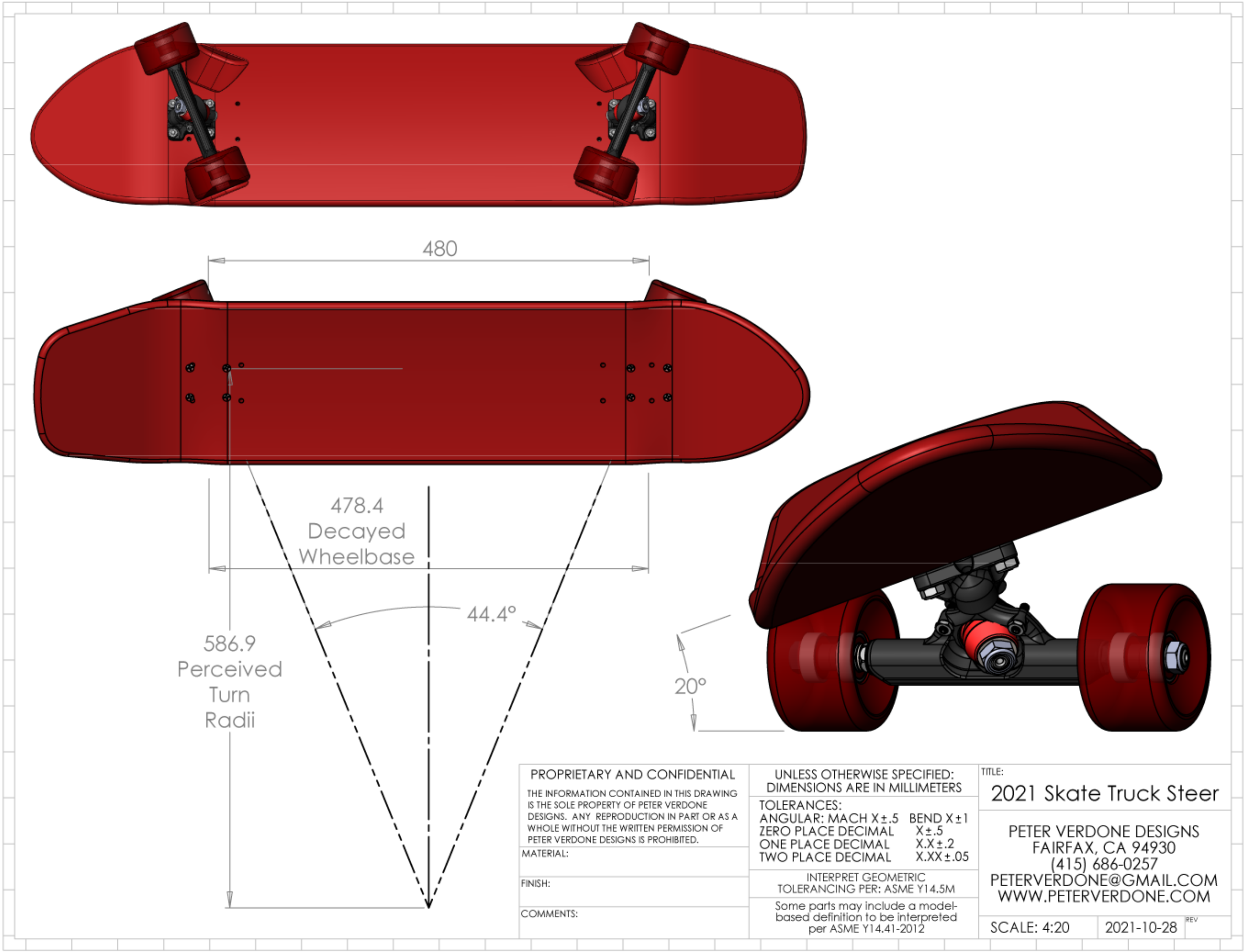
Modern Bicycle Design & Engineering for the Framebuilder

A lecture on the basic principles and methods for modern and progressive bicycle design with an emphasis on use in dirt.

Because this topic would far exceed one hour, the talk will scan the methodological concepts and meanings without going into granular detail. Ideal for framebuilders looking to take advantage of state-of-the-art performance developments in modern bicycle design.

Peter Verdone
Saturday November 6, 2021
4:30-5:30pm

Breakout following lecture:
Aldo and Manny Pizza and Pasta
1431 Arch St. (@ N. 15th, across from venue)



"All of the math and science in the world won't tell you what will work at the racetrack…
but it will tell you what won't."

-Dan Kyle

Marketing and sales is not engineering

- The problem with the profit model: sell more crap
- Selling bicycles is a marketing problem
- No matter how much better you make a bike, it means little to the market
- The consumer is shopping for increased status, not for a better bike

Problems in the zeitgeist

- Everything you've read is from marketing guys
- Early builders and designers didn't know what they were doing
- Bike design has been shaped around what is easiest to make
  - Antique road bikes were designed with lugs to reduce BOM, to make fixturing simple, sales simple, and to be built by the lowest possible skill level
  - Early mountain bikes were just copies of road bikes, now welded together
  - Consumers weren't interested in improvements so there was no need to try
  - It wasn't (very simply) until the rise of the Downieville All-Mountain Pro, the popularity of enduro racing, and the dropper post that we really saw major changes happening
  - Nothing has changed in road bike design except additional importance made for aerodynamics

The McNamara Fallacy:

"If you can't measure what's important, make important what you can measure."

Meaning: What got me here

- 1980s/1990s Boston skate scene, made a lot of small and large ramps
- Maximus/Kenny Deutsch. Building of young men and a skatepark
- Bike messenger/Fat City Cycles/CNC machinist/Durango/Motorcycle mechanic/Marin/Factory Pro/AMA Superbikes/Toolroom machinist/Sears Point/SFSU-STEM
- Learning to take the hard line
- Publishing to the internet since ~1999
- Independent fabrications dropouts in ~1998; Ground Effect skate trucks 2000-2001; Motorcycle suspension and tuning 2004-6; Framebuilding 2006; Firefly fly wing dropout; Engin dropouts, yokes, seat collar, and 90% of the stem
- The tuner – When you can’t compete on skill or strength, use brains

What got you here?

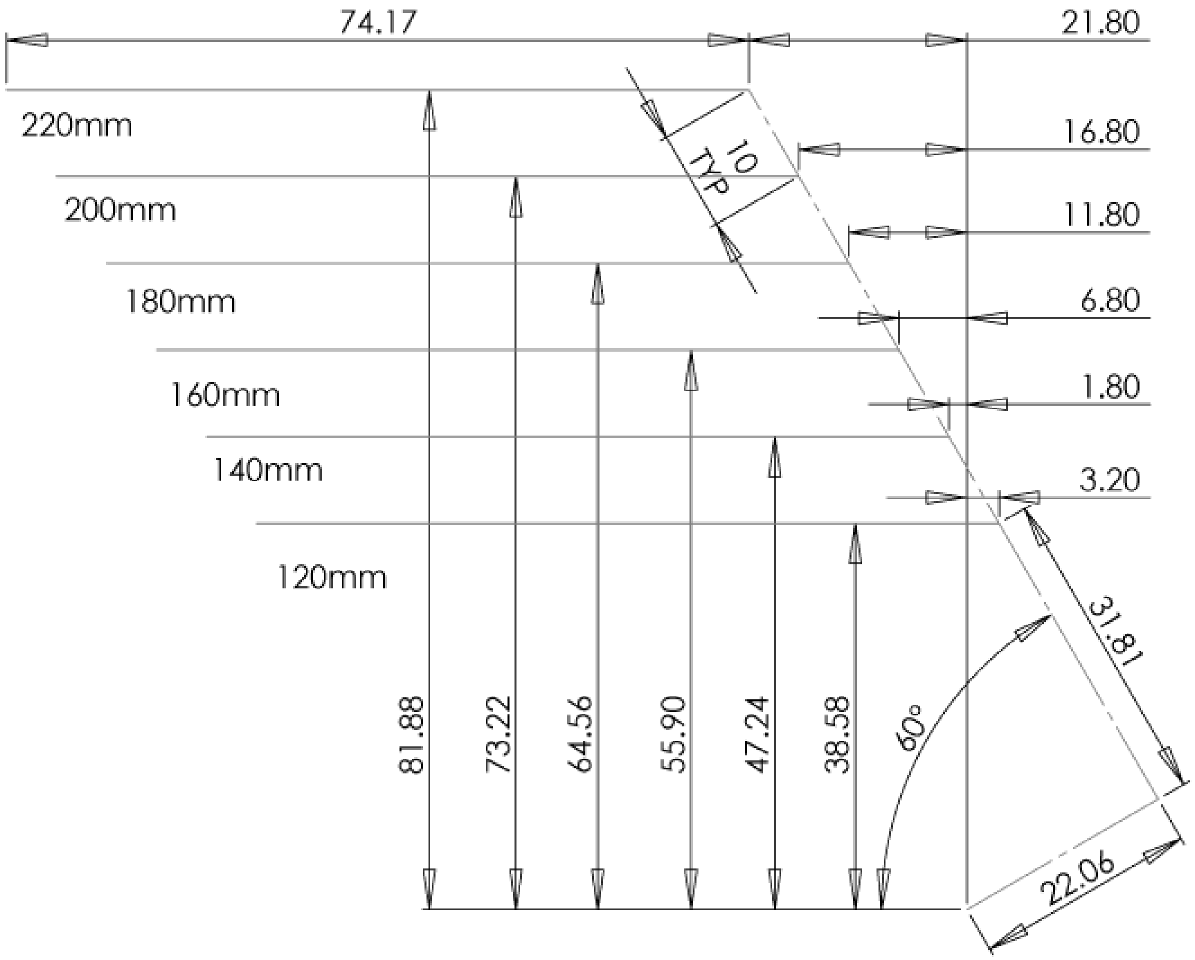
Authenticity, value, truth, and status

- Why are you doing this?
  - Is this really what is most important to you?
  - Don’t make when you can buy
  - Are you just looking for attention?
  - Are you filling your time rather than doing something?
  - Nobody cares about your story
- Learn the rules before you decide to break them
  - Why are you deviating from ‘normal’?
  - What makes you think you’re right?
- Do you really need a better bike? Why?
- How are you creating value? Are you just making more junk?
- Are you brave enough to leave the cave?
- Will you lose status if you are truly honest?
- The truth isn’t contained in facts. It’s in our stories. Tell yourself the story that motivates you to do <u>real</u> work. Work that connects with your truth.

Engineering, or *what is the problem that needs to be solved*?

- “Necessity is the mother of invention”
- It is difficult to compete playing by the rules of the powerful
  - You will never beat Taiwan at their game
  - You can never work harder than the Chinese
- A problem well-defined is a problem half solved
- Always: What are your goals?
- Is this a legitimate problem? Instagram or YouTube content is a terrible motivator
- Speed? Climbing? Descending? Cargo? Special purpose? Special users?
- Worthy adversaries / Teams of rivals / Competition
- You need to be able to defend EVERY decision in the solution and design
- Are you looking to ‘easy’ solutions rather than ‘great’ solutions?
- Complex/expensive solutions are bad. Simple/cheap solutions are good.
- AR-15 (M4) vs AK-47 (AK-74M) vs Sturmgewehr 44

Ride other peoples bikes!!



Note: This 60 degree translatioin does not conform with current Shimano Post Mount 57 degree specification. Suprisingly, Shimano and SRAM calipers are designed around approximately 60 degrees.

COMMENTS:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS

TOLERANCES:
ANGULAR: MACH X ±.5 BEND X ±1
ZERO PLACE DECIMAL X ±.5
ONE PLACE DECIMAL X.X ±.2
TWO PLACE DECIMAL X.XX ±.5

INTERPRET GEOMETRIC
TOLERANCING PER: ASME Y14.5M

MATERIAL:

FINISH:

TITLE:
PVD 2020PM 60

PETER VERDONE DESIGNS
FAIRFAX, CA 94930
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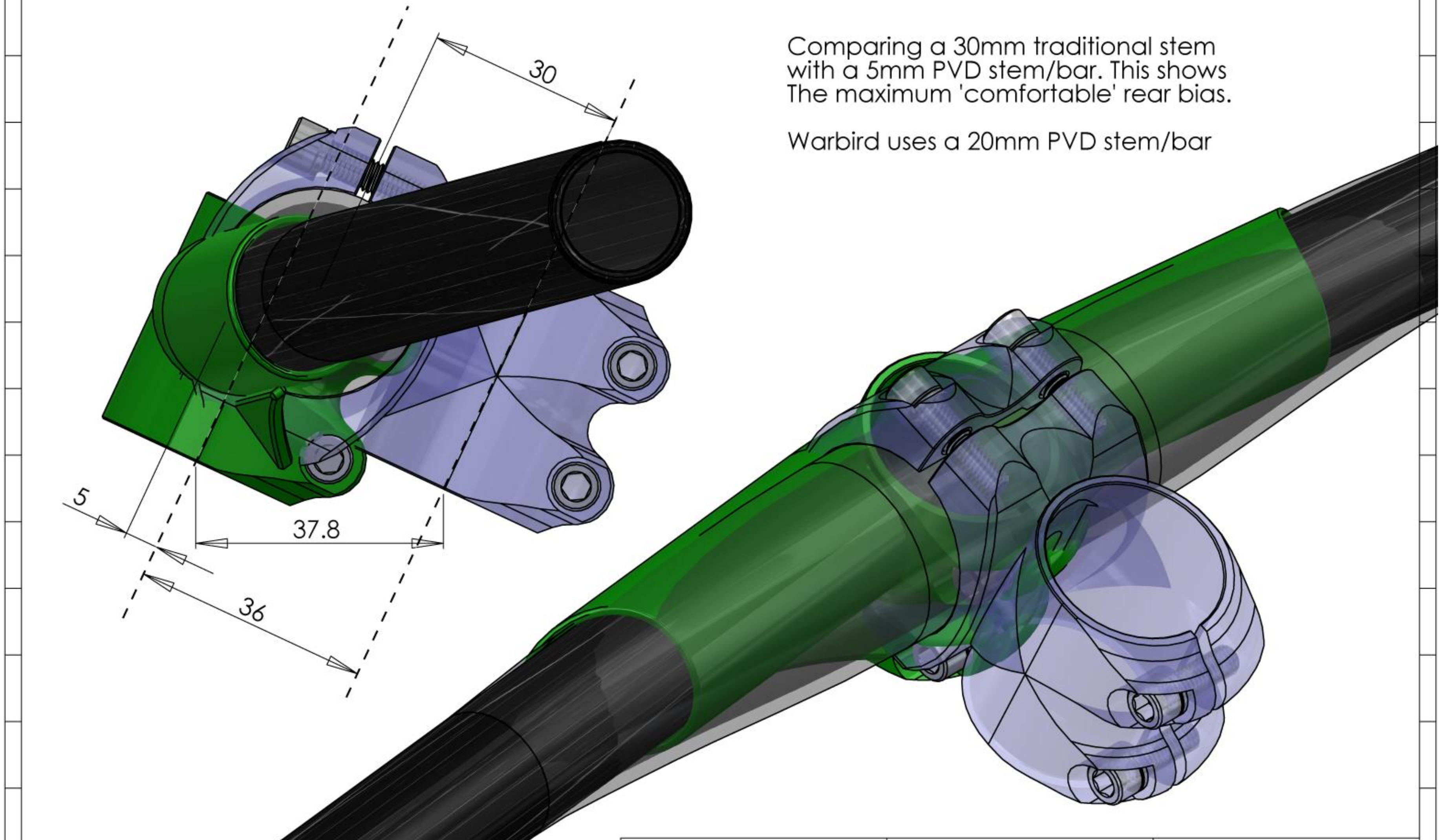
SCALE: 3:2 | 2019-11-02 | REV

Comparing a 30mm traditional stem
with a 5mm PVD stem/bar. This shows
The maximum 'comfortable' rear bias.

Warbird uses a 20mm PVD stem/bar



MATERIAL:

FINISH:

COMMENTS:

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UNLESS OTHERWISE SPECIFIED:

IF DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL $\pm 1/32$
ANGULAR: MACH $\pm .5$ BEND ± 1
TWO PLACE DECIMAL $\pm .010$
THREE PLACE DECIMAL $\pm .005$

INTERPRET GEOMETRIC
TOLERANCING PER: ASME Y14.5M

Some parts may include a model-based
definition to be interpreted per ASME Y14.41-2012

TITLE: PVD comparison

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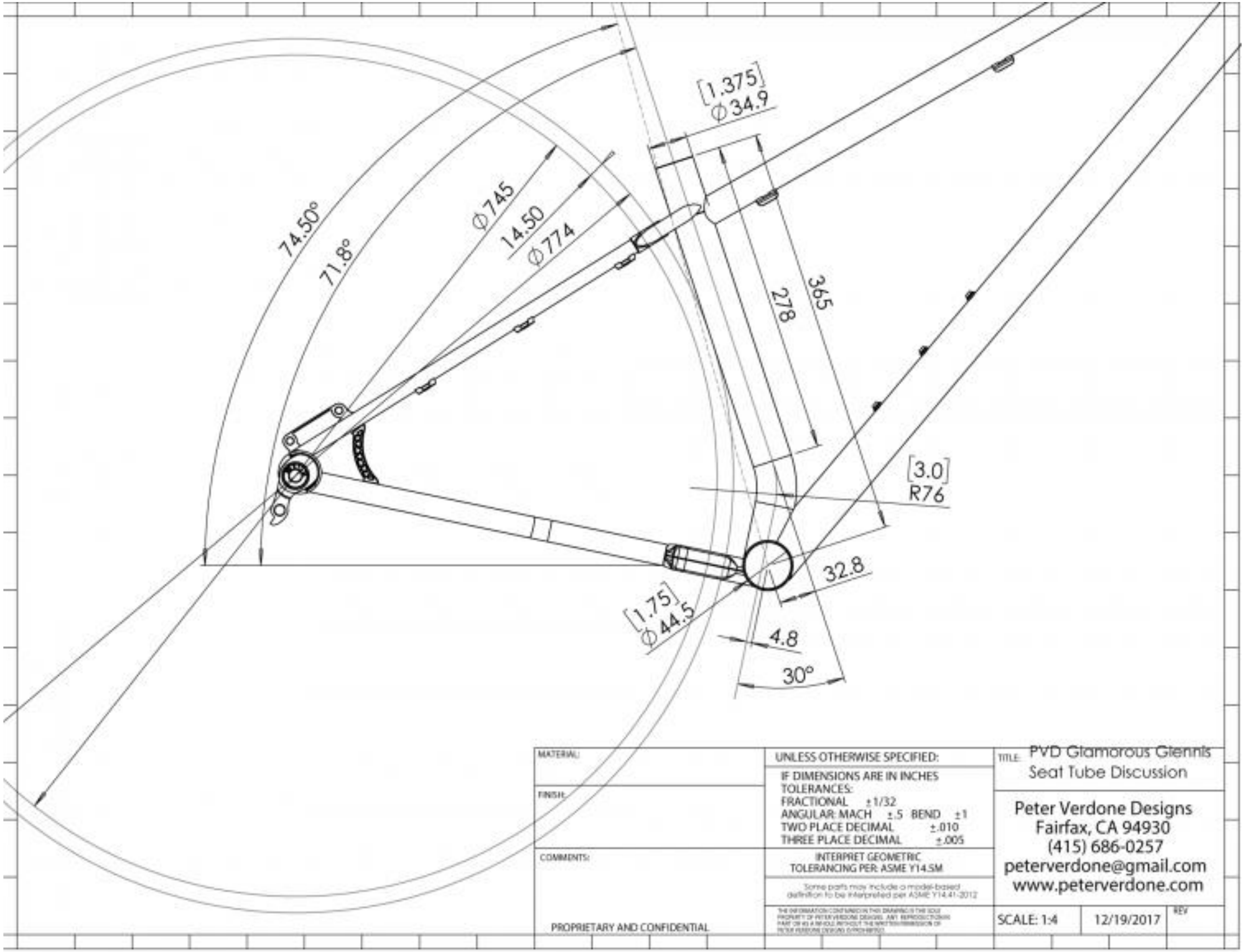
SCALE: 5:4 | 10/3/2018 | REV


[1.375]
Ø34.9
74.50°
71.8°
Ø745
14.50
Ø774
278
365
[3.0]
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32.8
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4.8
30°
MATERIAL:
FINISH:
COMMENTS:
PROPRIETARY AND CONFIDENTIAL
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IF DIMENSIONS ARE IN INCHES
TOLERANCES:
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ANGULAR: MACH ±.5 BEND ±1
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005
INTERPRET GEOMETRIC
TOLERANCING PER: ASME Y14.5M
Some parts may include a model-based
definition to be interpreted per ASME Y14.41-2012
TITLE: PVD Glamorous Glennis
Seat Tube Discussion
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SCALE: 1:4
12/19/2017
REV

Risks and failure

- You are 100% responsible!
- Fail fast, fail often
- Fortune favors the bold
- When bikes break…
- If your mistake kills someone else, you will go to hell
- Picking yourself up off the floor
- Why projects die

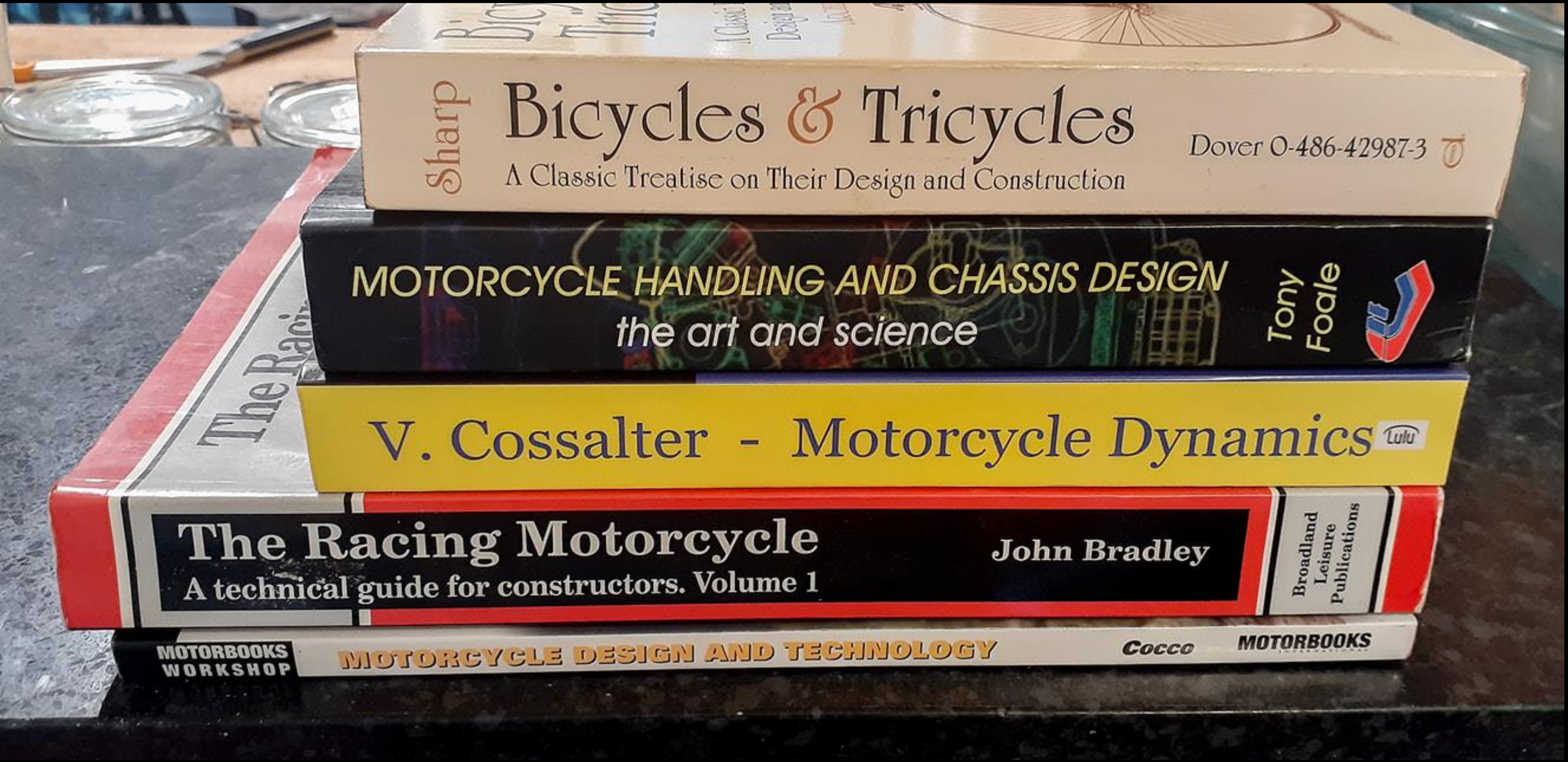
What does it mean to fail?

Failsafe!


TRUVATIV
EC90 SLX
ULTEGRA

Talking to experts

- Who is an expert?
- How do you evaluate the people that you talk to?
- Weighting information depending on the source
- Cold calling
- Motorcycle books
  - Motorcycle Handling and Chassis Design, The Art and Science. Tony Foale
  - Motorcycle Dynamics. V. Cossalter
  - The Racing Motorcycle, A Technical Guide for Constructors. Volume 1. John Bradley
  - Motorcycle Design and Technology. Cocco
  - Bicycles & Tricycles, A Classic Treatise on Their Design and Construction. A. Sharp
- Follow up
  - Stay in touch
  - Let them know how they helped


Sharp
Bicycles & Tricycles
A Classic Treatise on Their Design and Construction
Dover 0-486-42987-3
MOTORCYCLE HANDLING AND CHASSIS DESIGN
the art and science
Tony Foale
V. Cossalter - Motorcycle Dynamics
Lulu
The Racing Motorcycle
A technical guide for constructors. Volume 1
John Bradley
Broadland Leisure Publications
MOTORBOOKS WORKSHOP
MOTORCYCLE DESIGN AND TECHNOLOGY
Cocco
MOTORBOOKS

Sandy Kosman,
Windsor, CA
2008

Testing

- *"One good test launch is worth a thousand expert opinions."* –Werner von Braun
- If you imagine that your first draft is your final draft, you're not cut out for the game
- *"All of the math and science in the world won't tell you what will work at the racetrack, but it will tell you what won't."*
- Never waste a prototype
- Racers are the worst
  - Cumulative distribution function
- Good riders, with an understanding of engineering, that can feel differences, in a variety of conditions, and can communicate in writing. AND THEY DON'T JUST TALK
- Bracketing
  - The limits is where we do the most learning
  - By deciding where we want to be between the limits, we have a target
- Margin of error in design
  - How close to optimal does the rider need to perform?
- You, alone, are a terrible engineer. Utilize test riders and critics
- Pride is one of the deadly sins
- Was your test rider 'average'?
  - Goofy vs regular footing
  - Skinny legs vs fat legs
  - Wide vs skinny hips
  - A roadie testing a DH bike?
- Telemetry
  - Strain gauging
  - Potentiometer
  - Logging
  - What does this mean?
- The importance of cleaning the bike
  - Finding what you didn't realize
  - Remembering issues on the trail
  - Spotting wear, rub, cracks
  - Time to think deeper

…Testing

- Laboratory testing
  - Non-destructive
    - Stress deflection
    - Spring Scales
    - Dynomometer
  - Destructive
    - Fatigue cycling
  - Virtual testing
    - FEA
    - CFD
      - In what state?

- Official testing specifications
  - EN
    - EN 4210
    - EN 14764:2005 for City and Trekking bicycles
    - EN 14765:2005 for Children's bicycles
    - EN 14766:2005 for Mountain bicycles
    - EN 14781:2005 for Racing bicycles
    - EN 14872:2005 for Bicycles – Accessories for bicycles – Luggage carriers
    - EN 15194:2005 for Electrically Power Assisted Cycles
  - ISO
    - 43.150
      - ISO 4210-1:2014 – Cycles – Safety Requirements
      - ISO 8098 – Cycles – Safety Requirements for bicycles for young children
      - Others
  - United States
    - CPSC
      - Code of Federal Regulations (CFR)
      - Title 16, Part 1512
  - Testing Services
    - ACT Lab
      - Long Beach, CA and Asian locations
    - Engineering Materials Laboratory (EML)
      - Santa Fe, NM; Springs CA


ROSS BELL

Drawing and data

“I’m the worlds worst writer but I’m one hell of a re-writer.”

Design for manufacturing!

File names with dates in them

Save waypoints!

Driving versus driven parameters
- Boolean vs parametric

The more times you return to the model, the better it will become

Paper drawing is for notes on the fly, not production or documentation

BikeCAD
- Dimension Templates!!!
  - Communicating the bike
  - Building the bike
- Handlebar, stem, seatpost, and saddle data are crucial! (CRUCIAL!)

RattleCAD

3D parametric CAD
- Solidworks
  - Siemens Parasolid
  - Industry ‘standard’
  - 3DExperience Solidworks for Makers. $99 per year solidworks.com/makers
  - Watermarks? Storage? Local option
- Fusion360
  - Cheap
  - CAM, CAE Support
  - CNC
  - Additive
  - FEA
  - Generative (?)
- Common
- Import/export
- .edu friendly
- Who owns your data?

OnShape
- Who owns your data?
- When does it cost you?

FreeCAD (BikeCAD Export)
- Free
- Buggy

Others
- Siemens Solid Edge, Catia, Pro Engineer, ZWsoft

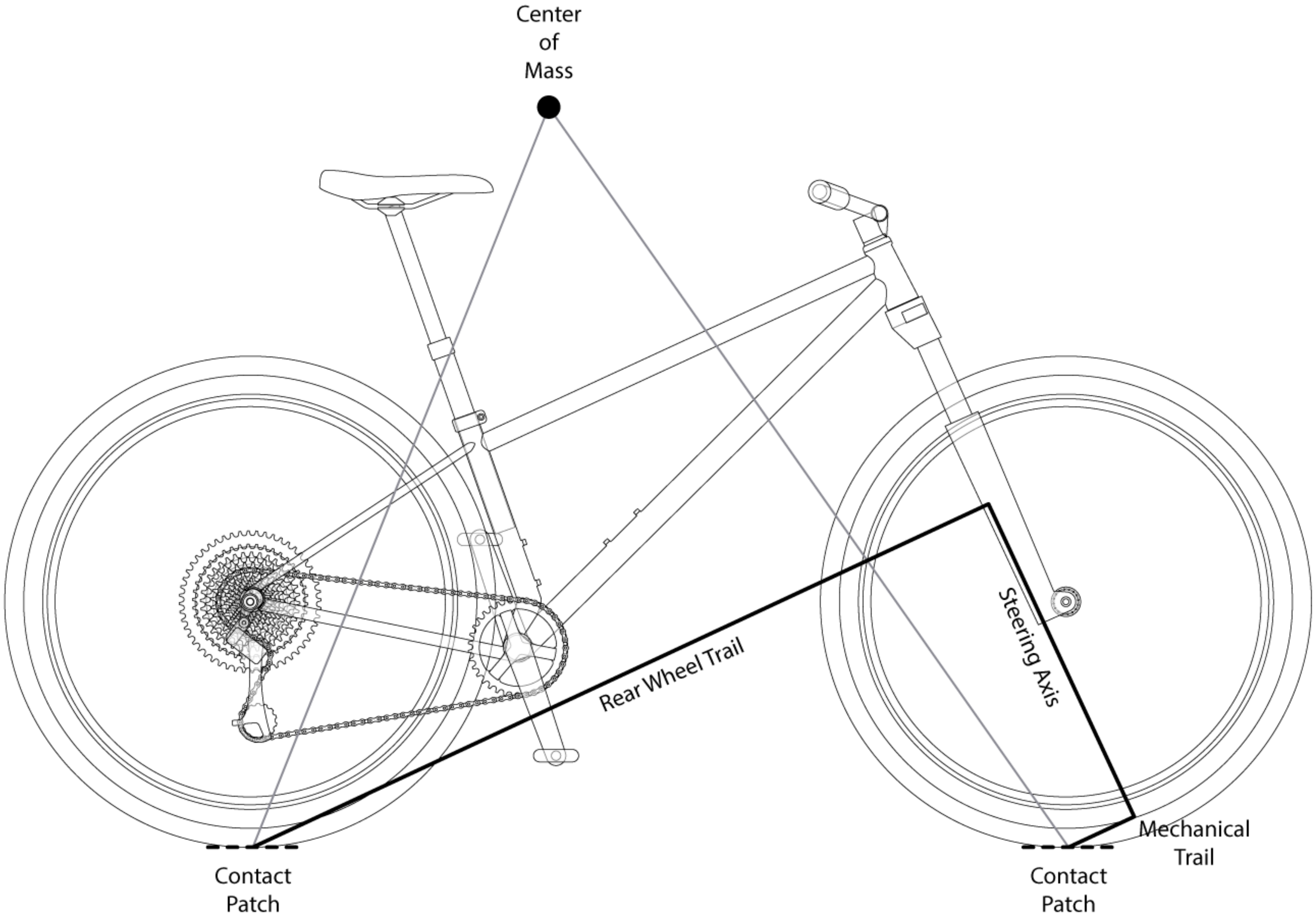
Construction geometry and Equations
- Always mate to geometry!!!
- Seriously, Geometry based on equations is the foundation for durable, flexible models.
- Pay attention to the normal direction
- Be careful of layered references

Additive Manufacturing software
- AutoDesk Nettfab
- Printing alignment
- Supports

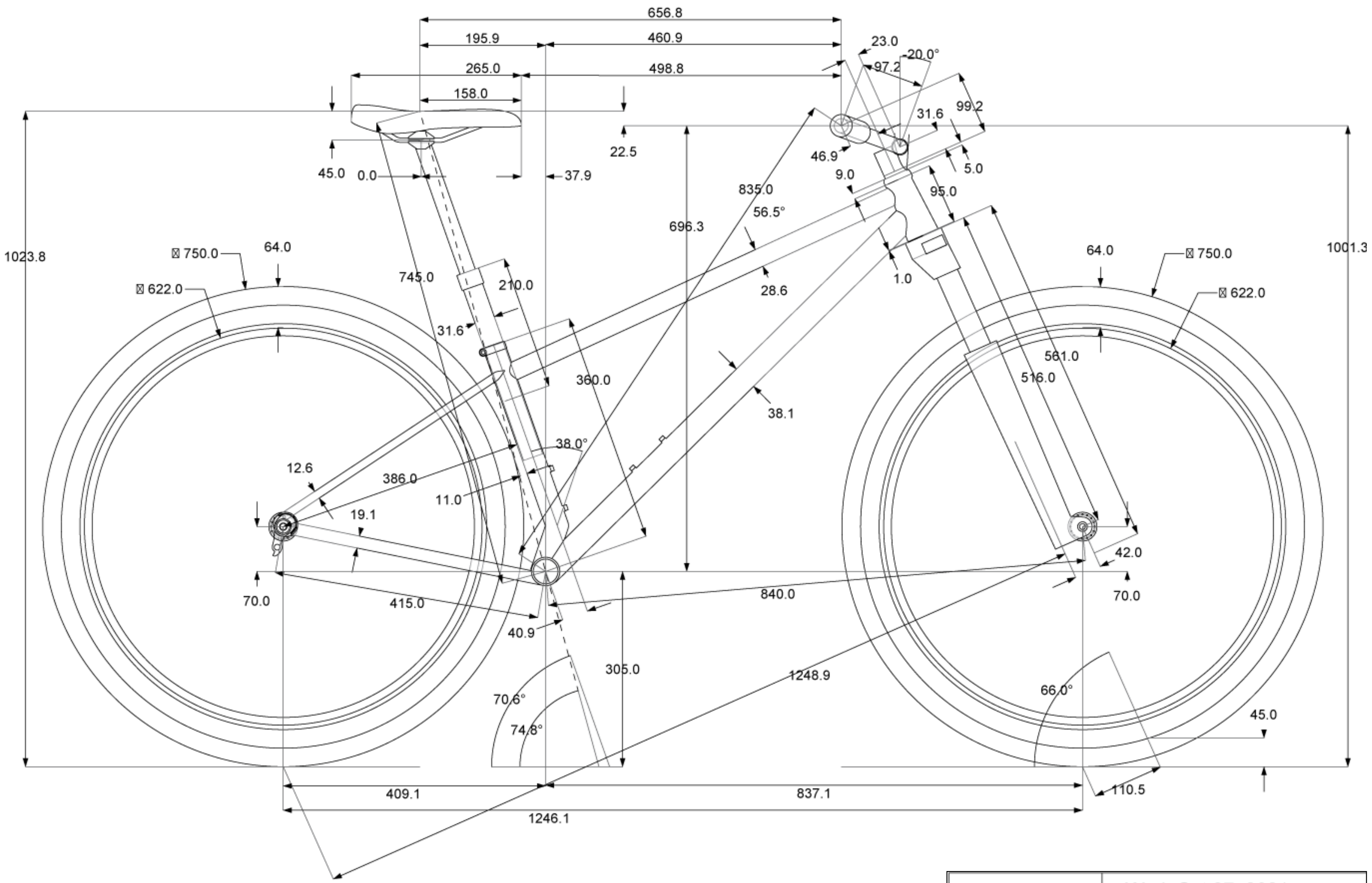
Geometric dimension and tolerance and Units
- Work in metric (for describing bicycles)
- Less than 1/10th mm precision is useless with bicycle fabrication
- What is important, geometrically, in a frame

Proper 2D drawings are IMPORTANT
- Make proper 2D drawings
- Change of perspective
- Finding problems and improving design
- Always be loosening tolerances!!!
- Good 2D .pdf can be emailed for critique and communication

Do the math
- Trigonometry
- Spreadsheets
- Shortcuts for models
- Understanding



	Fri, Oct 29, 2021
PVD	Peter Verdone
MiG-31 Firefox	peterverdone@gmail.com
2022	www.peterverdone.com



Fork
RockShox Pike Ultimate
150mm, 561mm, 42mm, @30%

Dropper
OneUp V2
210mm, Ø31.6mm

Cranks
Sram Force
175mm, Q150, GXP

Saddle
WTB Volt
160/150mm

	Wed, Oct 27, 2021
PVD	Peter Verdone
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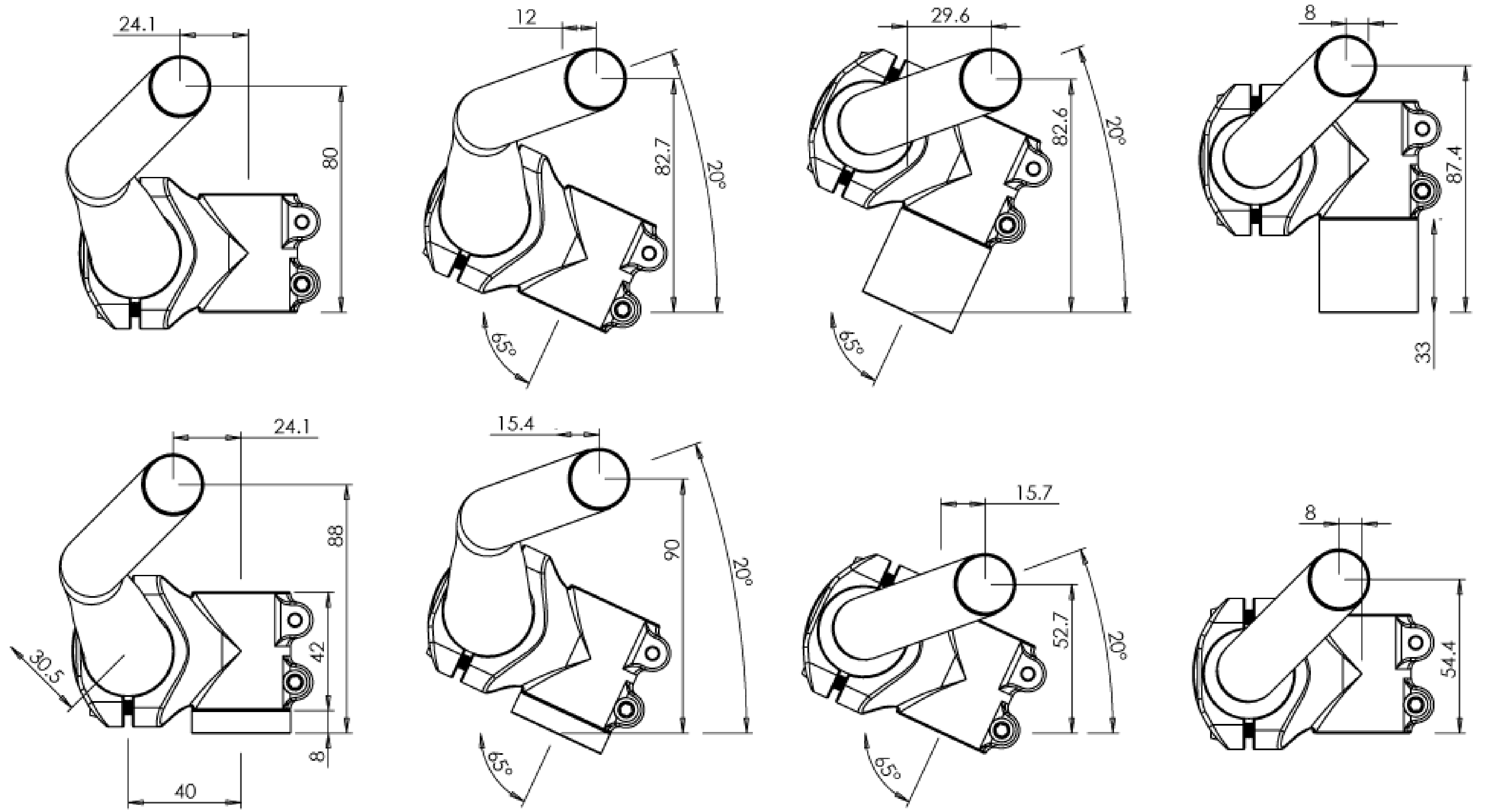
2022	www.peterverdone.com

40mm Stem w/ Race Face Riser 1.25"

40mm Stem w/ Race Face Flat



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FRACTIONAL ±1/32
ANGULAR: MACH ±.5 BEND ±1
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

INTERPRET GEOMETRIC TOLERANCING PER: ASME Y14.5M

MATERIAL:

FINISH:

TITLE: Stem/Bar Contrast

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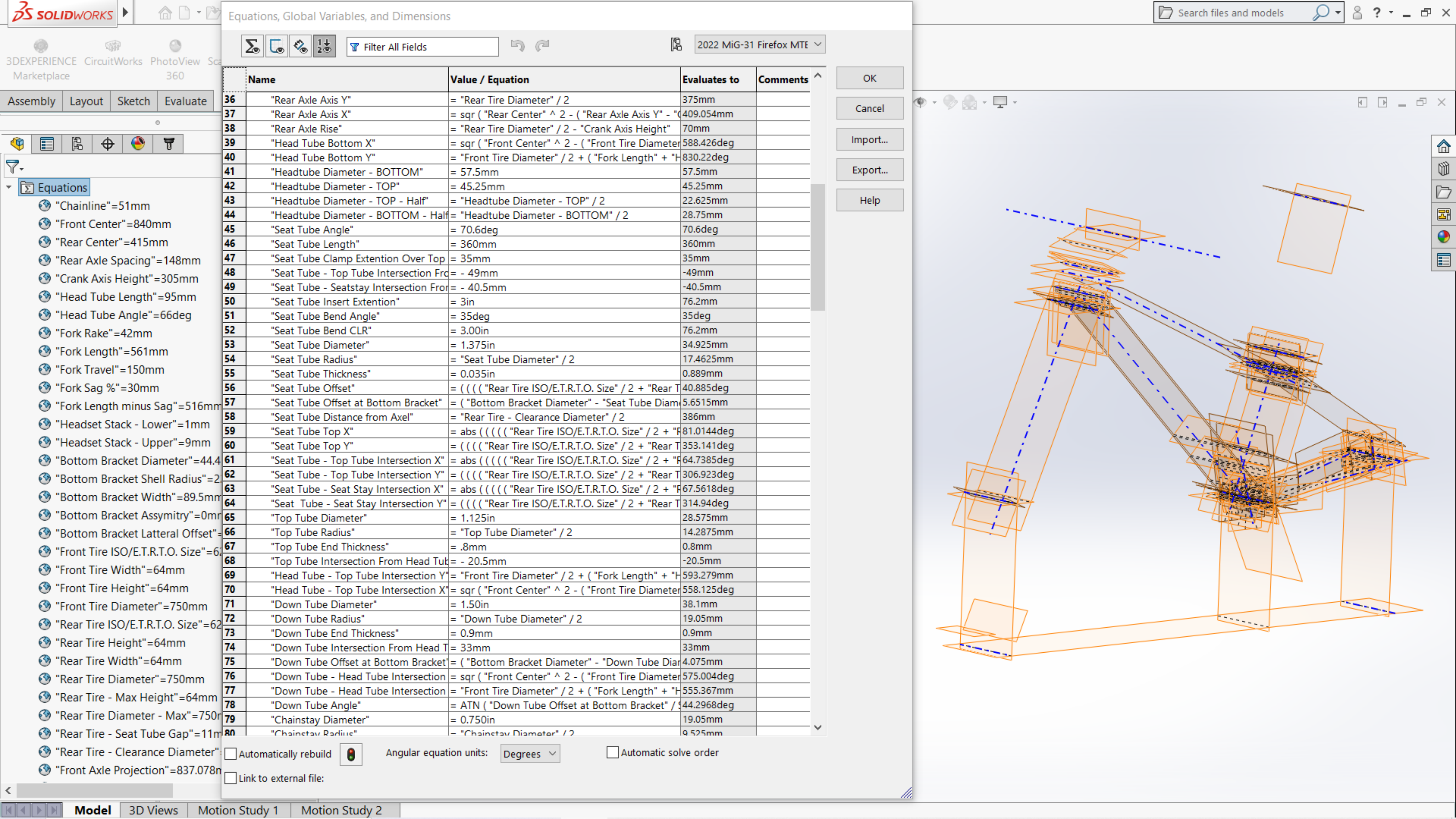
SCALE: 1:2 | 2019-06-04 | REV

Driving Parameters		**MiG-31 Firefox MTB**	**2021-10-03**

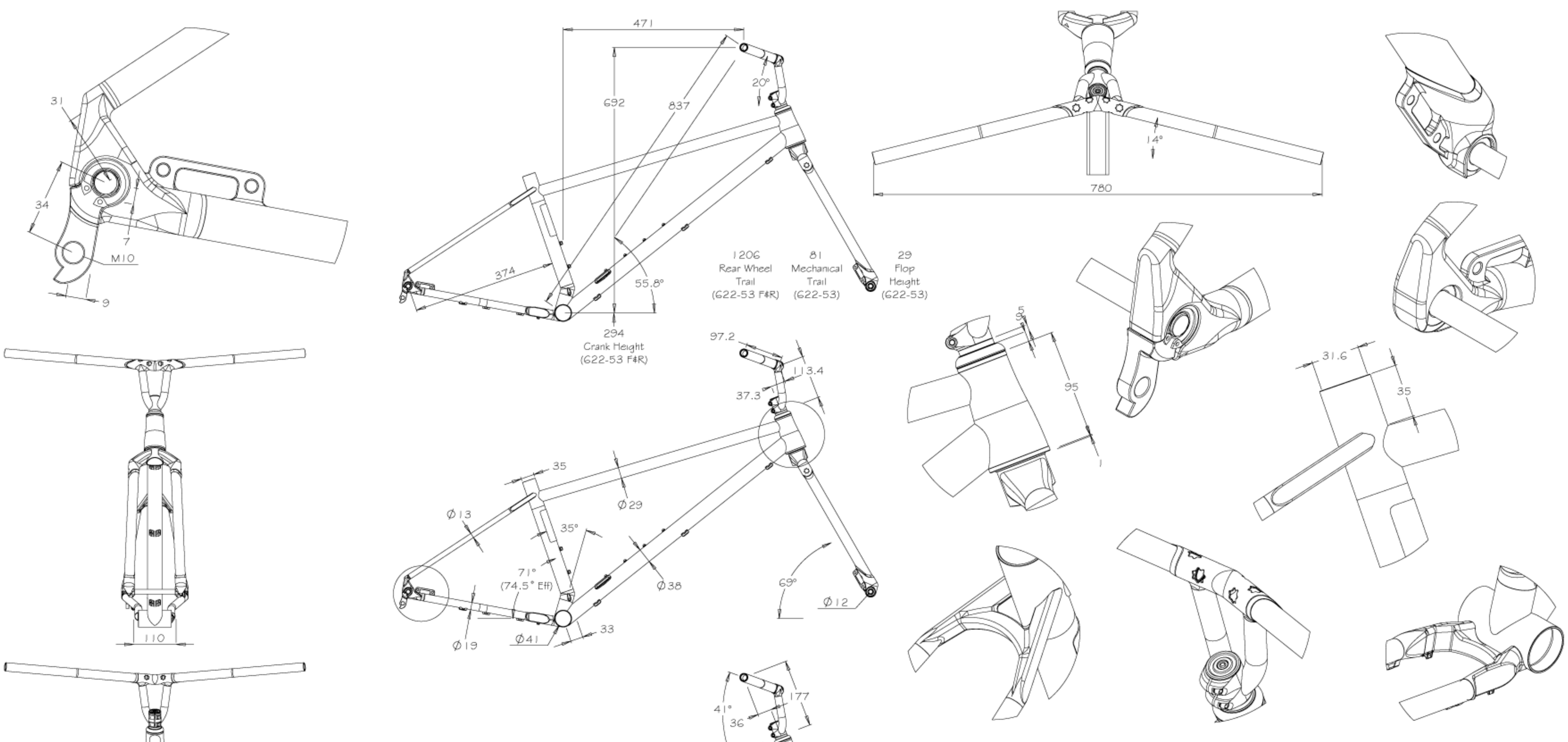
Front Center	840.0
Rear Center	415.0
Crank Height	305.0
Bottom Bracket Diameter	44.5
Down Tube Diameter	38.1
Down Tube Thickness at Bottom Shell	0.9
Top Tube Diameter	28.6
Head Angle (°)	66.0
Head Tube Length	95.0
Seat Tube Angle (°)	70.6
Seat Tube Length	360.0
Seat Tube Diameter	34.9
Seat Tube Wall Thickness	0.9
Bent Seat Tube?	Y
Seat Tube Bottom Tangent to Rear of BB Shell?	Y
Seat Tube Bend Angle	35.0
Seat Tube Bend CLR	0.0
Front Tire ISO/E.T.R.T.O. Size	622.0
Front Tire Height	64.0
Rear Rim ISO/E.T.R.T.O. Size	622.0
Rear Tire Height	64.0
Rear Tire Height -Max	64.0
Rear Tire Gap	11.0
Fork Length	561.0
Fork Offset	42.0
Fork Travel	150.0
Sag %	30.0
Lower Headset Stack	1.0
Construction Details	
Clamp Area From Seat Tube Top	-37.5
Down Tube Intersection Above Head Tube	32.0
Top Tube Intersection From Head Tube Top	-23.0
Top Tube Intersection From Seat Tube Top	-49.0
Chainstay From Crank Axis	-11.5
Chainstay From Rear Axle Axis	-5.5
Seatstay Intersection From Seat Tube Top	-40.5
Seatstay From Rear Axle Axis	35.0
Head Tube Top Diameter	
Head Tube Bottom Diameter	

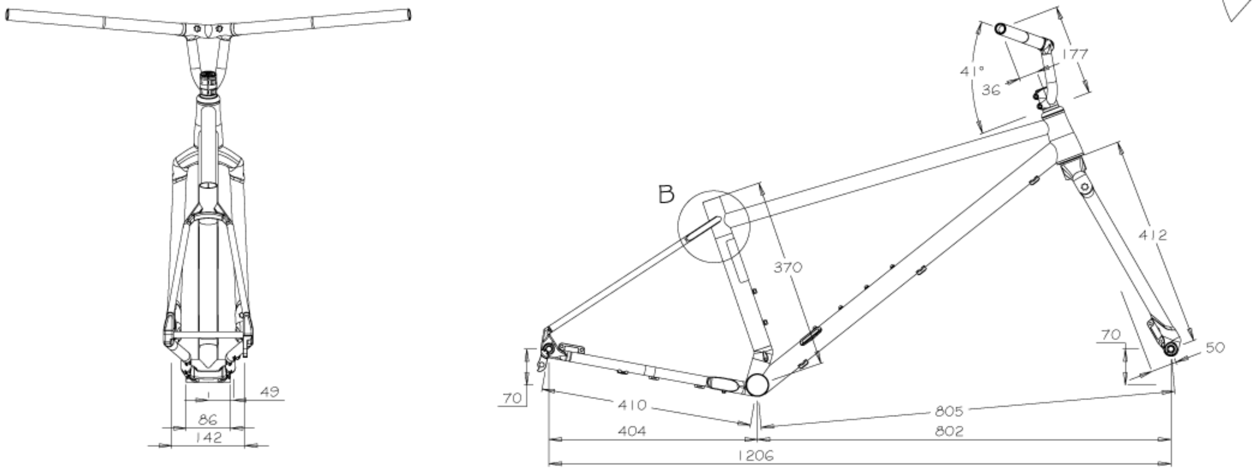
Geometric Properties	
Mechanical Trail	110.5
"Flop" Height	45.0
Rear Wheel Trail	1248.9
Front Wheel Diameter	750.0
Rear Wheel Diameter	750.0
Maximum Rear Tire Diameter	750.0
Limit Tire Diameter	772.0
Seat Tube Distance from Axle	403.5
Seat Tube Back from Axle	386.0
Seat Tube Bend from BB Center	5.7
Wheelbase	1246.1
Front Center to Rear Center Projection	67.2 / 32.8
Bottom Bracket Drop - Rear	70.0
Bottom Bracket Drop - Front	70.0
Sag Amount	45.0
Fork Length minus Sag	516.0
Seat Tube Offset	40.9
bent)	5.7
Frame Relative to Crank Axis	
Crank Axis X	0.0
Crank Axis Y	0.0
Rear Axle X	-409.1
Rear Axle Y	70.0
Front Axle X	837.1
Front Axle Y	70.0
Head Tube Bottom X	588.4
Head Tube Bottom Y	525.2
Head Tube Top X (Reach)	549.8
Head Tube Top Y (Stack)	612.0
Head Tube Top Tube Intersection X	559.1
Head Tube Top Tube Intersection Y	591.0
Head Tube Down Tube Intersection X	575.4
Head Tube Down Tube Intersection Y	554.5
Down Tube Direct	799.1
Seat Tube Top X	-81.0
Seat Tube Top Y	353.1
Seat Tube Top Tube Intersection X	-64.7
Seat Tube Top Tube Intersection Y	306.9
Seat Tube Seatstay Intersection X	-67.6
Seat Tube Seatstay Intersection Y	314.9
Axis	4.1
Top Tube Angle	24.5
Down Tube Angle	44.2
Chainstay Angle (Theoretical) (°)	9.7
Chainstay Correction Angle (°)	0.8
Chainstay Angle (Actual) (°)	10.5
Seatstay Angle (Theoretical) (°)	35.7
Seatstay Direct	420.3
Seatstay Correction Angle (°)	4.8
Seatstay Angle (Actual) (°)	30.9

Fixture Inputs	
Fixture Centerline Height	140.0
Head Tube Rail Y	304.8
Seat Tube Rail Y	304.8
Head Tube Pivot Y from BB	345.0
Seat Tube Pivot Y from BB	345.0
Cosine Pin Radius	270.0
Cosine Pin Angle Shift	0.0
Cosine Pin Diameter	16.0
Centerline from Rail	18.0
Fixture Settings	
Seat Tube Pivot X from BB	-78.1
Head Tube Pivot X from BB	668.7
Head Tube Bottom From Pivot	197.3
Head Tube Cosine Spacer	83.8
Seat Tube Cosine Spacer	63.7
Rear Axle X	-409.1
Rear Axle Y	70.0
Frame Relative to Ground	
Crank Axle X	0.0
Crank Axle Y	305.0
Rear Axle Height	375.0
Rear Axle Projection	-409.1
Front Axle Projection	837.1
Front Axle Height	375.0
Head Tube Height	830.2
Head Tube Projection	588.4
Head Tube Top Projection	549.8
Head Tube Top Height	917.0
Hand Grip Information	
Hand Grip End Width	780.0
Crank Axis	835.0
Crank Axis	56.5
Upper Headset Stack	9.0
Headset Spacers	5.0
Hand Grip Sweep Angle	14.0
(Ground)	20.0
(Stem)	46.0
X	460.9
Y	696.3
X	544.1
Y	624.8



	Name	Value / Equation	Evaluates to	Comments
36	"Rear Axle Axis Y"	= "Rear Tire Diameter" / 2	375mm	
37	"Rear Axle Axis X"	= sqr ("Rear Center" ^ 2 - ("Rear Axle Axis Y" - "(	409.054mm	
38	"Rear Axle Rise"	= "Rear Tire Diameter" / 2 - "Crank Axis Height"	70mm	
39	"Head Tube Bottom X"	= sqr ("Front Center" ^ 2 - ("Front Tire Diameter	588.426deg	
40	"Head Tube Bottom Y"	= "Front Tire Diameter" / 2 + ("Fork Length" + "H	830.22deg	
41	"Headtube Diameter - BOTTOM"	= 57.5mm	57.5mm	
42	"Headtube Diameter - TOP"	= 45.25mm	45.25mm	
43	"Headtube Diameter - TOP - Half"	= "Headtube Diameter - TOP" / 2	22.625mm	
44	"Headtube Diameter - BOTTOM - Half	= "Headtube Diameter - BOTTOM" / 2	28.75mm	
45	"Seat Tube Angle"	= 70.6deg	70.6deg	
46	"Seat Tube Length"	= 360mm	360mm	
47	"Seat Tube Clamp Extention Over Top	= 35mm	35mm	
48	"Seat Tube - Top Tube Intersection Fro	= - 49mm	-49mm	
49	"Seat Tube - Seatstay Intersection Fror	= - 40.5mm	-40.5mm	
50	"Seat Tube Insert Extention"	= 3in	76.2mm	
51	"Seat Tube Bend Angle"	= 35deg	35deg	
52	"Seat Tube Bend CLR"	= 3.00in	76.2mm	
53	"Seat Tube Diameter"	= 1.375in	34.925mm	
54	"Seat Tube Radius"	= "Seat Tube Diameter" / 2	17.4625mm	
55	"Seat Tube Thickness"	= 0.035in	0.889mm	
56	"Seat Tube Offset"	= (((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "Rear T	40.885deg	
57	"Seat Tube Offset at Bottom Bracket"	= ("Bottom Bracket Diameter" - "Seat Tube Diam	5.6515mm	
58	"Seat Tube Distance from Axel"	= "Rear Tire - Clearance Diameter" / 2	386mm	
59	"Seat Tube Top X"	= abs ((((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "R	81.0144deg	
60	"Seat Tube Top Y"	= (((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "Rear T	353.141deg	
61	"Seat Tube - Top Tube Intersection X"	= abs ((((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "R	64.7385deg	
62	"Seat Tube - Top Tube Intersection Y"	= (((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "Rear T	306.923deg	
63	"Seat Tube - Seat Stay Intersection X"	= abs ((((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "R	67.5618deg	
64	"Seat Tube - Seat Stay Intersection Y"	= (((("Rear Tire ISO/E.T.R.T.O. Size" / 2 + "Rear T	314.94deg	
65	"Top Tube Diameter"	= 1.125in	28.575mm	
66	"Top Tube Radius"	= "Top Tube Diameter" / 2	14.2875mm	
67	"Top Tube End Thickness"	= .8mm	0.8mm	
68	"Top Tube Intersection From Head Tut	= - 20.5mm	-20.5mm	
69	"Head Tube - Top Tube Intersection Y"	= "Front Tire Diameter" / 2 + ("Fork Length" + "H	593.279mm	
70	"Head Tube - Top Tube Intersection X"	= sqr ("Front Center" ^ 2 - ("Front Tire Diameter	558.125deg	
71	"Down Tube Diameter"	= 1.50in	38.1mm	
72	"Down Tube Radius"	= "Down Tube Diameter" / 2	19.05mm	
73	"Down Tube End Thickness"	= 0.9mm	0.9mm	
74	"Down Tube Intersection From Head T	= 33mm	33mm	
75	"Down Tube Offset at Bottom Bracket"	= ("Bottom Bracket Diameter" - "Down Tube Diar	4.075mm	
76	"Down Tube - Head Tube Intersection	= sqr ("Front Center" ^ 2 - ("Front Tire Diameter	575.004deg	
77	"Down Tube - Head Tube Intersection	= "Front Tire Diameter" / 2 + ("Fork Length" + "H	555.367mm	
78	"Down Tube Angle"	= ATN ("Down Tube Offset at Bottom Bracket" / S	44.2968deg	
79	"Chainstay Diameter"	= 0.750in	19.05mm	
80	"Chainstay Radius"	= "Chainstay Diameter" / 2	9.525mm	





* Fork is shown steel. Carbon fiber used, 412mm AC, 50mm offset, 100mm, 12mm TA.
* Swapping to 400/50 fork results in: -3mm FC, +0.4 HA, +0.4 eSTA -3mm BBH, +5mm grip-x, -4 grip-y
* Handlebar system is steel and carbon fiber.
* Frame caliper mount: PVD-SW32R/140, Clearance for FM32/140-180, PM60/160-180
* Seatpost: 210 mm Stroke, 31.6 mm
* Tires are 622-53mm max rear, 622-53 max front

MATERIAL: High Carbon Steel	UNLESS OTHERWISE SPECIFIED: IF DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/32 ANGULAR: MACH±.5 BEND ±1 TWO PLACE DECIMAL ±.010 THREE PLACE DECIMAL ±.005	TITLE: PVD TIE Advanced X1 (All-Road, 2021)
FINISH: RAL 5015 - Sky Blue Powder Coat		Peter Verdone Designs Fairfax, CA 94930 (415) 686-0257 peterverdone@gmail.com www.peterverdone.com
COMMENTS: Ride fast. Take chances	INTERPRET GEOMETRIC TOLERANCING PER: ASME Y14.5M Some parts may include a model-based definition to be interpreted per ASME Y14.41-2012	
PROPRIETARY AND CONFIDENTIAL	THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF PETER VERDONE DESIGNS. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF PETER VERDONE DESIGNS IS PROHIBITED.	SCALE: 1:10 | 2021-07-03 | REV

Metrology

- Calipers, micrometers
- Gauging, comparators
- CMM
- Using a DRO mill to measure (ghetto CMM)
- Laser levels
- Imaginary measurements!
  - Handlebar sweep points to the belly button when seated
  - You can ride as fast as you can look ahead
  - Flat light is like darkness

Reverse engineering

Copy the work of others

- Good practice
- Gets you into someone else's mind
- Learn important details

3D scanning

- LiDAR
- IR
- Photogrammetry
- White light and blue light scanning
- CT scan

Sagitta and Cord

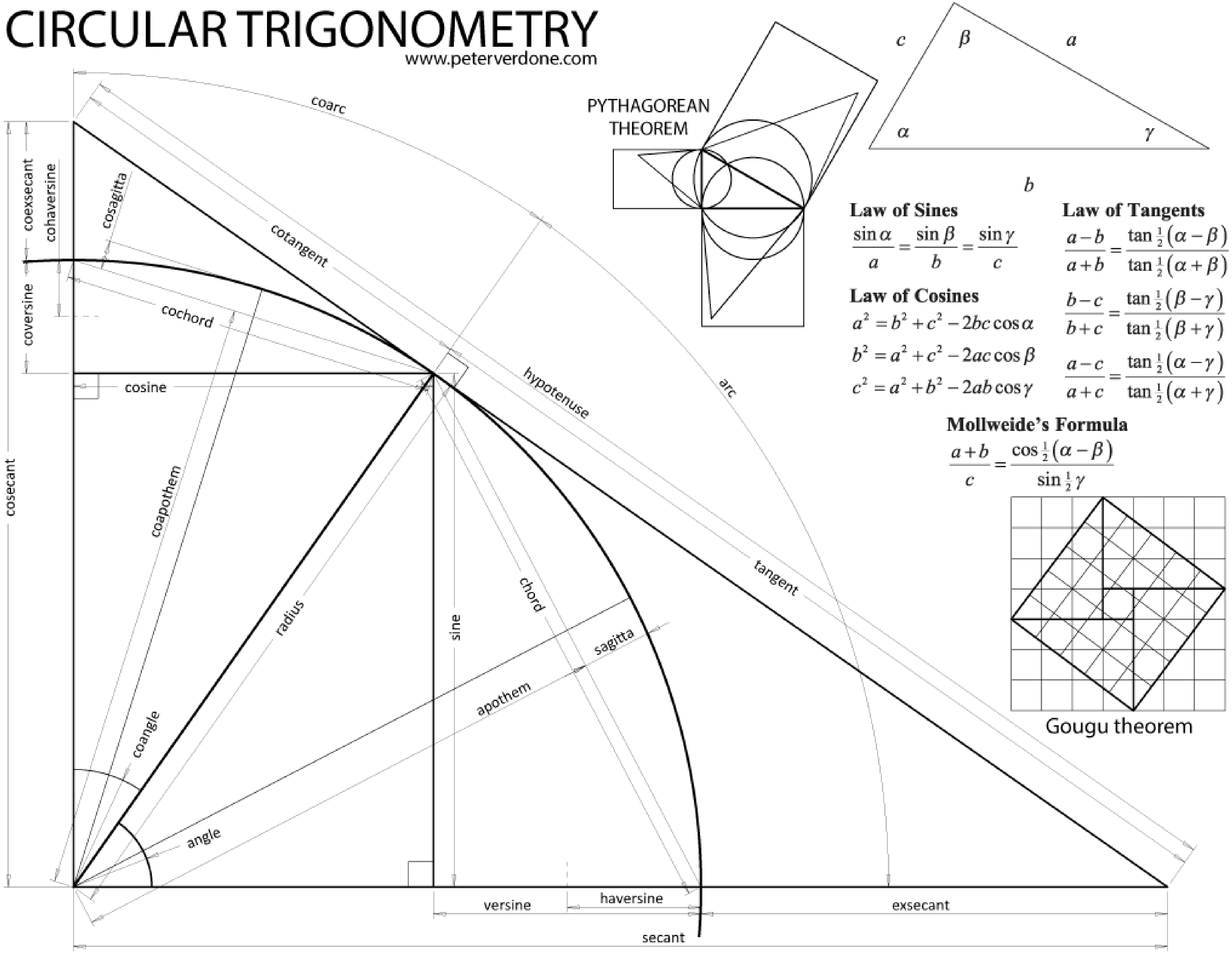
Imperial vs metric

- Imperial – Divisions
- Metric – Decimals
- Example: 3.375mm and 1.3″ is super rare

Learn how to take photographs at bike shows

CIRCULAR TRIGONOMETRY

www.peterverdone.com



PYTHAGOREAN THEOREM

Law of Sines

$$\frac{\sin\alpha}{a}=\frac{\sin\beta}{b}=\frac{\sin\gamma}{c}$$

Law of Cosines

$$a^2=b^2+c^2-2bc\cos\alpha$$

$$b^2=a^2+c^2-2ac\cos\beta$$

$$c^2=a^2+b^2-2ab\cos\gamma$$

Law of Tangents

$$\frac{a-b}{a+b}=\frac{\tan\frac{1}{2}(\alpha-\beta)}{\tan\frac{1}{2}(\alpha+\beta)}$$

$$\frac{b-c}{b+c}=\frac{\tan\frac{1}{2}(\beta-\gamma)}{\tan\frac{1}{2}(\beta+\gamma)}$$

$$\frac{a-c}{a+c}=\frac{\tan\frac{1}{2}(\alpha-\gamma)}{\tan\frac{1}{2}(\alpha+\gamma)}$$

Mollweide's Formula

$$\frac{a+b}{c}=\frac{\cos\frac{1}{2}(\alpha-\beta)}{\sin\frac{1}{2}\gamma}$$

Gougu theorem

Modern production methods in common use

Waterjet cutting

- The king of machine tools!!!
- No dead stop corners
- Keep table cost down

Fiber laser

- Cutting
  - No dead stop corners
  - No titanium
- Engraving
  - Marking metal parts
  - Tooling marks

CO2 laser

- Plastic
- Leather
- Paper

3-axis CNC

- Common
- Maximize cutter radii
- Minimize use of ball nose

5-axis CNC

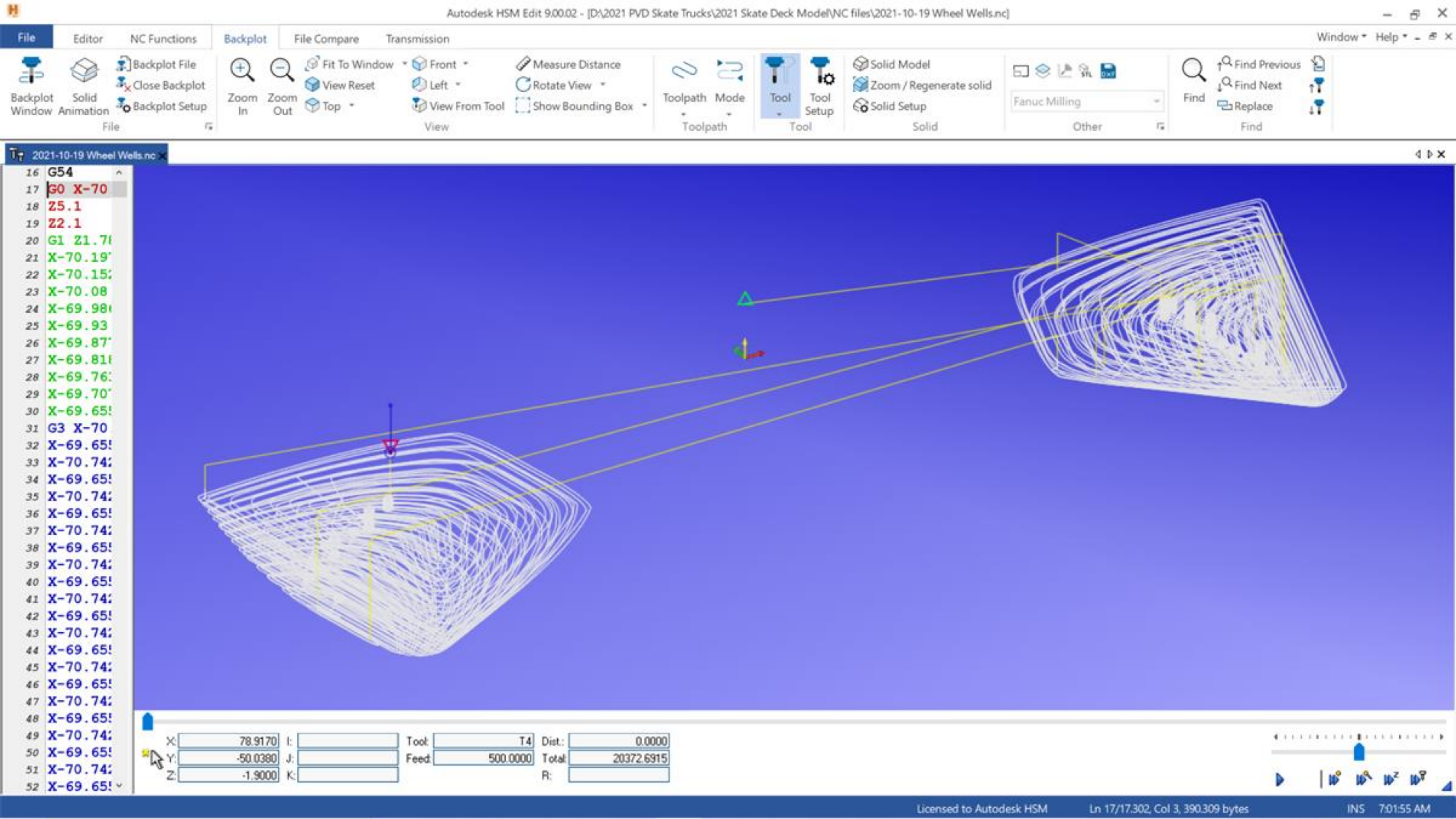
- Used to be unobtainable
- Expensive
- Choose your parts wisely, reducing setups.

3D printing

- DMLS, Direct Metal Laser Sintering
- SLM, Selective Laser Melting
- CMF, Cold Metal Fusion
- Learning to think for printing

Keep trying new things!


70
75
80
85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File
Editor
NC Functions
Backplot
File Compare
Transmission
Window
Help
Backplot Window
Solid Animation
Backplot File
Close Backplot
Backplot Setup
File
Zoom In
Zoom Out
Fit To Window
View Reset
Top
Front
Left
View From Tool
Measure Distance
Rotate View
Show Bounding Box
View
Toolpath
Mode
Toolpath
Tool
Tool Setup
Tool
Solid Model
Zoom / Regenerate solid
Solid Setup
Solid
Fanuc Milling
Other
Find
Find Previous
Find Next
Replace
Find
2021-10-19 Wheel Wells.nc
16 G54
17 G0 X-70
18 Z5.1
19 Z2.1
20 G1 Z1.7
21 X-70.19
22 X-70.15
23 X-70.08
24 X-69.98
25 X-69.93
26 X-69.87
27 X-69.81
28 X-69.76
29 X-69.70
30 X-69.65
31 G3 X-70
32 X-69.65
33 X-70.74
34 X-69.65
35 X-70.74
36 X-69.65
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Working with vendors

- The importance of drawings and MBD
- When to farm out
- Paragon Machine Works – Mark Norstad
- Local machine shops
- Remote machine shops
- Mail order brides, the printing paradox
  - Domestic vs offshore
  - Quality differences
  - Engineering support
  - Create your own supports!

Debrief

- The notebook
- Organize files for storage
- Clean up
  - Models
  - Assemblies
  - Spreadsheets
  - Equations
  - Reference Geometry
- Photographs, lots of photographs
  - Cropped for attention focus
  - Adjusted levels for clarity
- Critique, critique, critique
  - *“Pay attention to your enemies, for they are the first to discover your mistakes.”* – Antisthenes

- Make nice clean prints!!
- Was this a success?
- Was the problem solved?
- Were new problems created?
- Who needs to know?
- Intellectual honesty
  - See: Julia Galef

Posting my work to the internet has served me far more than anyone else.

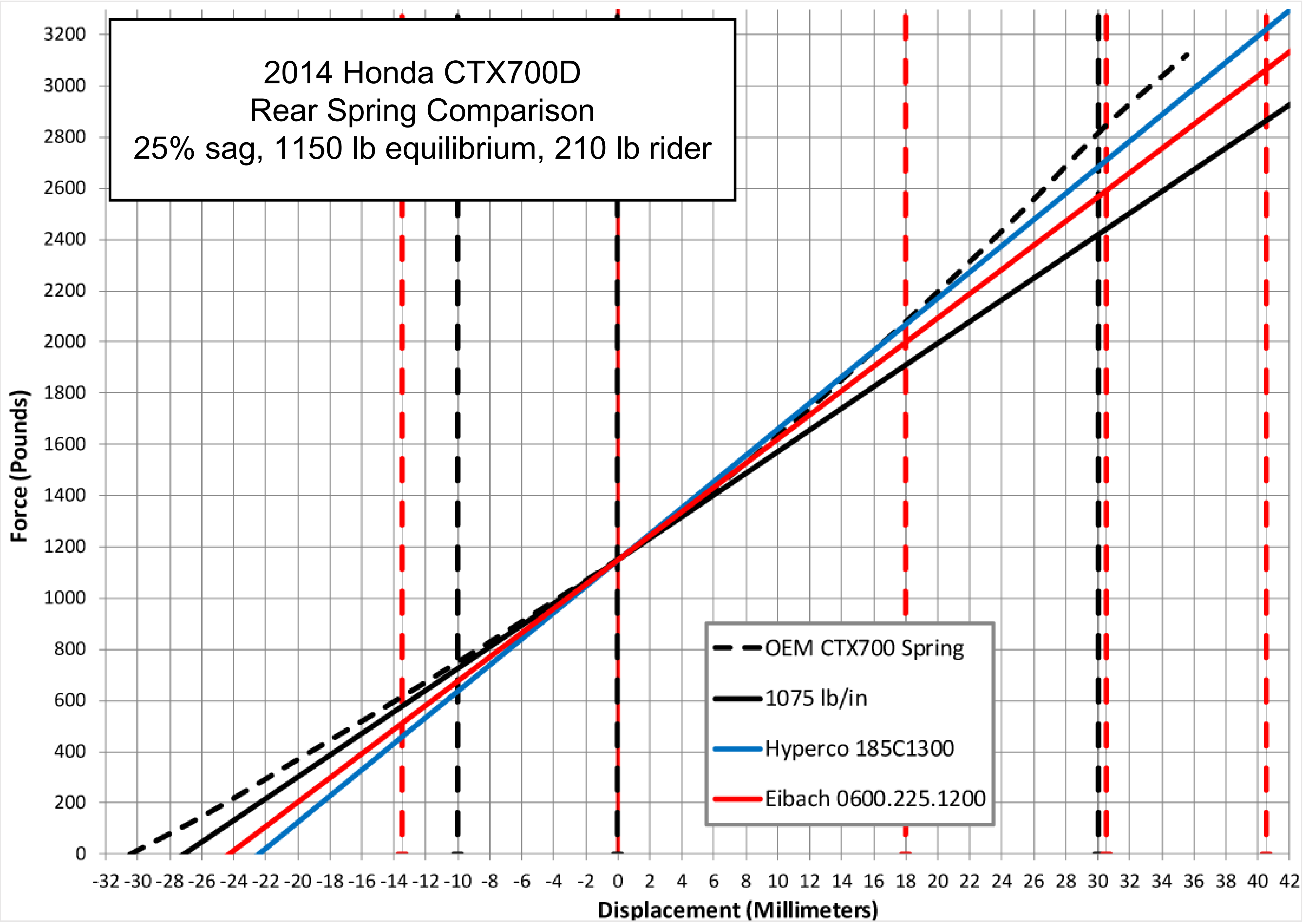
Development

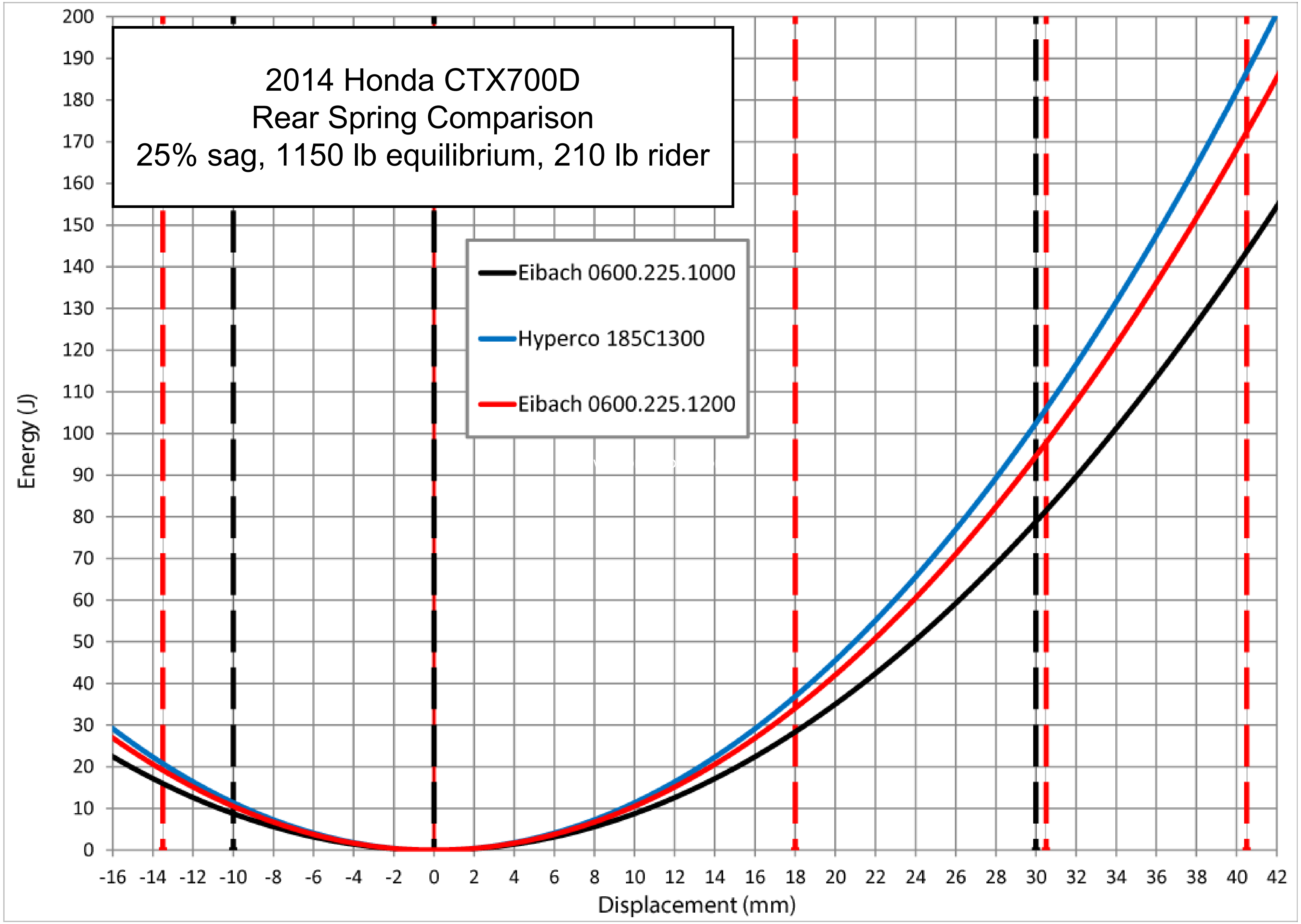
- Step-by-step progress
- Pattern of documentation over time
- Predicting paths for change
- Learning lessons
- Every time you get on a bike be critical
  - Look for the flaws
  - What is it doing poorly?

Learn to Write!!! This is a superpower


pb
MATT WRAGG


pb
ROSS BELL


2014 Honda CTX700D
Rear Spring Comparison
25% sag, 1150 lb equilibrium, 210 lb rider
Force (Pounds)
Displacement (Millimeters)
OEM CTX700 Spring
1075 lb/in
Hyperco 185C1300
Eibach 0600.225.1200
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-32 -30 -28 -26 -24 -22 -20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42



2014 Honda CTX700D
Rear Spring Comparison
25% sag, 1150 lb equilibrium, 210 lb rider
Eibach 0600.225.1000
Hyperco 185C1300
Eibach 0600.225.1200
Energy (J)
Displacement (mm)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-16
-14
-12
-10
-8
-6
-4
-2
0
2
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6
8
10
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18
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38
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42

Tooling

The frame fixture

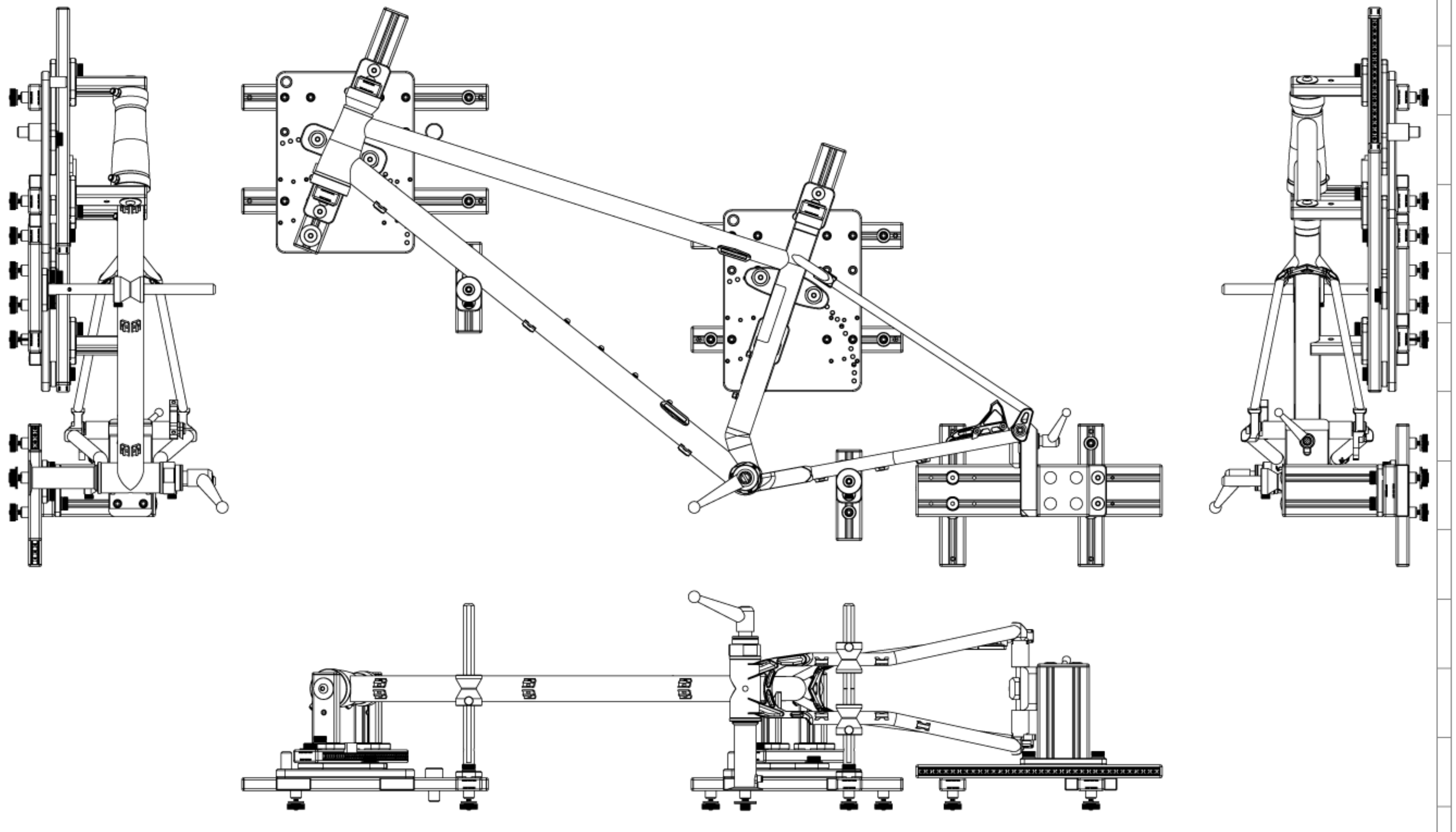
- Range and capacity
- Configurable
- Offset seat tube capability
- X/Y location needed for FS bikes
- How important is access?
- Opportunity costs, space costs

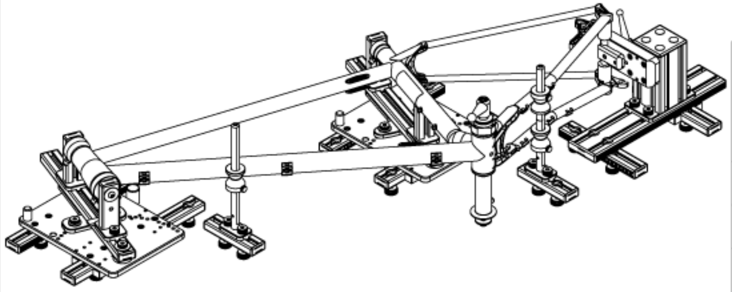
Accessory fixtures

- Fork
- Caliper mounting
- Stay fixturing

Bending

- Die and follow block
- Press bending
- Mandrel bending





PROPRIETARY AND CONFIDENTIAL

MATERIAL:

FINISH:

COMMENTS:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES

TOLERANCES:

ANGULAR: MACH X $\pm$.5	BEND X $\pm$1
ONE PLACE DECIMAL	X.X $\pm$.1
TWO PLACE DECIMAL	X.XX $\pm$.01
THREE PLACE DECIMAL	X.XXX $\pm$.005

INTERPRET GEOMETRIC
TOLERANCING PER: ASME Y14.5M

Some parts may include a model-based definition to be interpreted per ASME Y14.41-2012

TITLE:

PVD SKYNET Frame Fixture

PETER VERDONE DESIGNS
FAIRFAX, CA 94930
(415) 686-0257
PETERVERDONE@GMAIL.COM
WWW.PETERVERDONE.COM

SCALE: 1:8 | 2021-05-26 | REV

	Frame Driving Parameters (mm)	PVD All-Road (2021)	PVD Warbird	PVD Supermarine Spitfire
1	Front Center	805.0	850.0	845.0
2	Rear Center	410.0	425.0	410.0
3	Crank Height	281.0	300.0	305.0
4	Head Angle (°)	69.0	65.0	65.0
5	Seat Tube Angle (°)	71.4	69.8	68.5
6	Seat Tube Diameter	34.9	34.9	34.9
7	Front Rim ISO/E.T.R.T.O. Size	622.0	622.0	622.0
8	Front Tire Height	40.0	64.0	76.2
9	Rear Rim ISO/E.T.R.T.O. Size	622.0	622.0	622.0
10	Rear Tire Height	40.0	64.0	64.0
11	Max Rear Tire Height	53.3	66.0	66.0
12	Rear Tire Gap	10.0	12.0	8.0
13	Fork Length	412.0	591.0	440.0
14	Fork Offset	50.0	51.0	42.0
15	Fork Travel	0.0	180.0	0.0
16	Sag (%)	0.0	30.0	0.0
17	Lower Headset Stack	1.0	1.0	1.0
	Fixture Inputs			
1	Fixture Centerline Height	150.0	150.0	150.0
2	Head Tube Pivot Y from BB	355.6	457.2	355.6
3	Seat Tube Pivot Y from BB	152.4	152.4	152.4
4	Cosine Arm Radius	228.6	228.6	228.6
5	Cosine Pin Angle Shift (°)	9.0	9.0	9.0
6	Cosine Pin Diameter	15.9	15.9	15.9
7	Centerline from Beam Face	19.1	19.1	19.1
	Fixture Settings			
1	Seat Tube Pivot X from BB	18.3	13.7	3.9
2	Head Tube Pivot X from BB	638.8	612.2	667.2
3	Head Tube Bottom From Pivot (Minimum: 79mm)	87.89	92.51	119.75
4	Rear Axle X	404.0	418.3	404.0
5	Rear Axle Y	70.0	75.0	70.0
6	Head Tube Cosine Spacer	87.31	100.84	100.84
7	Seat Tube Cosine Spacer	78.92	84.57	89.04
	Important Value for BikeCAD			
1	Seat Tube Offset	31.2	39.8	52.2

Materials

- Choose with intention
- Why are you working with the materials you choose? What is being made easier/harder with this choice?
- Full discussion outside scope this seminar
- Titanium is a terrible material for prototyping!

Fundamental details and why

How bikes work
- Handling
- Fit
- The devil in the details

The chassis starts at the tires
- Big wheels
- 27.5/650b is a very special case
- Rear tire width
- Big tires on front of rigid bikes

Center of mass
- The triangle
- Bikes don't (often) get ridden backwards

Fit and 'handling'
- Aggressive XC on a DH bike

Stack and reach can help for basic sizing, but not in real design

Front center
- What's the limit?
- The front center tells me how fast a bike can go

Rear center
- Typically, we want these as short as possible. How short is too short?
- Why is the industry using long rear centers? For easy work

Mechanical trail
- We don't use ground trail, ever
- Caster effect
- Contact patch, it's important

Top tube length doesn't exist

Flop
- Potential energy
- Mellowing agent

Head angle
- The steering rate
- Stanchion bind
- Slacker is generally much worse
- Aligning forces along stroke

Head tube and bearings
- Best choices
- EC49 - lower
- IS41/52
  - IS42, FFS
- Tapered steerers
- Angle Adjust Components
- Gimbles vs. junk
- Not really needed anymore

Rear wheel trail

PVD/RAD – Formulaic approaches to fit

The dropper post
- Longer is almost always better
- 31.6 bore beats 30.9. Give up on 27.2mm
- This is a short term solution

Effective seat tube angle
- Marketing driven design
- PNW vs. the rest of us
- What is right?
  - Hardtails vs. suspension

Brake caliper mounting
- Why not radial calipers?
- Flat mount is the current standard
- Post mount refinements
- Wildcat systems

Cranks
- Crank length
- Q-factor
- Shell interface

Crank shell specifications
- What went wrong with BB30/PF30?
- PF41/86(92)(89.5)
- TH47/86(92)(89.5)
- TH35/68(72)

Down tube bends

Seat tube bends

Handlebars
- The problem with handlebars and stems
- Flat bar width
- Sweep angle
- Rise
- What do drop bars do?
- Wide drop bars?
- Bi-planes!!!!
- 31.8mm vs 35mm

E-bikes
- Sensors!!!!
  - Cadence sensor
  - Wheel Speed sensor
- Battery

Wheels
- Moment of Inertia

Hose and housing routing
- Flat mount on the mounted stay
- Seat tube entry
- Down tube entry
- The hole in the roof.

Flat pedals
- Pedal height higher than with clipless

The hybrid
- Gravel, all-road, etc.
  - Dirt 'road' racing
  - Actual riding
- What is the real use?
- Tires
- Handlebars
- Gearing
- Dropper

Anti-squat percent should not be used on bicycle

Coil vs Air
- Breaking force
- Progression

UDH
- What's it for?
- What are the issues?

Aerodynamics
- Especially for road bikes
- Not important in dirt (other than dirt road race)