AS501363

Autodesk Fusion 360 for Architects and Designers

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BWC Architects

Learning Objectives

- Learn about where Autodesk Fusion 360 can help your creative construction projects.
- Learn about the strengths and weaknesses of Autodesk Fusion 360 when it comes to using it in construction projects.
- Learn how Autodesk Fusion 360 can empower your digital fabrication workflow and complex Revit software needs.
- Review some real-world example projects done for AEC using Autodesk Fusion 360.

Description

While Autodesk Fusion 360 software is really focused on product design and development, there are many times this wonderfully useful, flexible, and affordable tool comes in handy when putting a building together. In this class, we'll dive into using Autodesk Fusion 360 as a design tool for building elements, show some real-world examples of its use on architecture projects, and talk about how to use Autodesk Fusion 360 along with Revit software and other building information modeling (BIM) tools as part of the overall construction project. You'll see examples of creative fabrication, generative design, FEA, sheet metal modeling, complex organic forms, and digital fabrication-all things Revit isn't so hot at but Autodesk Fusion 360 handles with ease. You'll also see examples of creating Revit families from Autodesk Fusion 360 imports.

Speaker(s)

My goal is to make the world a more interesting place. For over 20 years I've done this by making great things. Along the way, I've become a licensed architect, designed and built one of the world's finest bars, turned shipping containers into playrooms, revitalized defunct commercial spaces, and helped built one of the largest digitally-fabricated structures in history. I've founded companies, advised startups and industry, built software, and brought many products to market. Since 2006, I've been the co-founder of Because We Can, an award-winning design-build architecture studio in Oakland, California. I'm also a co-founder of Model-no.com, an exciting new startup launched in 2019 bringing 3D printed user-customized designer furniture to the mass market.

Why Fusion is a great tool to add to your work

Because you can do things with it you can't do in Revit or AutoCAD

- Complex, parametric, highly detailed models
- Sheet metal
- Organic forms
- FEA
- CAM

It's easy to learn, easy to use, and really affordable

- Built-in Learning features
- Designed for designers
- A quarter of the cost of other similar CAD apps

It's much more supportive of design work than other MCAD platforms

- It's workflow is much more forgiving for big changes late in the design
- Great materials, animation, renderings
- Integrated part catalogs

It works with Revit and AutoCAD (kinda)

- You can easily manually import and export to and from Fusion and your main AEC apps

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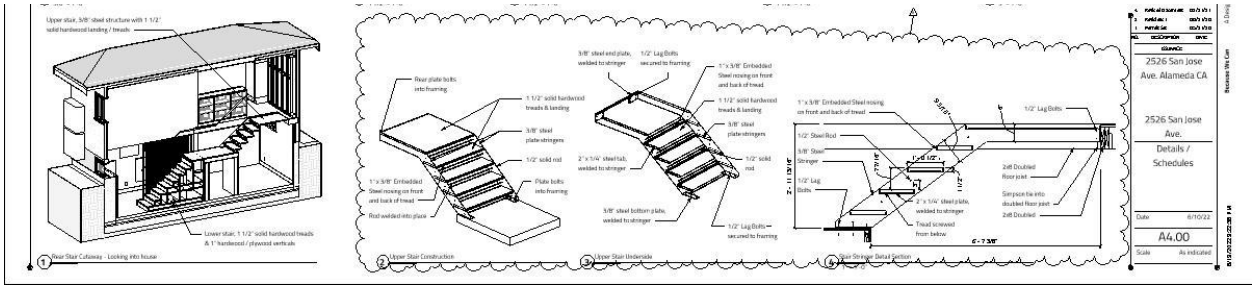
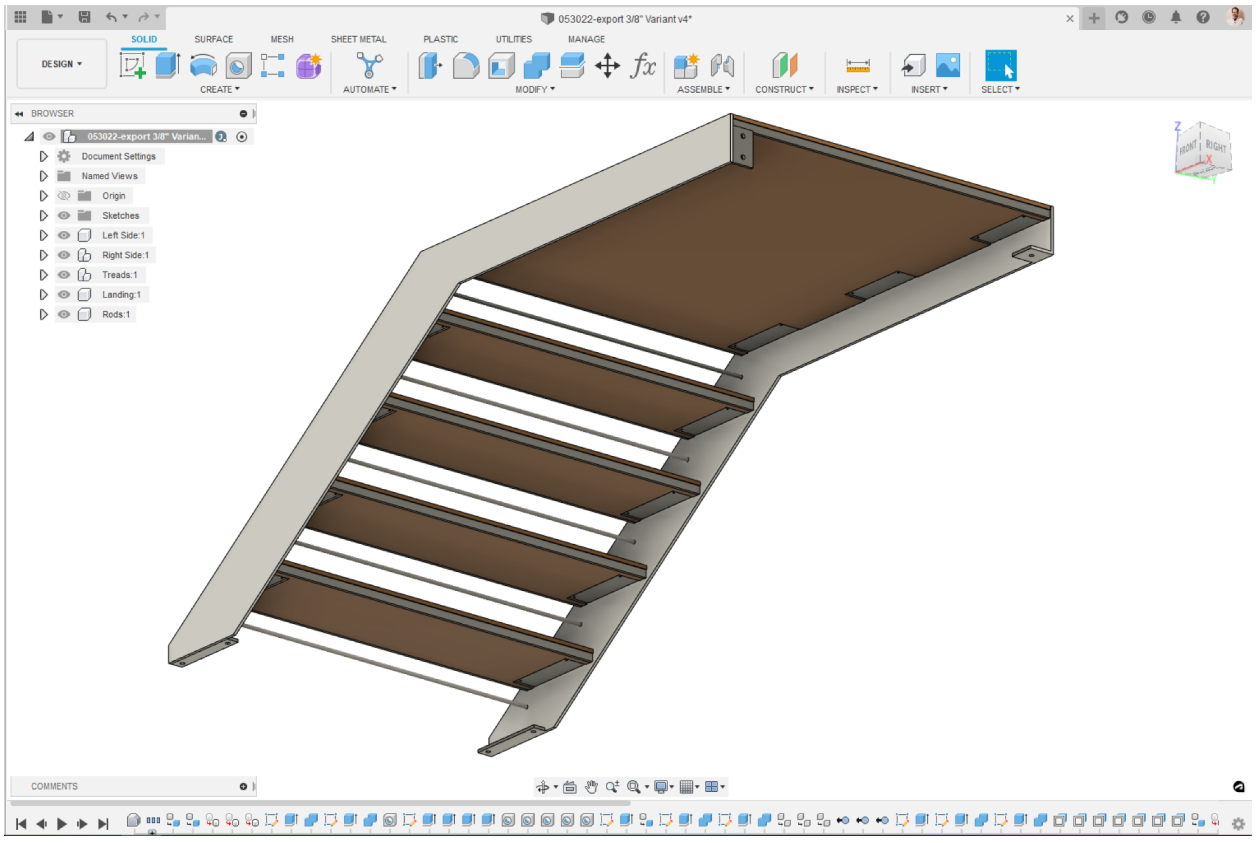
Case Study #1: Easy FEA for design

One great thing in Fusion is the easy-to-use FEA. Finite Element Analysis ala FEA is where you can run simulations on your 3D models to try and predict how your design might perform. There's all sorts of different tests you can run, and Fusion makes it really easy for non-experts to leverage these tools into your workflow.

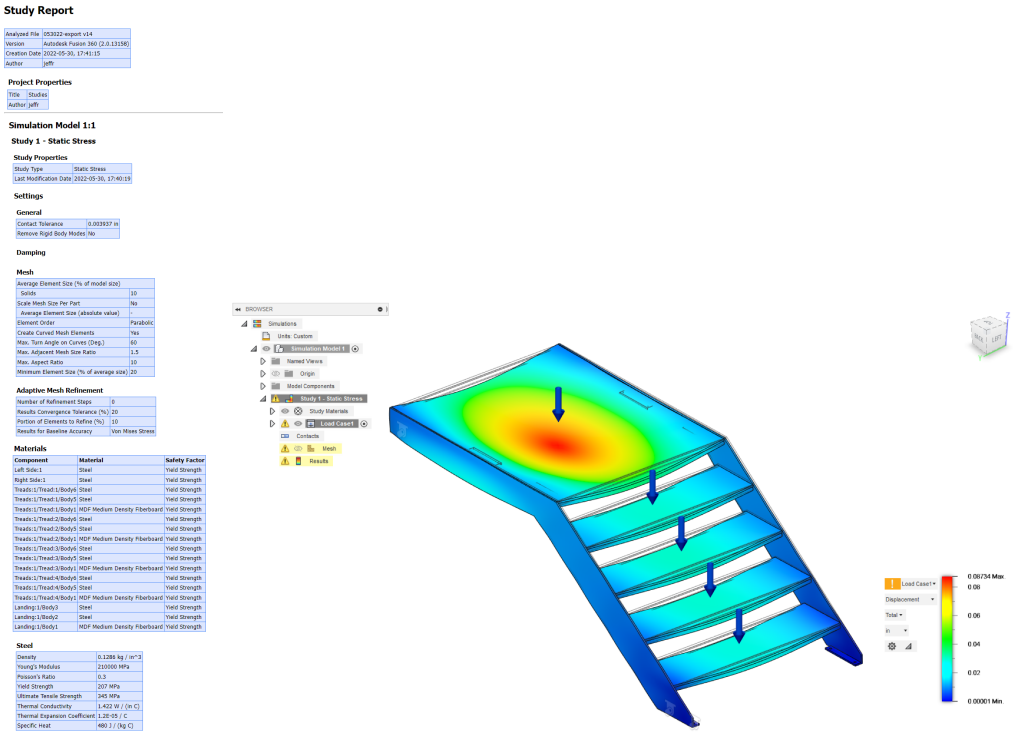
Where we can apply that in architecture is in testing designs before we reach out to the structural engineer, and then being empowered to work with the engineers at a much higher level. For example, I was designing this open steel stringer, wood tread staircase for a residential project.



I took the initial Revit model, which is what we call a ‘design model’ at BWC as it just captures the design intent but isn’t detailed enough for full fabrication or FEA, and I exported it to .SAT by isolating it into its own view. We’ll talk more about this later.



Then I imported it into Fusion, and added the details needed to get it to be what we call a ‘fabrication model’, and then ran some ‘linear stress’ FEA tests on it to see how it would perform under load.



Study Report

Analyzed File	053022-export v14
Version	Autodesk Fusion 360 (2.0.13158)
Creation Date	2022-05-30, 17:41:15
Author	jeff

Project Properties

Title	Studies
Author	jeff

Simulation Model 1:1

Study 1 - Static Stress

Study Properties

Study Type	Static Stress
Last Modification Date	2022-05-30, 17:40:19

Settings

General

Contact Tolerance	0.003937 in
Remove Rigid Body Modes	No

Damping

Mesh

Average Element Size (% of model size)	
Solids	10
Scale Mesh Size Per Part	No
Average Element Size (absolute value)	
Element Order	Parabolic
Create Curved Mesh Elements	Yes
Max. Turn Angle on Curves (Deg.)	60
Max. Adjacent Mesh Size Ratio	1.5
Max. Aspect Ratio	10
Minimum Element Size (% of average size)	20

Adaptive Mesh Refinement

Number of Refinement Steps	0
Results Convergence Tolerance (%)	20
Portion of Elements to Refine (%)	10
Results for Baseline Accuracy	Von Mises Stress

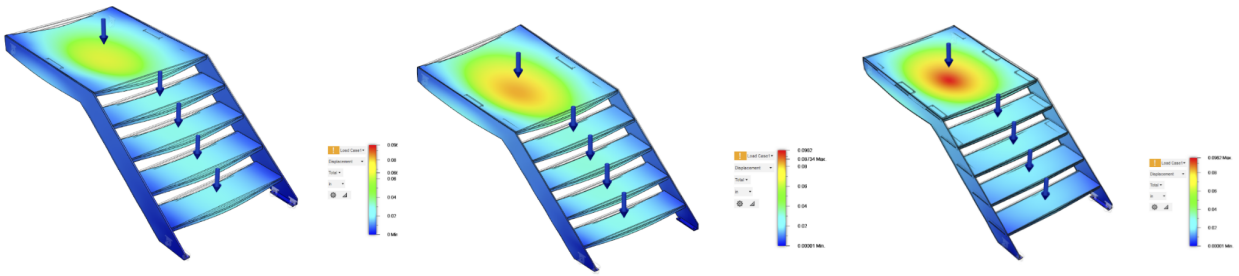
Materials

Component	Material	Safety Factor
Left Side:1	Steel	Yield Strength
Right Side:1	Steel	Yield Strength
Treads:1/Tread:1/Body4	Steel	Yield Strength
Treads:1/Tread:1/Body5	Steel	Yield Strength
Treads:1/Tread:1/Body1	MDF Medium Density Fiberboard	Yield Strength
Treads:1/Tread:2/Body4	Steel	Yield Strength
Treads:1/Tread:2/Body5	Steel	Yield Strength
Treads:1/Tread:2/Body1	MDF Medium Density Fiberboard	Yield Strength
Treads:1/Tread:3/Body4	Steel	Yield Strength
Treads:1/Tread:3/Body5	Steel	Yield Strength
Treads:1/Tread:3/Body1	MDF Medium Density Fiberboard	Yield Strength
Treads:1/Tread:4/Body4	Steel	Yield Strength
Treads:1/Tread:4/Body5	Steel	Yield Strength
Treads:1/Tread:4/Body1	MDF Medium Density Fiberboard	Yield Strength
Landing:1/Body3	Steel	Yield Strength
Landing:1/Body2	Steel	Yield Strength
Landing:1/Body1	MDF Medium Density Fiberboard	Yield Strength

Steel

Density	0.1286 kg / in^3
Young's Modulus	210000 MPa
Poisson's Ratio	0.3
Yield Strength	207 MPa
Ultimate Tensile Strength	345 MPa
Thermal Conductivity	1.422 W / (m C)
Thermal Expansion Coefficient	1.2E-05 / C
Specific Heat	480 J / (kg C)

This generated a report I was able to share with the structural engineer, who was able to provide much higher-level feedback about connection details and recommendations on how to optimize the design to use thinner material. I was able to re-run the analysis using different thicknesses of stringers to help figure out an optimal size.

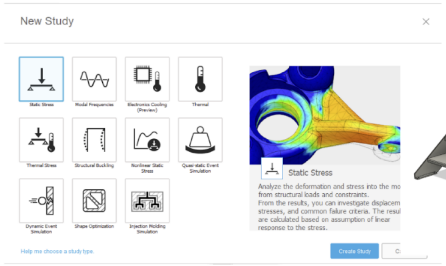


½” Stringers ⅜” Stringers ¼” Stringers

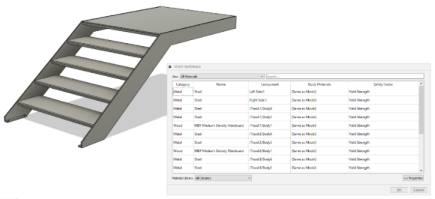
Running ‘linear stress’ FEA is really simple; you just:

1. Set your materials, in this case Steel and ‘MDF’ as the wood, as actual hardwood is non-linear (as it’s stronger in the grain direction) and a more difficult thing to do FEA on, but MDF is linear and thus easy to run tests with. I figure if it works with MDF it will work with the Oak that we’re actually going to use for these treads! Also this is just a study, it’s the structural engineer who’s going to vet the final scheme on this, we’re just exploring options.

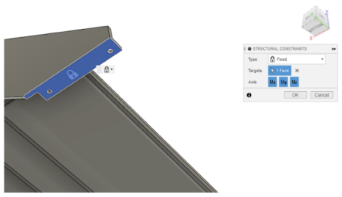
2. Set your Constraints, which is the parts of our model that aren't going to move. In this case, it's where the stair will be attached to it's surrounding structure.
3. Set your Loads, which is easy and pretty obvious as to what they are!
4. Set your Contacts, which can be automatically done. This is where things can get more complex, for the automated Contacts is going to assume everything touching is actually 'welded' together, which in our case with our treads isn't so, they are screwed to the stringer mounts; so watch your connections or you'll not get the right results!
5. Then run your Analysis, and see what you get!



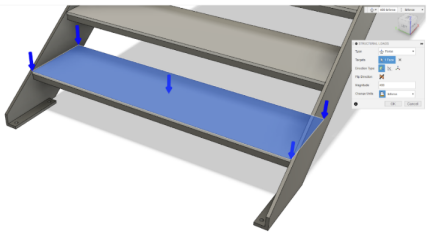
1. Create a New Study, and use Static Stress



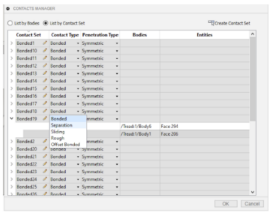
2. Set Materials



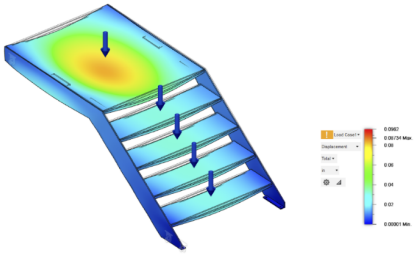
3. Set Constraints



4. Set Loads



5. Set Contacts (be careful of Automatic Contacts!)



6. Run!

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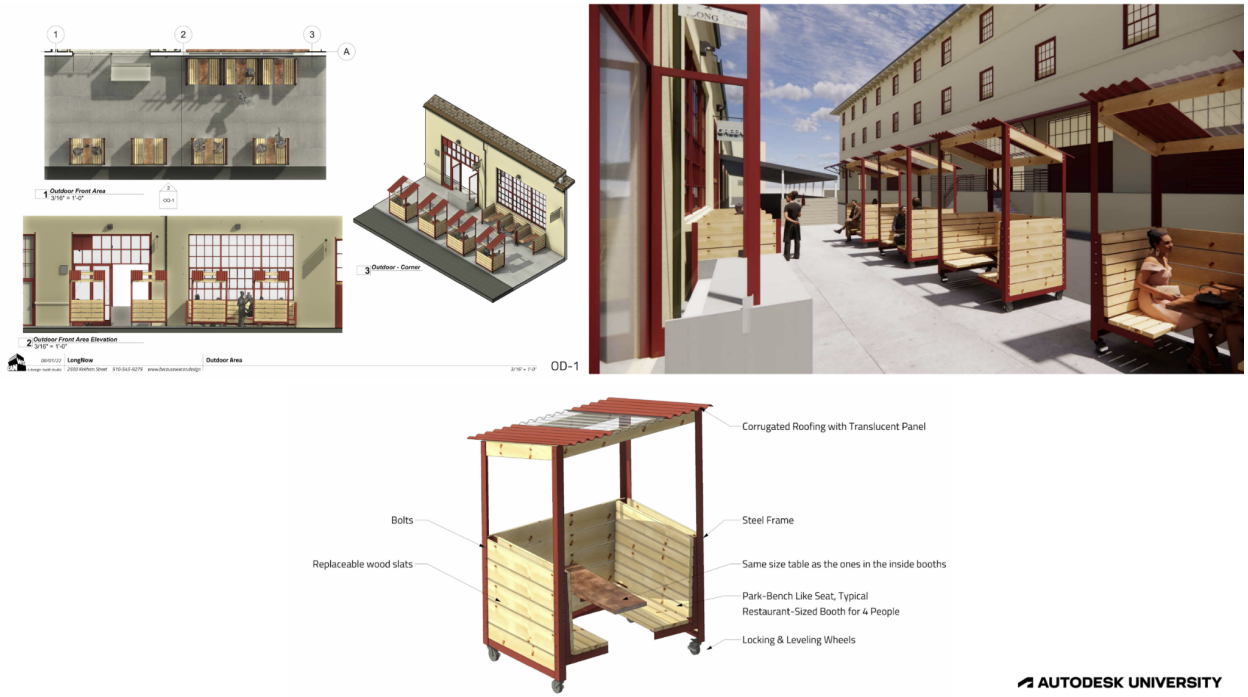
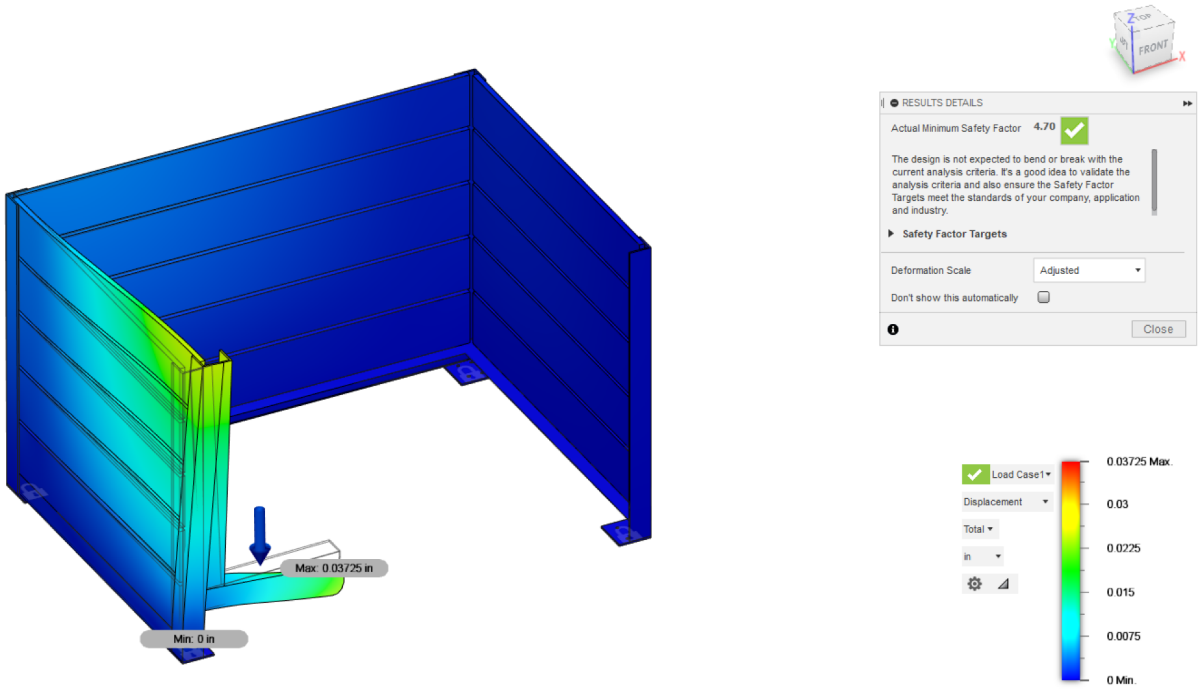
Or another example, we were designing these 'parklets' that were going to be made out of steel and wood, and we were concerned about the cantilevered seats flexing too much. Some quick FEA studies allowed for some back-and-forth with the steel fabricators to get these working well!





So FEA is a pretty awesome design tool to use! Just be careful, as it's a whole field of study / career in it's own right, so as an architect I'd recommend you just use it as a design guide and leave the final results what you come up with by working directly with the engineers. It's just that

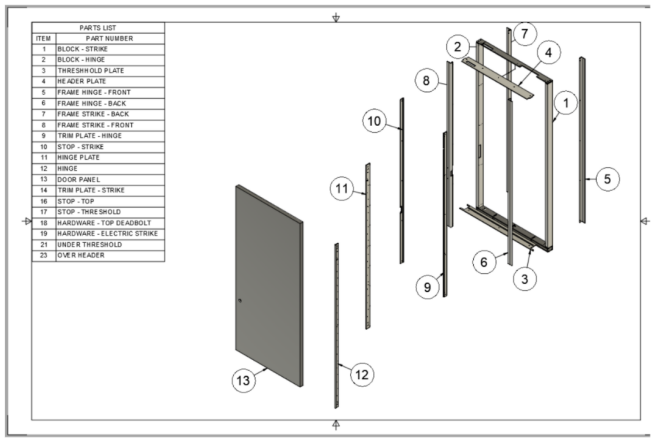
you'll be able to start with much more viable ideas, and work with those engineers in a much better way!

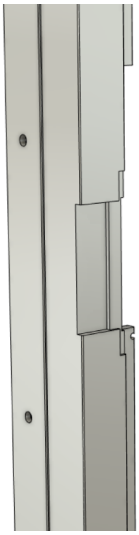
Case Study #2: Modeling things Revit & AutoCAD aren't good at modeling

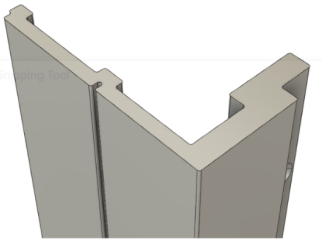
While Revit is an amazing modeler for construction-scale items, it's not so good at smaller complex items. And while you can use it's Massing toolset to make organic forms, it's terribly slow at times. And while AutoCAD can model these things Revit isn't very good at, it's also not the best way to go about it, for those models aren't going to be parametric, and could possibly be harder to manufacture from.

We were helping out with a high-end modernist house, and the client wanted a front door that matched the already installed aluminum and glass exterior wall system.

Again, while we had a 'design model' in Revit, we needed to model various aluminum frame parts, some of which were going to be custom-made aluminum extrusions, some fabricated aluminum parts, and some even a combo of both!

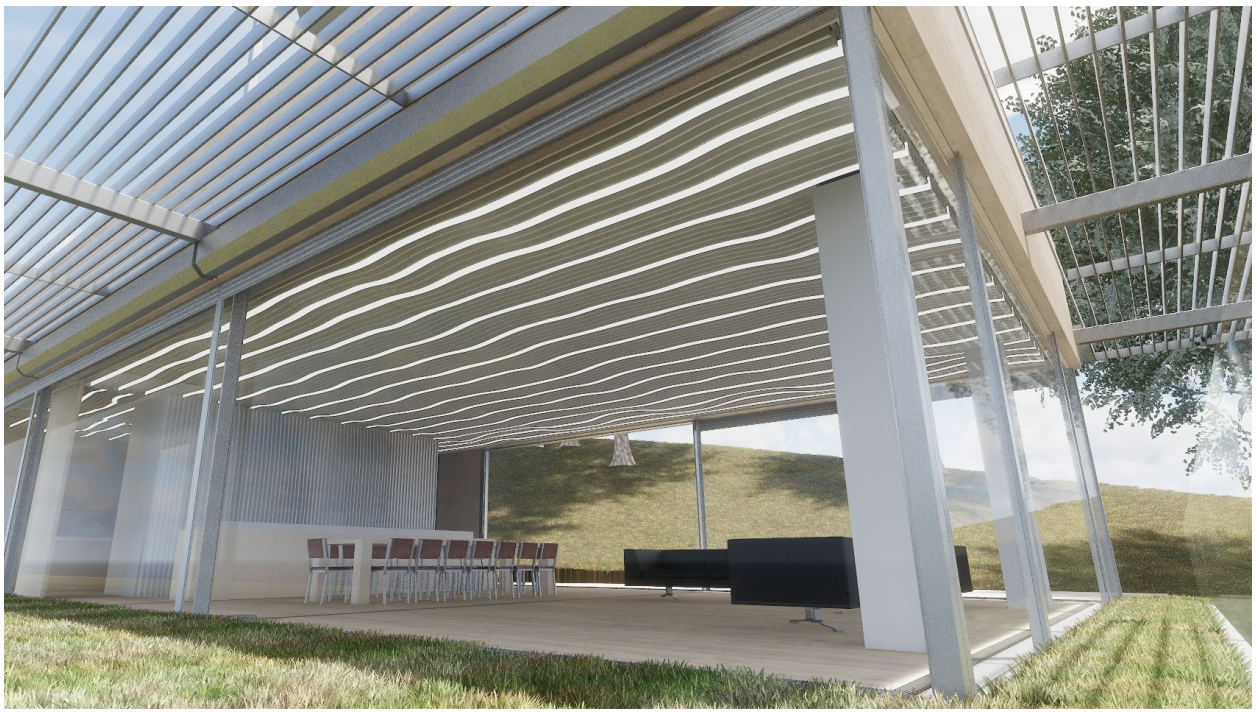






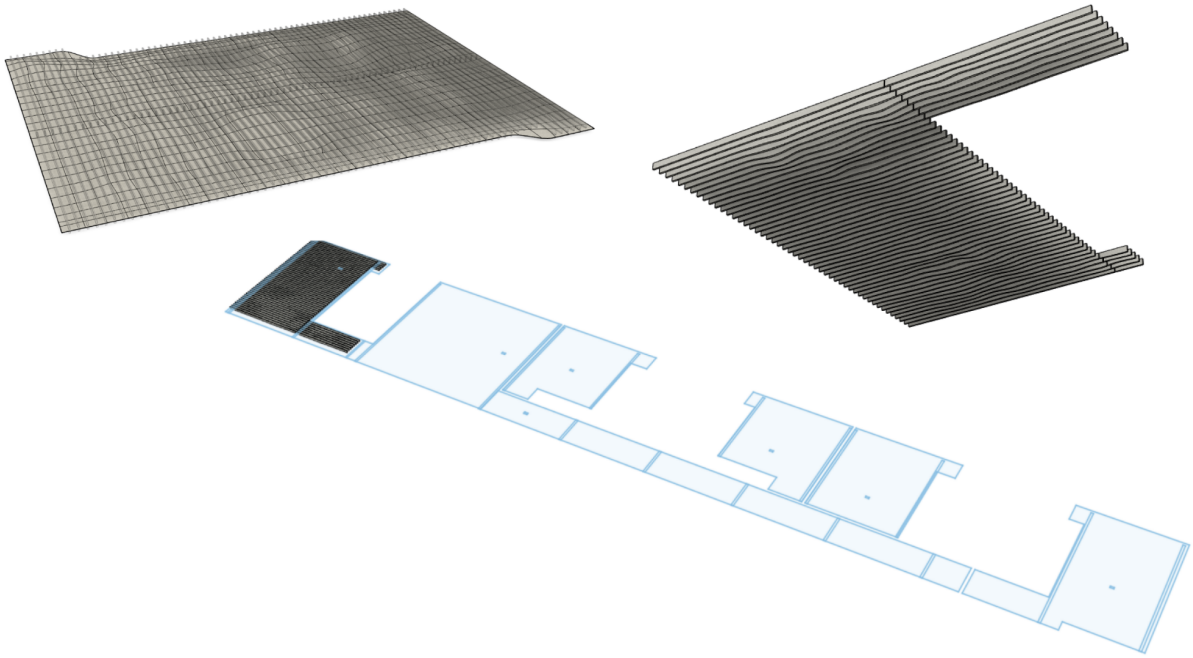
Fusion made modeling this a breeze, it was very fast and easy, and it produced models and drawings we could directly share with the various subs to get this done. So while it could have been done in Revit, it would have been a lot more challenging!

Speaking of Challenging, the other thing the client wanted was a complex organic wood ceiling. As the house was already designed (not by us!) and mostly built, it quickly became a very complex modeling project.



While this could have been modeled in Revit using the Massing tools and/or Dynamo, it would have been slow and difficult. And it could have been modeled in AutoCAD, but then it would have been harder (for us) to coordinate back into Revit and to then prototype.

So we took the ‘outline’ of all the rooms and exported them out of Revit, and into a ‘sketch’ in Fusion. Then we were able to parametrically model each room’s ceiling ribs such that design changes could be made quickly as the client changed their mind and the existing conditions of the house came together.

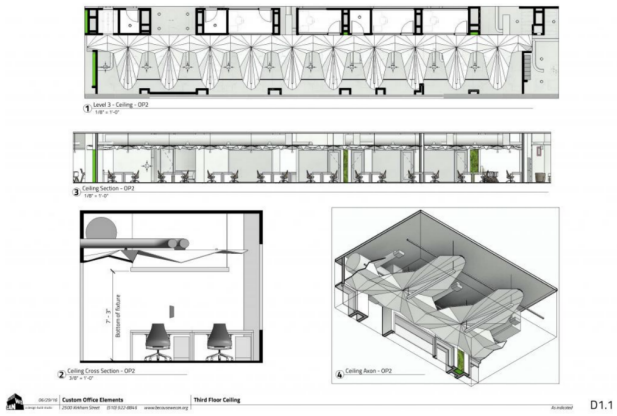


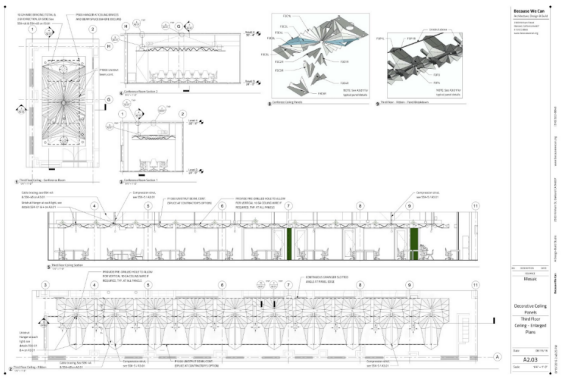
Then these Fusion models were exported, and brought back into Revit, to make for a final model for install drawings, permits, and presentation renders.

Case Study #3: Modeling things Revit & AutoCAD don’t automate

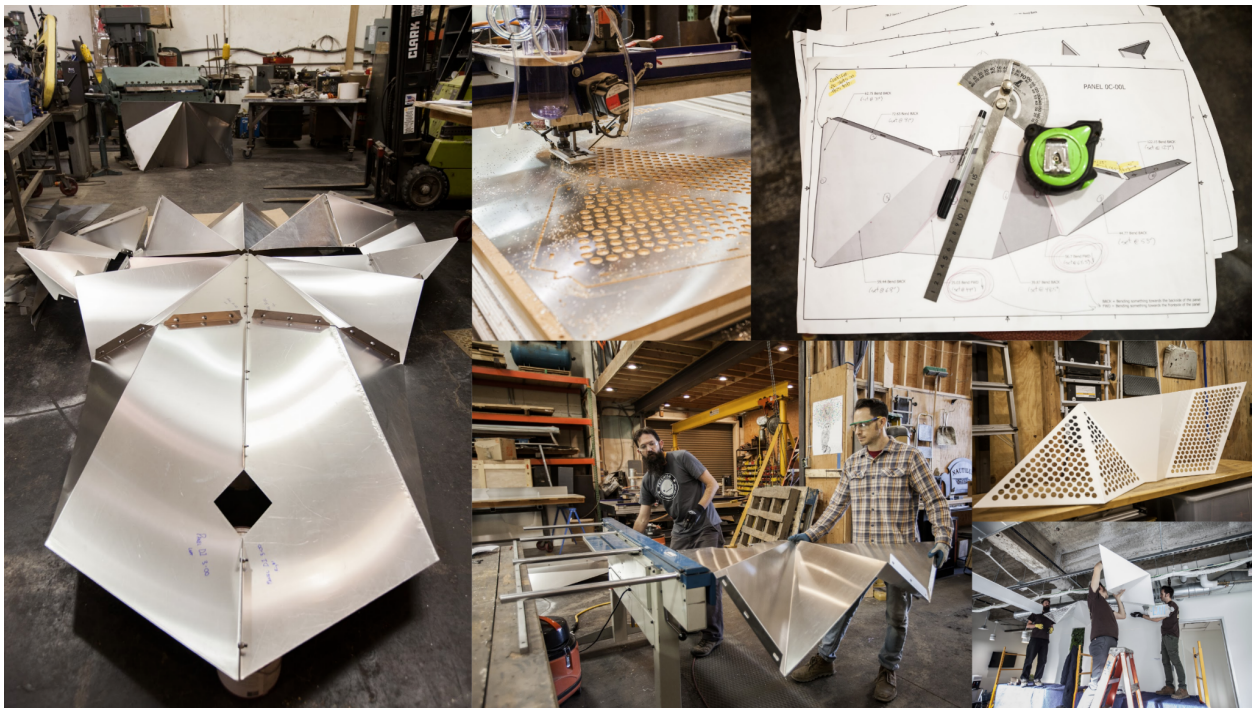
There’s also some types of construction that Fusion handles in an automated way, but Revit and AutoCAD don’t. One great example is Sheet Metal, while we can produce design models in Revit and AutoCAD, we can’t then properly ‘unfold’ them. We can’t produce the flat patterns needed for prototyping and production using k-factors and proper reliefs and such, and have them properly work. But there’s a whole toolset in Fusion that does just this, and it makes doing things in sheet metal a total breeze!

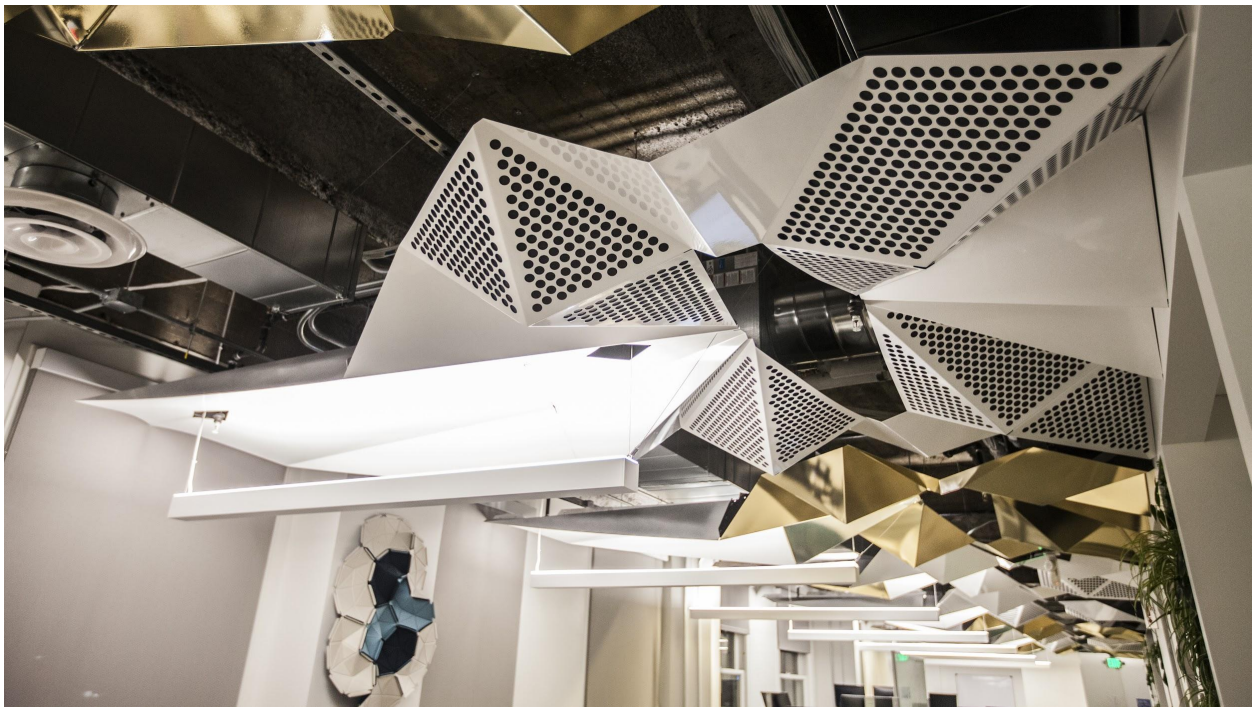
We were doing a ceiling where the client wanted it to be a complex series of folded metal panels that would be hung from a frame.





The design models were exported from Revit, brought into Fusion, and remodeled using it's great Sheet Metal toolset, which then produced all the flat patterns and shop drawings we needed for production.





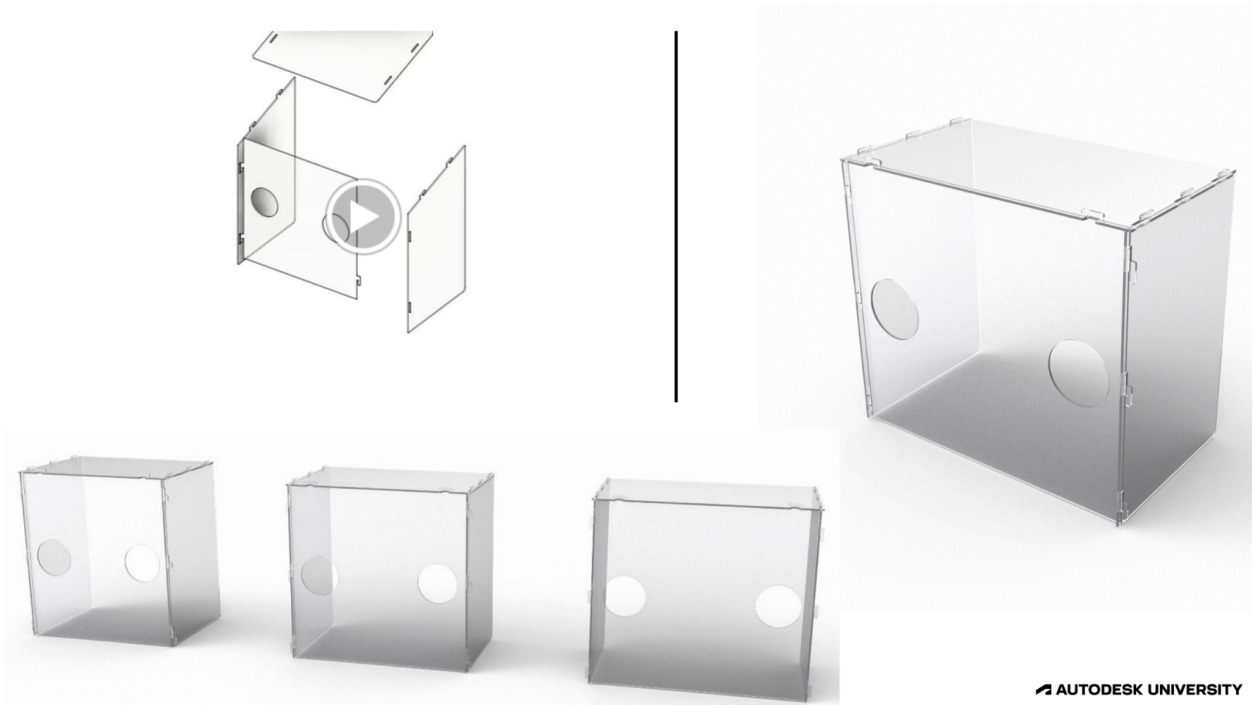
Finally the Sheet Metal toolset can actually be used to solve all sorts of folding problems! Here we used it to make the flat patterns we needed for the leather when designing this slung chair:

Also while you can model parametric families in Revit, the parametric NURBs surfaces and T-splines in Fusion can allow you to model parametric products that normally you'd have to use Dynamo, Grasshopper, or custom code to do:

Case Study #4: Modeling Products (that can be used as Families)

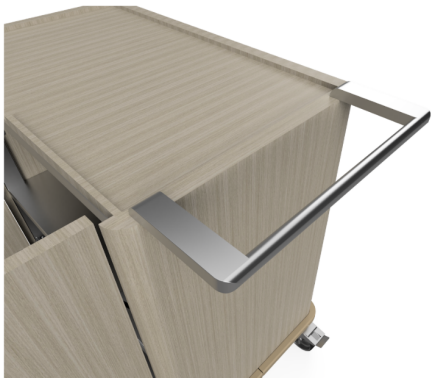
When Covid hit, like many who had some sort of in-house production capacity, we quickly jumped in making things to help. We joined some different online groups, such as Helpful Engineers, and got involved in a project to help re-invent a design for an intubation shield from a Tiwanise doctor into something that could be flat-pack, easier to produce, and easier to clean.

Because Fusion works in the cloud, and is made for making products, it was easy to get involved, collaborating with others, and quickly get to a final design.

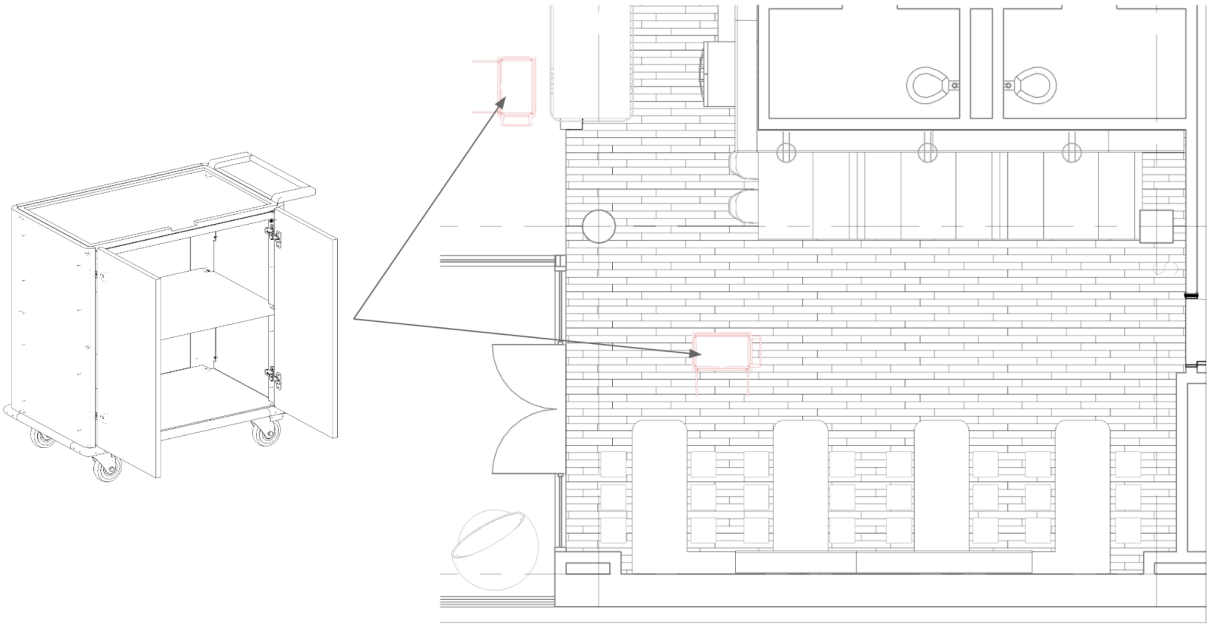


We then made about a hundred and fifty of these and shipped them out all around to emergency rooms around America to help with the early days of Covid. Also it turns out that most emergency room beds are different sizes, and so we had to make the design parametric so it could be customized to fit.

There's also times where as an architect we're called upon to help make elements that will go into a larger project that while could be modeled in Revit alone really are more of a 'product' and might be better done in Fusion. Here's a custom rolling hospitality cart, made to go into a high-end boutique hotel.



It was modeled in Fusion from the start, and then exported out and turned into a Revit Family so it could be included in the project.

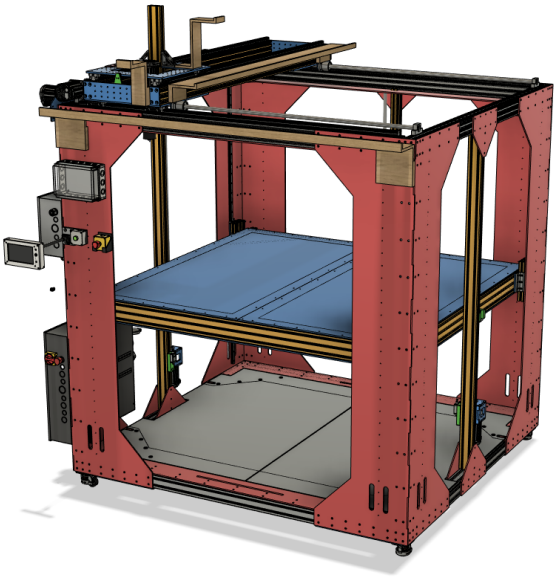


And again, all of these products we've been designing at Model-no.com can easily be turned into Revit Families to then use in space plans and more.

Case Study #5: Modeling Machines (that can also be used as Families)

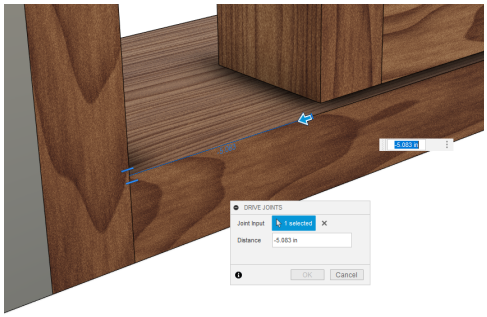
So somewhat of a lesser use case for an architect, but Fusion is also really great at modeling machines. Among other helpful features it understands what Joints are, which allows one to model functional machines and test their motion prior to construction.

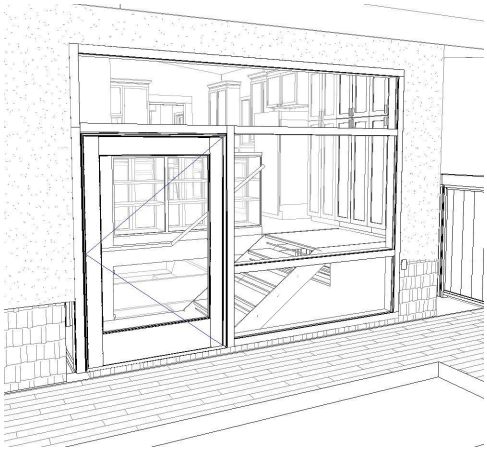
At model-no.com, when we were starting out there weren't many options for the large-format 3D printers we needed, so we just designed and built our own.



Fusion really helped make that possible, for we were able to really think through a whole machine, fabricate and/or order it's parts, and then assemble it using the model as a guide.

A more pragmatic architecture example is in something as simple as designing a large custom sliding door.



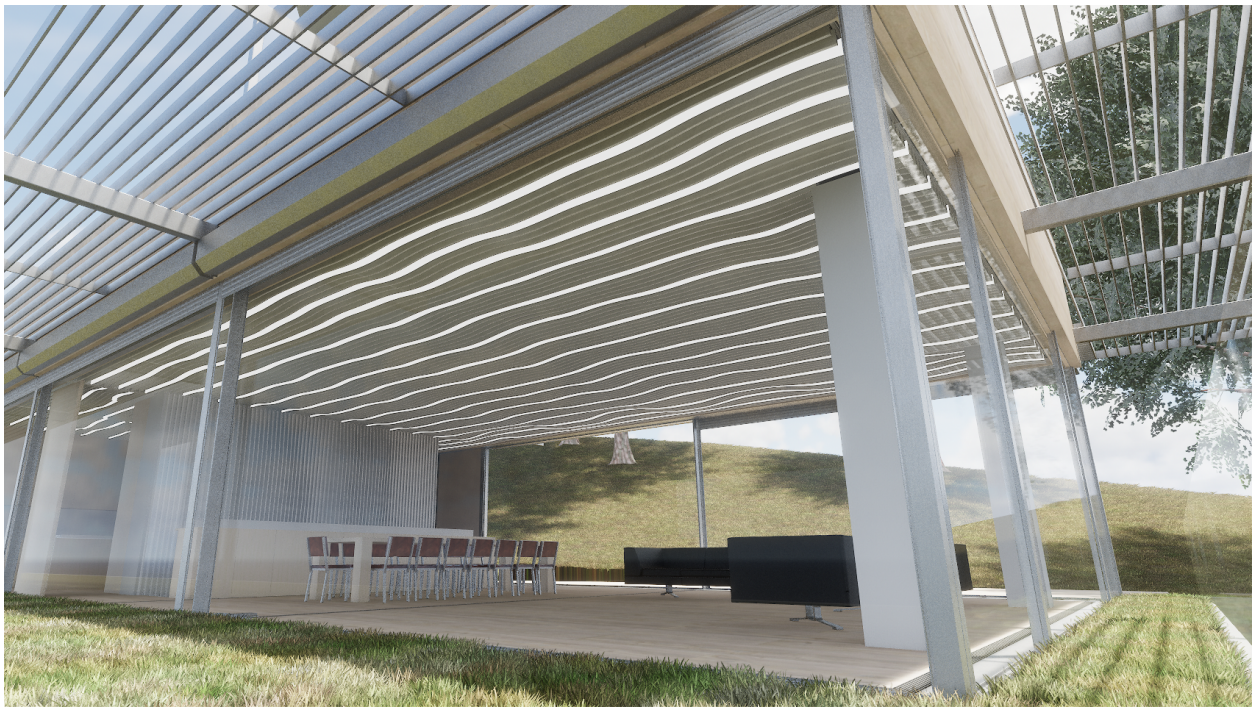


Due to the Joints and Animation Studies, Fusion is a much better tool for designing things that are going to move!

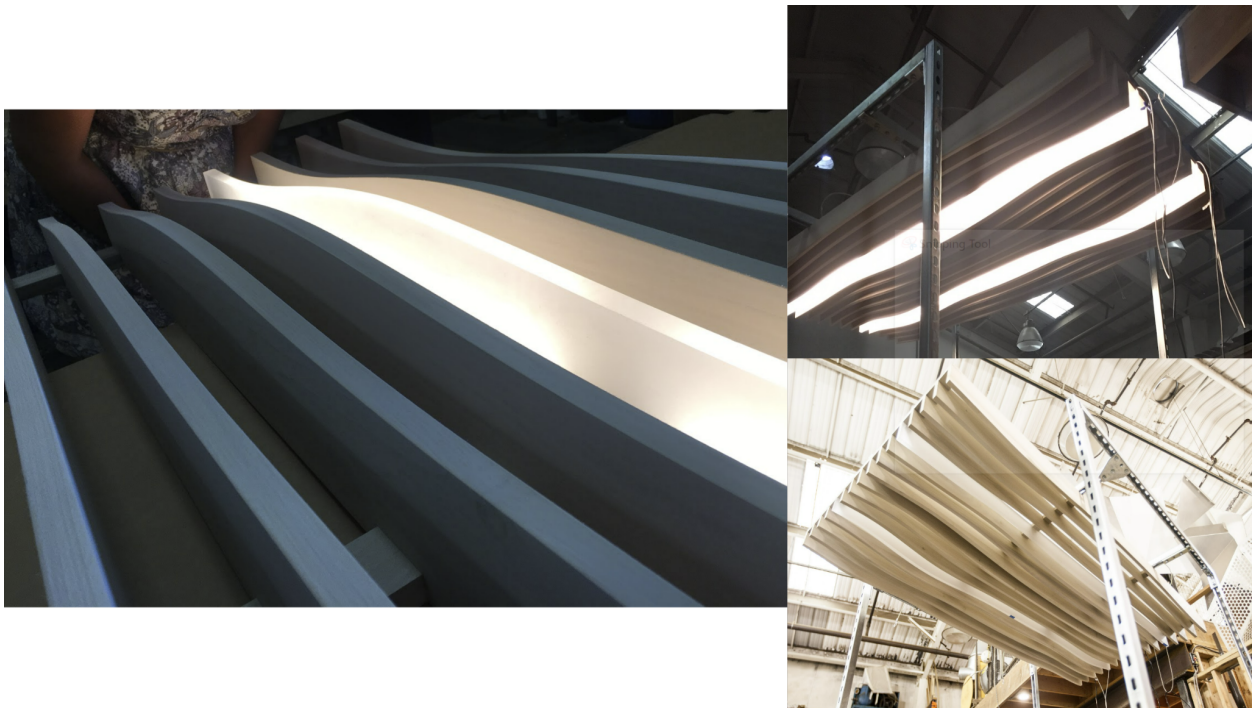
Case Study #6: Modeling for Fabrication

Our last case study is on fabrication. While you can fabricate from models you've made in Revit, there are many manufacturing-specific features in Fusion that make it much easier and faster.

If we return to our earlier example of the slat wood ceiling from before:

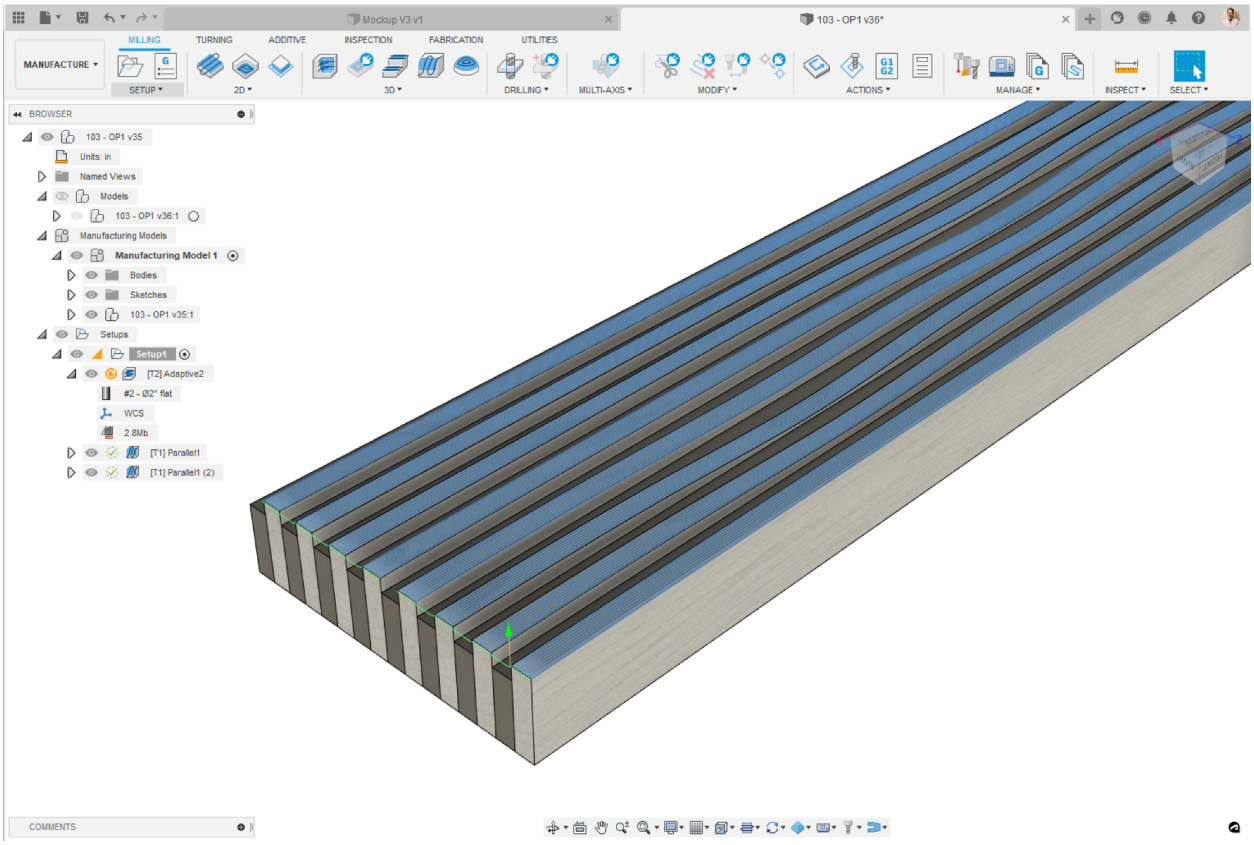


By using Fusion for this project, we were able to make the panel prototypes much faster and easier:



Because instead of having to make lots and lots of shop drawings of everything, or having to try and model this complex element in Revit and then break it down into smaller panels, and detail

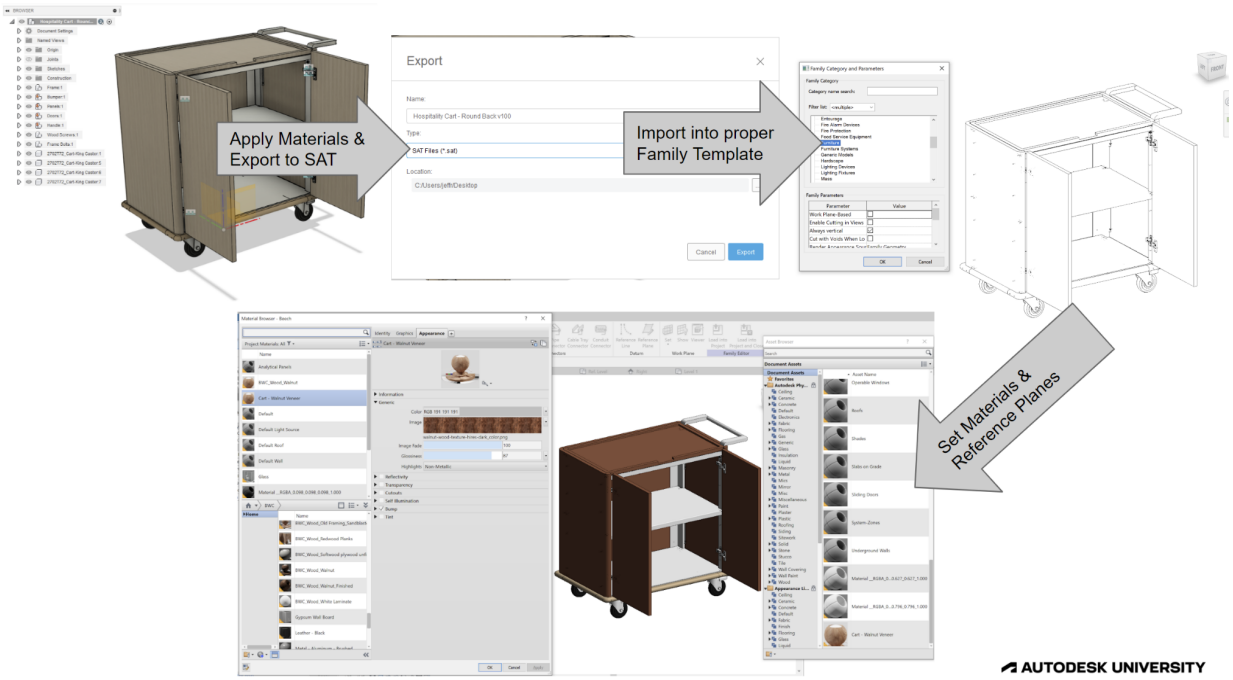
the panels, etc. we were instead able to model them in Fusion, and then have Fusion break them down into smaller panels, detail out those panels, re-organize the models for manufacturing, and then use the integrated CAM to directly produce the slats for each panel.



Fusion to Revit

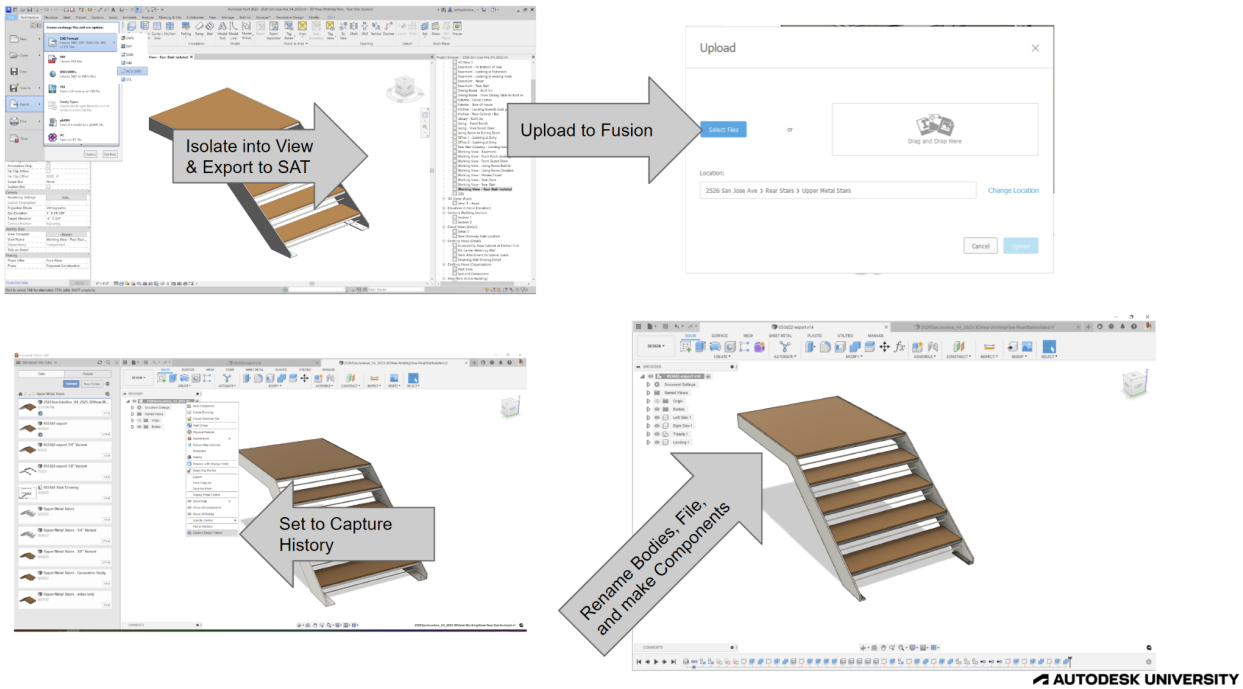
Going from Fusion to Revit

- Set your Materials in Fusion & name your Bodies / Components
- Export to .SAT
- Insert into a Family Template of the right category
- Snap into position & rename materials



Going from Revit to Fusion

- Isolate your Revit content into a single view (what you see is what you export)
- Export to a .SAT file
- Upload to your Fusion project folder
- Open in Fusion & set it to ‘Capture History’
- Reorganize your model!



Fusion vs. Inventor

Fusion:

- Really affordable
    - $545 per year vs. $2,300 - $5,000 for Inventor per year (or Solidworks, which is even more!). When you factor in the totally decent integrated CAM, FEA, Rendering, and animation Fusion is a *steal*.
- Easy to learn and simple to use
    - I've seen users new to MCAD pick up Fusion really quickly, and the integrated help and tutorial videos are amazing.
- Great for design work & really forgiving of big later changes
    - Personally I've found the separation of the timeline vs. sketches / bodies / components / joints, and the way Fusion mangages it's timeline, makes it much easier for me as a designer to make big changes late in the design than when working in Inventor or Solidworks
- Have to manually import / export
    - Bit of a bummer, the import & export to Revit or AutoCAD is fully manual.
- Great for teams under five people
    - Fusion works really well when you've got five or less people working together on the same project together, I've heard that Inventor is better if you have larger teams than that.
- Not great at shop drawings
    - Honestly the 'drawing' module in Fusion is worse than Inventor's, and is a very far cry from the great tools we have in Revit.

Inventor:

- Costs as much (or more!) than Revit

    - $2,300 - $5,000 per year, depending on what package you go with
    - Sadly there is no package anymore that includes Inventor and Revit together
- More effort to learn & more complex
    - Inventor being older, and more powerful, it's got a steeper learning curve.
- Harder for design work & less forgiving of big later changes
    - Again, personally, I've found Inventor hard to work with for design than Fusion or Revit.
- Syncs with Revit & AutoCAD nicely
    - You can set up Inventor in a way where it will sync with your work in Revit and/or AutoCAD, and vise-versa, to make for some great and efficient workflows.
- Works well for larger teams
    - Again, just from what I've heard, but it seems that Inventor works better with much larger teams.
- Way better at shop drawings (but Revit is still way better!)
    - While Inventor does have a better drawing toolset than Fusion, it's still a far cry away from what Revit has.

Fusion Pros & Cons

Pros:

- Easy
    - Super easy to learn and use!
- Affordable
    - Much cheaper than other pro-level MCAD options
- Runs on Windows or OS X the same
    - One of the only decent CAD apps on OS X!
- Cloud saves / Cloud Services
    - Everything is versioned, backed up, available anywhere
- Full modeling package with CAM
    - The integrated CAD and CAM along with the 'manufacturing' workspace is a fantastic advantage over other MCAD and CAD platforms.

Cons:

- Can be slow to compute complex models
    - Sure wish some parts of it were faster!
- More and more features that were included you now have to pay extra for
    - Moving the FDM to cloud-only stinks
- Screen refreshing Can be really slow sometimes (when compared to Inventor / Revit / AutoCAD)
    - Sure wish it had a better 'regen' sometimes!
- Cloud Saves / Cloud Services
    - Everything is in the Cloud, and requires a subscription and internet connection
- Terrible drawing module…

[Helpful hint: Create a heading for each learning objective.]

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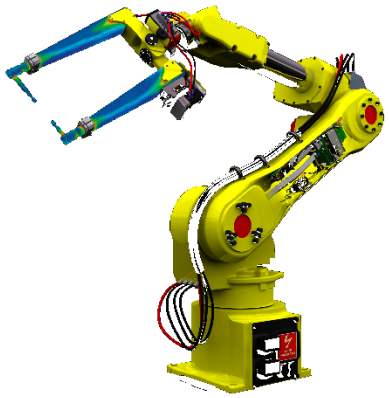

Insert AU caption.

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