AUTODESK UNIVERSITY

All the Skeletons in the Closet: Skeleton Modeling Master Class

Primary Speaker:

Ben Cornelius

PLM-PDM-CAD Systems Manager

Dynamic Attractions/ Dynamic Structures

Co-Speaker:

James Collins

CAD/PDM Administrator

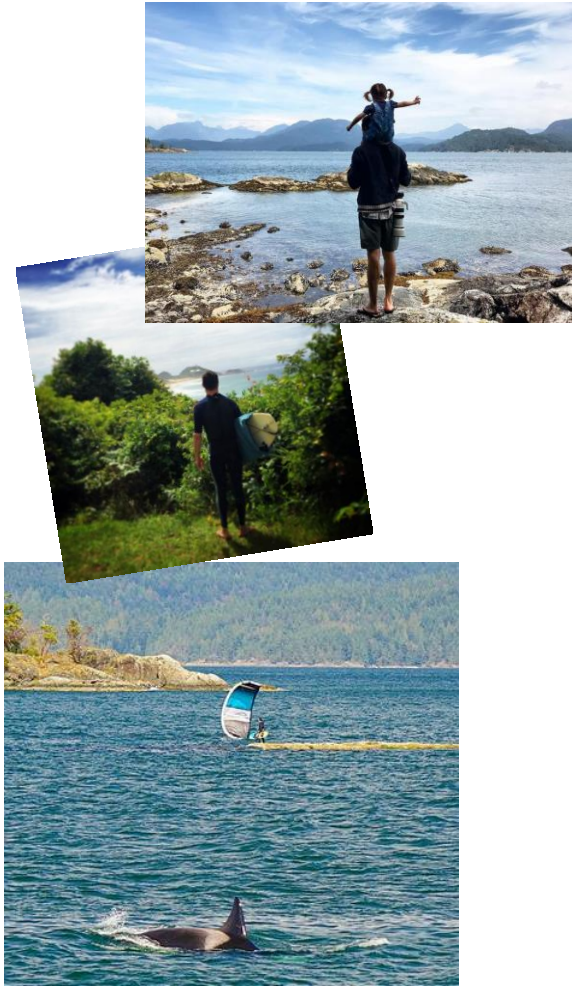
Dynamic Attractions/ Dynamic Structures

About the Speaker

Ben Cornelius

PLM-PDM-CAD Systems Manager @ Dynamic Attractions/ Dynamic Structures

Originally from the UK where I did a bachelor of science in product design where I started using Inventor in the early 2000's. I have used inventor and vault in industry ever since starting in the aerospace industry working on aircraft interiors. Then when I moved to Canada I worked for an Autodesk reseller helping customers conducting technical support, training, setup, installation and services whether in-house or on site. I then created configurators for the mining industry. I now work for Dynamic Attractions/ Dynamic Structures starting as Senior lead CAD modeler & CAD admin now as the PLM-PDM-CAD Systems Manager where I take care of the day to day running of the various CAD related systems. In my spare time I am either snowboarding, walking my dog, on the idea station or beta forum



About the co-Speaker

James Collins

CAD/PDM Administrator @ Dynamic Attractions/ Dynamic Structures

Originally from Australia where I completed a Mechanical Drafting apprenticeship with a sawmilling equipment manufacturer. During that time I started using Inventor (about 2005) and saw how magical 3d design could be. After completing my apprenticeship I worked in various industries from materials handling to minerals processing and started using Vault. I was transferred to Canada in 2012 to head up the drafting team, where I first started using iLogic and saw how powerful a tool it was. I now work for Dynamic Attractions/Dynamic Structures as CAD/PDM Administrator. In my spare time I can be found snowboarding, kiteboarding, running, taking photos or painting

What we do

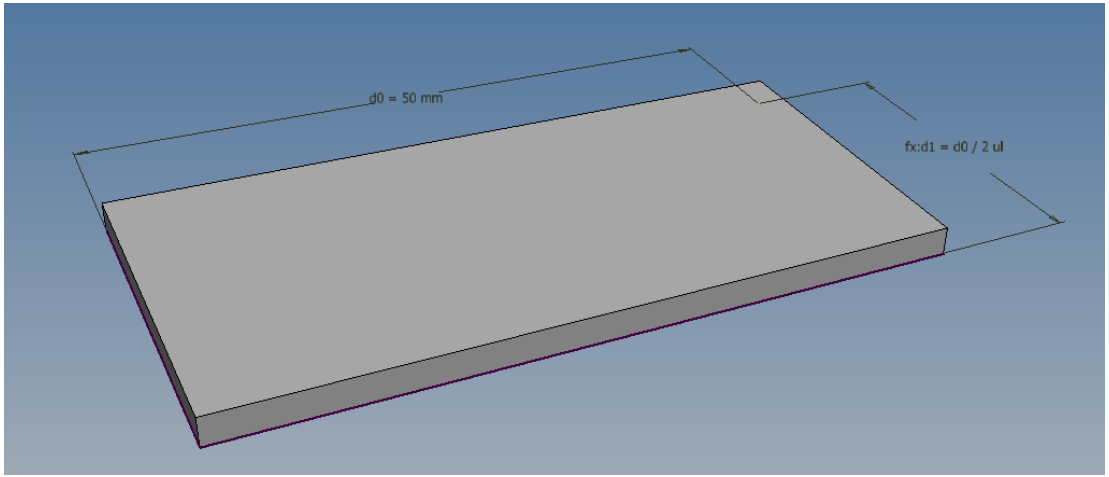
- Canada France Hawaii Telescope
- William Herschel Telescope
- Starfire Optical Range
- Keck I and Keck II
- Atacama Cosmology Telescope
- Thirty Meter Telescope (TMT)
  (Still an active project)

What we do

- Dark Rides
- Theaters
- Coasters
- Custom Attractions
- Parts & Service

Creating intelligence & design intent in parts

A very simple example of intelligence and design intent within a part file
d0 = 50 mm d1= d0/2



How do we now create intelligence and design intent within assemblies?

Why skeletal modeling?

Lets look at the different ways of creating intelligent assemblies by looking at how parts can talk to one another through different adaptive methodologies.

Methodology	Pros	Cons
Skeleton Modeling Top Down Sketching all or some geometry needed within one or multiple files (sub skeletons), to create the desired area. Then deriving the needed geometry into each part file to create the desired features required.	Part files have common geometry	The centralized geometry files are sensitive to deleted & changed geometry, and the file itself being deleted
	Easier and quicker to constrain in assemblies	Not always clear when other users are making changes
	The skeleton can be used for constraining reused parts in assemblies	
	Very stable and repeatable results	
	Capture design intent, the model adapts to your needs based on defined relationships	

Why skeletal modeling?

Methodology	Pros	Cons
Solid body modeling Top Down Sketching all or some geometry needed then filling them with features. Each solidbody being a different part within one or multiple files (sub files), to create the desired area then deriving out each body as a part file	Part files have common geometry	The centralized geometry files are sensitive to deleted & changed geometry, and the file itself being deleted
	Easier and quicker to constrain in assemblies	Not always clear when other users are making changes
	Is more visual then skeletal modeling	No geometry for constraining reused parts in assemblies
	Can be good breaking up complex plastic parts	Geometry file is very performance heavy when putting all the sketches and features in one file
		There is an overriding urge to sketch on the face of features, this causes more dependencies. Instead, it is more optimal to reduce them to make the geometry file more stable
		Moving features within the model browser can be difficult due to the history-based system
		The part file contains no features if the link is broken, its affectively like a step file

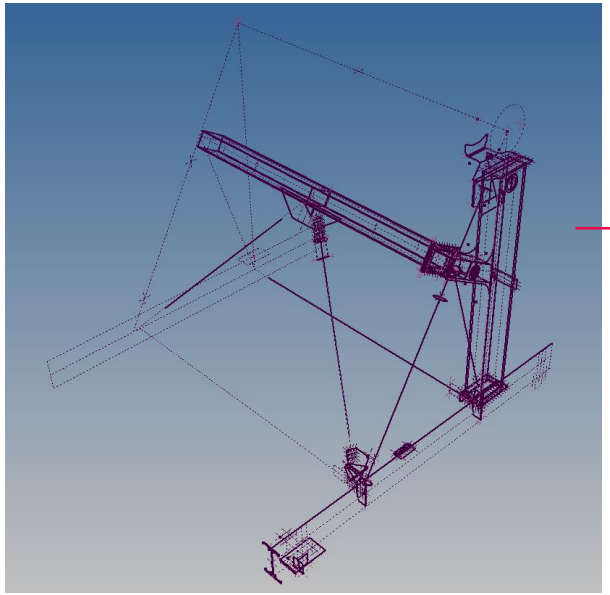
Why skeletal modeling?

Methodology	Pros	Cons
Adaptivity Bottom up Creating each part and constraining them in an assembly, then editing them in place. Then projecting geometry from one part to another	Good for hoses and cabling	Unstable
		Does not work with many parts
		Can prevent constraining
		No advantage for constraining
		No common geometry but a projected link
Middle out E.g. Taking an engine block then deriving it into a file, then building another part from that	Is more visual then skeletal modeling	The parts are dependent on the original faces and features of the middle out component
		The centralized geometry files are sensitive to deleted & changed geometry, and the file itself being deleted
		No geometry for constraining reused parts in assemblies

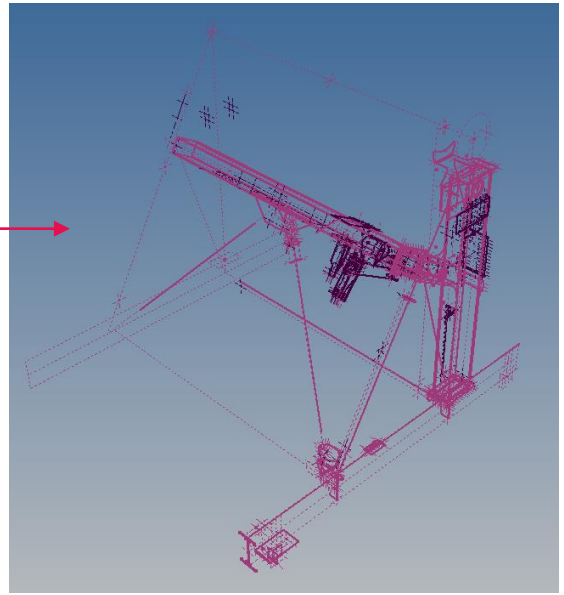
Skeletal Modeling Methodology

Now we have seen that skeletal modeling is our methodology of choice

Example of a main skeleton
Create the sketches needed for the area

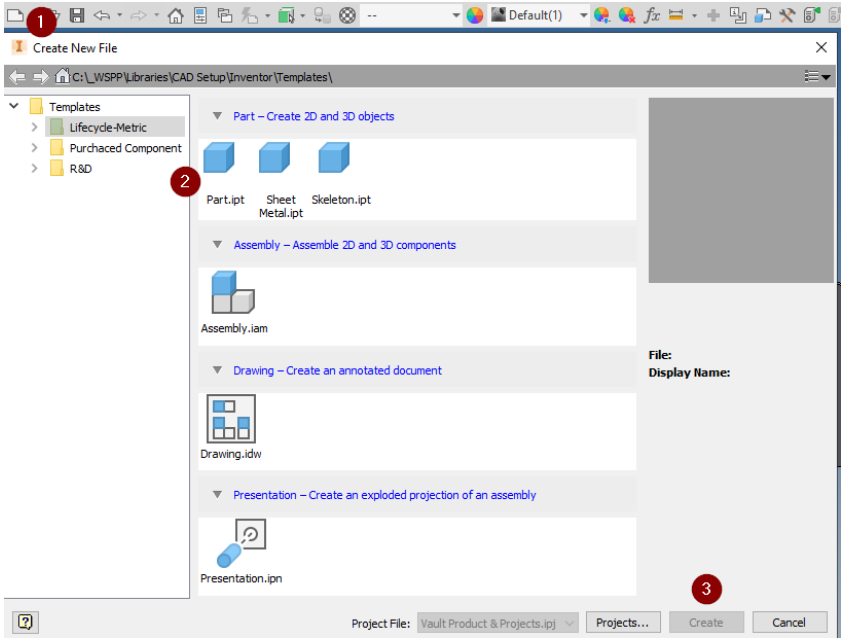


Example of a sub skeleton where the main is skeleton is derived in if required

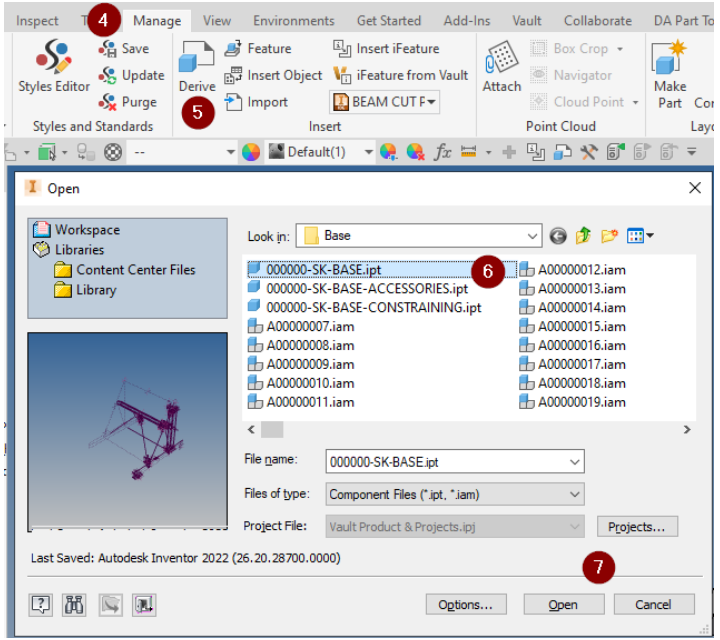


Skeletal Modeling Methodology

Create a new part file

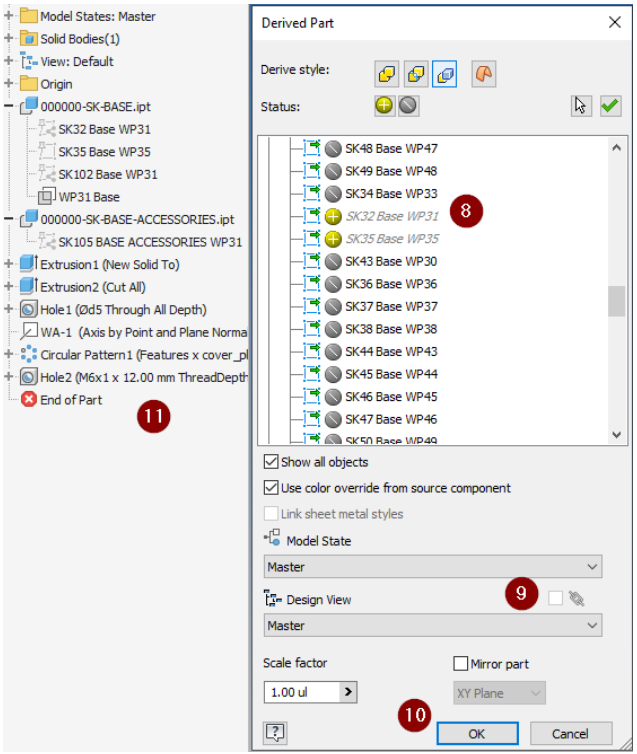


Derive the skeleton through

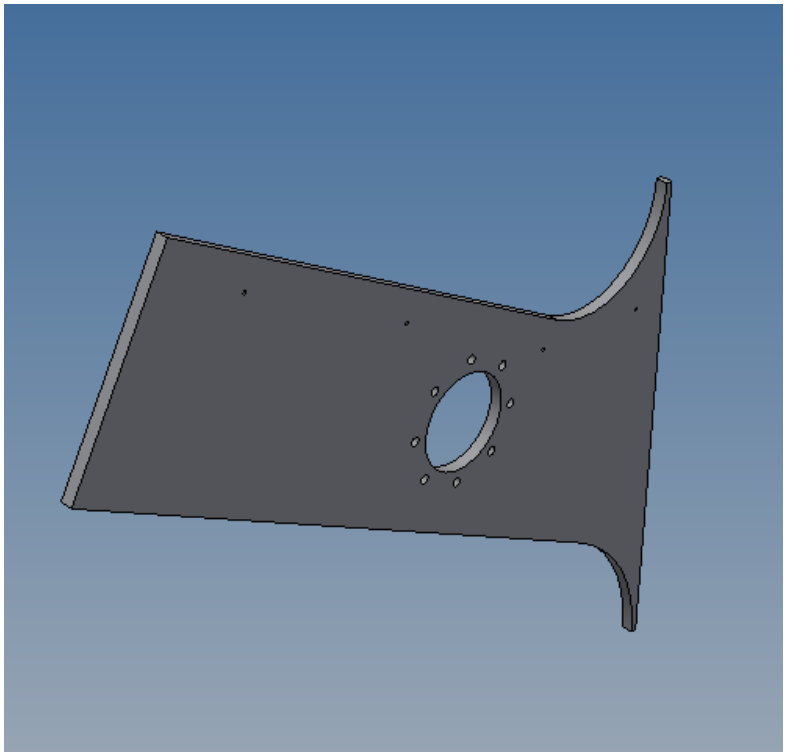


Skeletal Modeling Methodology

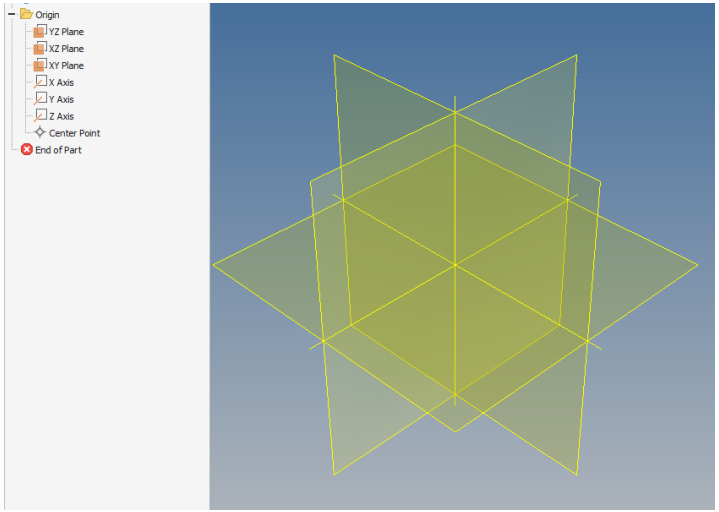
Chose the desired sketches and workfeatures



Create the features



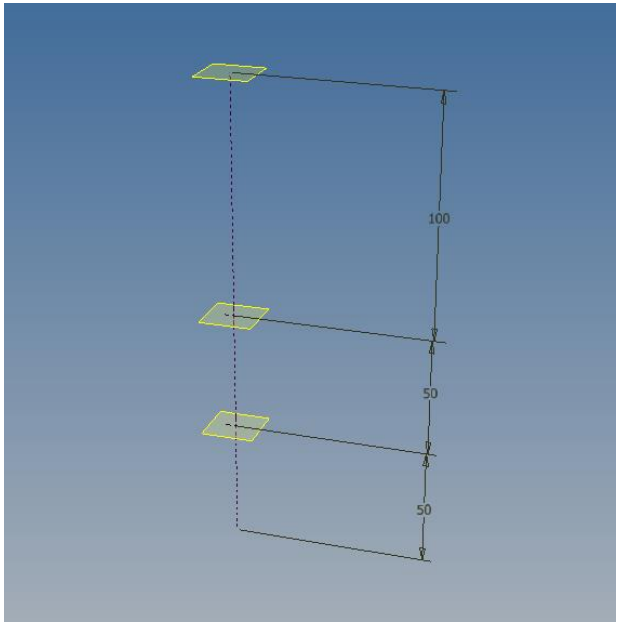
Skeletal Modeling 101

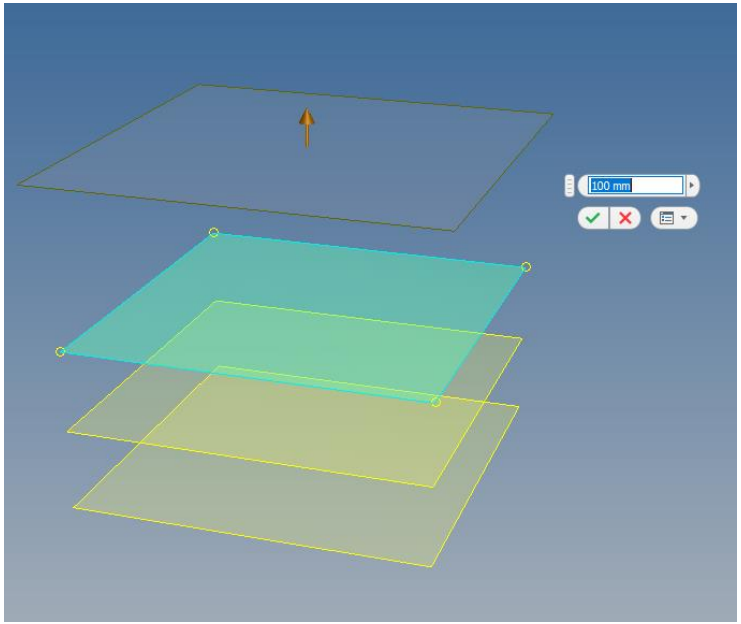


Do not commit a main sketch to an origin work plane. This is a fixed reference which can be good, but if you require the plane to move it will not. You will then have to redefine the sketch to a different plane which may have adverse reactions. Use a custom work plane instead where possible.

Skeletal Modeling 101

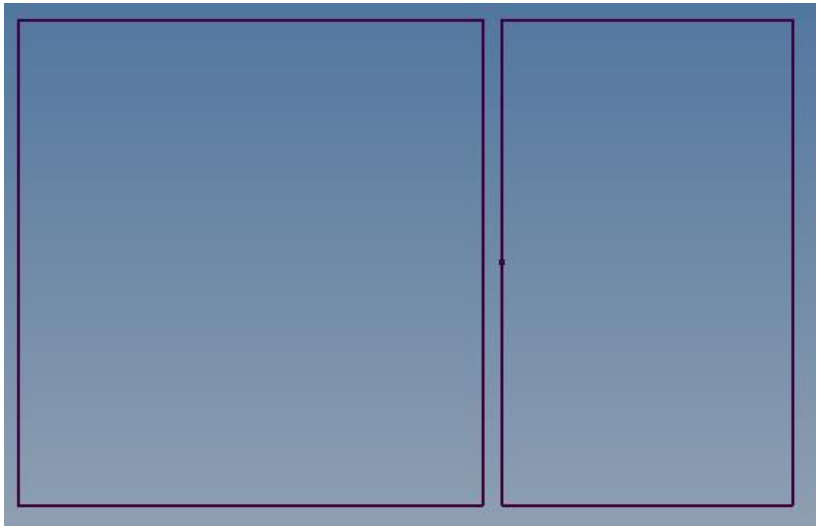
When creating a custom workplane create them from sketch geometry vs offsetting planes. This will make it more visual in terms of how it was created, and being able to change its dimension. Also, this will reduce the dependencies, for example, if a lower plane was deleted the upper planes would also be deleted.

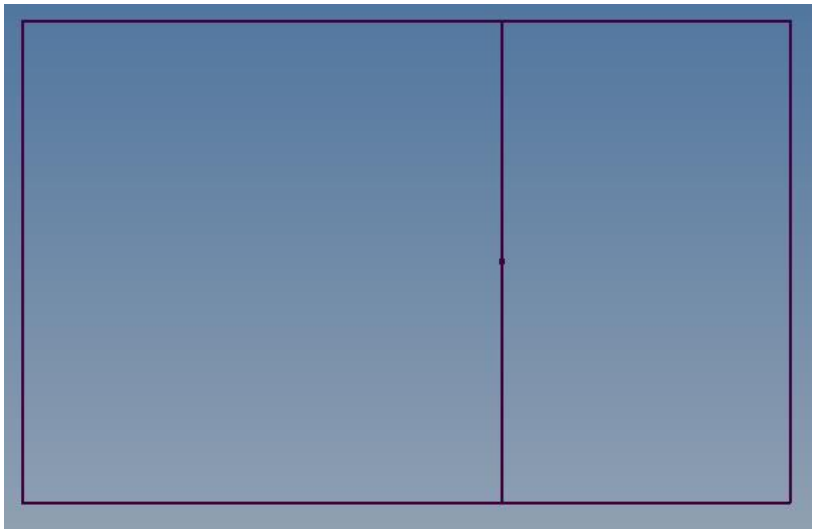




Skeletal Modeling 101

Keep sketch profiles separate even if they are butted up together e.g. based on the example don’t sketch a rectangle and then put a line through it.





Skeletal Modeling 101

- Sketches should be fully constrained. Otherwise you will have adverse reactions when making changes.
- Do not delete geometry unless you explicitly know the downstream effect, as this could destroy part features and assembly constraints.
- Be dimensionally dominant over sketch constraint dominant.
- Avoid projecting projections, otherwise you are creating more dependencies and you to do the opposite.
- Do not project work axis or workplanes their length is not controlled and you will have large projection lines through your skeleton.
- Keep a view rep that is clean e.g. no workfeatures or sketch dimensions on, or it will get messy.
- Do not use patterns or mirror within sketches. This is better suited to features within the parts.
- Do not use solids, only surfaces in very complex situations.
- Try to use lines instead of points.
- Limit the amount within a sketch, try and break it up as much as possible.
- Limit the number of sketches within the skeleton to around 300.
- Do not put lines on top of lines where possible.
- Do not use chamfers or fillets within a sketch. This is better at the end of the part file as a feature.
- Avoid using project cut edges or 3D sketch intersections, use work points for intersections.
- Avoid using 3D sketches. 2D sketches are more stable and easier to control.

Skeletal Modeling Naming

Skeleton file

XXXXX-SK-? A vault numbering scheme is used for this

- Open 18 characters max forced to capitals
- Project/Product Number

Browser Node Naming

Skeleton non iFeature Sketches

SK2 SP CON WP4

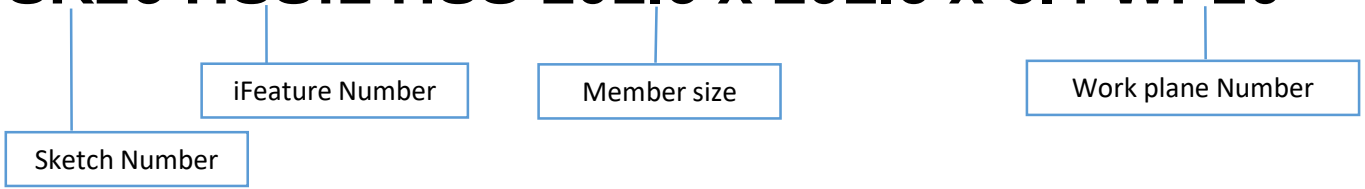
This is automated with an iLogic external rule triggered by before save

- Work plane Number
- Optional Additional suffix
- Optional suffix
- Sketch Number

Skeletal Modeling Naming

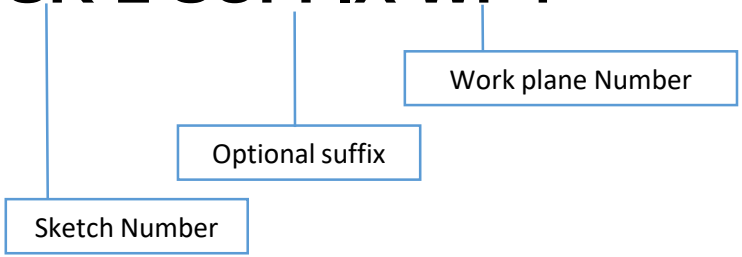
Skeleton iFeature Sketches

SK26 HSS:1 HSS 101.6 x 101.6 x 6.4 WP20



Part file Sketch Naming

SK-2 SUFFIX WP4

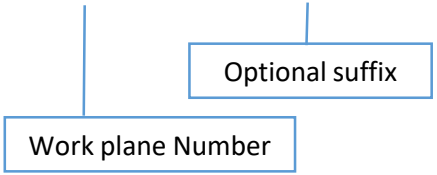


These are both automated with an iLogic external rule triggered by before save

Skeletal Modeling Naming

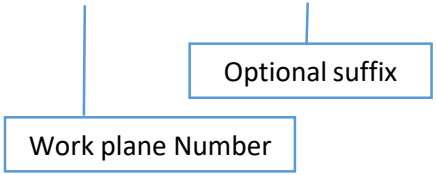
Skeleton WorkPlane

WP20 SUFFIX



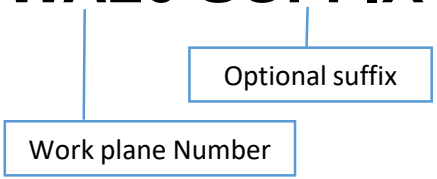
Part WorkPlane

WP-20 SUFFIX



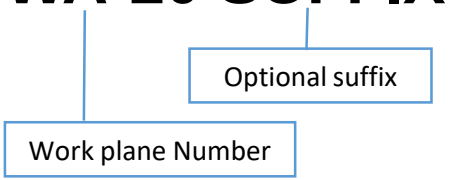
Skeleton WorkAxis

WA20 SUFFIX



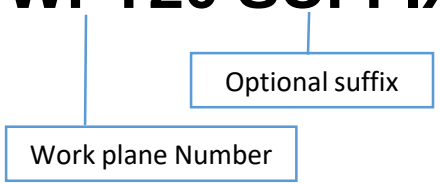
Part WorkAxis

WA-20 SUFFIX



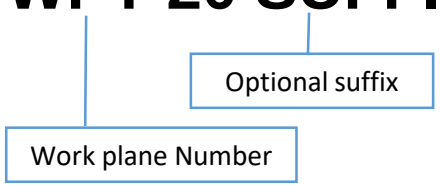
Skeleton WorkPoint

WPT20 SUFFIX



Part WorkPoint

WPT-20 SUFFIX



These are all automated with an iLogic external rule triggered by before save

Skeletal Modeling Naming

Parameter Naming

I would not recommend naming everything, unless creating a configurator as this is very time-consuming. Coming up with naming conventions and enforcing them is difficult. I would, however recommend creating overall and critical dimensions as user parameters. When a sketch dimension is used downstream it can be deleted, whereas the user parameter will stay. If you are naming parameters make sure they are clear as others will need to use this.

Parameters

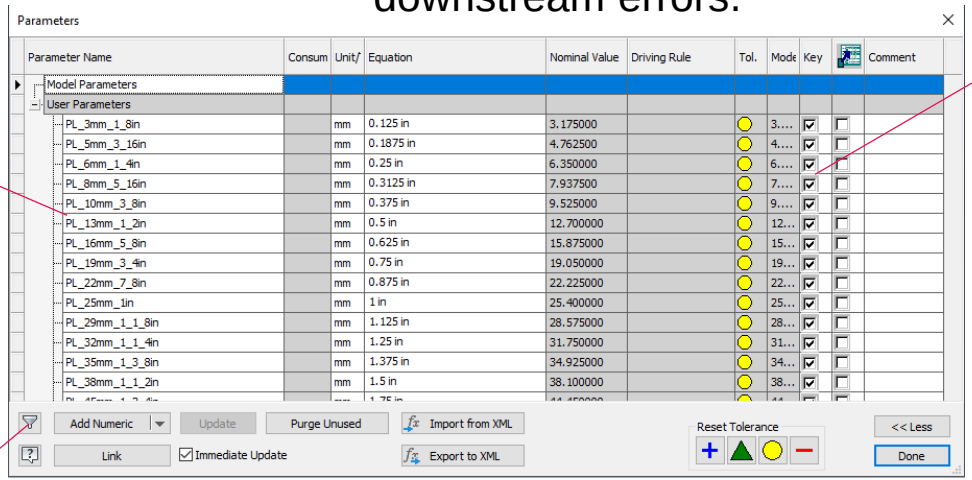
Parameter Name	Consumed by	Unit/Type	Equation
Model Parameters			
Reference Parameters			
User Parameters			
Grating_thk	d1508, d1505, d1502, d1491, d1478, d1475	mm	25.4 mm
Ladder_width	d1532	mm	16 in
Column_Length	d2	mm	7155 mm
Column_width	d1	mm	2175 mm
top_elevation	d15	mm	6530 mm
elevation_diff	Top_elevation_diff	mm	1900 mm
frame2_width	d134	mm	1535 mm

Why do we have a skeleton template? & What automation is on the template?

BOM structure is set to phantom so it does not show up on the parts list.
The user parameters list out the material sizes which is convenient and causes fewer downstream errors.

Material Sizes

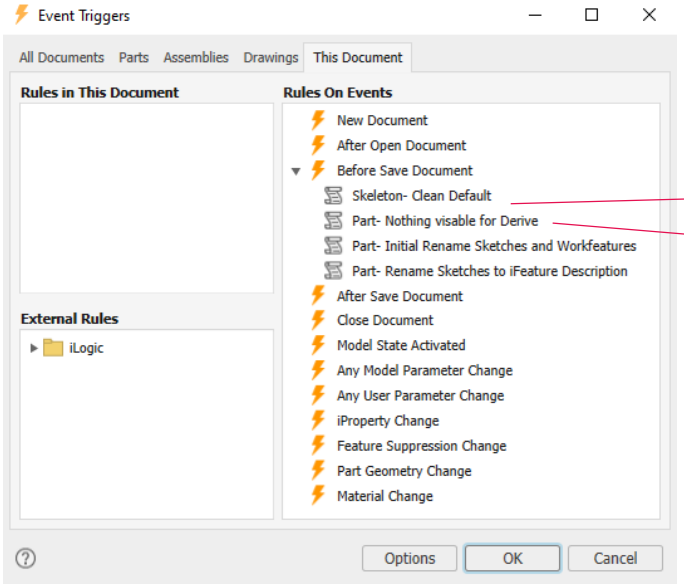
Key

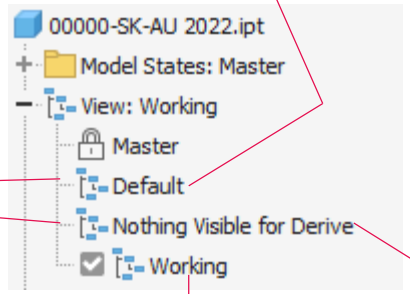


Key can be filtered off

Why do we have a skeleton template? & What automation is on the template?

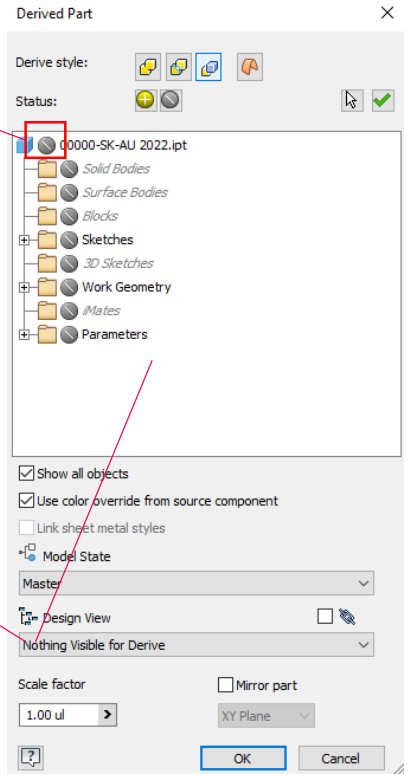
Turns off all objects except sketches. In a part file it turns off all objects except solid bodies



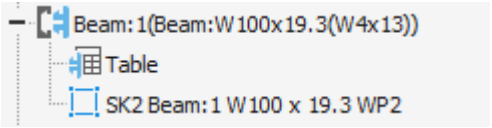


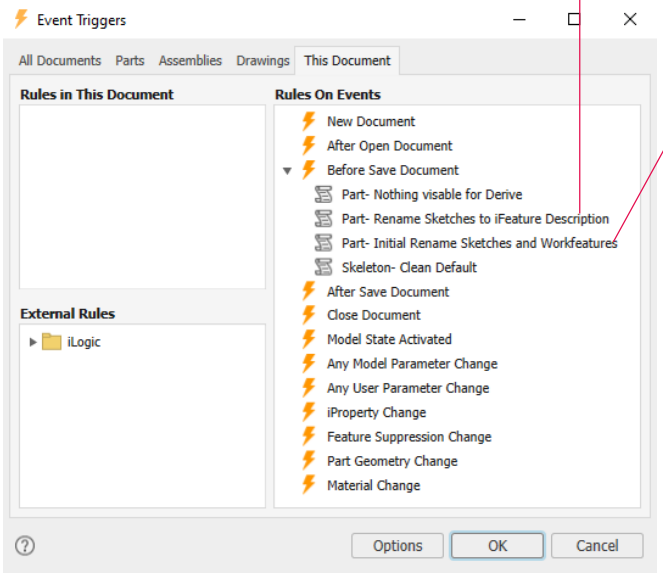
User defined

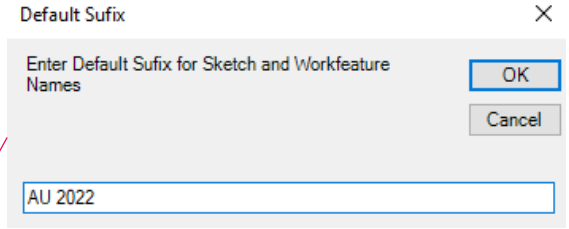
Can quicker and easier then turning everything off



Why do we have a skeleton template? & What automation is on the template?

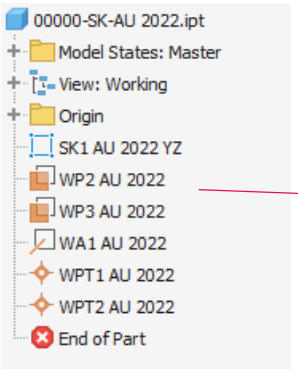


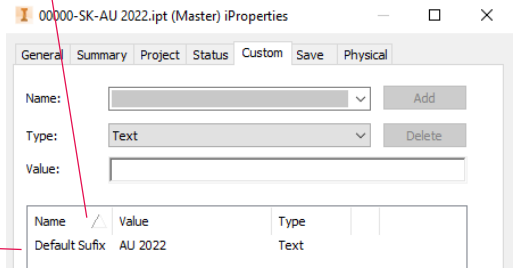




Prompts on first save. Does not do that on a part file

Renames if it's a default name





Can be changed at anytime

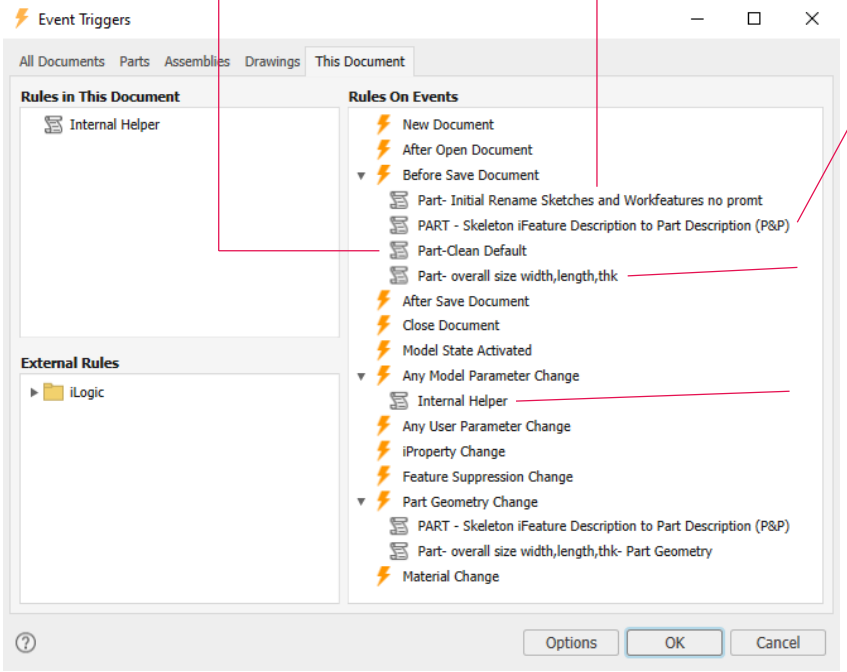
Part template automation

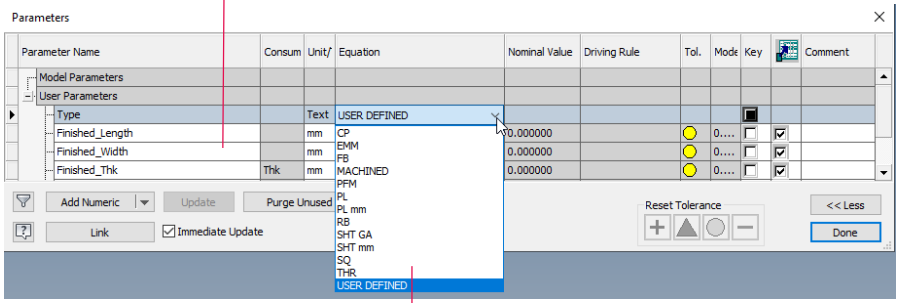
Turns visibility off all objects off except solidbodies on default view rep

Rename the browser nodes the same as the skeleton, except there is no prompt and the scheme has an additional “-”

Push the in the material size/ description to iProperties can updates if there is a size change

This is automated based on the minimum orientated bounding box

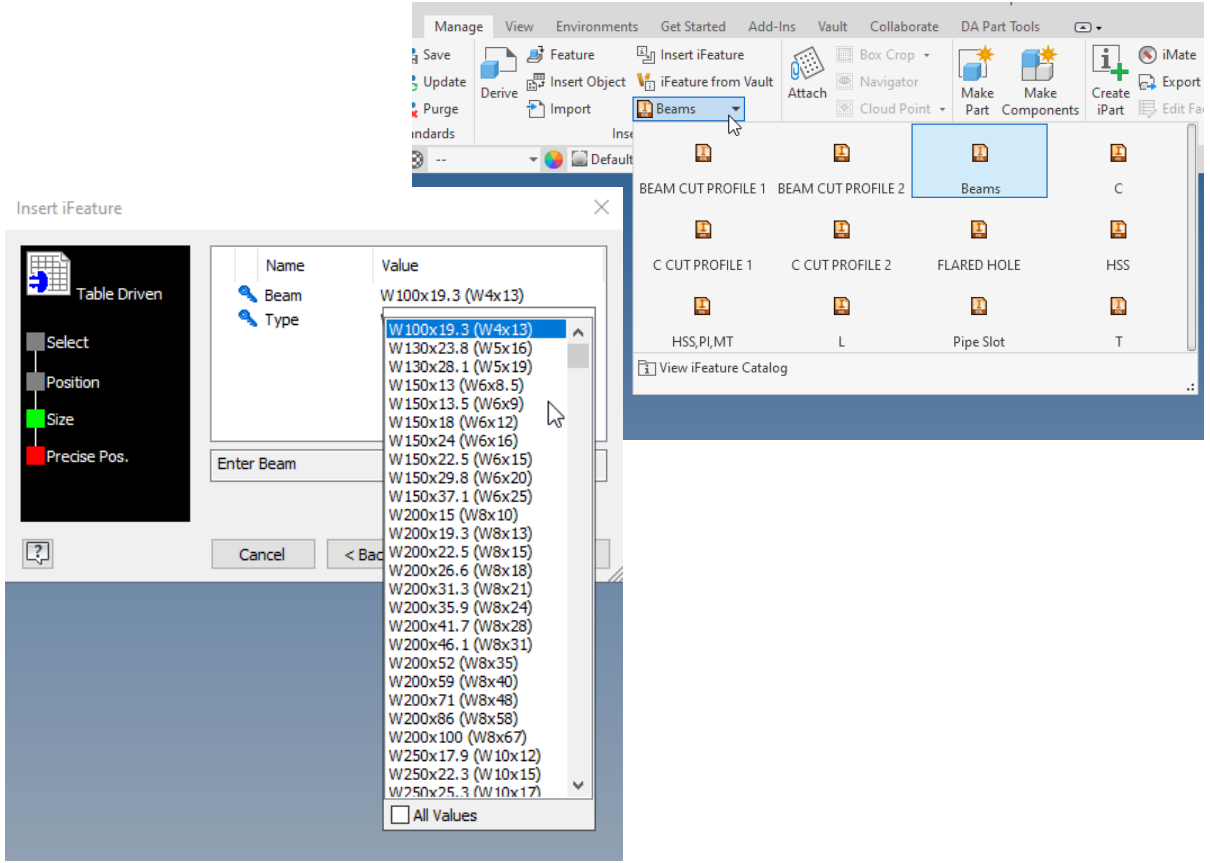




For non iFeature items pushes in the relevant equation, this is quicker and drives more consistent data vs typing and it is linked to the geometry

The need for a structural modeling system

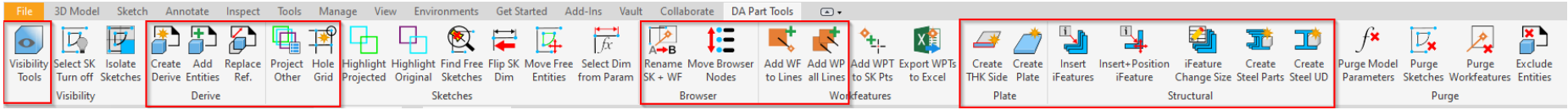
We ultimately need the structural shape within the skeleton as it drives the connection shape and size. We also have a lots of custom cut outs. Sketch blocks are static therefore this is no good if the shape changes size, which lead us to using table driven iFeatures.



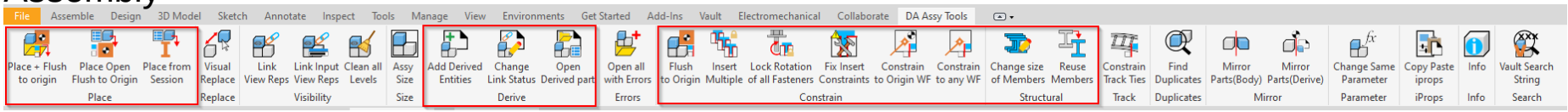
Dynamic set of ilogic tools

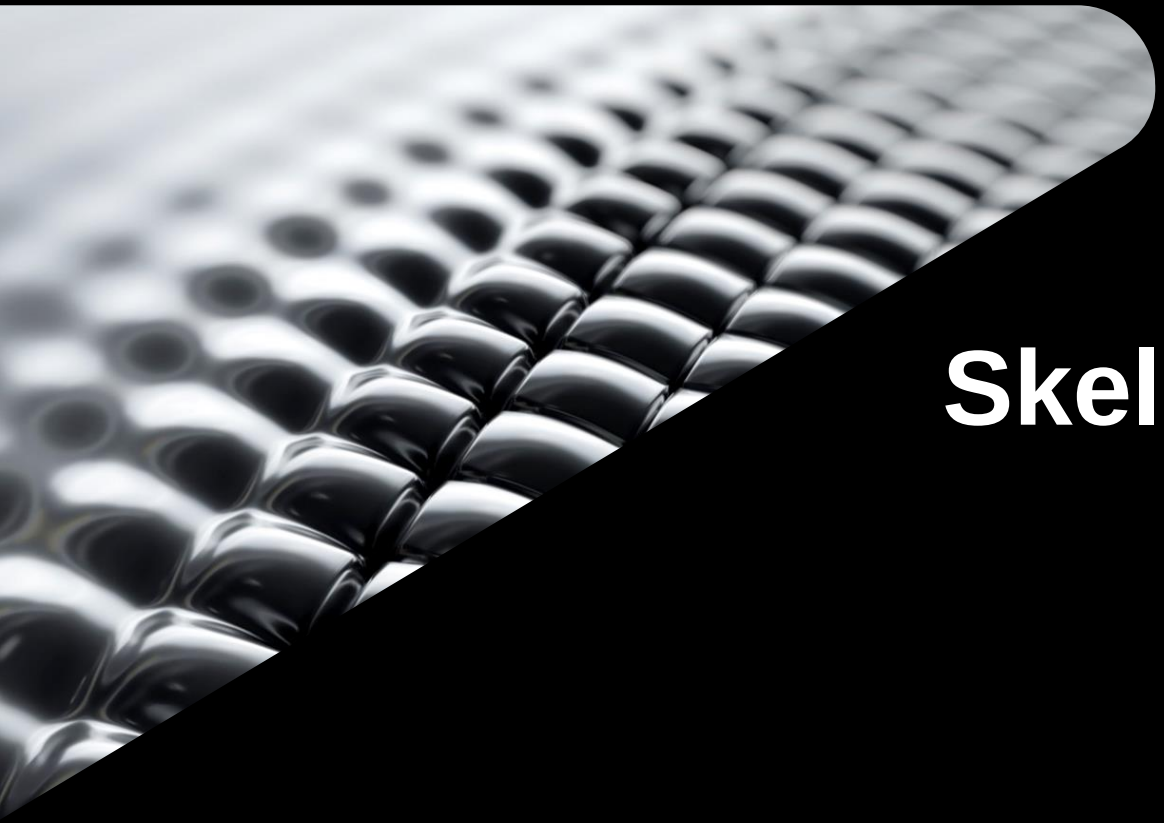
A lot of these tools where created or inspired by methodology used on TMT. Below is iLogic rules on custom ribbons using an app from the app store button constructor.

Part



Assembly





Skeletal Modeling Example

Demo

Thirty Meter Telescope (TMT)

This is a new class of extremely large telescopes that will allow us to see deeper into space and observe cosmic objects with unprecedented sensitivity. With its 30m diameter prime mirror, TMT will be three times as wide, with nine times more area, than the world's largest currently existing visible-light telescope. This will provide an unparalleled resolution, with TMT images more than 12 times sharper than those from the Hubble Space Telescope.

Thirty Meter Telescope (TMT)

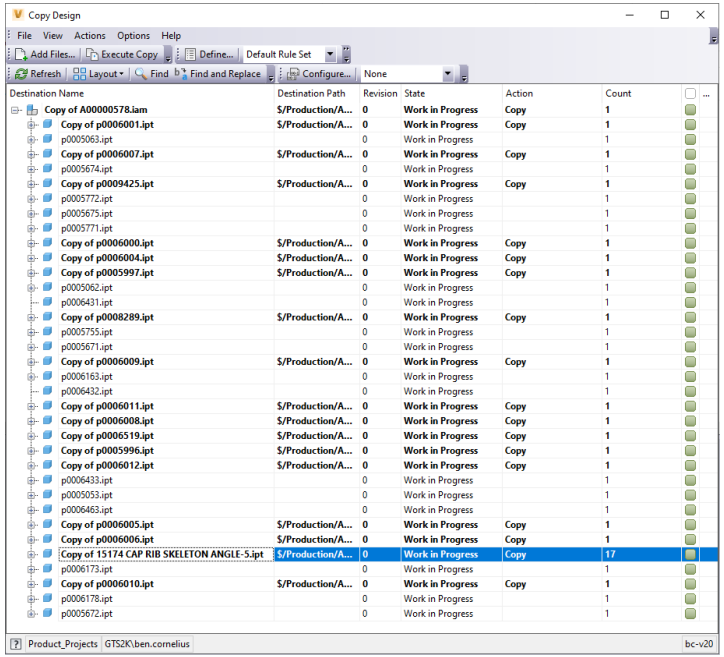
This project is not only complex but has a huge amount of volume.

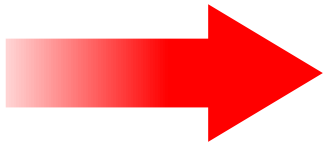
The cap and shutter turning planes are also not perpendicular to the axis, making the connections similar but different all the way around.

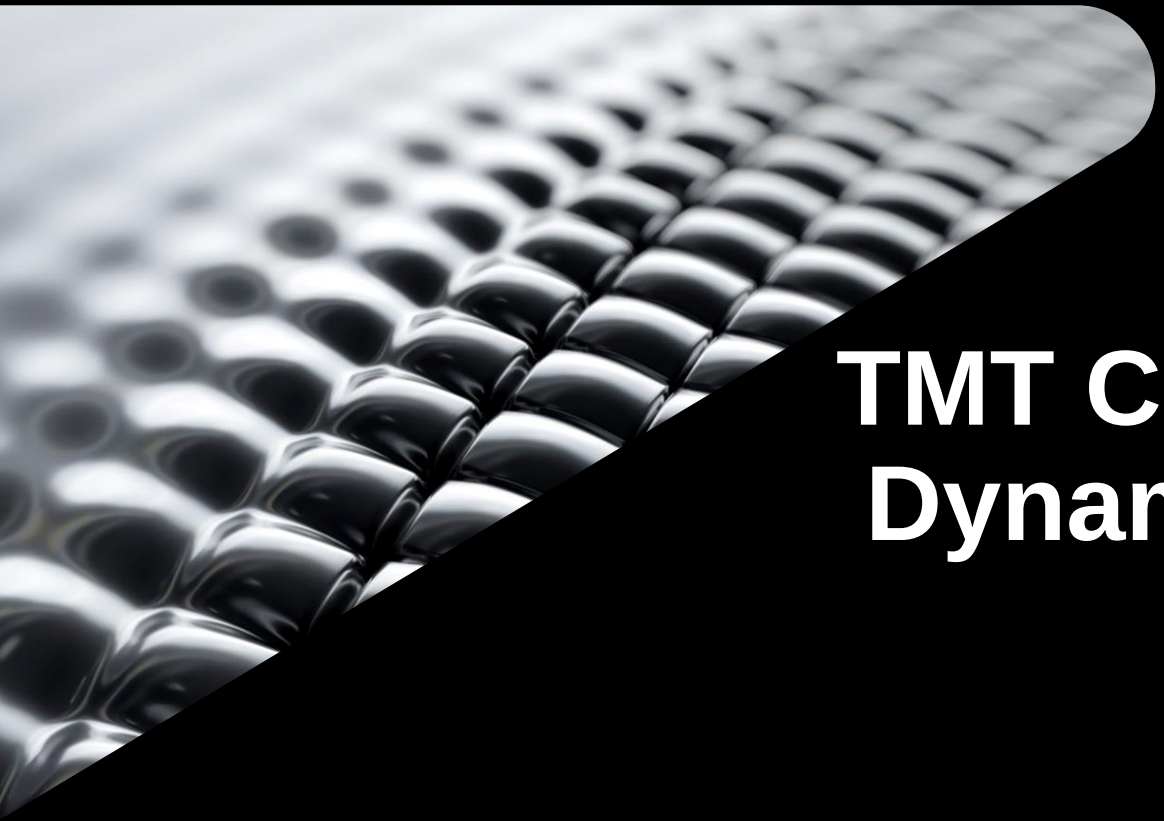
You can also see not only is a large amount of sketch data within one file going to be a performance issue, but also having to re-sketch similar but different geometry.

Automation is needed here if we are to complete this to deadlines.

Utilizing vault copy design & Dynamic skeletons







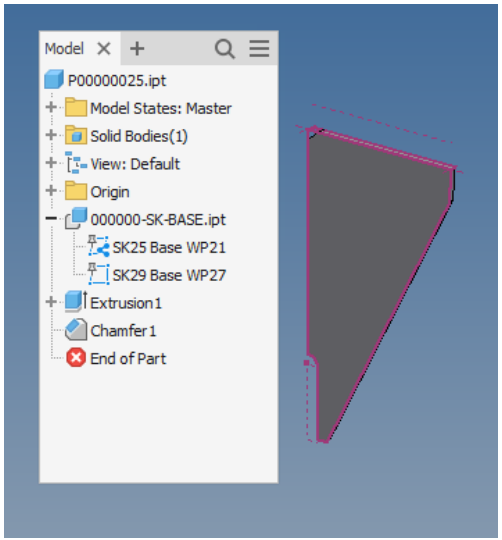
TMT Copy Design & Dynamic Skeletons

Demo

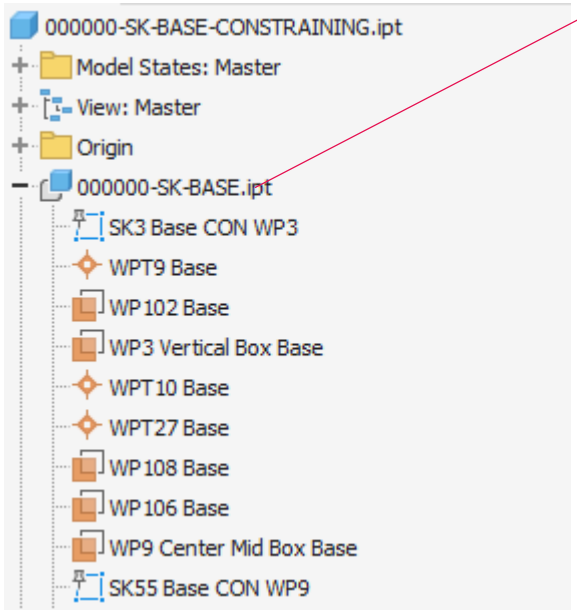
Flying Theater Productization & Taking the Methodology Further

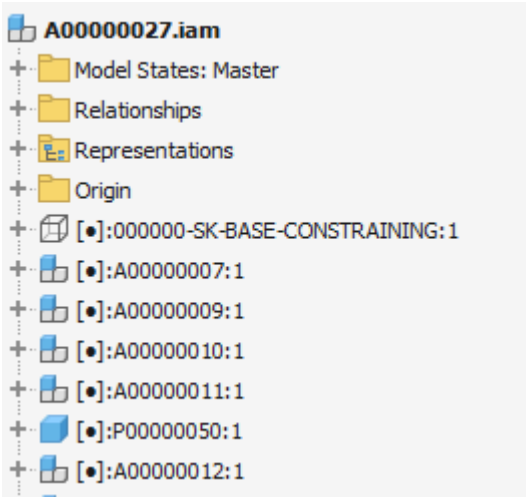
A consideration here that any additional sketch geometry that does not pertain to components will need an update if changed. Also any assembly files that contain the skeleton file will need an update again even if the geometry change has no effect.

Breaking down sketches so the least amount of geometry is brought through



You will now have the option to suppress the link





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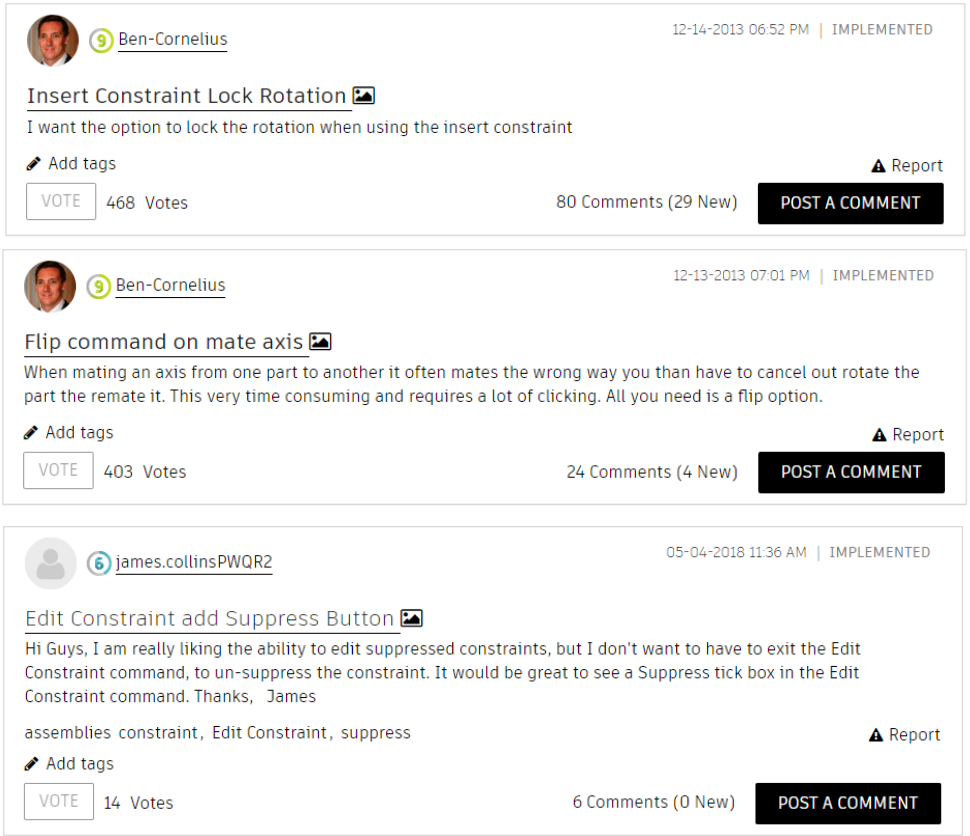

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