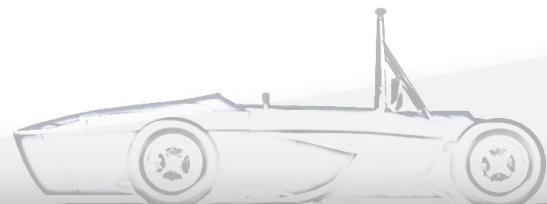
- Include wire harness, brake lines, misc lines and hoses
 - This is a balancing act. If they are cleanly integrated they can enhance a drawing, but a mess of hoses and wires can instead make it confusing.



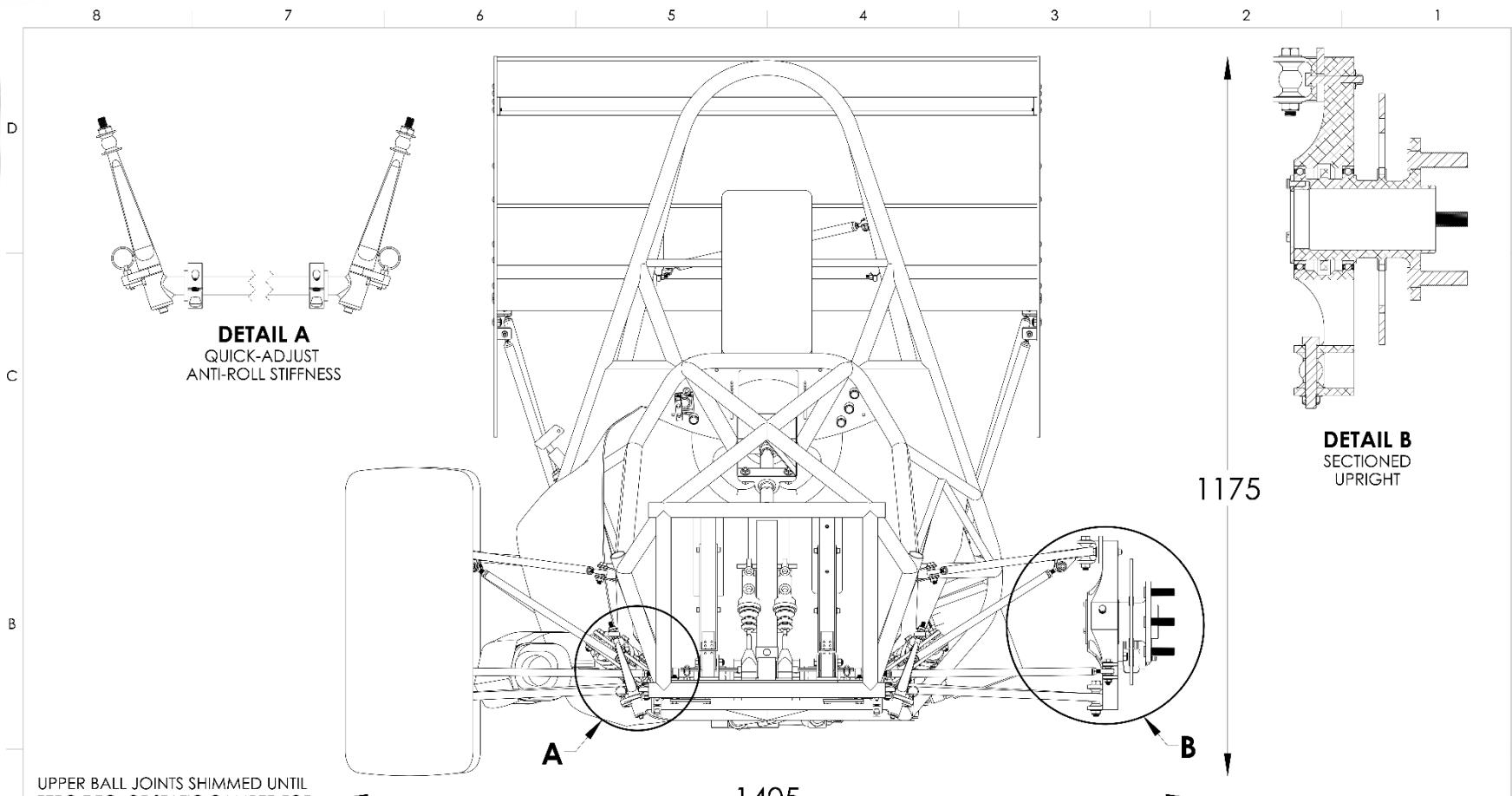
An Outstanding Drawing

- Find minor touches

- Center your steering wheel
- Cutaway seat to show hidden components
- Include a reference grid in your sheet format
- Make sure sectioned faces are hatched
- Call out components in section views if not obvious
- If aero is adjustable, mention configuration
- Provide sections or deconstructions of structural composites



Strong Example: UBC



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INTERPRET GEOMETRIC
TOLERANCING PER: Y14.5 2009

DIMENSIONS IN MM HAVE
TOLERANCES:

ANGULAR: $\pm 1^\circ$
X: ± 1

CAR #122
UNIVERSITY OF BRITISH COLUMBIA

DRAWN

J. CRONKITE

CHECKED

J. LEONG 32

DATE

2/27/2016

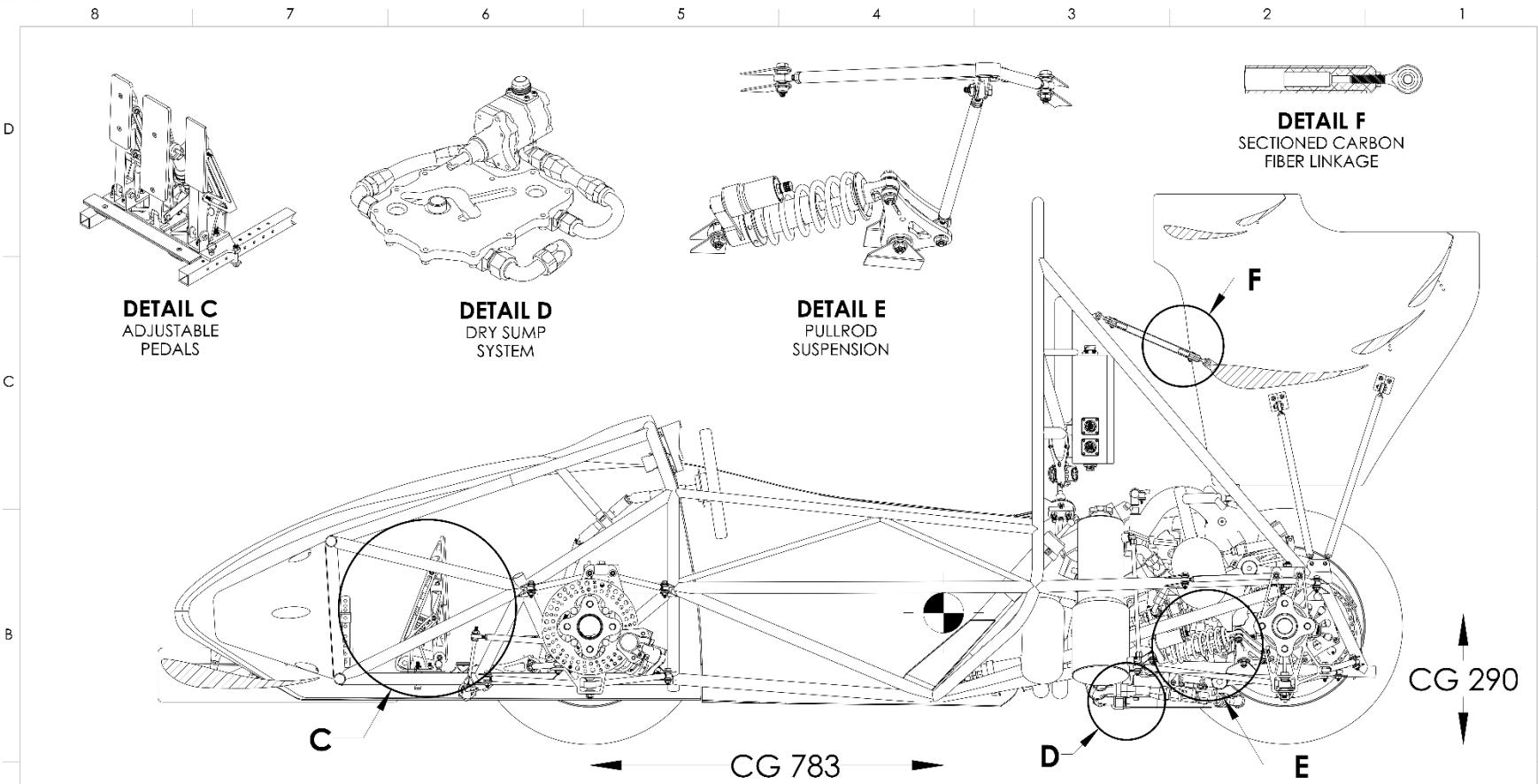


FORMULA UBC
R A C I N G

FORMULA UBC
6250 APPLIED SCIENCE LANE
VANCOUVER, BC V6T 1Z4
TEL: 604-822-2970
FAX: 604-822-2403
INFO@FORMULAUBC.COM

TITLE
2016 TOP LEVEL VEHICLE
SIZE DWG. NO. REV
D 100-000 F
SCALE UNITS SHEET
1:3 mm 1 OF 3

Strong Example: UBC



CG = CENTER OF GRAVITY
WB = WHEELBASE

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INTERPRET GEOMETRIC
TOLERANCING PER: Y14.5-2009

DIMENSIONS IN MM HAVE
TOLERANCES:

ANGULAR: - 1°
X: 1

CAR #122
UNIVERSITY OF BRITISH COLUMBIA

DRAWN
J. CRONKITE

CHECKED
J. LEONG

DATE
2/27/2016



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R A C I N G

FORMULA UBC
6250 APPLIED SCIENCE LANE
VANCOUVER, BC V6T 1Z4
INFO@FORMULABC.COM

TEL: 604-822-2970
FAX: 604-822-2403

TITLE
2016 TOP LEVEL VEHICLE

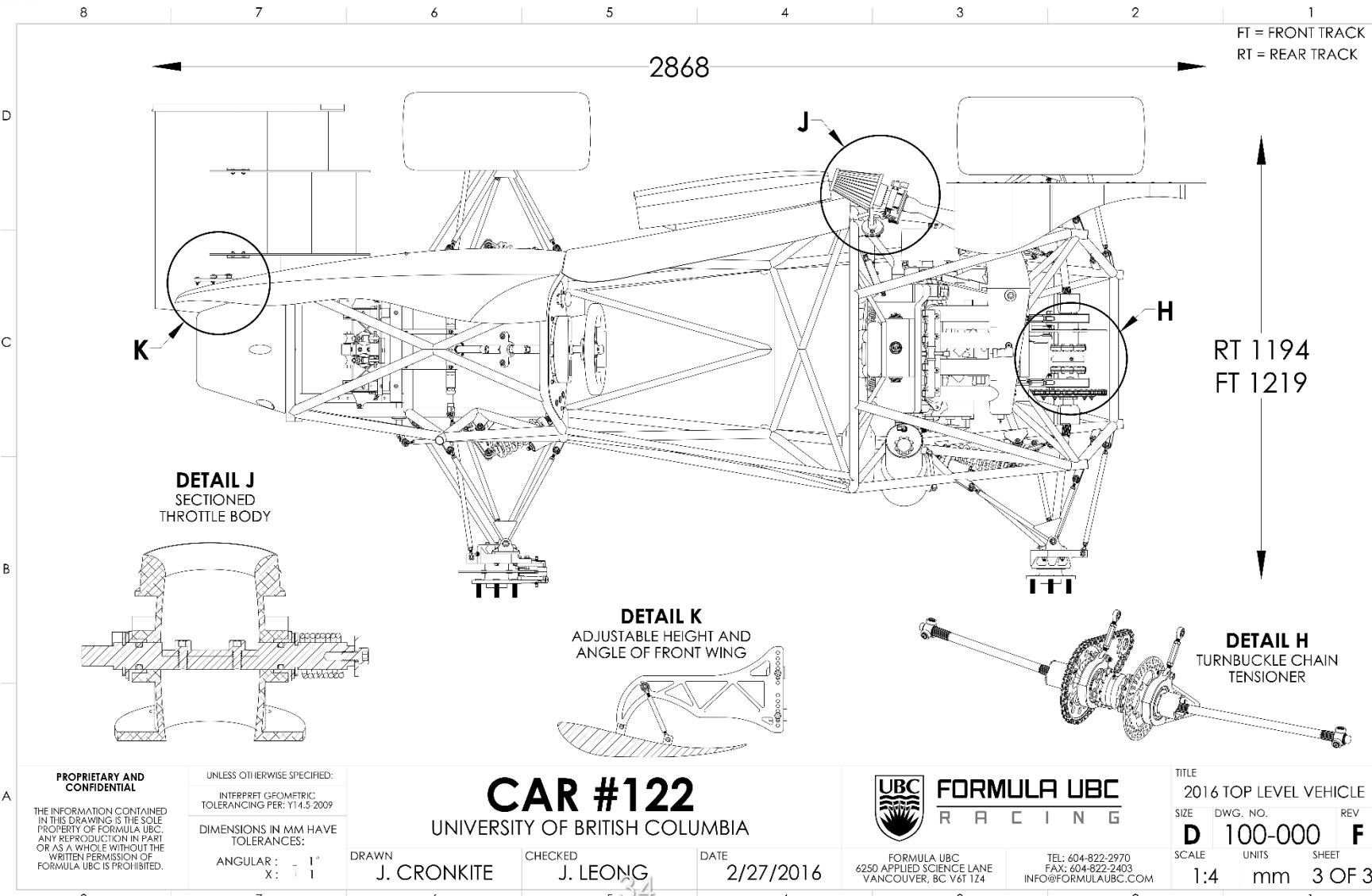
SIZE DWG. NO. REV

D 100-000 **F**

SCALE UNITS SHEET

1:4 mm 2 OF 3

Strong Example: UBC

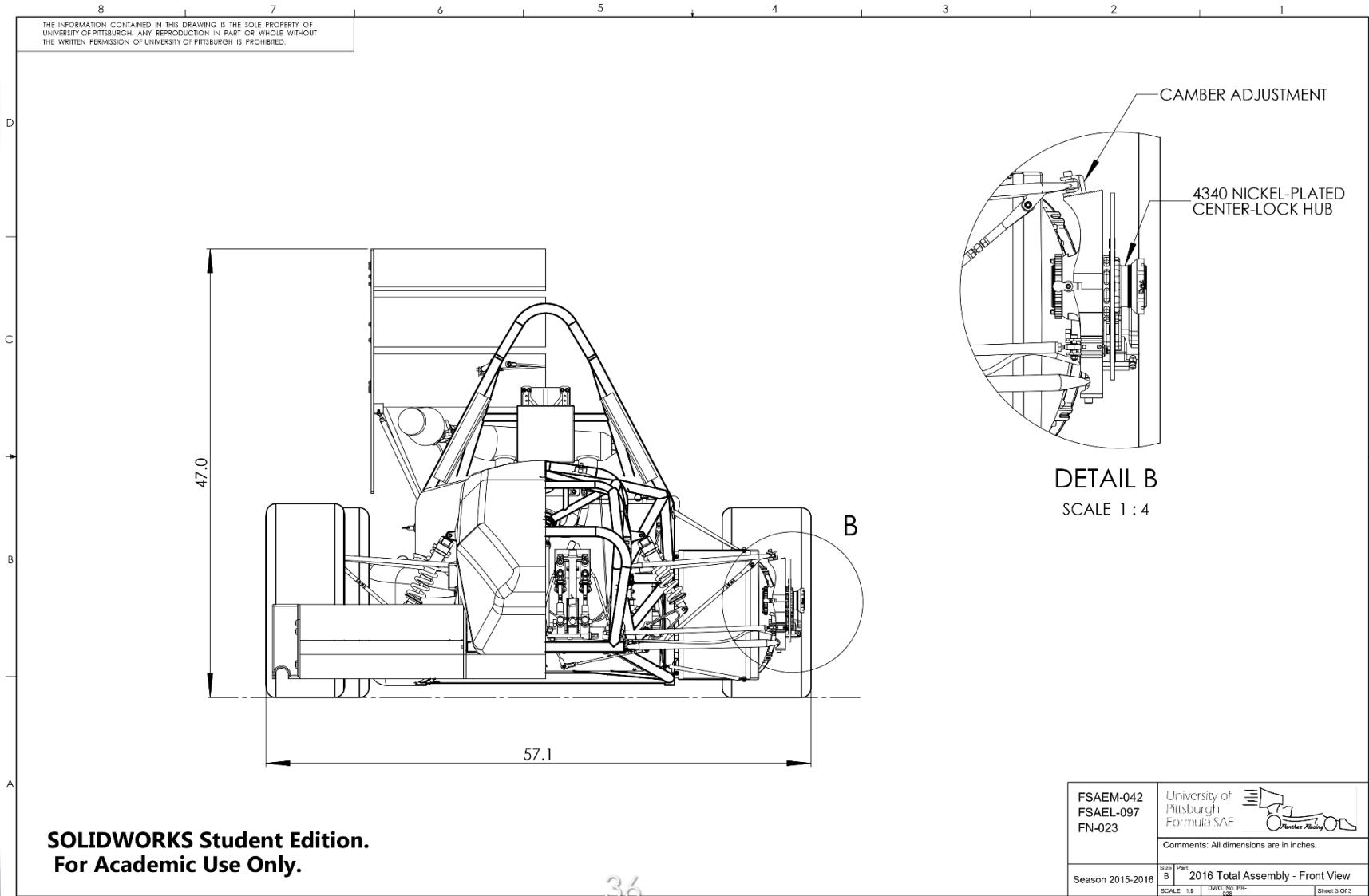


Strong Example: UBC

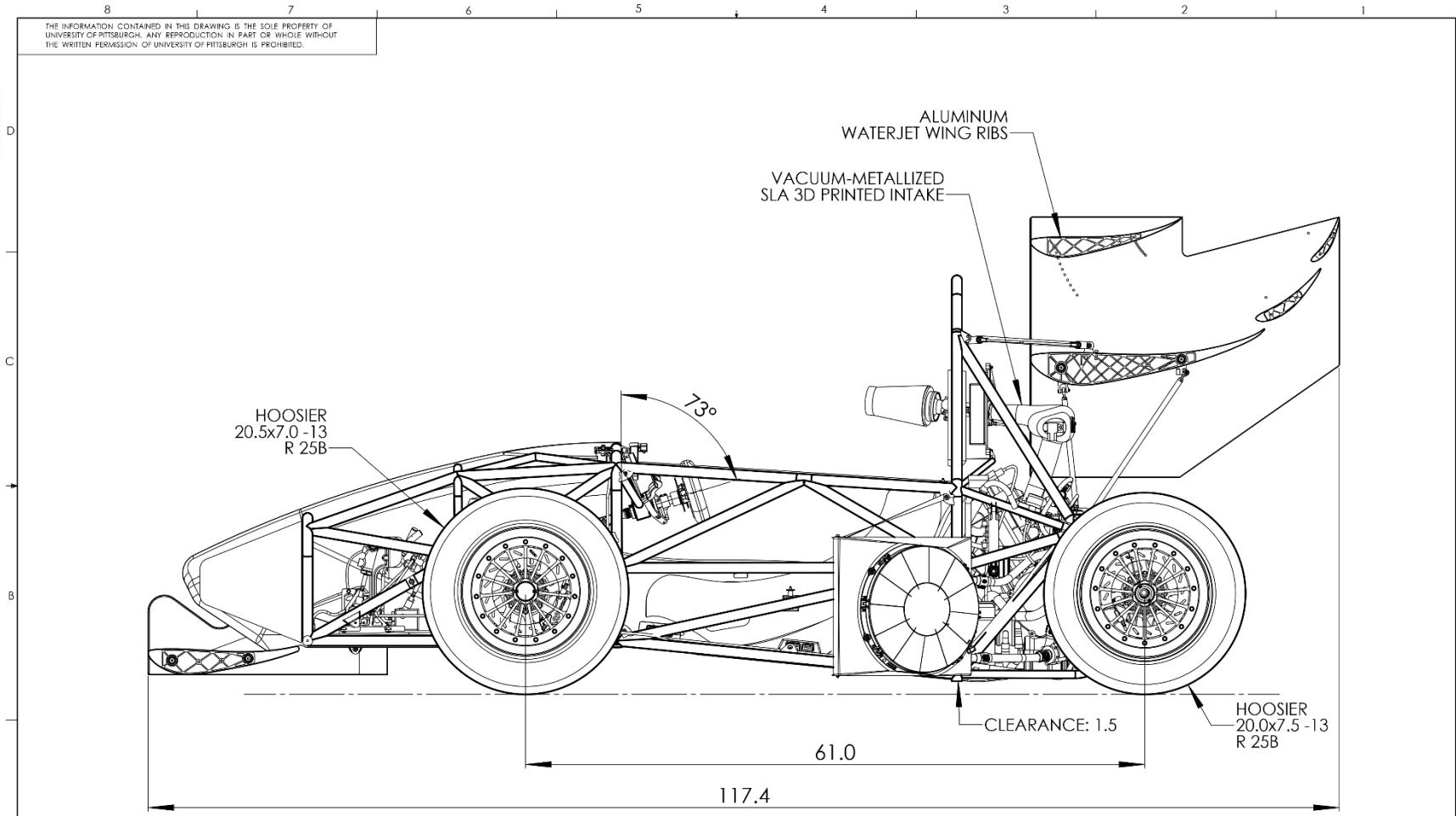
- What the judges said:
 - Excellent level of detail and information
 - Every detail view adds value
 - Unreasonable tolerance on CG, avoid tolerances on reference drawings
 - Line weights are good on computer, but could be better in print
 - Detail views need scales defined
 - Needs ground plane
 - Partial aero cutaways needed



Strong Example: Pittsburgh

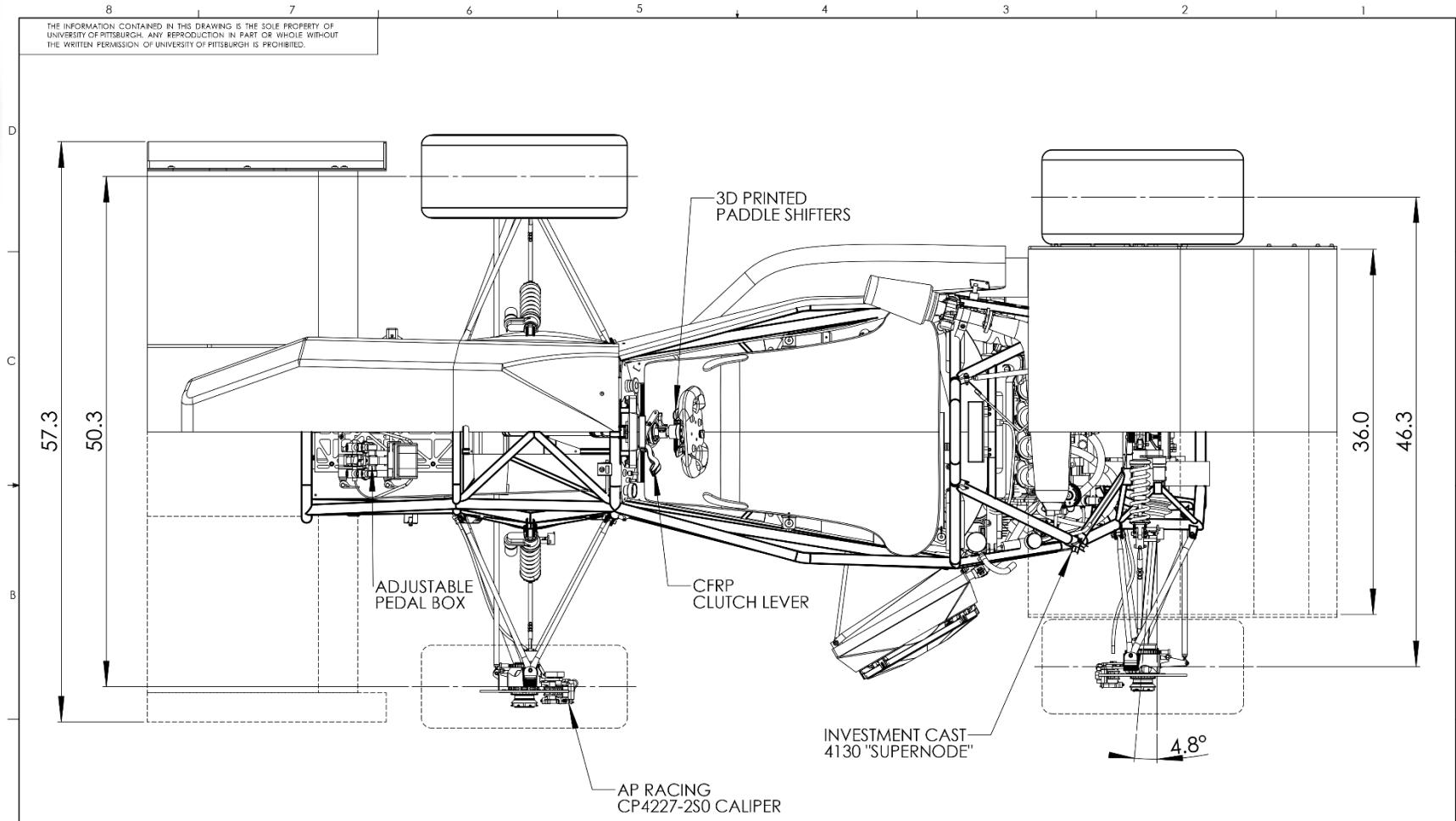


Strong Example: Pittsburgh



SOLIDWORKS Student Edition.
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Strong Example: Pittsburgh



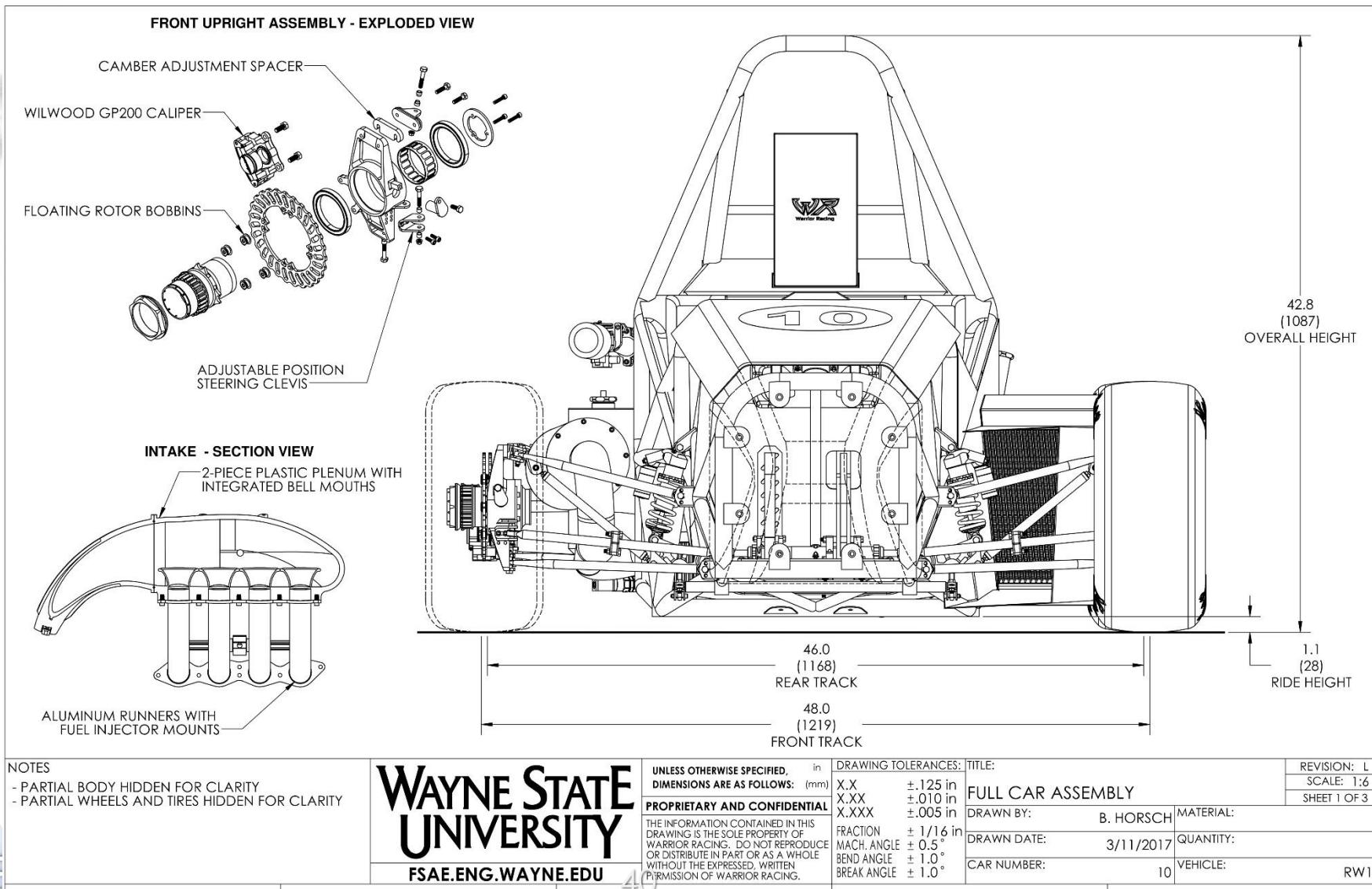
SOLIDWORKS Student Edition.
For Academic Use Only.

Strong Example: Pittsburgh

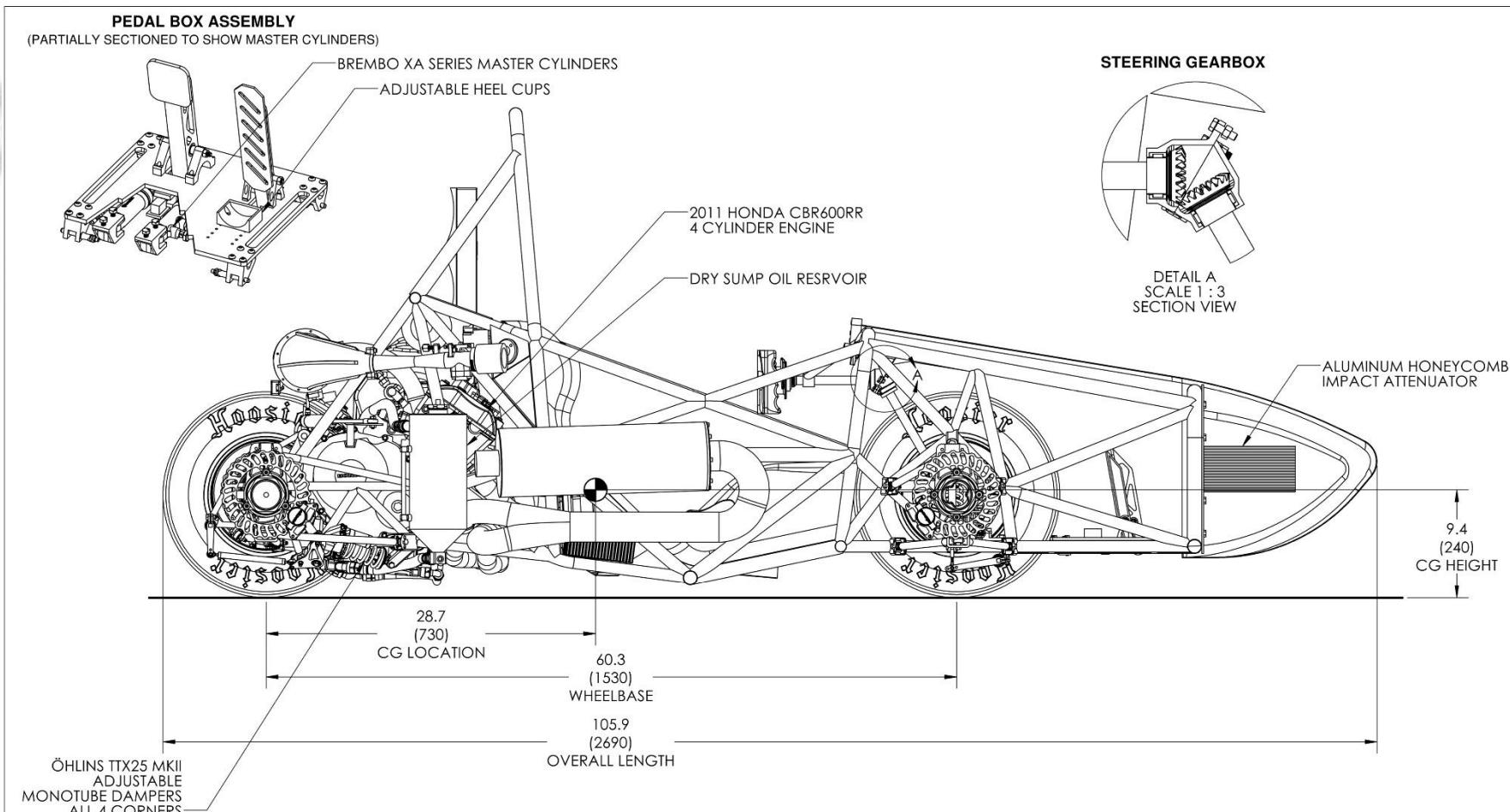
- What the judges said:
 - Lots of detail
 - Good use of leaders
 - Effective title block and reference grid
 - Good use of dashed lines
 - Seat should be cut away to show obscured parts
 - Steering wheel is not centered
 - Some irrelevant dimensions
 - Impact attenuator missing in top view



Strong Example: Wayne State



Strong Example: Wayne State



NOTES

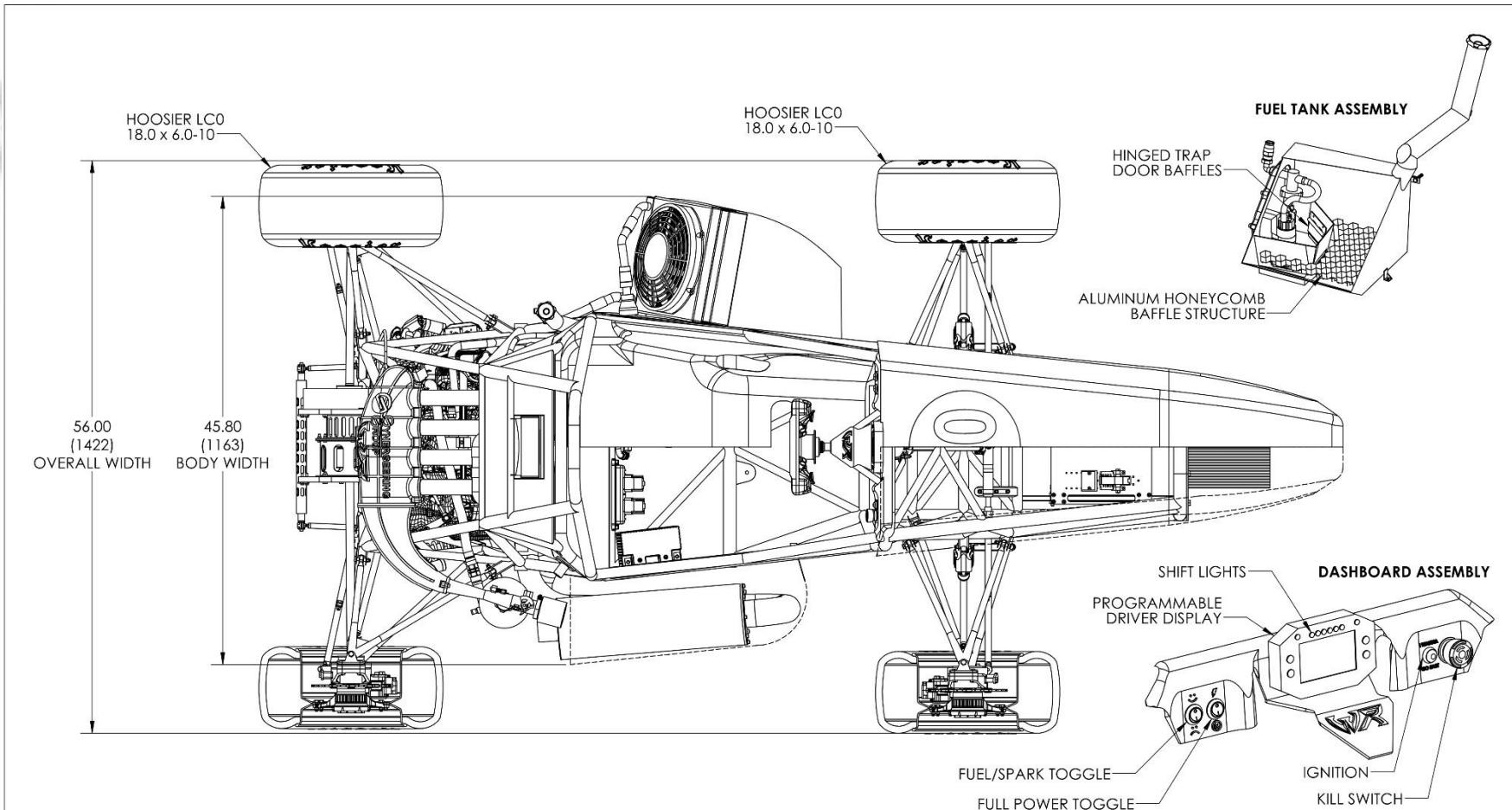
- PARTIAL BODY HIDDEN FOR CLARITY
- PARTIAL WHEELS AND TIRES HIDDEN FOR CLARITY
- PARTIAL SEAT HIDDEN FOR CLARITY

WAYNE STATE
UNIVERSITY
FSAE.ENG.WAYNE.EDU

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DIMENSIONS ARE AS FOLLOWS: (mm)
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| DRAWING TOLERANCES: | | TITLE: | | REVISION: L |
|---------------------|-----------|--------------------------|--|---------------|
| X.X | ± .125 in | FULL CAR ASSEMBLY | | SCALE: 1:8 |
| X.XX | ± .010 in | DRAWN BY: B. HORSCH | | SHEET 2 OF 3 |
| X.XXX | ± .005 in | MATERIAL: | | |
| FRACTION | ± 1/16 in | DRAWN DATE: 3/11/2017 | | QUANTITY: 1 |
| MACH. ANGLE | ± 0.5° | CAR NUMBER: 10 | | VEHICLE: RW11 |
| BEND ANGLE | ± 1.0° | | | |
| BREAK ANGLE | ± 1.0° | | | |

Strong Example: Wayne State



NOTES

- PARTIAL BODY HIDDEN FOR CLARITY
- PARTIAL WHEELS AND TIRES HIDDEN FOR CLARITY
- PARTIAL SEAT HIDDEN FOR CLARITY

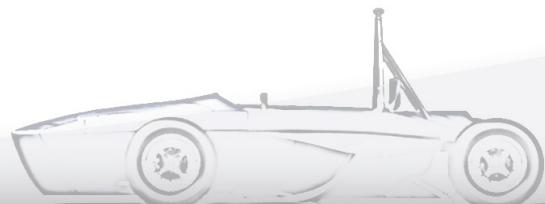
**WAYNE STATE
UNIVERSITY**
FSAE.ENG.WAYNE.EDU

UNLESS OTHERWISE SPECIFIED, in
DIMENSIONS ARE AS FOLLOWS: (mm)
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS
DRAWING IS THE SOLE PROPERTY OF
WARRIOR RACING. DO NOT REPRODUCE
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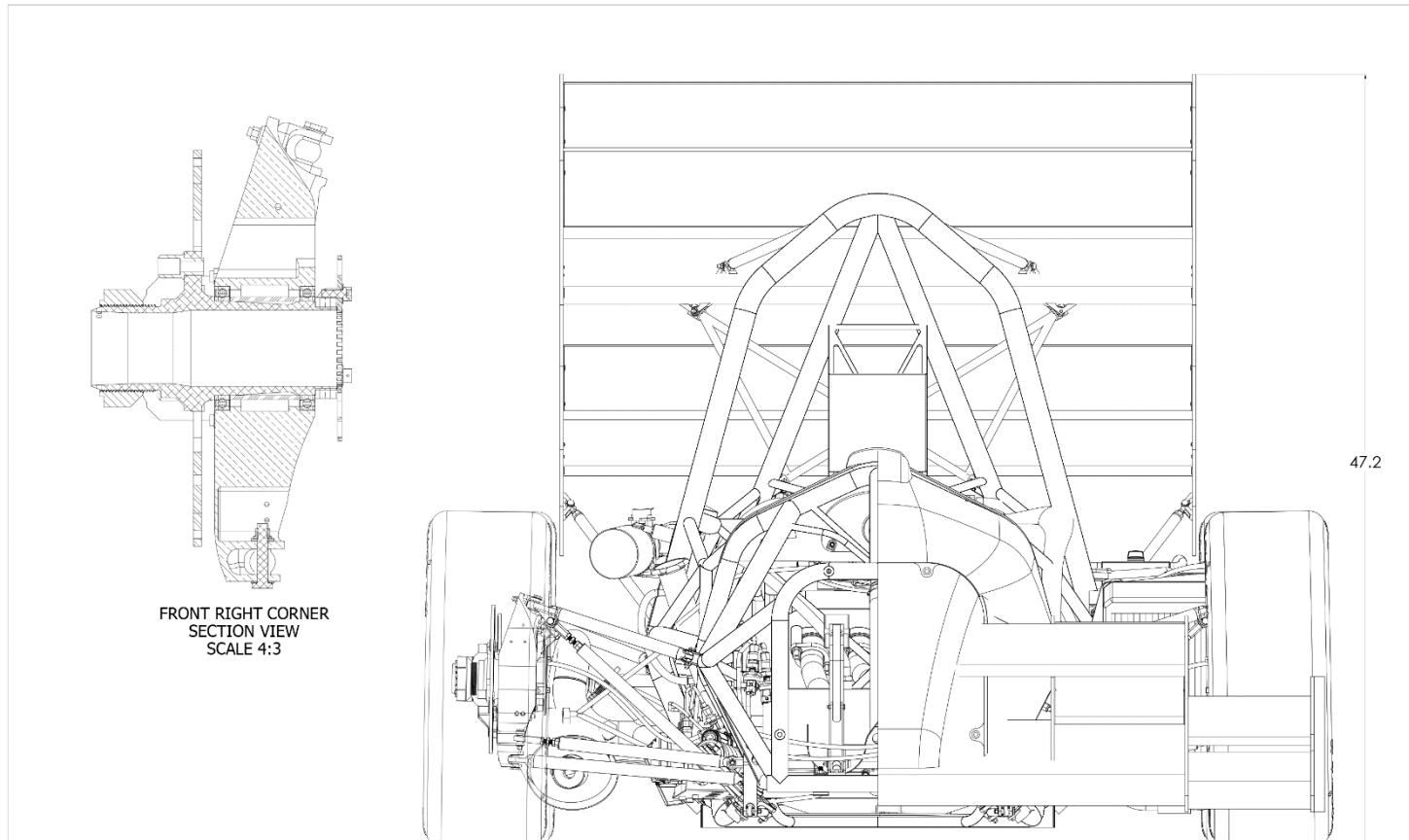
| DRAWING TOLERANCES: | TITLE: | REVISION: L |
|-----------------------------|--------------------------|---------------|
| X.X $\pm .125$ in | FULL CAR ASSEMBLY | SCALE: 1:9 |
| X.XX $\pm .010$ in | DRAWN BY: B. HORSCH | MATERIAL: |
| X.XXX $\pm .005$ in | DRAWN DATE: 3/11/2017 | QUANTITY: 1 |
| FRACTION $\pm 1/16$ in | CAR NUMBER: 10 | VEHICLE: RW11 |
| MACH. ANGLE $\pm 0.5^\circ$ | | |
| BEND ANGLE $\pm 1.0^\circ$ | | |
| BREAK ANGLE $\pm 1.0^\circ$ | | |

Strong Example: Wayne State

- What the judges said:
 - CG location needs notes, does not specify vehicle configuration to make CG relevant
 - Line weights are too heavy in finely detailed areas and cause them to blur together
 - More useful detail and section views could be implemented, not all included are helpful
 - Use of hidden line to depict transparent components is good
 - Detail views need scales defined



Strong Example: Florida



GATOR MOTOSPORTS

SHEET 3 OF 3

DRAFTER

CHRISTIAN MILLER

DATE DRAWN

3/1/2016

SCALE

1:2

SHEET SIZE

34" x 44"

NOTES

RIGHT HALF OF FRONT WING AND BODY REMOVED AND RIGHT TIRES SHOWN AS OUTLINE TO DISPLAY COMPONENTS

CAR # 2 FRONT VIEW DRAWING

UNIVERSITY OF FLORIDA
GATOR
MOTOSPORTS
FORMULA AND BAJA RACING

Strong Example: Florida

The image contains three technical drawings of a Formula SAE race car. The main drawing is a side view of the car's frame, suspension, and drivetrain components. An inset labeled 'DIFFERENTIAL ASSEMBLY SCALE 1:2' shows a detailed exploded view of the differential gear assembly. Another inset labeled 'DETAIL A SCALE 1 : 1' shows a detailed view of the front wheel hub and suspension components. At the bottom, there is a logo for 'GATOR MOTOSPORTS' featuring a stylized alligator head and checkered racing flags. Below the drawings is a table with drafting information.

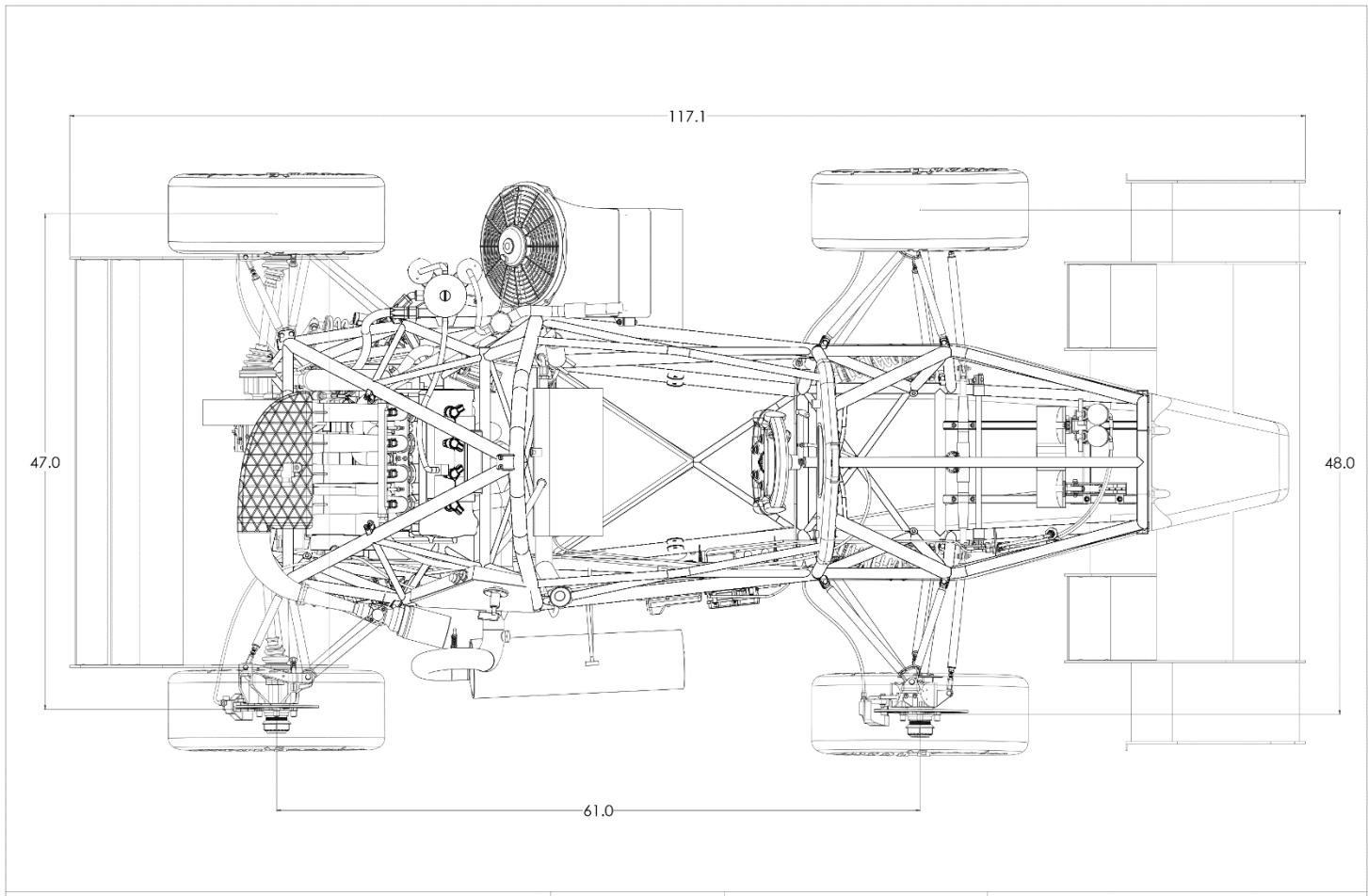
| | | | |
|---|---|--|---------------------------|
|  GATOR MOTOSPORTS | DRAFTER DATE DRAWN SCALE SHEET SIZE NOTES | CHRISTIAN MILLER 3/1/2016 1:3 34"x44" FRONT AND REAR WINGS SHOWN AS CROSS SECTION TO SHOW DETAIL RIGHT SIDE TIRES AND BODY REMOVED TO SHOW COMPONENTS | CAR # 2 SIDE VIEW DRAWING |
|---|---|--|---------------------------|

SHEET 1 OF 3

45

UNIVERSITY OF FLORIDA
GATOR
MOTOSPORTS
FORMULA AND BAJA RACING

Strong Example: Florida



SHEET 2 OF 3

DRAFTER

CHRISTIAN MILLER

DATE DRAWN

3/1/2016

SCALE

1:3

NOTE

34"x44"

REAR WING AND RIGHT TIRES SHOWN AS OUTLINE AND BODY REMOVED TO DISPLAY
COMPONENTS

CAR # 2 TOP VIEW DRAWING

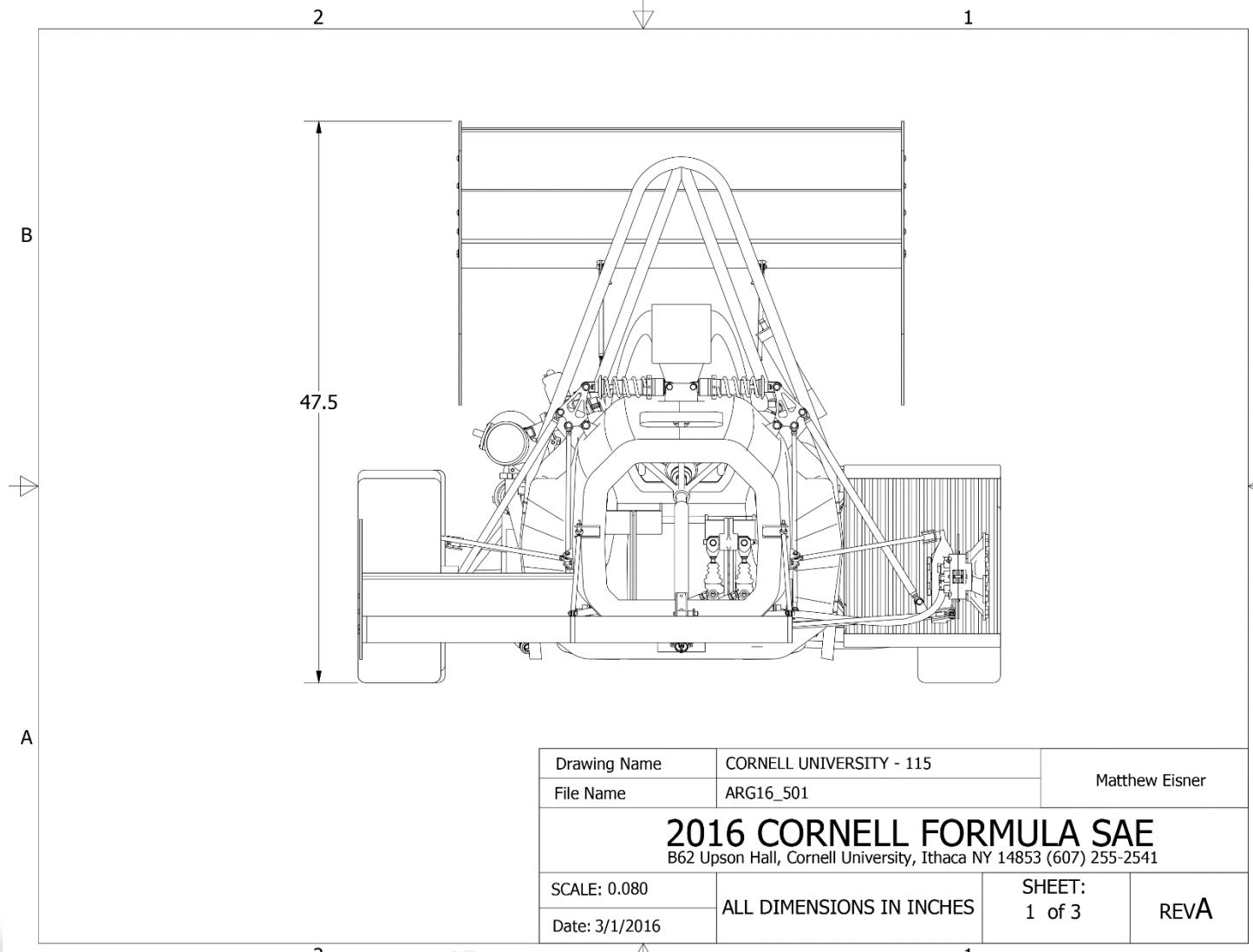
UNIVERSITY OF FLORIDA
GATOR
MOTORSPORTS
FORMULA AND BAJA RACING

Strong Example: Florida

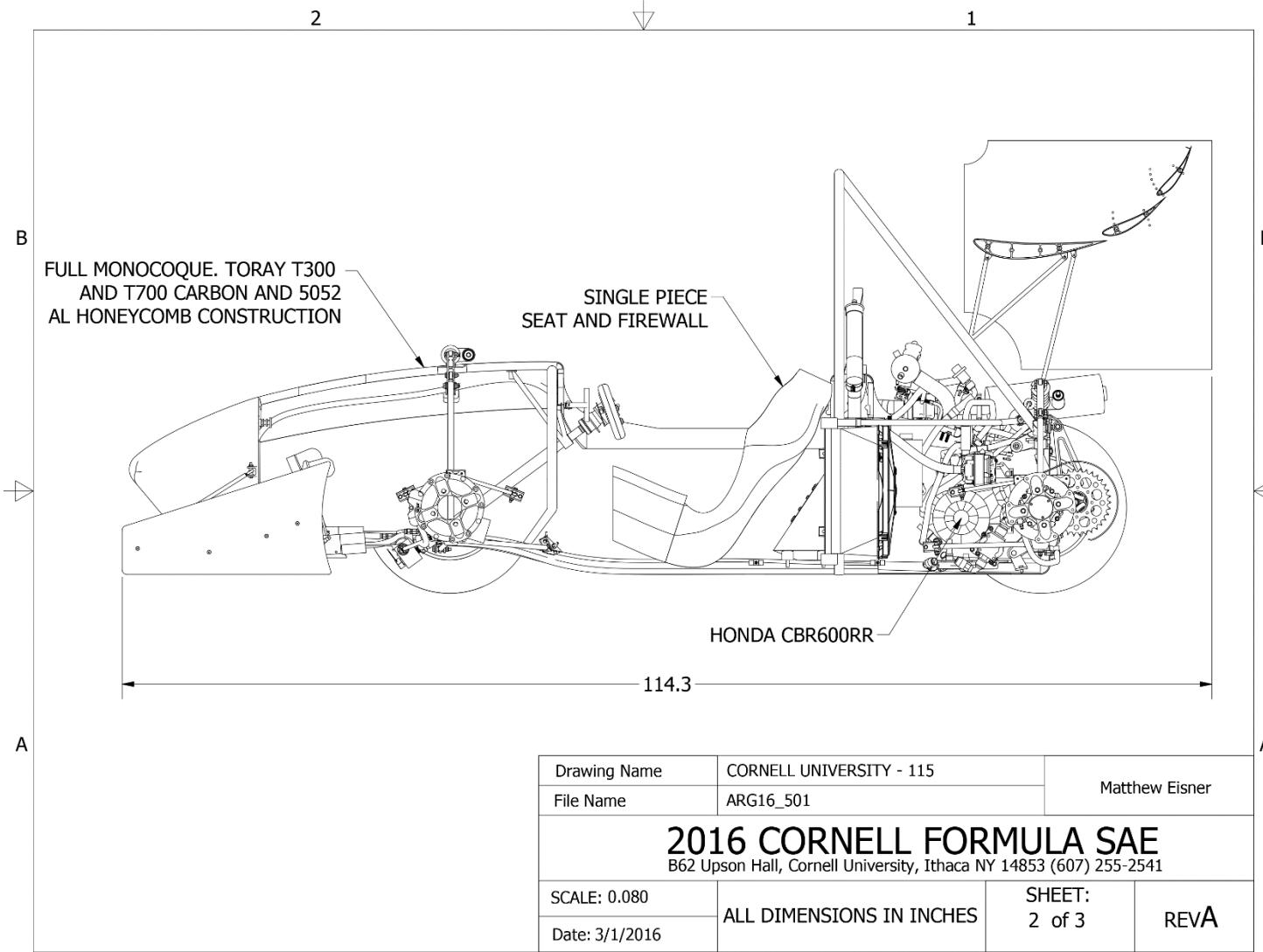
- What the judges said:
 - Solid drawings with exceptional detail
 - Exploded and sectioned views add value
 - Line weights are strong on-screen and in print
 - Sectioned view of upright not called out properly and lacks component descriptions
 - Dimension lines sometimes cross aero and become confusing
 - 1:1 suspension view does not add value
 - Needs reference grid



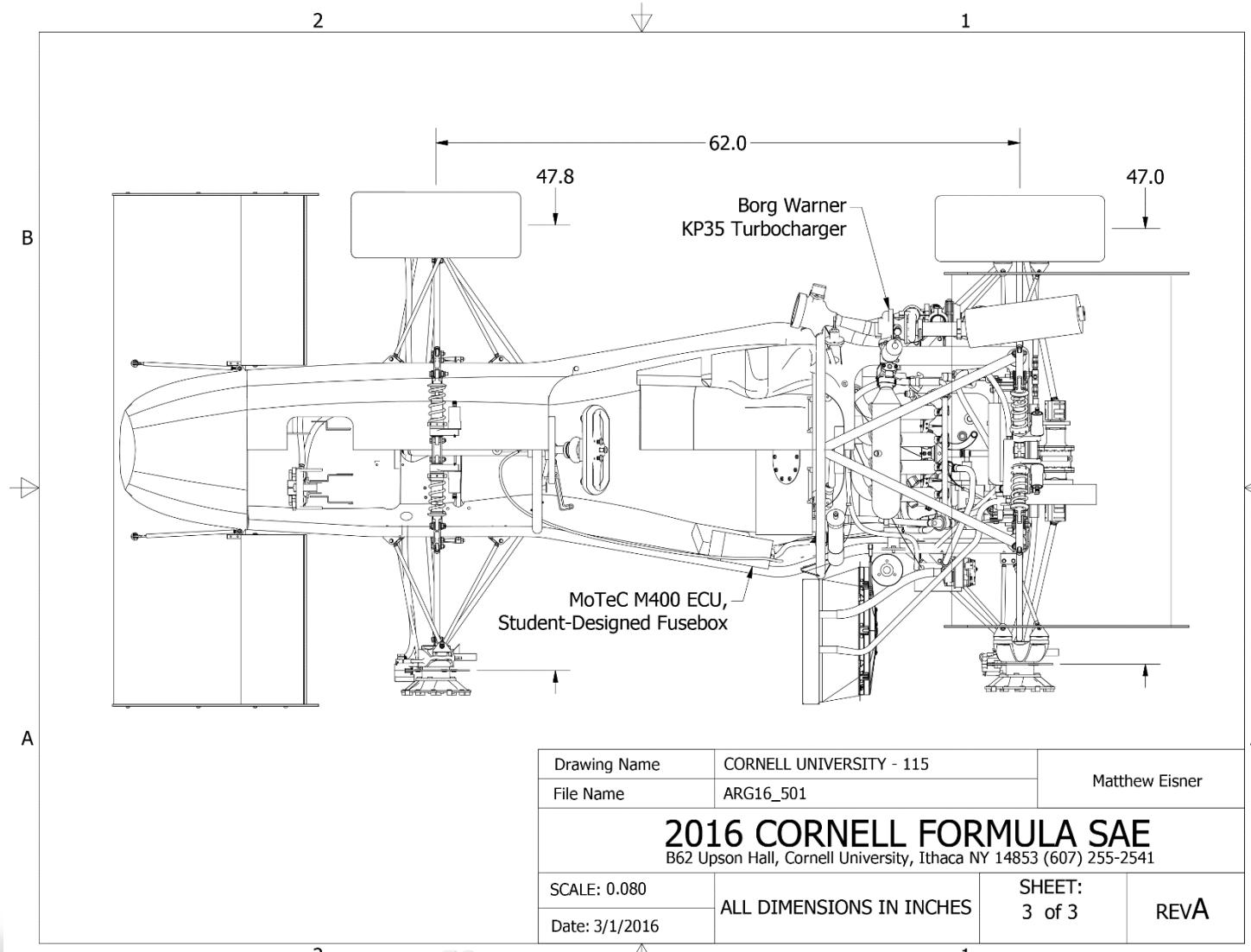
Strong Example: Cornell



Strong Example: Cornell



Strong Example: Cornell



Strong Example: Cornell

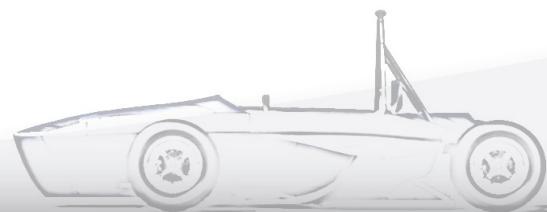
- What the judges said:
 - Clean and elegant drawing
 - Good title block and leaders
 - Monocoque sectioning is good, but would be better with hatching or display of deconstruction
 - Endplates obscure aero and detail views of wing profiles are not provided
 - Needs ground plane
 - No detail views or section views



Reference

- **Three View Drawing Excellence**
What the Design Judges are REALLY Looking For... - By Steve Fox
 - Free document available to all teams
 - Available from FSAEonline.com

<http://www.fsaeonline.com/cdsweb/gen/DownloadDocument.aspx?DocumentID=e28b695e-f35b-44a1-99ab-7e1c9ec74cac>



Special Thanks

- Thank you to all the schools who provided drawings to help make this presentation possible:
 - University of Florida
 - University of Pittsburgh
 - University of British Columbia
 - Cornell University
 - Wayne State University

