Using SIMSOLID with Autodesk Fusion 360 - IM123395

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AUTODESK UNIVERSITY


Photo credit: Newport Beach, the Wedge by Ken Welch

Inspiration

Course Outline

- Syllabus:

  SIMSOLID™ is next generation, high capacity, structural FEA. It uses new computational methods which allow the solution of assemblies with hundreds to thousands of parts directly on a standard desktop computer. SIMSOLID completely eliminates geometry simplification and meshing, the two most time consuming, expertise extensive and error prone tasks done in traditional FEA. SIMSOLID is the perfect complement to existing CAD embedded simulation. It extends the analysis range and provides feedback in seconds to minutes. This class will provide an introduction to SIMSOLID working with Autodesk Fusion 360. It will give an in-depth overview of SIMSOLID's unique meshless approach and will provide numerous industry examples including large assemblies and lattice based designs. The attendee will learn new techniques for performing preliminary design analysis on rapidly evolving designs.

- Learning Objectives:
  - Learn a new complementary software application for Fusion 360 – WHAT IT IS
  - Learn how to do structural analysis without meshing – HOW IT WORKS
  - Learn how to do large assembly design studies with evolving design geometry – APPLICATIONS
  - Learn how to do structural simulation of lightweight generative designed parts within the context of a large assembly – MORE APPLICATIONS

Solving the Geometry problem

Or, what is the #1 barrier to more widespread adoption of structural simulation?

The geometry of CAD and Analysis are different Why?

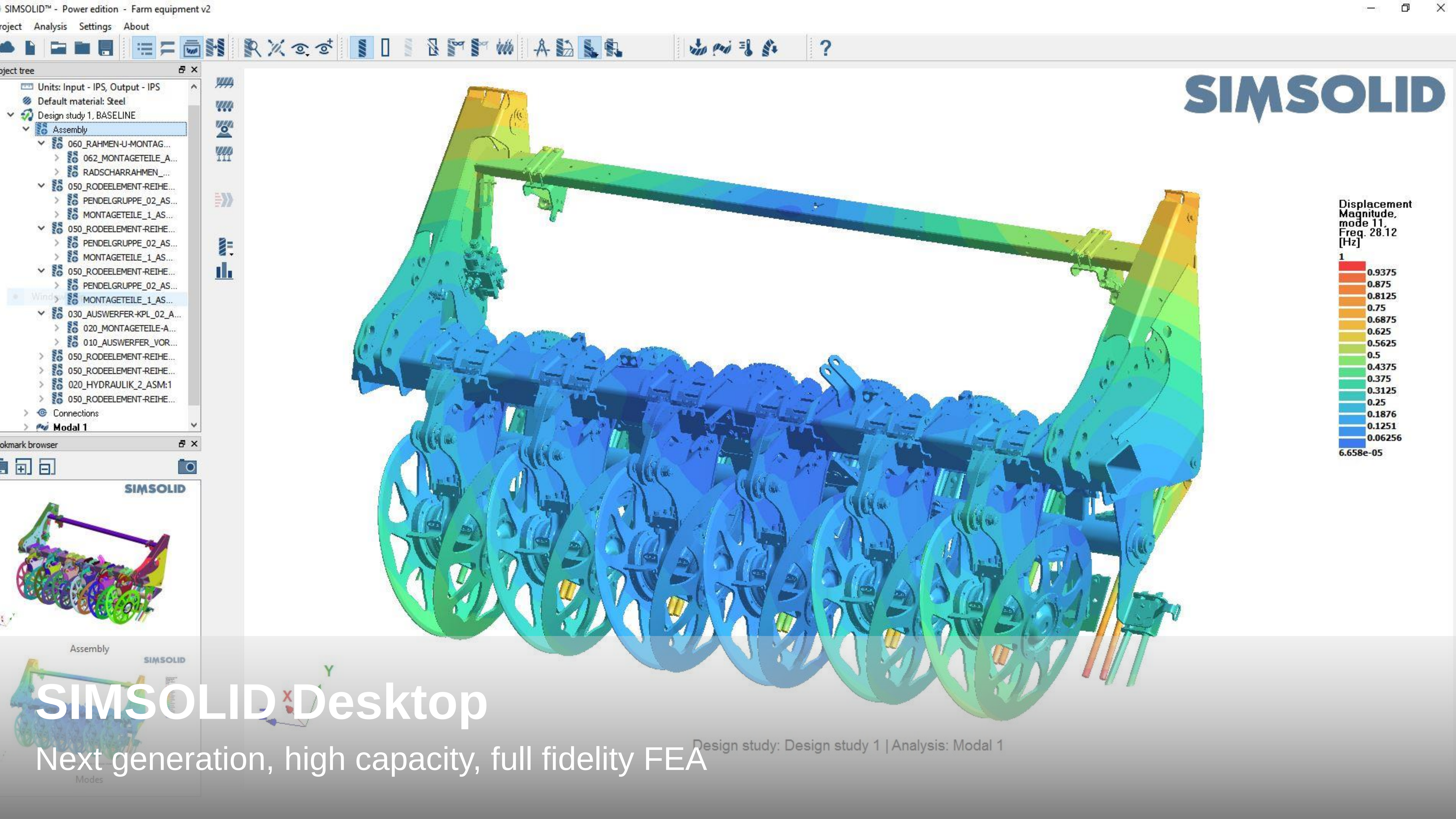
- That thing called “meshing”
- Creating a quality mesh is just too complex and takes too much time for typical product design workflows
  - Too COMPLEX
  - Too many TRADEOFFS
  - Too much DOMAIN KNOWLEDGE required

BOTTOM LINE: DESIGN ANALYSIS IS TIME LIMITED
MUST WORK AT THE “SPEED OF DESIGN” – SECONDS TO MINUTES

Meshing limitations leads to additional complexities

Many questions such as:

- What geometry is significant for my analysis?
- How do I identify and repair geometry defects
- How do I model my Connections, bolts, welds, etc? Especially for shells?
- If I break out a subset of parts, what are my Loads?



SIMSOLID Desktop

Next generation, high capacity, full fidelity FEA

SIMSOLID is

- NEW TECHNOLOGY – world's first built from the ground up assembly solver. Uses new "Feature based FEA", operates on unsimplified CAD geometry directly, does not create a mesh
- HIGH CAPACITY – it can solve large assemblies and complex parts
- ACCURATE – solution accuracy controlled using smart functions and a unique automatic multi-pass adaptive process.
- CAD CONNECTED – direct data integration with Fusion 360
- COMPLEMENTS EXISTING TOOLS – great complement to existing CAE specific or CAD embedded Simulation. It extends their analysis range to larger models and provides more rapid feedback in seconds to minutes

SIMSOLID notable features

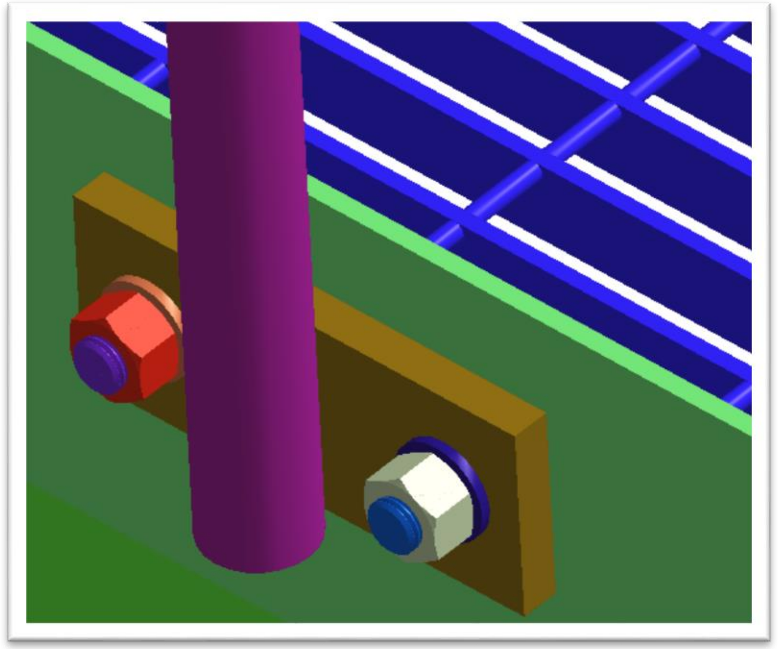
- Solver and solution adaptivity
  - Linear & **nonlinear** statics, modal, thermal, thermal-stress
  - Cylindrical hole & thin solid adaptivity
- Connectors
  - Virtual Connections – pin and general
  - Bolted – bolt tightening by turns of nut, torque & target axial force
  - Bonded, sliding, separating contact w/ friction
  - Welded – spot, fillet, weld creation automation
- Results
  - Reaction forces – spot weld forces, connections forces, part resultants
- Runs on the desktop **or the cloud**

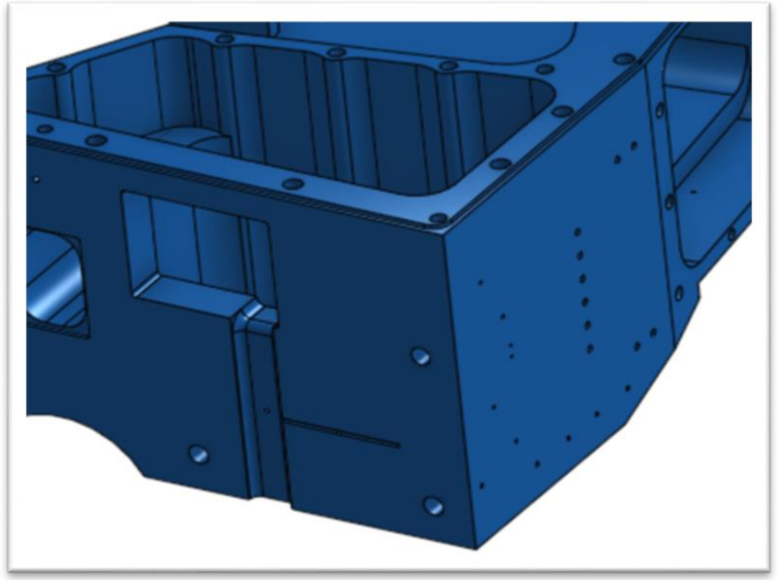
Thinking about FEA, the difficulty lies not so much in developing new ideas as in escaping the old ones.

Changing the analysis modeling paradigm

FEA → Requires GEOMETRY changes,
SIMSOLID → Accepts as is

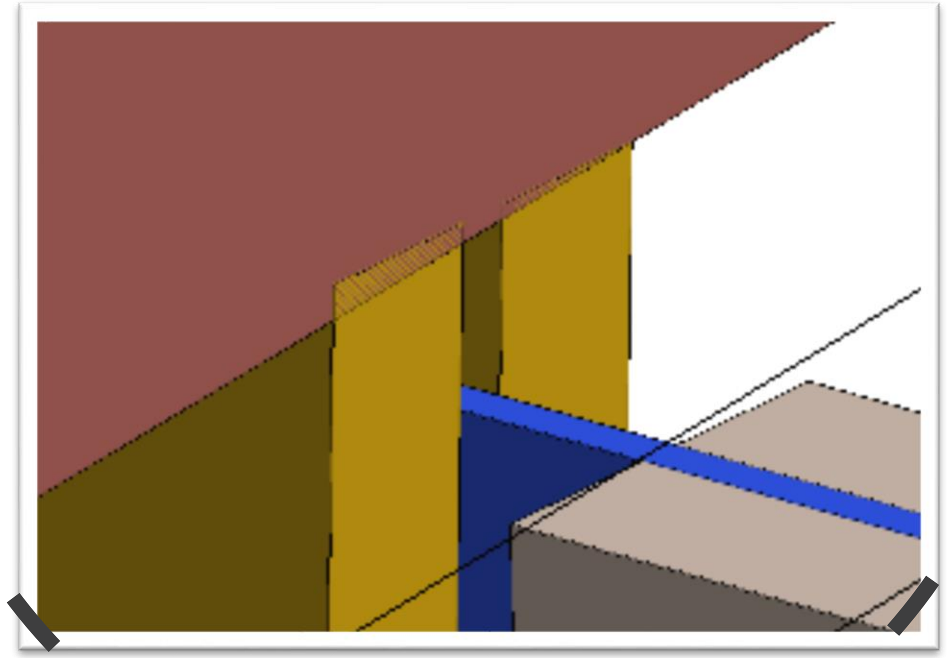
Assemblies with big/small or thick/thin parts are OK



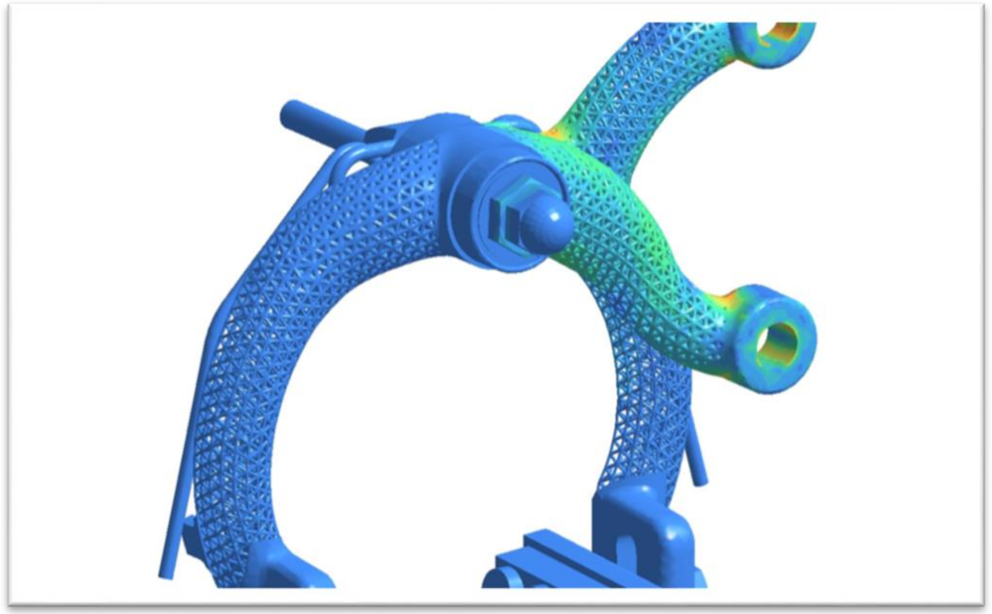


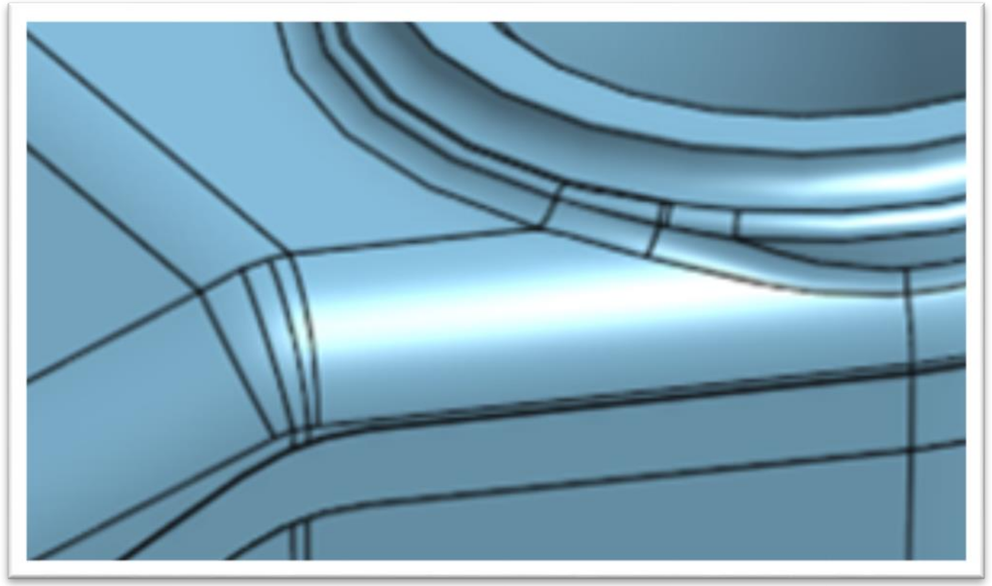
Small features Are OK to leave in

Part gaps and overlaps are OK



Extreme geometric complexity is OK





Odd face transitions or small splinter surfaces are OK

SIMSOLID compared to traditional FEA - Methods

Traditional FEA	SIMSOLID
Simple regions – TET, etc	Arbitrary regions – whole part can be a region
DOF is associated with a node - it is point-wise	DOF is not point-wise. It can be associated with volumes, surfaces, lines and/or point clouds
DOF are nodal Ux, Uy, Uz displacements	DOF are integrals over corresponding geometrical objects, not nodal
3 DOF per node	Many DOF per single associated geometry object are possible, depends on solution adaptation
Shape functions are simple low degree interpolation polynomials	Shape functions can be of arbitrary class • complete standard polynomials • divergence-free polynomials • harmonic polynomials • non-polynomials

SIMSOLID compared to traditional FEA - Accuracy

Traditional FEA	SIMSOLID
Geometry level of detail decision by user	Full geometry detail - modeling errors minimized
Types of elements decision by user	No elements
Mesh density and distribution based controls decision by user	No meshing
Correct interpretation of analysis settings by user • Solver & solution methods • Tolerances and options	No settings in dynamics and non-linear analyses including separating contact with friction
Solution adaptation is mostly based on local energy density change, it is relative • Rarely used for assemblies	Solution adaptation is based on local energy density change and absolute errors on boundary • Always active • Easy to set both global (whole assembly) and local (part based) solution adaption • Reaction forces at support and connections are very accurate

Why Change Now?
ANSYS user needs survey

- Survey of 1800
- Frequency when FEA model size and detail must be limited
  - 40% Almost always
  - 35% More than ½ the time

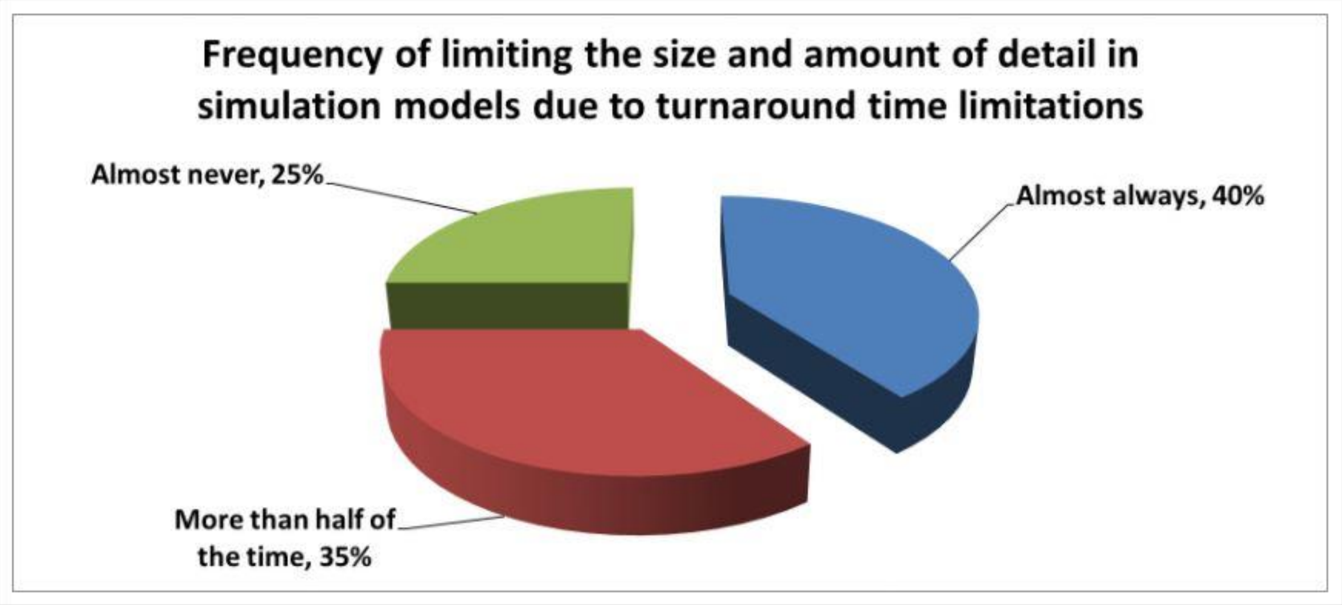
75%

- Frequency that this limitation leads to low fidelity results
  - 13% Almost always
  - 41% More than ½ the time

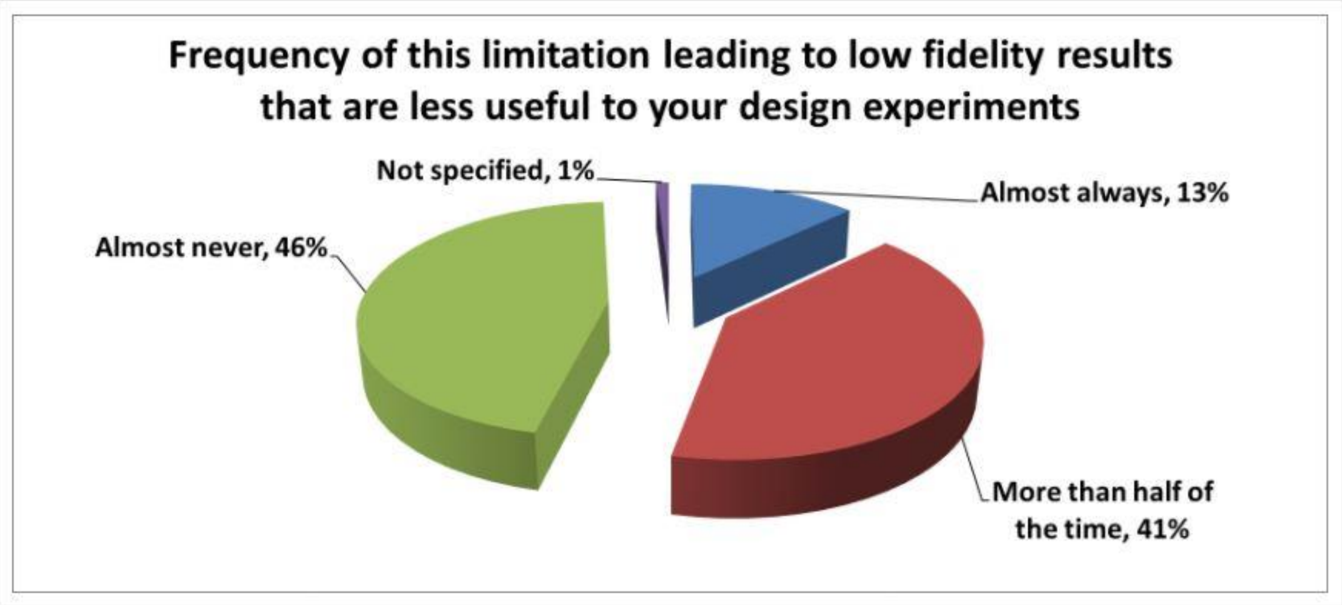
>50%

REFERENCE SOURCE: ANSYS Blog 31-OCT-2017

According to a survey of our customers conducted in conjunction with Intel and *Digital Engineering* magazine, 40% of the more than 1,800 respondents almost always limit the size or amount of detail in simulation models because of time constraints. More than a third (35%) limit it for more than half of the time!



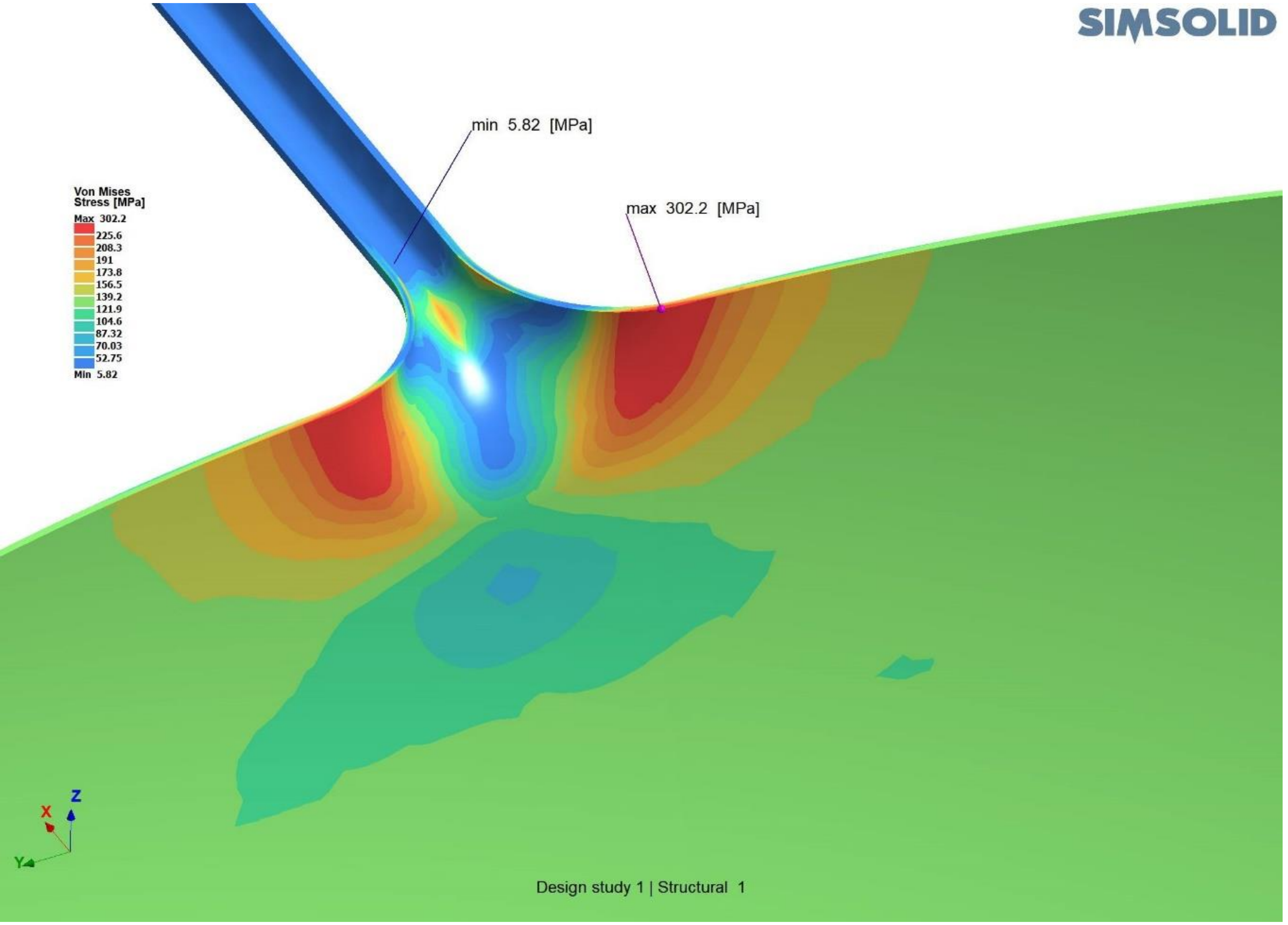
The same survey also reflects that, in many cases, limiting the size or amount of detail can result in lower-fidelity results that are less useful to respondents' design experiments!

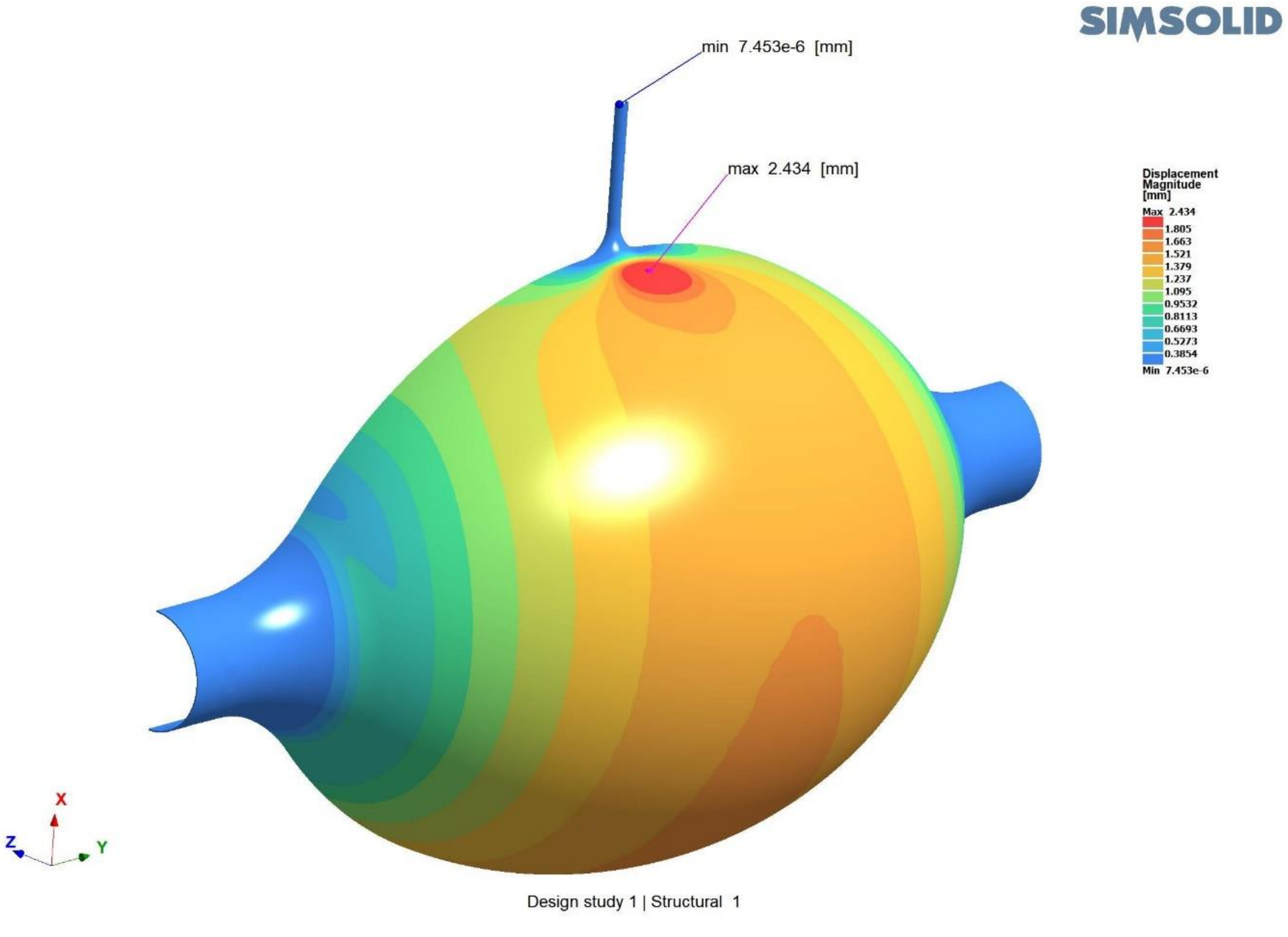


Demo 1 – SIMSOLID working with Autodesk Fusion 360

CAD integration, smart functions & design studies
[C Channel]

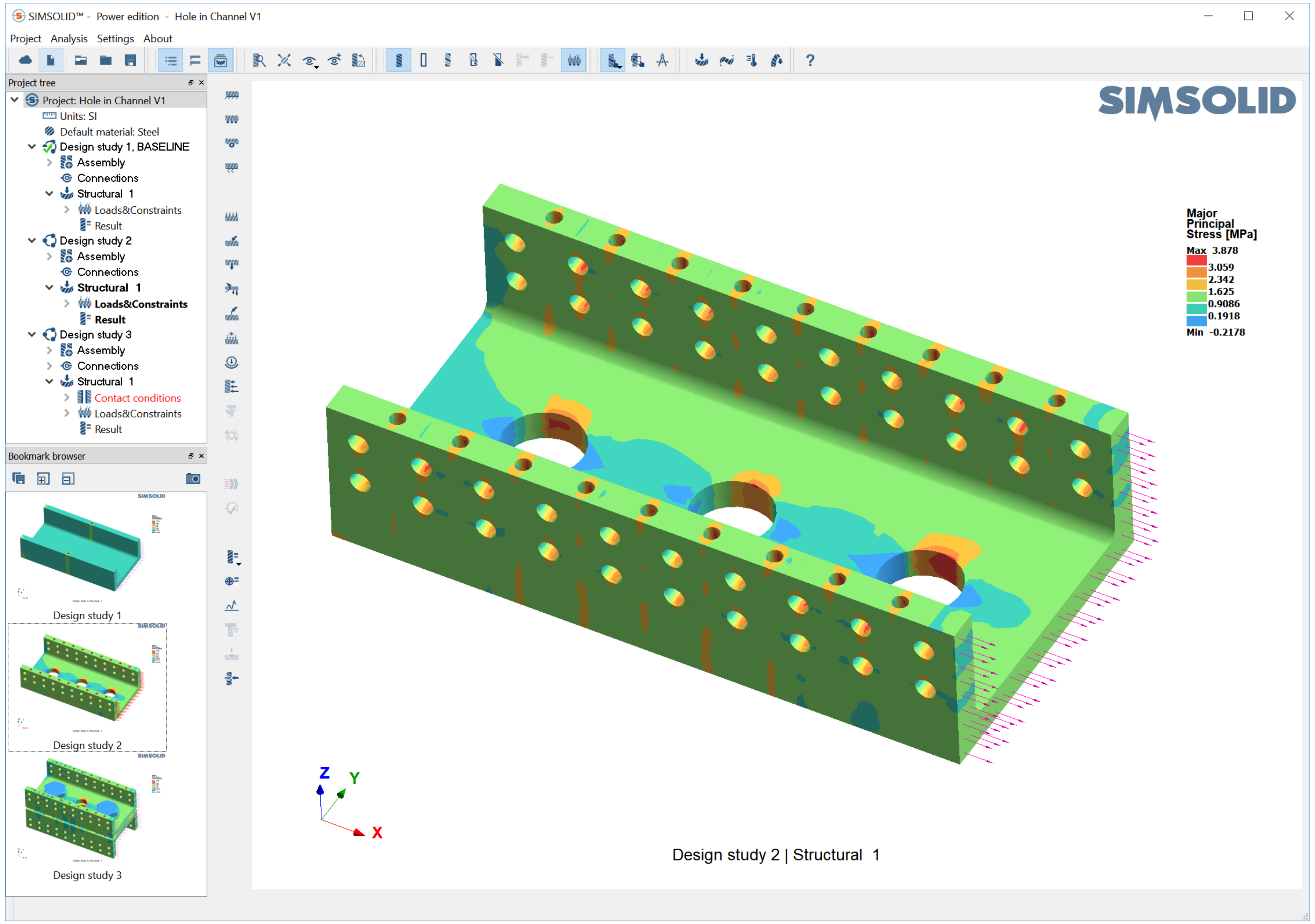
Smart functions – thin curved solids

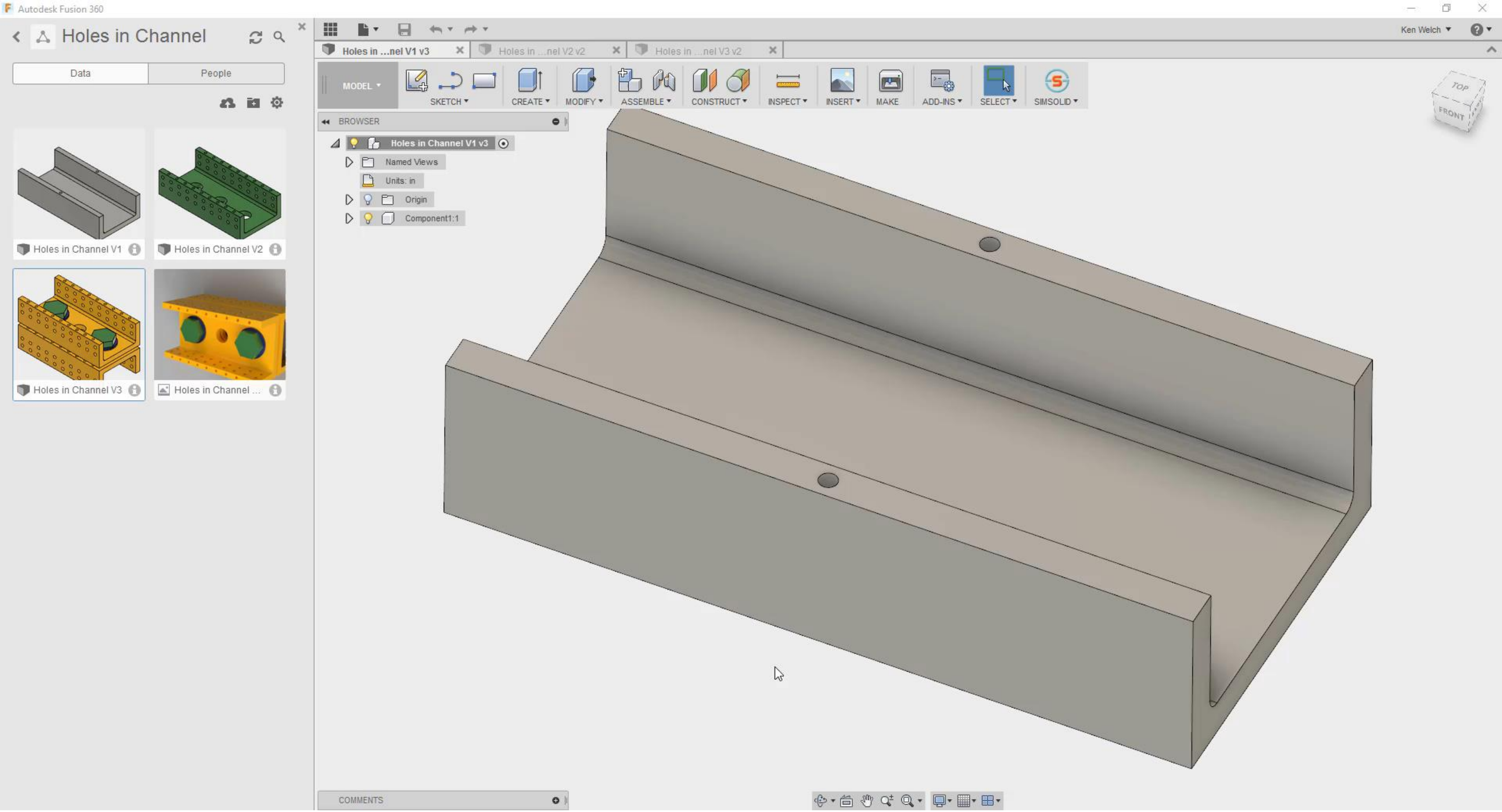




Smart functions - holes

- Special non-polynomial functions are associated with local CAD features
- Always active
- Adapt solution to local cylindrical stress concentrations
- Very accurate with low computational overhead



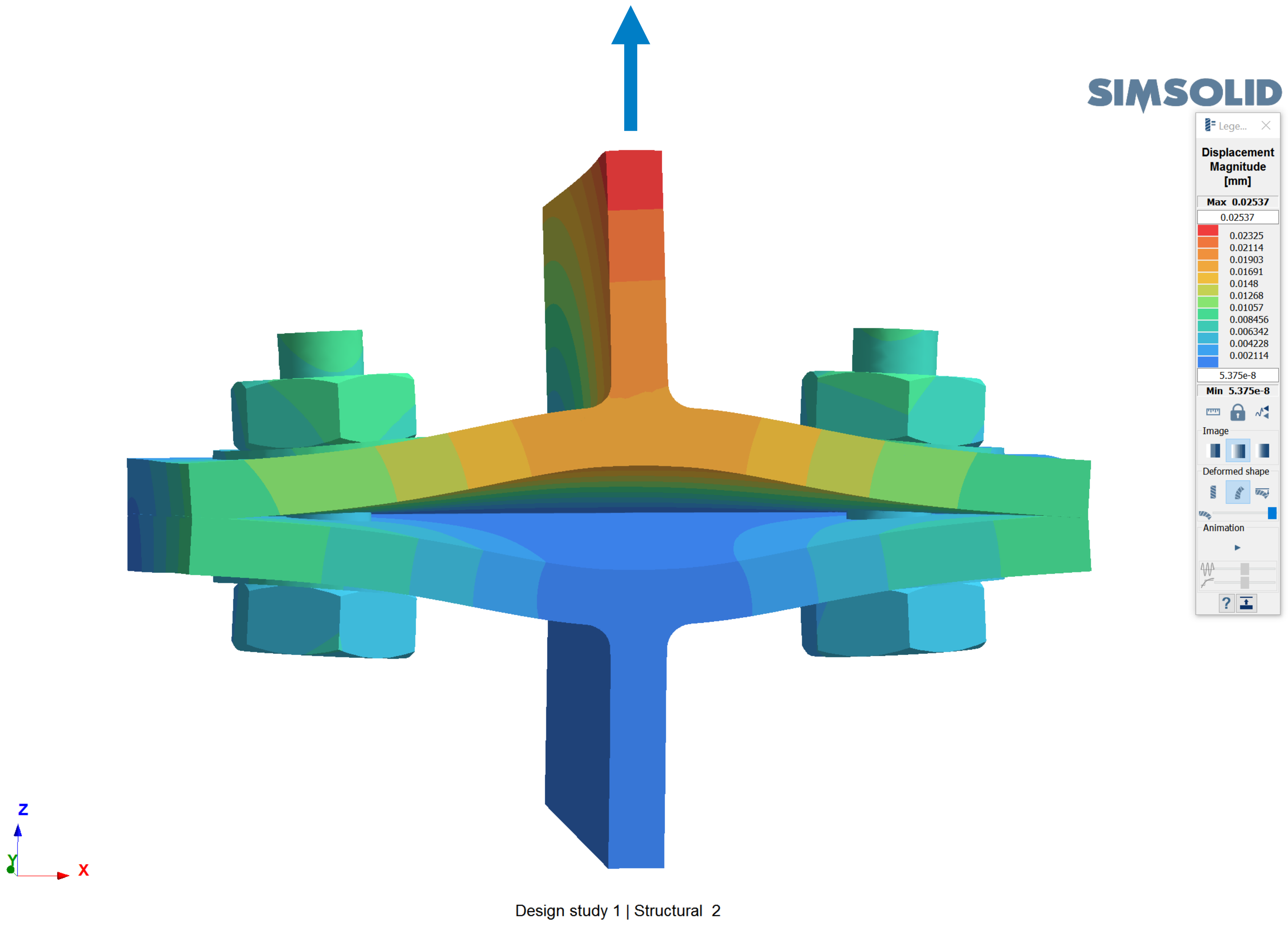


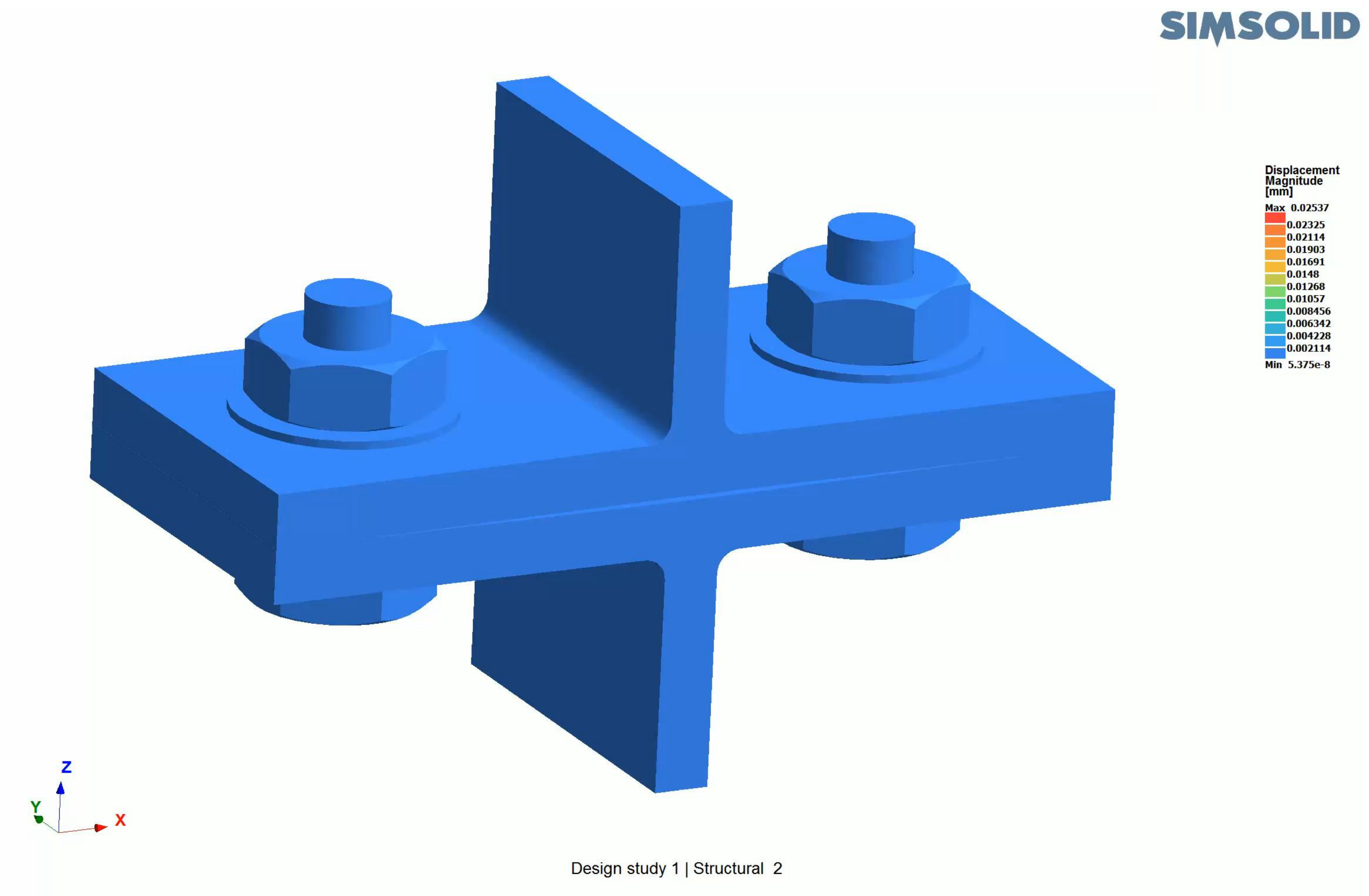
Autodesk Fusion 360
Holes in Channel
Data
People
Holes in Channel V1
Holes in Channel V2
Holes in Channel V3
Holes in Channel ...
Ken Welch
Holes in ...nel V1 v3
Holes in ...nel V2 v2
Holes in ...nel V3 v2
MODEL
SKETCH
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
MAKE
ADD-INS
SELECT
SIMSOLID
BROWSER
Holes in Channel V1 v3
Named Views
Units: in
Origin
Component1:1
TOP
FRONT
COMMENTS

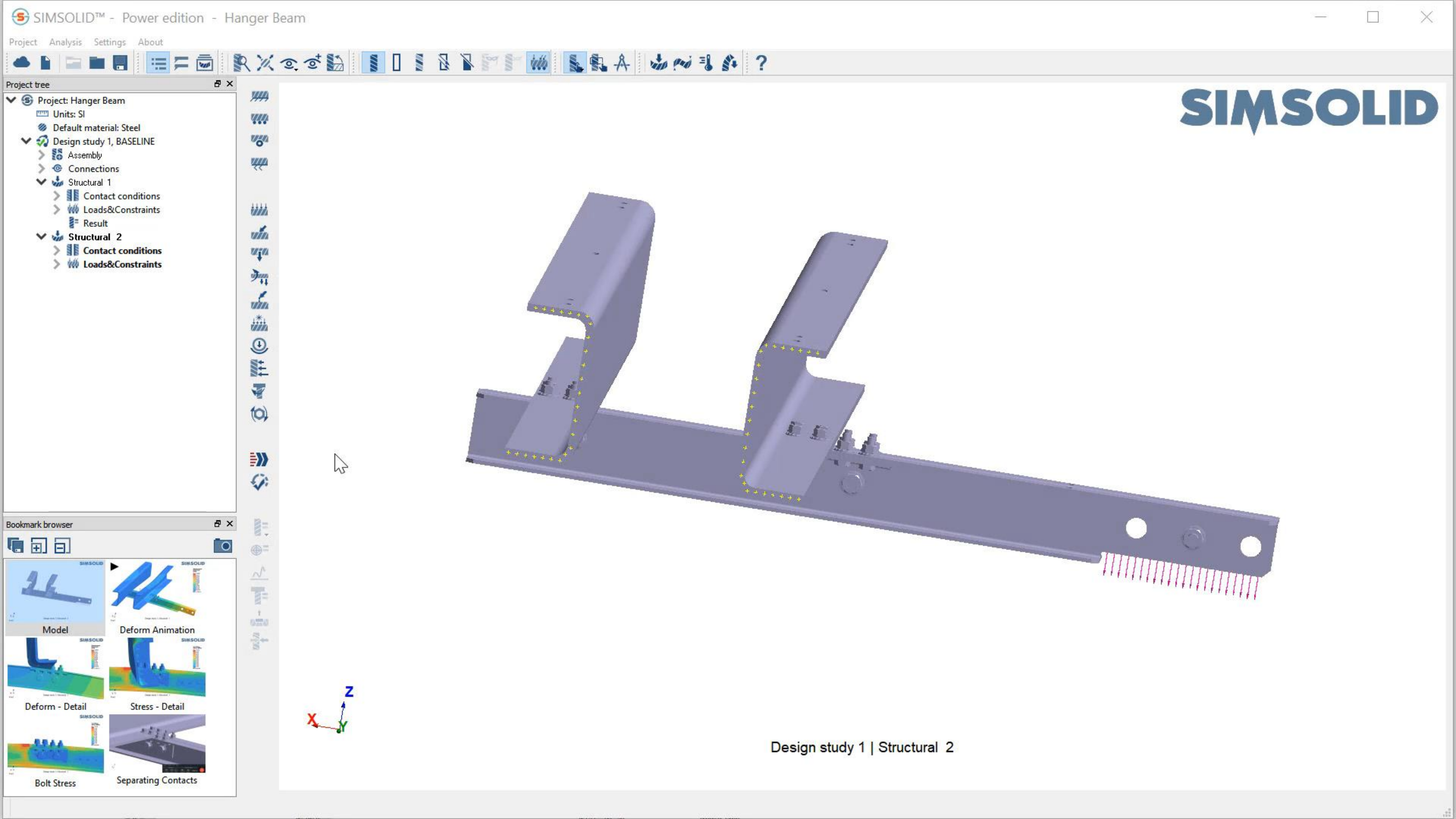
Demo 2 – SIMSOLID working with Autodesk Fusion 360

Advanced nonlinear separating contact
[Hanger beam]

Nonlinear separating contact



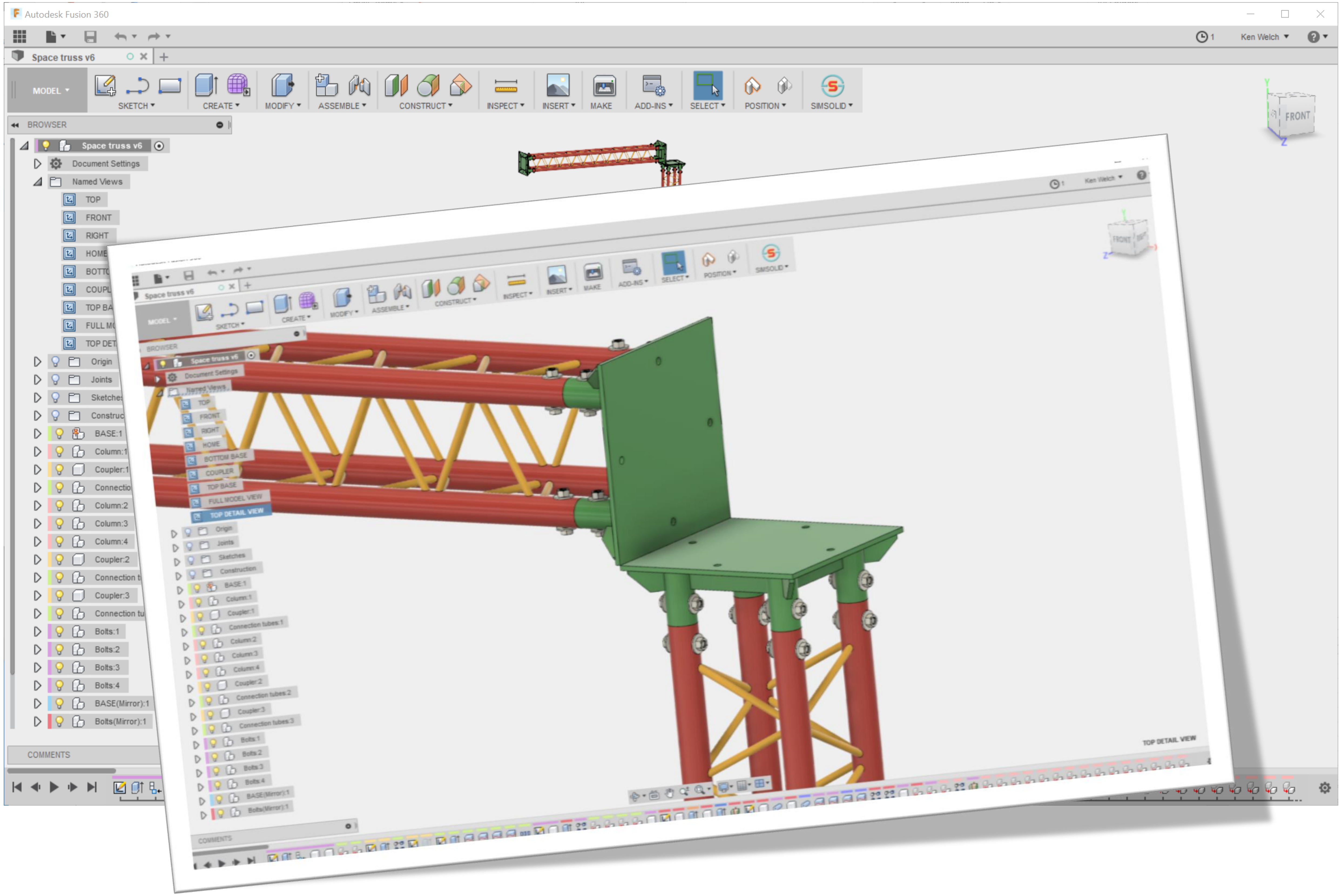


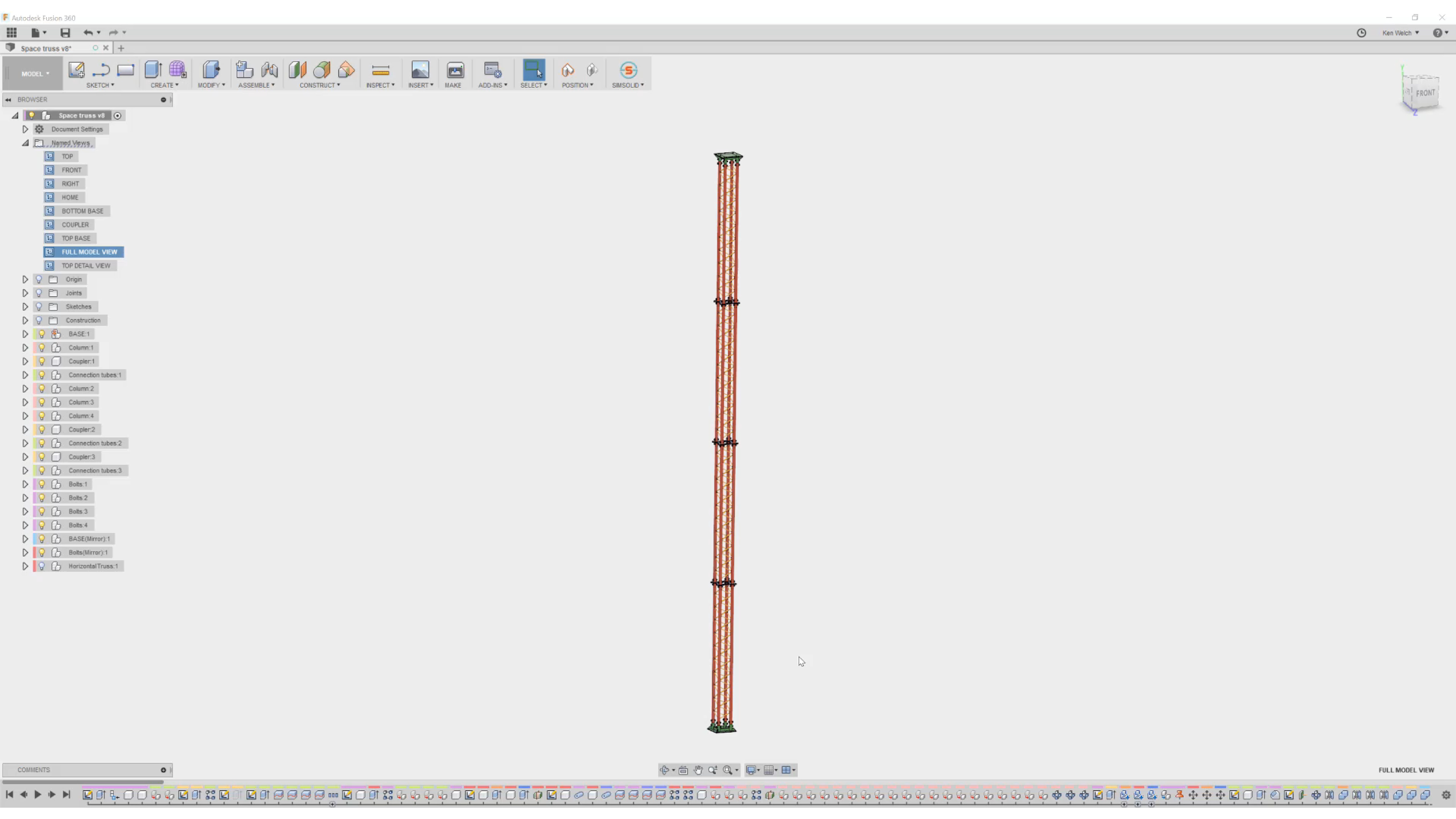

SIMSOLID™ - Power edition - Hanger Beam
Project
Analysis
Settings
About
Project tree
Project: Hanger Beam
Units: SI
Default material: Steel
Design study 1, BASELINE
Assembly
Connections
Structural 1
Contact conditions
Loads&Constraints
Result
Structural 2
Contact conditions
Loads&Constraints
Bookmark browser
Model
Deform Animation
Deform - Detail
Stress - Detail
Bolt Stress
Separating Contacts
SIMSOLID
Z
X
Y
Design study 1 | Structural 2

Demo 3 – SIMSOLID working with Autodesk Fusion 360

CAD integration, design studies, virtual connectors
[Mast vibration study]

Mast vibration with virtual connectors

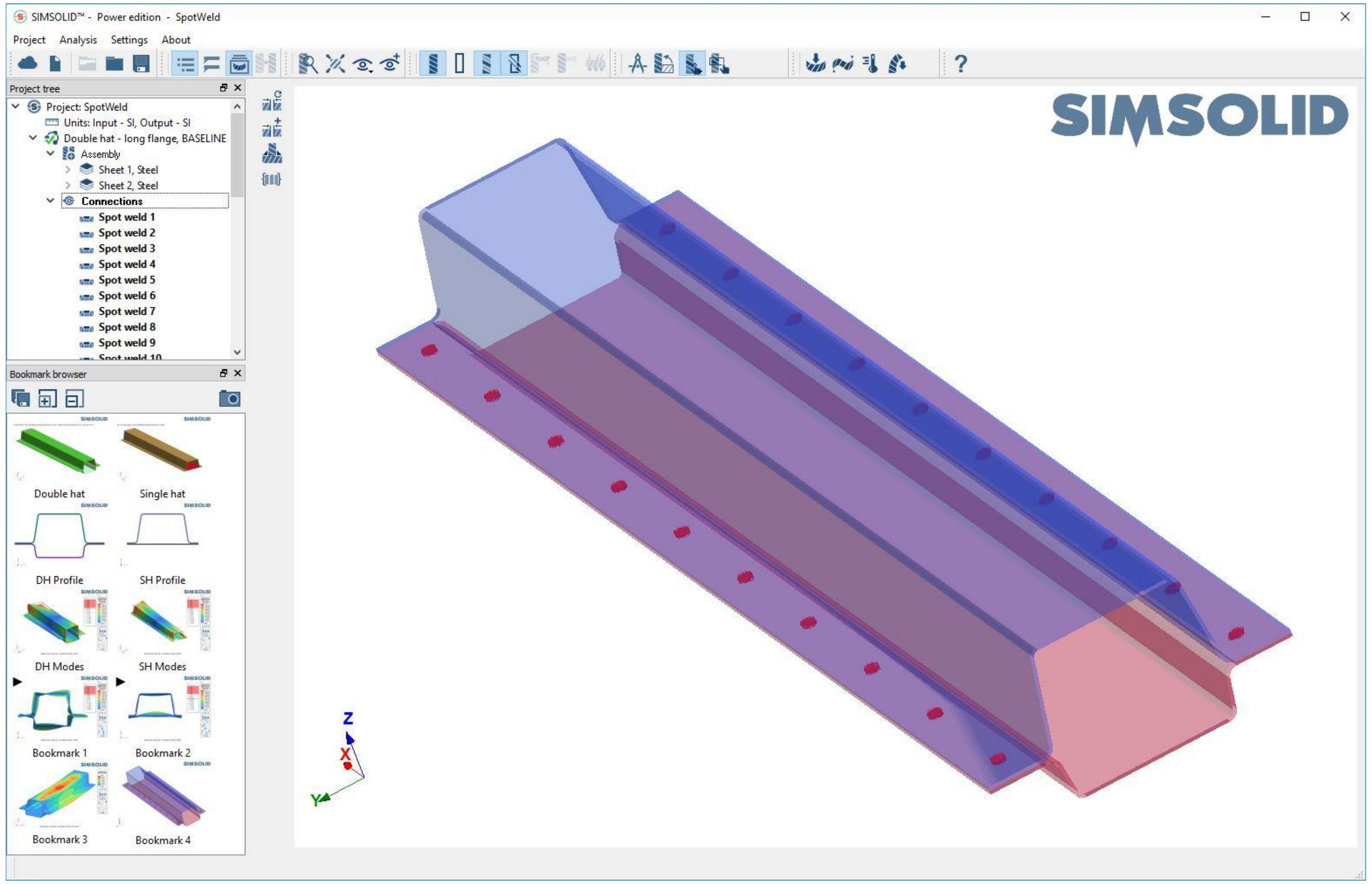


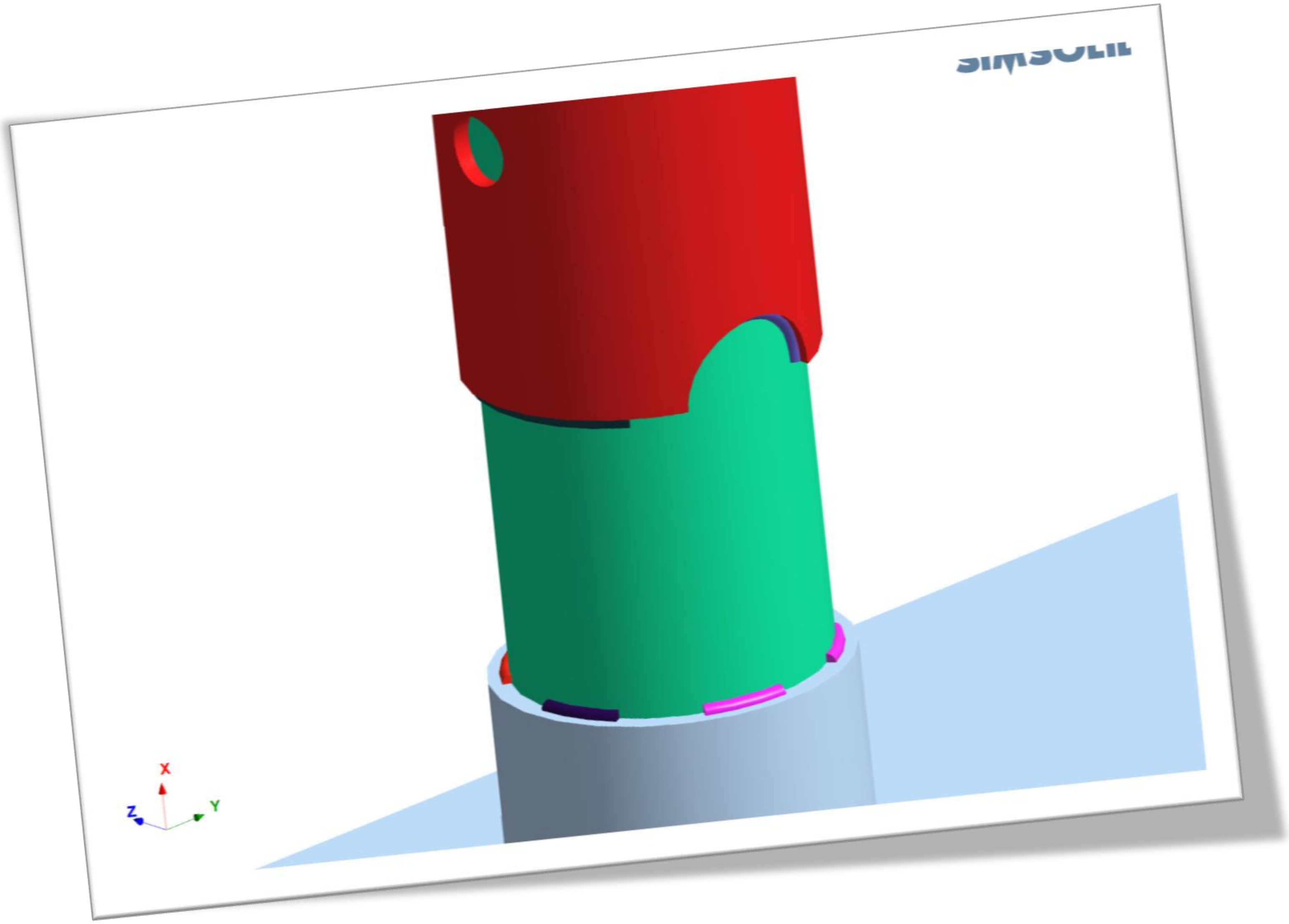

Autodesk Fusion 360
Space truss v8*
Ken Welch
MODEL
SKETCH
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
MAKE
ADD-INS
SELECT
POSITION
SIMSOLID
FRONT
BROWSER
Space truss v8
Document Settings
Named Views
TOP
FRONT
RIGHT
HOME
BOTTOM BASE
COUPLER
TOP BASE
FULL MODEL VIEW
TOP DETAIL VIEW
Origin
Joints
Sketches
Construction
BASE:1
Column:1
Coupler:1
Connection tubes:1
Column:2
Column:3
Column:4
Coupler:2
Connection tubes:2
Coupler:3
Connection tubes:3
Bolts:1
Bolts:2
Bolts:3
Bolts:4
BASE(Mirror):1
Bolts(Mirror):1
HorizontalTruss:1
COMMENTS
FULL MODEL VIEW

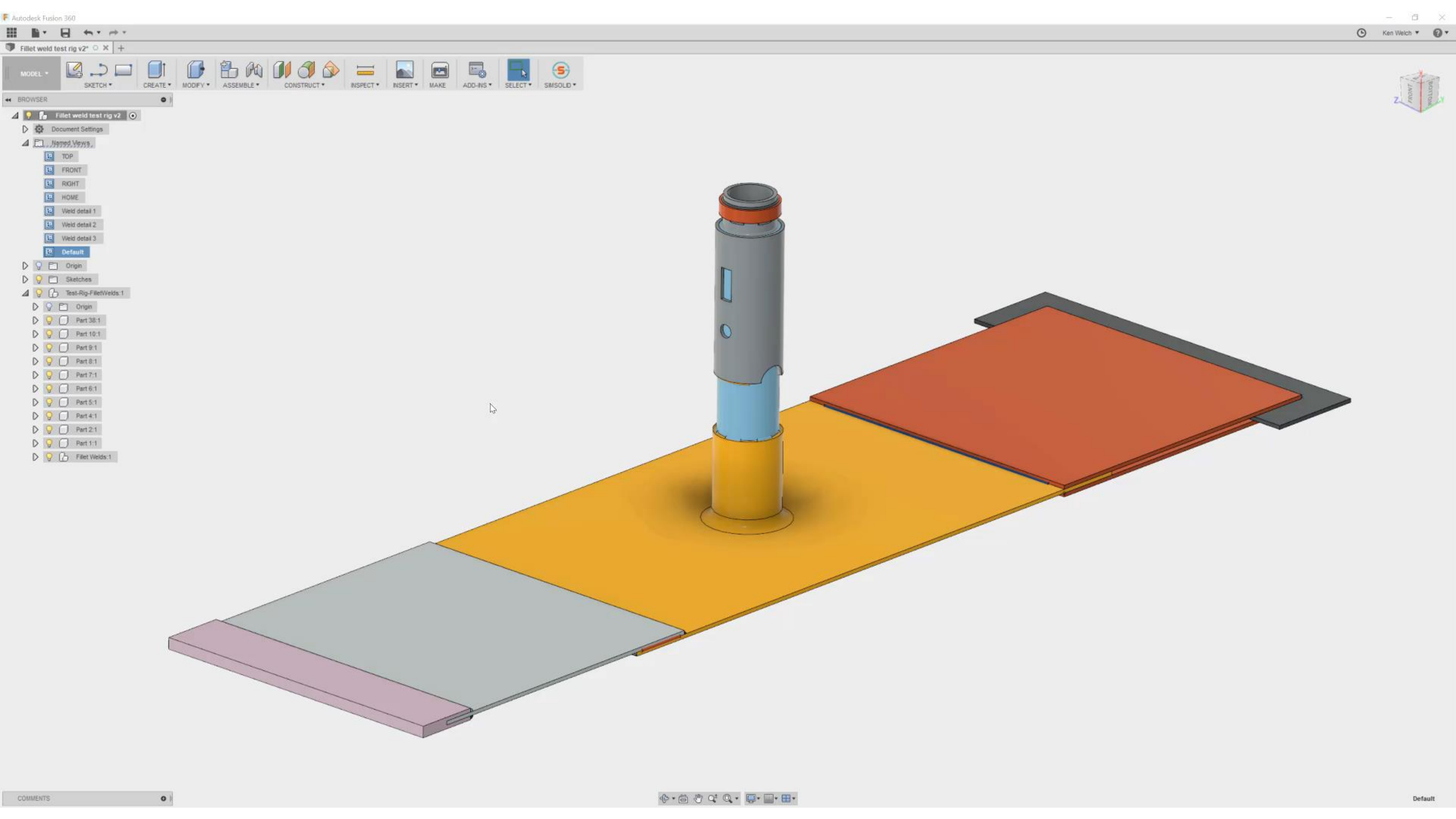
Demo 4 – SIMSOLID working with Autodesk Fusion 360

Advanced connectors – spot and fillet welds
[Weld validation model]

Spot and fillet welds



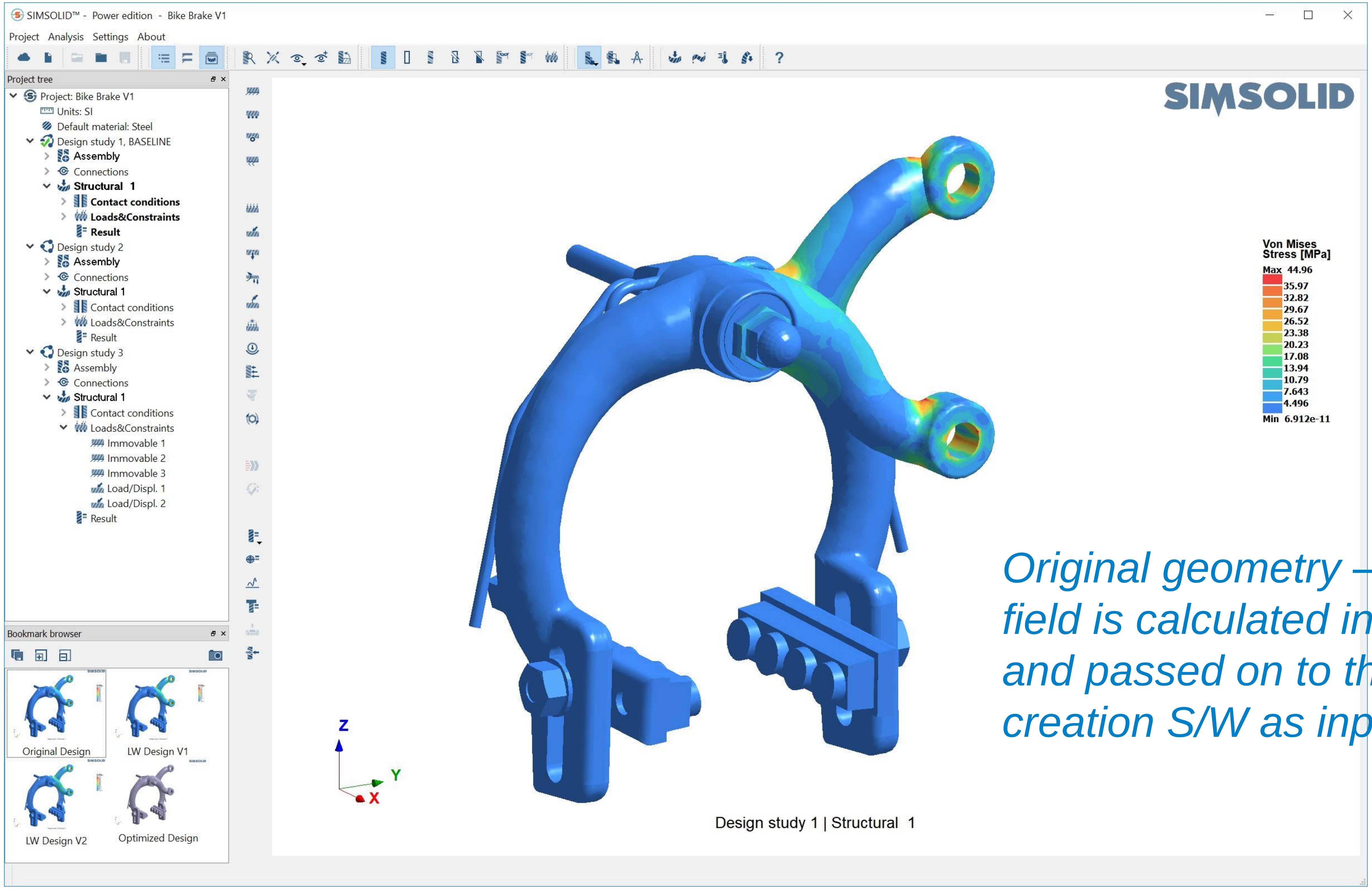



Autodesk Fusion 360
Fillet weld test rig v2*
Ken Welch
MODEL
SKETCH
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
MAKE
ADD-INS
SELECT
SIMSOLID
BROWSER
Fillet weld test rig v2
Document Settings
Named Views
TOP
FRONT
RIGHT
HOME
Weld detail 1
Weld detail 2
Weld detail 3
Default
Origin
Sketches
Test-Rig-FilletWelds:1
Origin
Part 38:1
Part 10:1
Part 9:1
Part 8:1
Part 7:1
Part 6:1
Part 5:1
Part 4:1
Part 2:1
Part 1:1
Fillet Welds:1
COMMENTS
Default

SIMSOLID combining solids and mesh based geometry

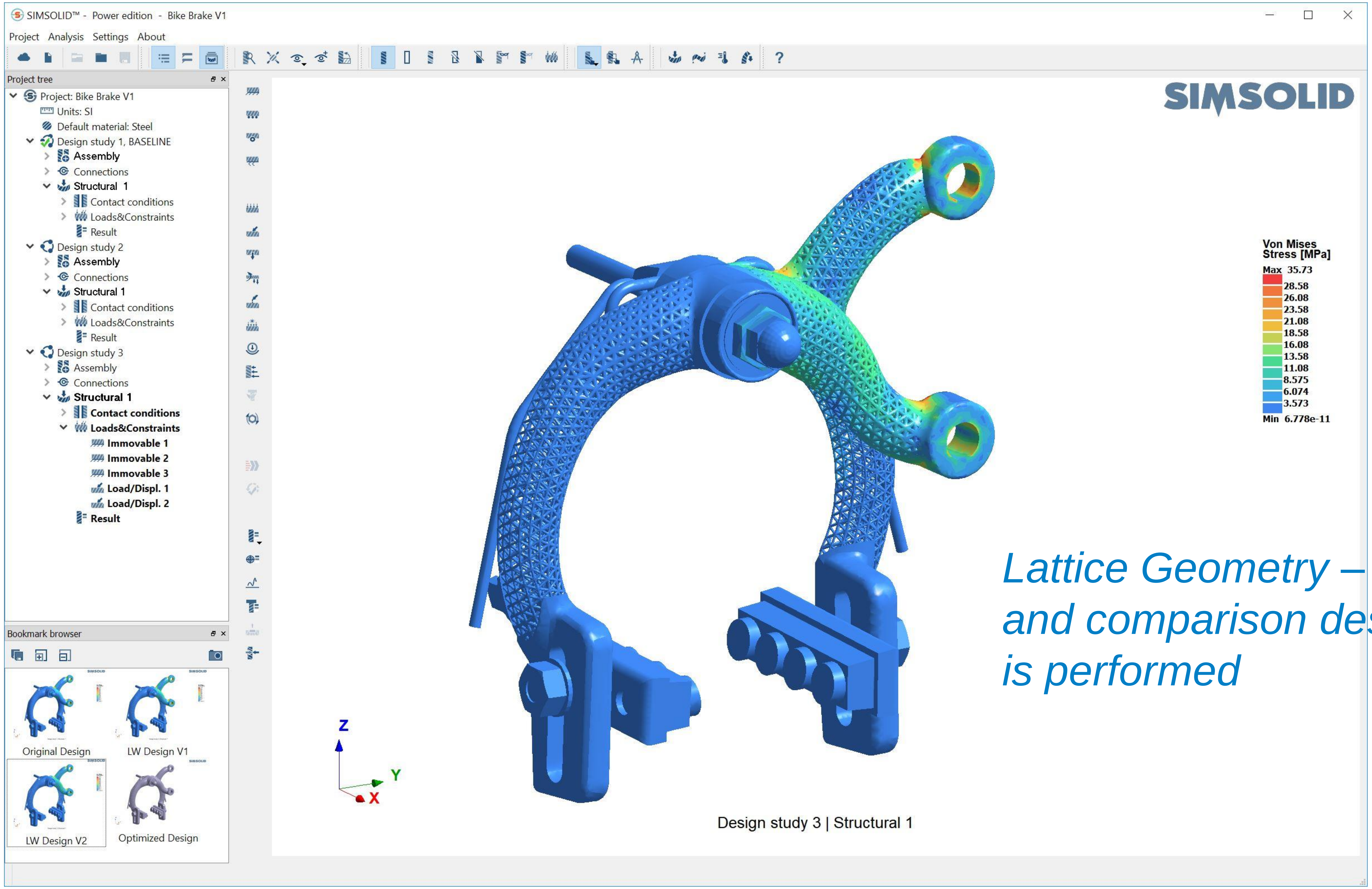
SIMSOLID results drives lattice creation
[Bike brake model]

Combining solids and mesh based geometry



Original geometry – stress field is calculated in SIMSOLID and passed on to the lattice creation S/W as input

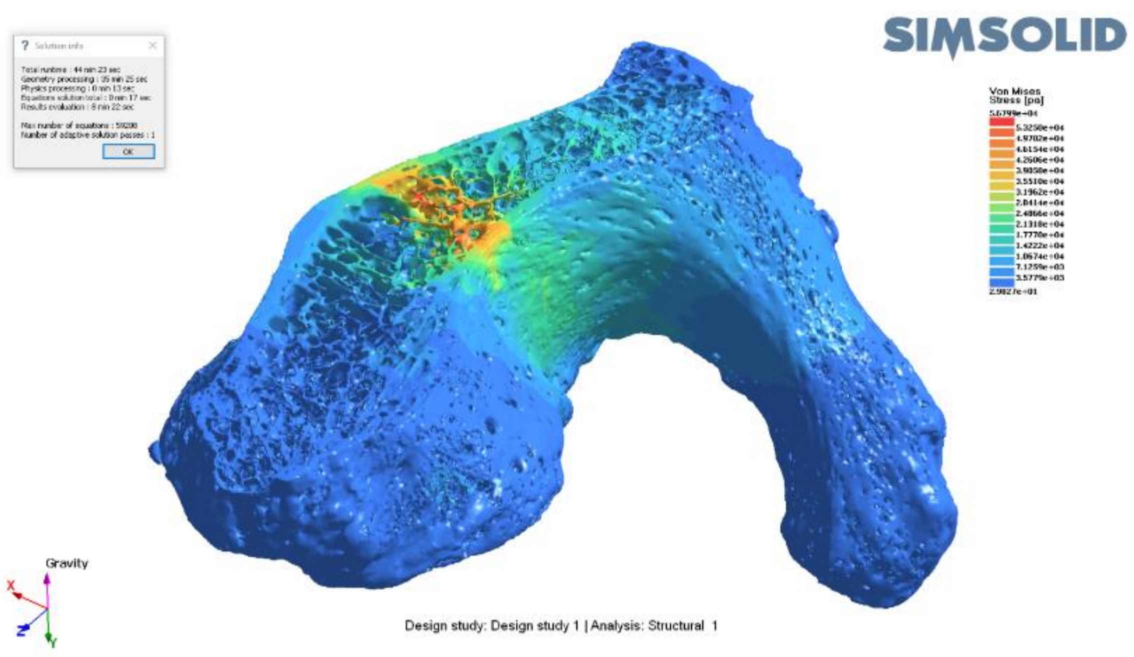
Combining solids and mesh based geometry

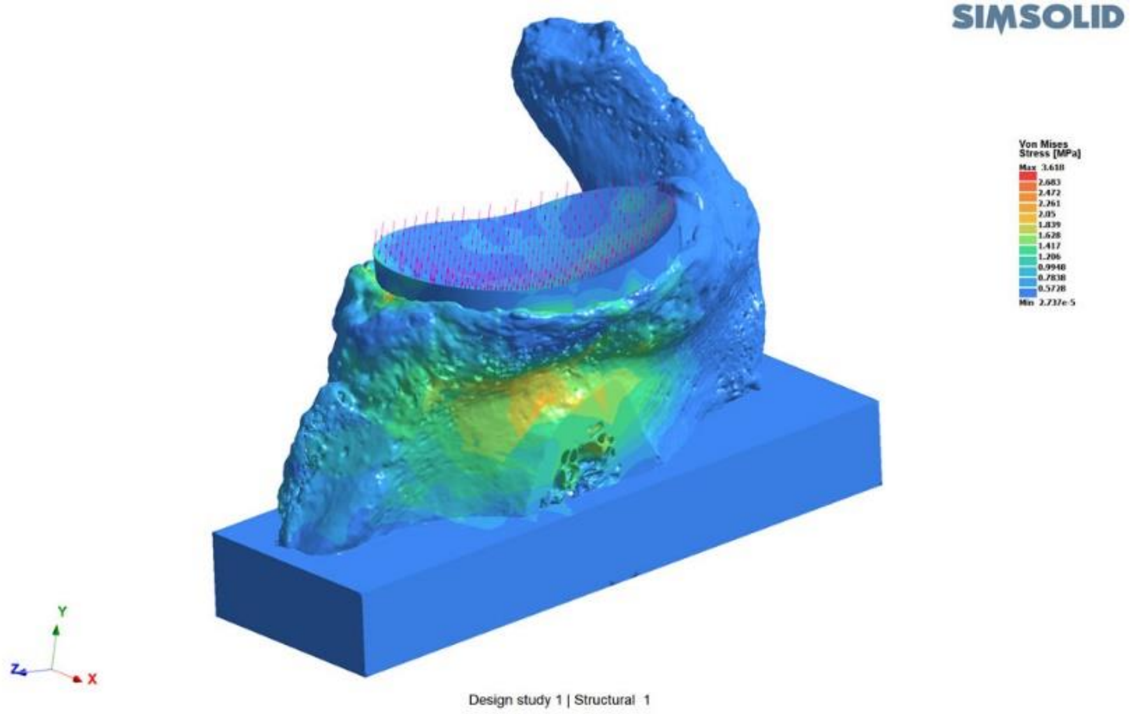


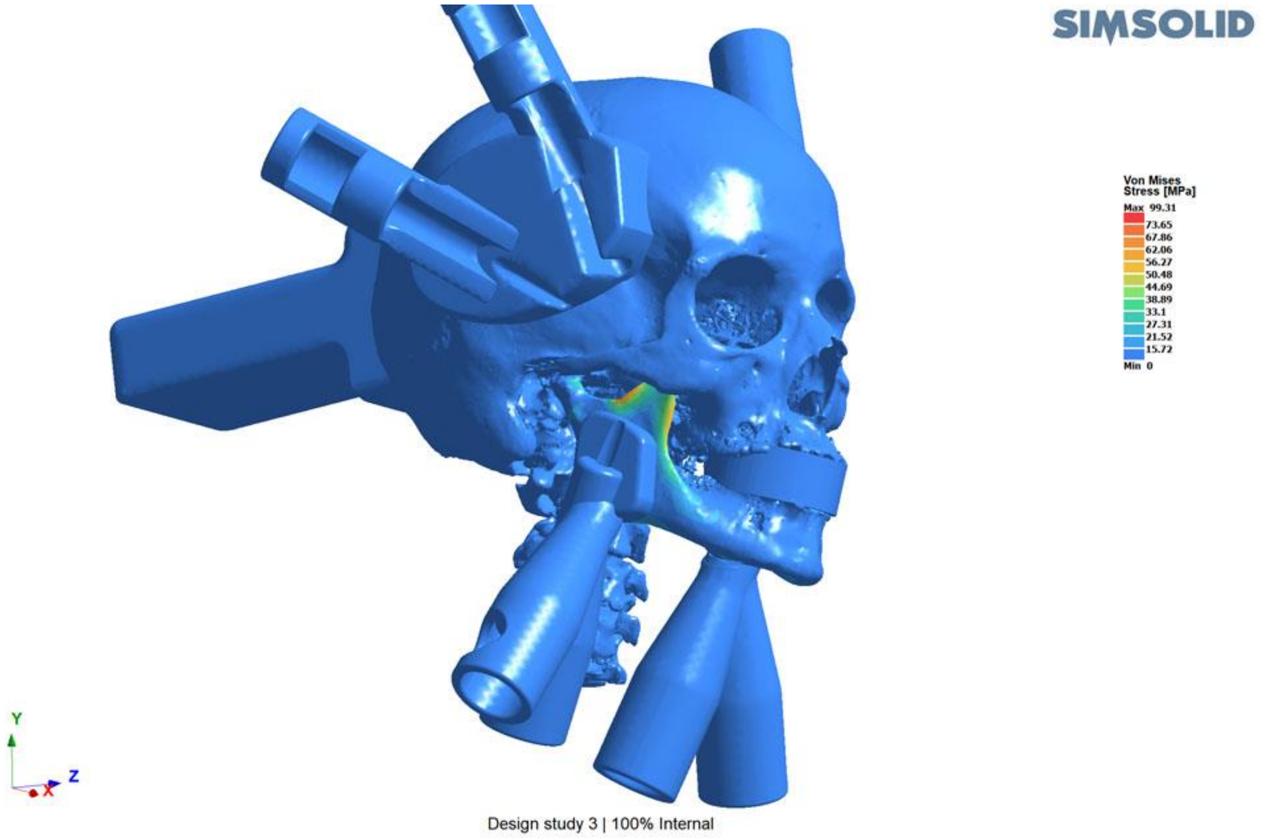
Lattice Geometry – is returned and comparison design study is performed

Model credit: nTopology, Inc

Biomechanics research







"We have found SIMSOLID to be an invaluable aid to our research work. It's ability to analyze complex bone geometry is a capability that is not practical with other FEA methods."

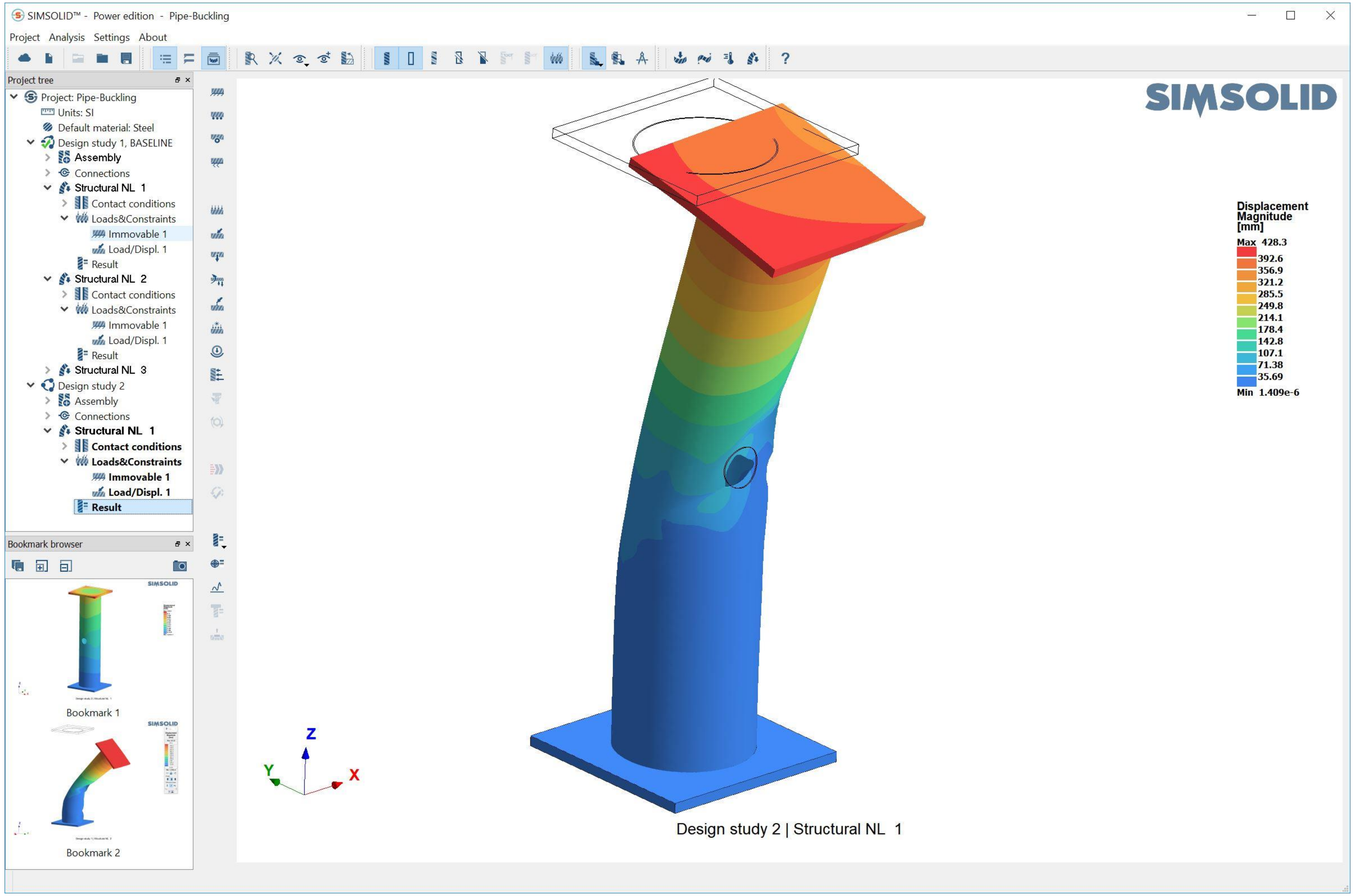
Louis Ferreira
Associate professor

Model credit: University of Western Ontario

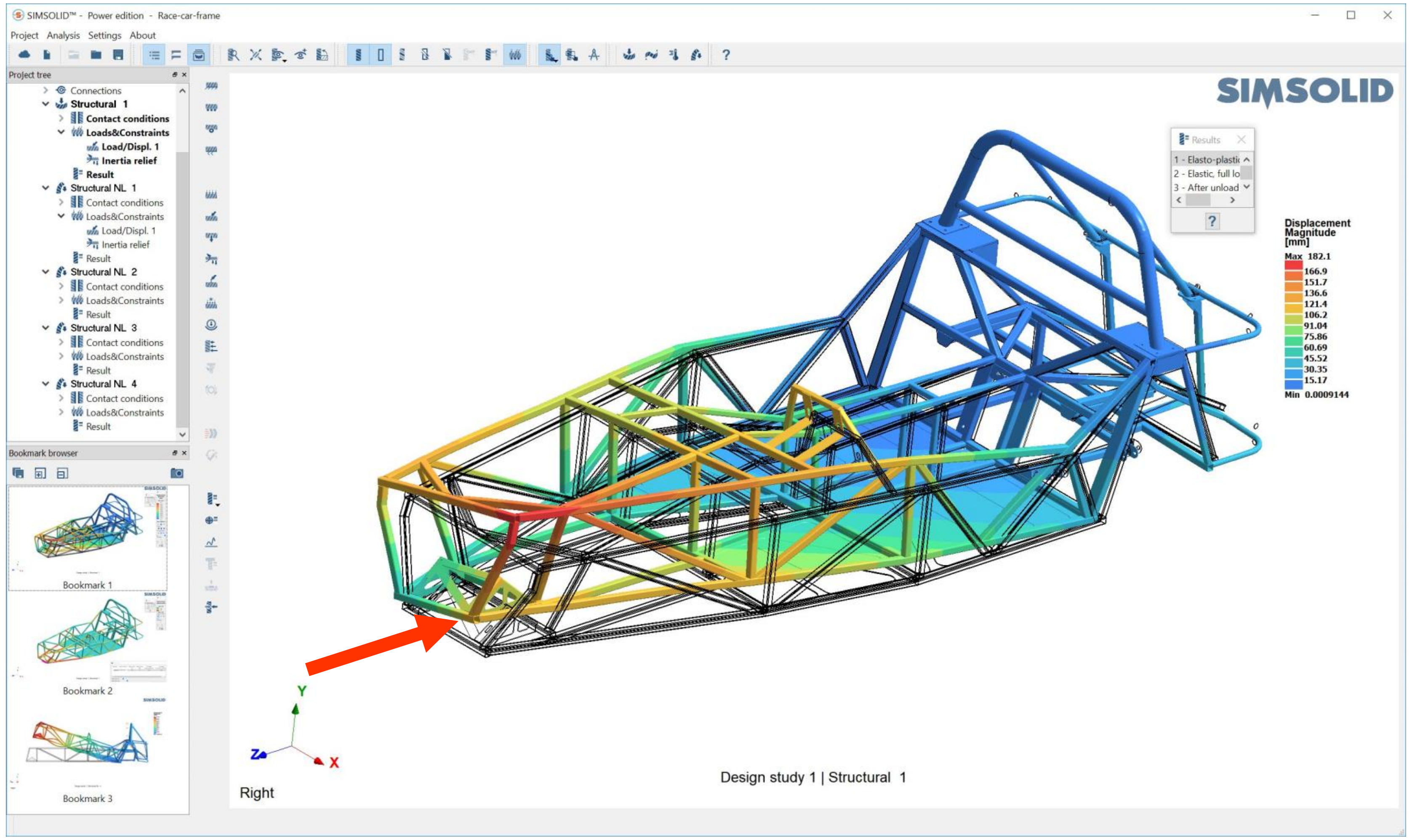
Extras

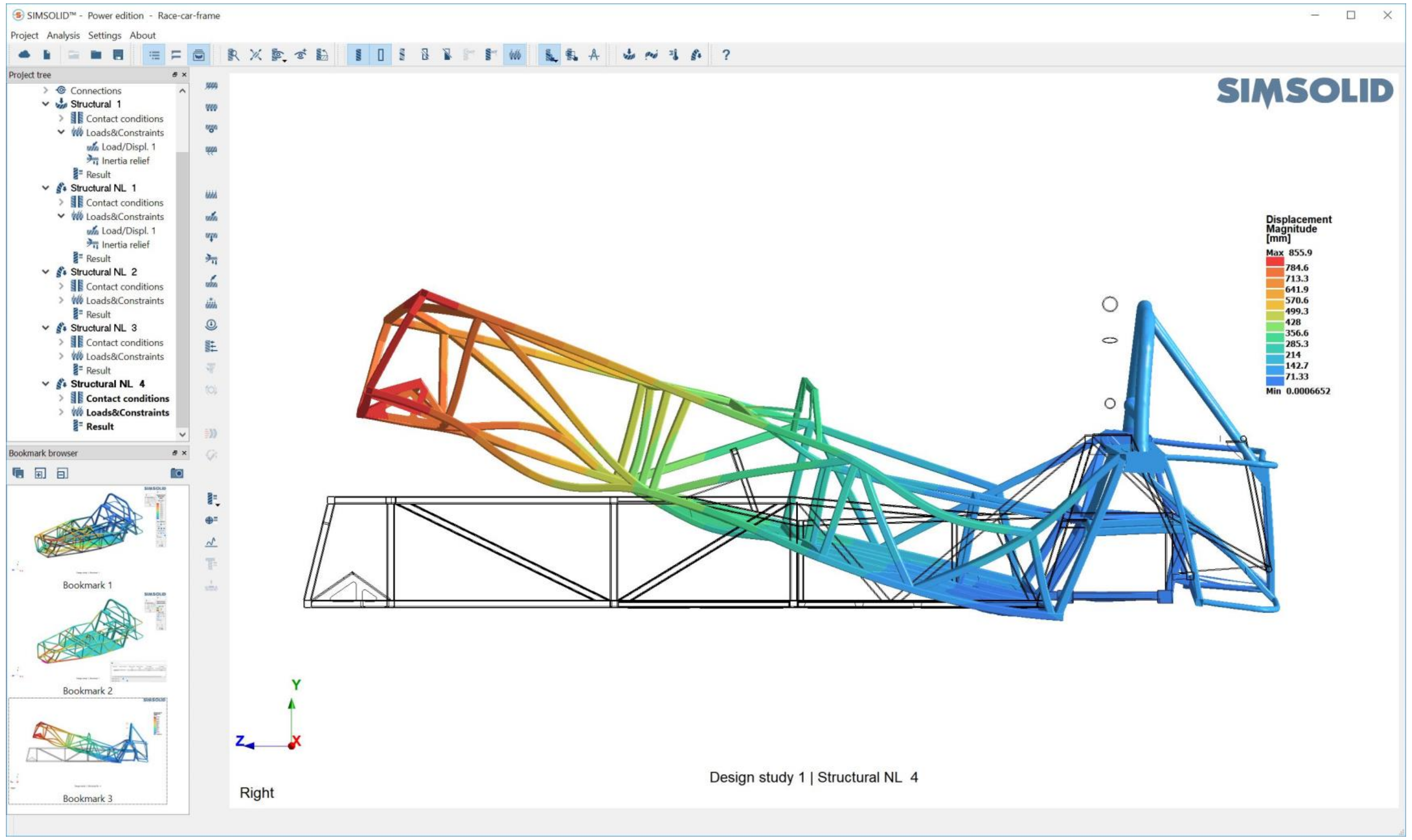
Geometric and material nonlinear analysis

Nonlinear buckling



plasticity and geometric NL





Racing car frame, 177 parts, plasticity + geometric nonlinear analysis
Shows nonlinear buckling of frame

Summary of course objectives

- Learn all about SIMSOLID, a new complementary software application for Fusion 360
- Learn about SIMSOLID unique solution methodology - how to do structural analysis without meshing
- Learn how to do large assembly design studies with evolving design geometry
- Learn how to do structural simulation of lightweight generative designed parts within the context of a large assembly

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