MFG225900

Framing the Future with Fusion 360: Cycling Product Design & Manufacturing

Aram Goganian
Predator Cycling, LLC

Michael Sagan
Autodesk, Inc.

Learning Objectives

- Create & enhance Fusion 360 production workflow from design to manufacturing
- Combine t-spline environment with parametric modeling environment
- Drive precision geometries within the modeling environment from sculpting environment
- Reduce time spent on product re-assembly and practice design efficiency

Description

Go beyond the basics of Fusion 360 and obtain the skills to effectively and rapidly alter design manufacturing of a single product from concept to creation. Learn how a small business utilizes the concept of parametric design to drive CAM objectives that easily modify changes based on individual customer requirements (Size, Simulation Data, Generative Design, and Shape Optimization). This class will assist Fusion 360 users wanting to increase design workflow knowledge within T-Spline structures for end-to-end design to product development. Learn advanced design & techniques, including simulation and additive/subtractive mold-making for production. Our demonstration will follow the creation of a bicycle part (TBD), custom built yet dynamically designed to fit a multitude of individual riders. Our focus is within three Fusion 360 environments; Sculpting for industrial design, Parametric Modeling for mold construction, fittings & inserts, and precision geometry, and CAM for CNC operation.

Speaker(s)
Aram Goganian
Founder & Co-owner, Predator Cycling LLC.

Aram Goganian is founder and co-owner of Predator Cycling, LLC. Predator is a custom carbon fiber bicycle manufacturer, repair shop, and component fabrication company located in the Greater Nashville area. Since 2005, Predator has expanded beyond hand-built carbon frames into the maker revolution with the addition of CNC manufacturing and 3D development via Fusion 360. Aram has built over 1,100 bicycles and repaired over 3,000 frames. Custom-made Predator handlebars were recently represented in the 2016 Rio Olympics during the omnium track event. Aram plans on advancing cycling innovation using Autodesk and streamlined

mechanics as well as continued testing of new mechanical processes for other evolving industries. Predator has developed dynamic manufacturing workflow programs within the medical, aerospace, and military industries respectively within the past three years.
info@predatorcycling.com

Michael Sagan
Technical Solutions Executive: Automotive, Autodesk, Inc.

Currently, Michael helps Autodesk Automotive customers find their personal Future of Making. Recently, Michael was a Customer Service Manager on the Fusion 360 Team. He has been building performance machines since the in the late 1900's with Trek Bicycle's Advanced Concept Group and has seen a fair share of Tour de France Victories come and go. A creative concept artist and modeler, he excels in product design & development and loves helping people make things. You can find him most Thursday's at Pier 9- Autodesk's San Francisco Technology Center.

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Why we use Fusion 360 in bicycle lean manufacturing?

Definition of Lean Manufacturing

Lean manufacturing is the concept to reduce waste, lower costs, and increase the value to customer-end products. Small businesses rely on lean principles to quickly create custom, repeatable productions to match or exceed the value of larger manufacturing competitors. The bicycle frame industry is largely mass-produced overseas to reduce high volume building costs. As a custom shop, manufacturing tailored frames for each customer's personal geometries, we know that becoming lean must go beyond the production line and collectively blend into design, concept, simulation, and prototyping.

Reasons Fusion 360 Contributes to Lean Manufacturing

There are numerous reasons a small company will benefit from using Fusion 360.

First, Fusion 360 alleviates the need for multiple software uses. Fusion integrates a vast array of helpful tools. For our bicycle frame production, the ability to synchronize our design, surfacing, simulation, and CAM operations into one unified workflow environment allows us to easily plan one frame design that can be malleable within Fusion so that it may accommodate a multitude of customer dimensions.

Secondly, Fusion 360 offers cloud sharing and storage. Cutting out the need and costs for purchasing and storing server devices, Fusion 360 allows for active workflows to literally follow you wherever you work best; be it in an office, a coffee shop, or your couch. Never before has it been so easy to digitally create on-the-go. We regularly co-design with other specialists all across the country updating and managing shared files.

The third reason is simple; cost. As an all-inclusive system, Fusion 360 solves the need for purchasing supplementary packages and tools for creating from design to manufacturing. Without adding extra costs for additional programs, a small business can lean out time consuming training, downloading, and over-spending.

Bicycle Design to Manufacturing Overview: A Quick Rundown

The Basic Process

Once our customer receives a full bike fit and custom measurements are recorded, the first objective is to provide 2D geometries and cross points within the Sketch environment of Fusion 360. Once reviewed, the sketch becomes a t-spline-formed 3D body in the Sculpt environment. From here, the frame is shaped, contoured, and molded to fit the customer's specifications. Using the Design environment, the frame design gains the bearings, races, and other important frame components that affect the production mold design. Our molds are created utilizing both the design and surfacing environments in conjunction with one another. The whole project comes to fruition within the CAM environment; preparing for the manufacturing process with CNC automation.

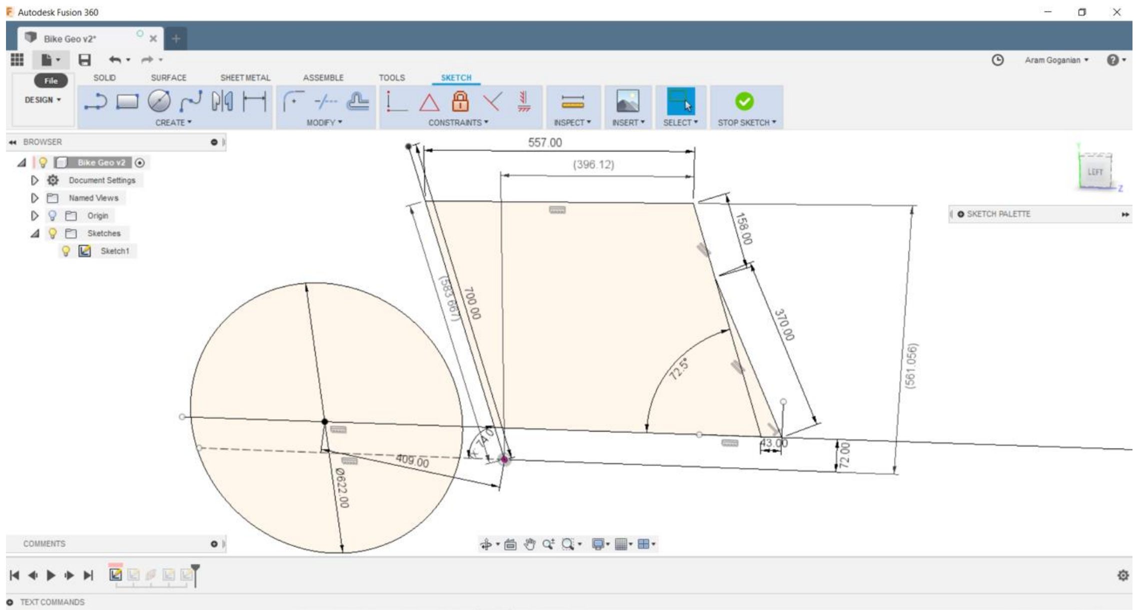
One Custom Bike Design; Two, Three, Ten Customers?

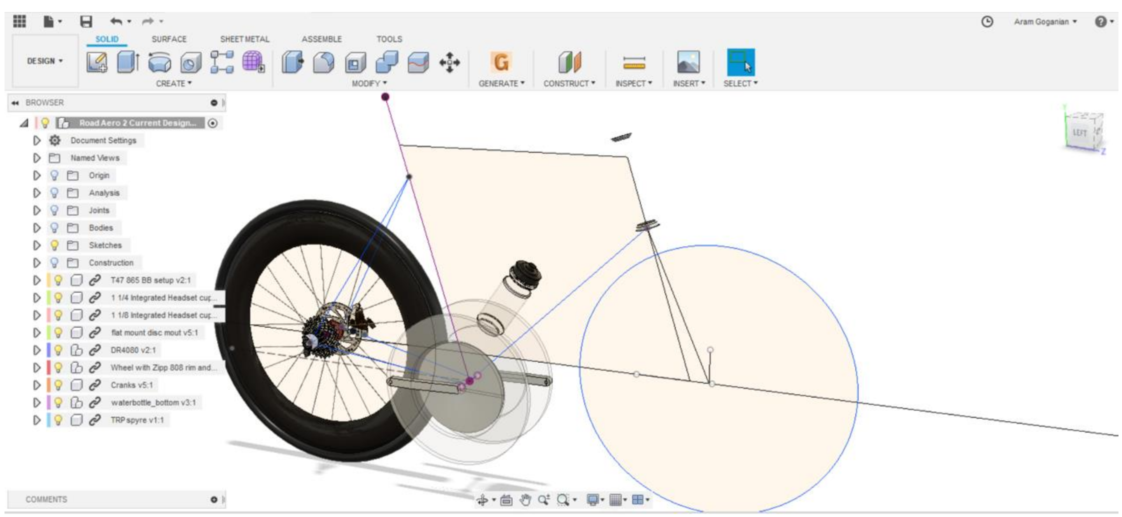
So, we have one design, but ten custom orders. Now what? Fusion 360 creates a parametric solution for an array of individually sized production orders. Found in Sketch environment, our parametric models contain variables that allow for quick alteration of custom geometries. Within these sketches, we are easily allowed to change size requirements that match each individual rider such as seat tube, head tube, and top tube lengths and angles. Many other flexible measurements can be adjusted and modified from one singular master design. In a way, this tool allows for a parent/child design template that allows for quick manipulations. Once the altered sketch is complete, you return to the Sculpt environment to update contact points of sculpted bodies to the sketch. The design environment is now easily linked and updated from any new sketch and sculpt configurations, thus making functional repeatability of the same part.

Sketch Environment: Precision Geometries for Bike Construction

Establishing Hard Points

Customer A has received a full head to toe bike fit. We are now ready to define his/her frame measurements by creating hard points in sketch. For our situation, we are concerned with three main hard points for bike construction; center bottom bracket, saddle position, and handlebar position. By defining these three main hard points, about 80% of the frame construction is geometrically correct. With this design framing, we now can alter the bottom bracket heights, head tube angles, and chain stay lengths. For our frames, we then add supplementary components (i.e. wheels, brake mounts, cranks, etc.) which are saved in our libraries to complete the sketch.





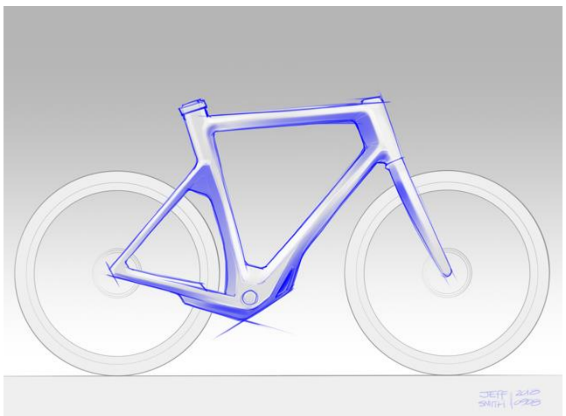
Sculpt Environment: T-spline Construction & Design

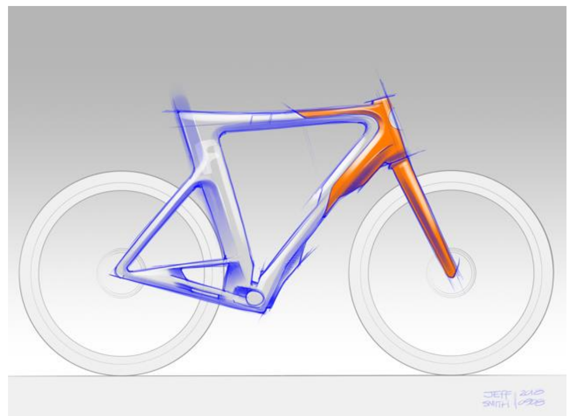
What is a T-Spline Surface?

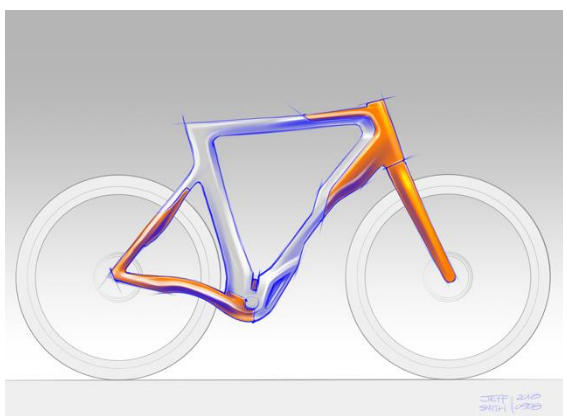
A T-spline surface as defined on Wikipedia is a NURBS surface for which rows of control points are allowed to terminate without traversing the entire surface. For bicycle frames, it makes sense to design composite parts within T-splines. Carbon fiber is a fabric that for all intents and purposes bends into tubular fashion, binding together into one solid customizable shape.

Shaping the Frame: 2D Sketch to 3D Model

Once we enter the Sculpt Environment, we reference the hard points that were constructed in Sketch. For this particular frame, we had drawn concept sketches created by Autodesk's Jeffrey Smith, Education Mgr./Industrial Product Mgr. Jeffrey provided us with multiple frame renderings from which we used as a launching point for our final conception.

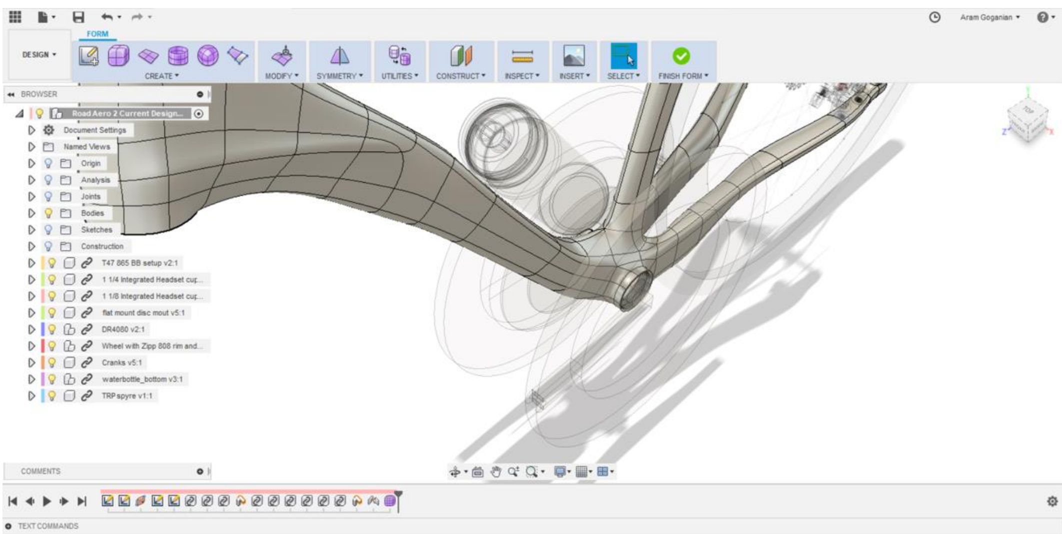


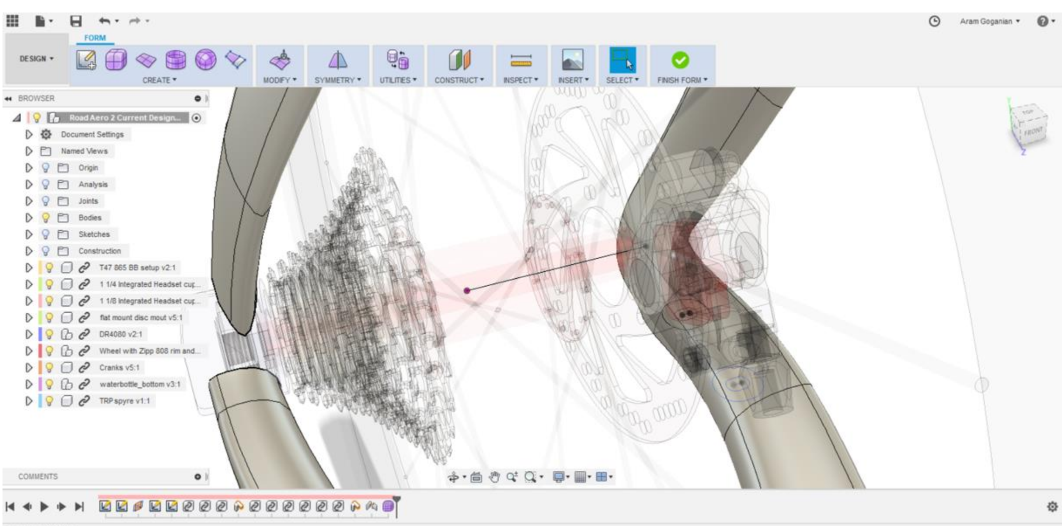




Utilizing these sketches as bottom layer references within Fusion, we constructed the main bicycle frame triangle. We also utilized the same sketch references in another body to create the chain stays and seat stays.

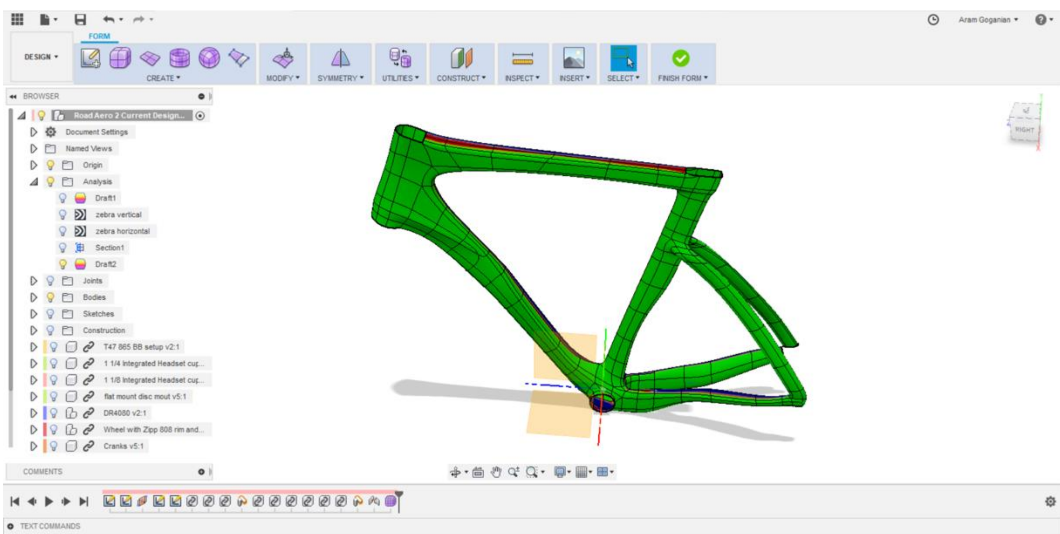
Now that we have created these two bodies, the frame begins to take shape. By using multiple tools within Sculpt, we fine tune each face to achieve our desired shapes within the parameters of the defined geometries. The bicycle components that we included from our library are added during Sculpt to ensure that angles and allowances will work for our final product. As the designer and manufacturer, it is important to consider product functionality in addition to testing the limits of ambitious artistry. These checks include wheel, brake, water bottle cage, front & rear derailleur, and crankset clearances.





Modeling for Composite Manufacturing

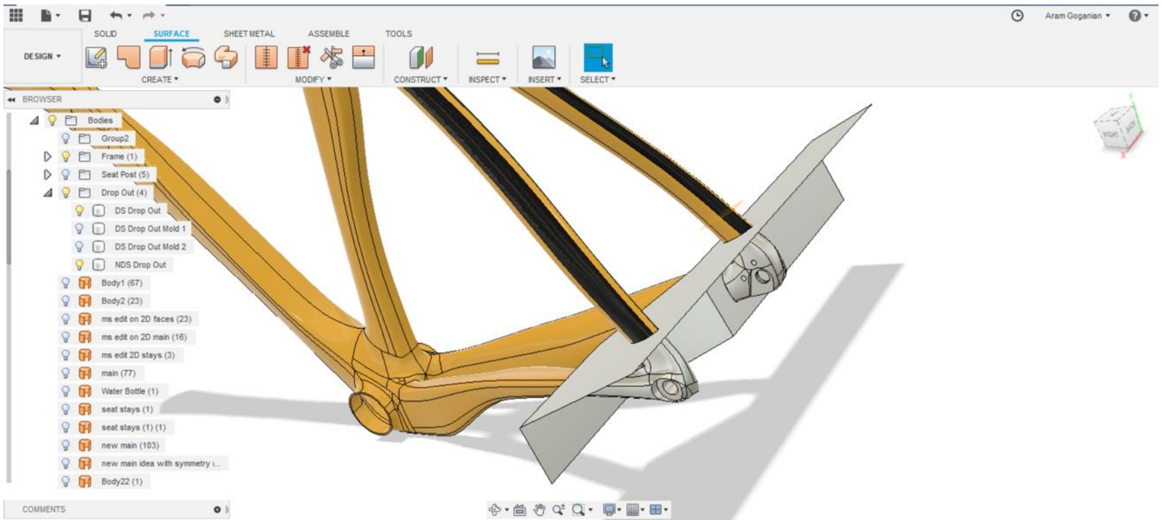
As a small manufacturer, Predator Cycling must consider designs that accurately portray the pliable and not-so-pliable qualities of working with carbon fiber as a material. Using the draft analysis tool, we can define plausible mold lines and draft angles of NURBS surfaces that may directly affect the layup of fibers, mold cavity imperfections, and shapes that may not de-mold cleanly. For this frame, our objective is to make the main frame in a one-piece mold. The stays and dropouts are individually molded. As a manufacturer, we see seven separate pieces to construct the frame. As a designer, we must acknowledge the parameters of the manufacturer within our idea construction. Design for manufacturing allows for fewer potential problems going forward and contributes a great deal to the idea of savings in lean manufacturing.



Design Environment: Component Assembly using Split, Surface, Extrude, & Loft

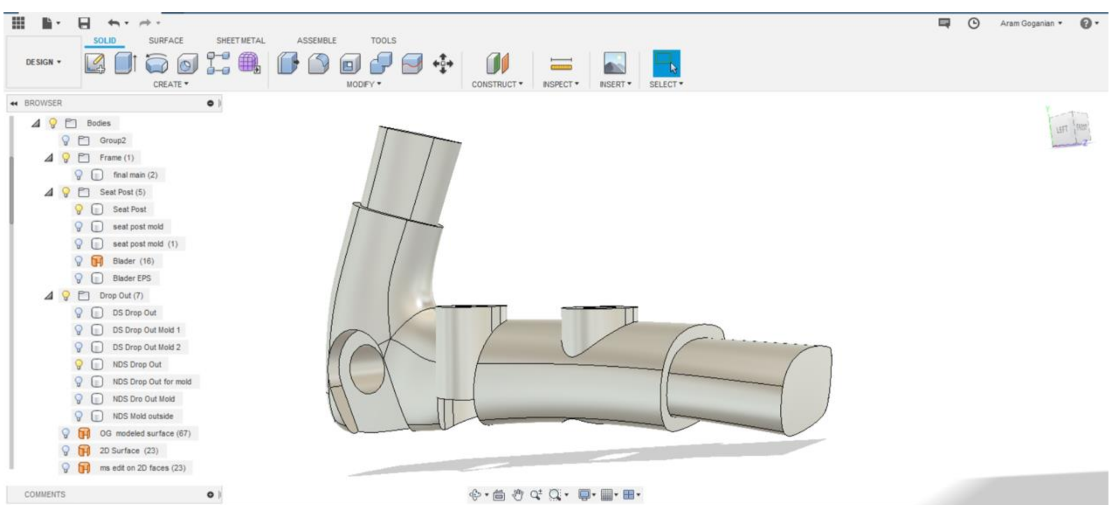
Cutting of the Frame

Using construction planes and the surface tools, it’s time to utilize the Fusion Design Environment to cut the frame and create cutting templates. These templates allow the bodies to be updated, altered, or edited in any future modifications of the frame. This practice of parametric modeling facilitates and expedites future frame construction for multiple customers of varying riding geometries.



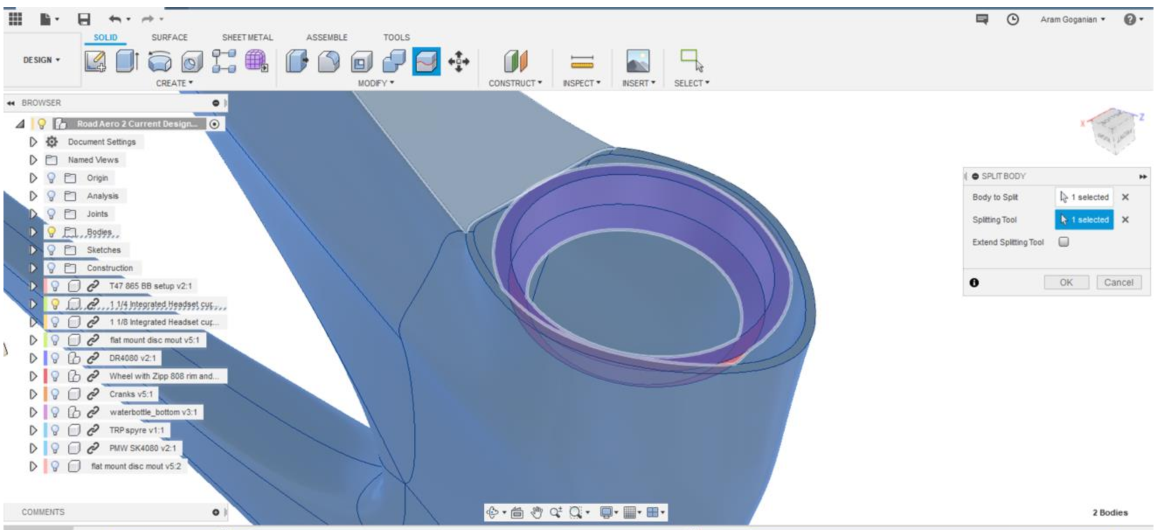
Connecting the Frame: Creating Plugs

From the lofted shapes of internal geometries, we then create plugs using the surface tools that connect each tube to one another. It is vital in composite bicycle manufacturing that these plugs, including their shape, width, and wall thicknesses are designed thoughtfully as they become main stress points for load transfer. These plug joints are key components when we enter the stress testing phase of our physical parts.



Extrude, Loft, Cutting Tools: Component Location and Mounting

For our frames, we use extrusion, loft, and cut to place important components within the design including bearing races, threaded inserts, brake mount locations, derailleur hangers, etc. These pre-designed linked components are inserted to create and define the splits within our surfaces. These split bodies and cutting tools pinpoint drilling holes, mounting points, and other post-op areas that need marked for parametric modeling of the geometries that may be affected in any future changes.

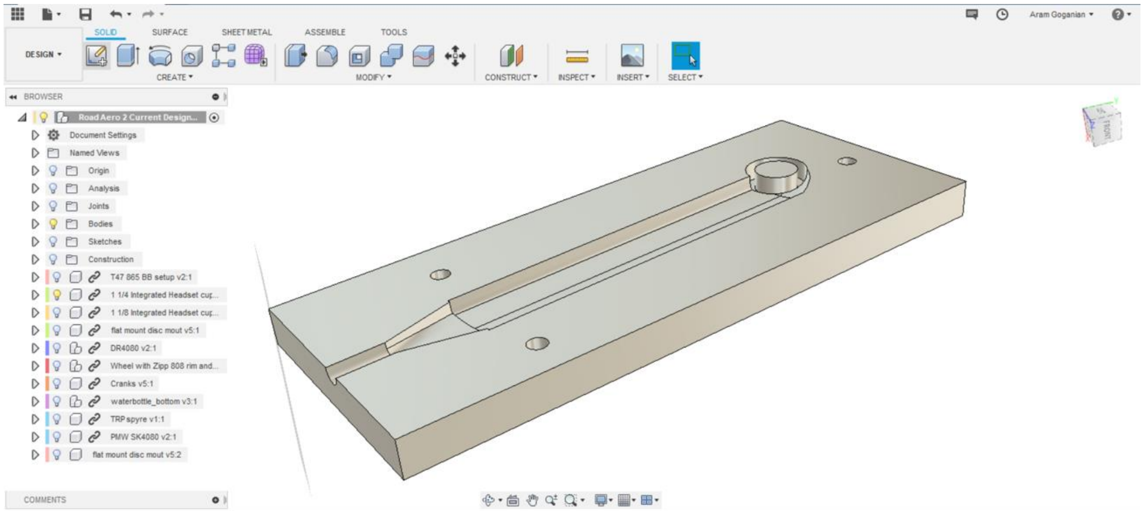


Mold Creation: Preparing for Manufacturing

Design Environment: Part Isolation & Thoughtful Machining

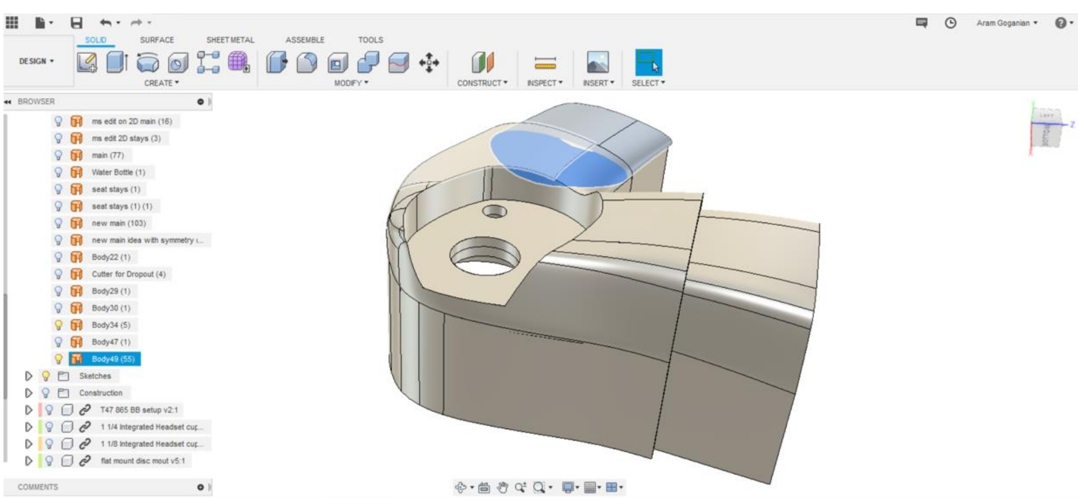
As a machinist, it is in this step that we apply a thoughtful approach when figuring out the easiest, most efficient, and precise paths for mold construction. Mold construction directly affects (and vice versa) the capabilities of the machinery, the software, and the materials. It is in this step in which a designer confides in the engineer's work and an engineer the machinist's. These steps must remain harmonious as what a designer dreams up must be achievable in practice as well as cost and time. It must be effective for mass production purposes.

For our purposes and this frame, our main mold consists of the front triangle. Chain stays, seat stays, seat post, and drop outs live in separate molds. These parts were isolated in previous design steps.



Project & Silhouette: Construction Planes & Cavities

Mold construction consists of defining the “view direction” within the Silhouette tool. This is a construction plane that is parallel to our mold line. Once this plane is created, we can use the Project tool to cast the body outline to a sketch. This projected sketch is extruded to the body and becomes the cut plane for our newly surfaced mold.



For our simpler shapes, we use the Silhouette tool in conjunction with the Offset tool to create mold surfaces. The Silhouette tool cuts mold lines. These mold lines become split surface faces. Once faces are selected, the offset tool allows for copies of the surface faces that will become the direct surfaces for a part mold.

Manufacture Environment (Formerly CAM Environment): Machining the Frame

Definition of CAM

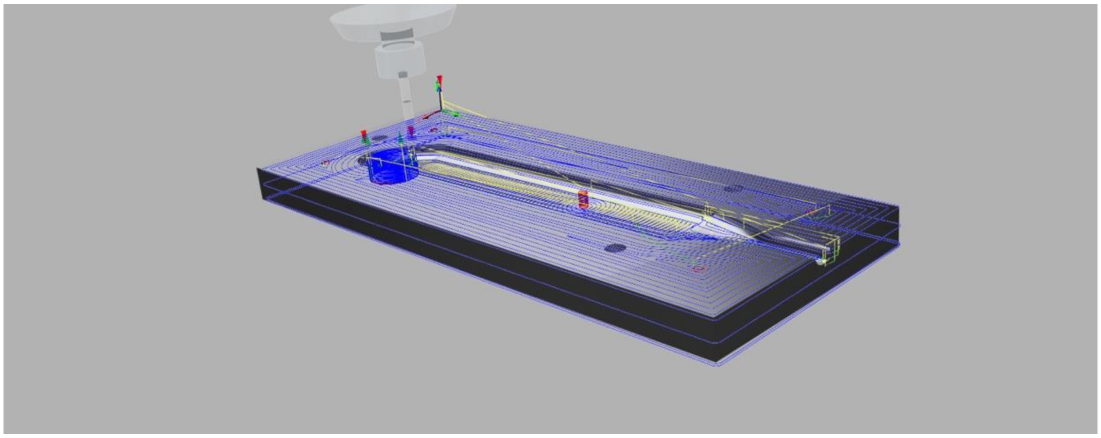
Computer Aid Manufacturing – The use of software to control machine tools.

CAM for Mold Construction

Each created mold gets placed into a setup within the CAM Environment. Our frame consists of fourteen individual mold setups. Tool paths are created from using varying 2d and 3d selections. Our tool paths are selected for aluminum and composite mold making for a gantry router built from kitted parts available from CNC Router Parts (http:cncrouterparts.com)

CNC: Overview & Approach

In the Manufacture Environment, we use the adaptive clear tool to remove almost 95% of our mold material from a single block of aluminum. This is followed by a pre-finish operation (scallop) to remove any remaining material, leaving around .005 of an inch. We use a combination of the parallel, flow, morph, and contour tools for our final surface finish. We are now left with a high-quality mold surface finish, ready for a composite layup.



Conclusion

Abiding by the general design to manufacturing approach outlined in this handout will allow your small business to flourish as a result of Fusion 360’s ease of use, time savings, parametric efficiencies, and streamlined workflows.

The benefits of Fusion 360 are far-reaching when you think beyond the design realm and comprehensively plan out your manufacturing and production timelines. One product can easily be created, manipulated, and finished; ready for testing, beta, or selling in an accelerated environment.