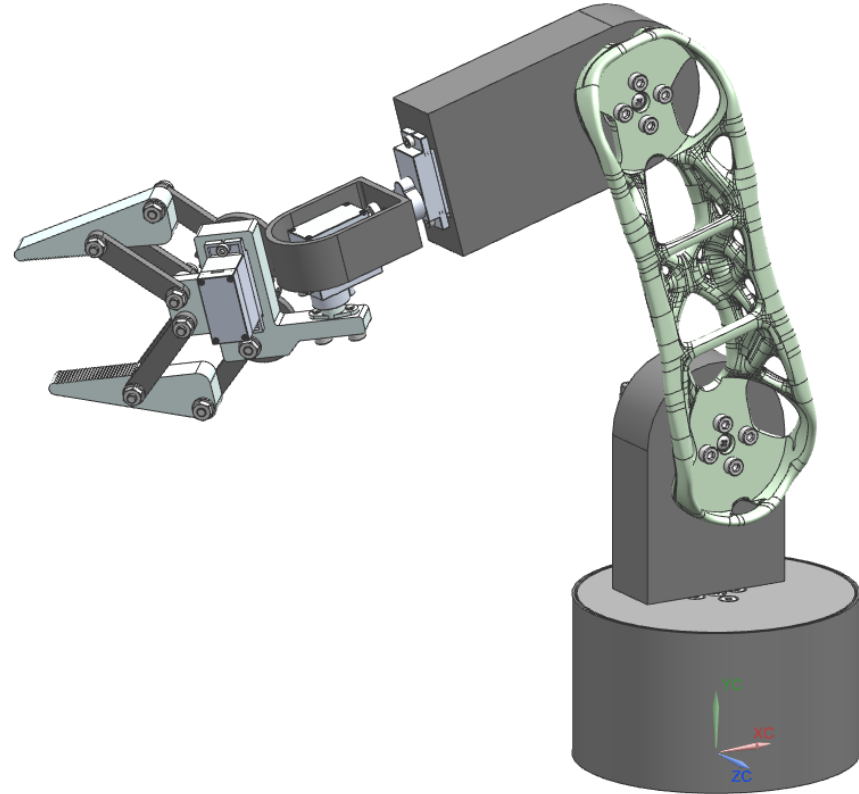


# nTopology

## Topology Optimization and CAD integration

November 2022

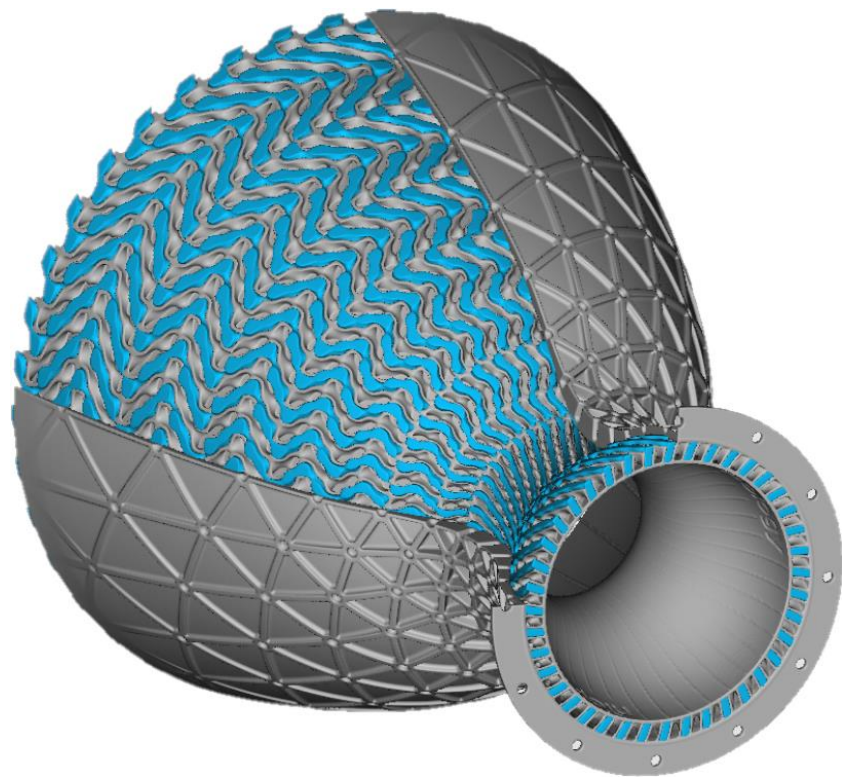
Presenting: Alejandro Carcel Lopez  
Senior Application Engineer, EMEA  
nTopology Inc.



# Agenda

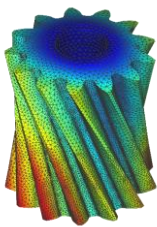
1. Intro: Implicit geometry
2. Implicit Fields and Topology Optimization
3. Topology optimization: from Implicit to CAD
4. Topology Optimization: integration into CAD

A New Approach  
to Modeling:  
***Implicit Geometry***

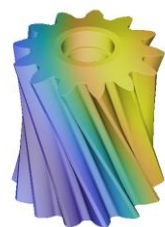




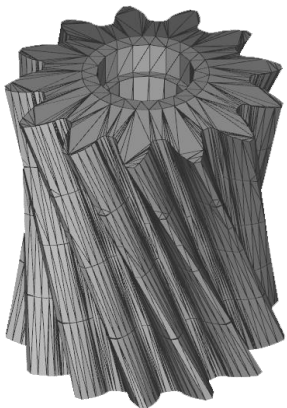
Volume Mesh



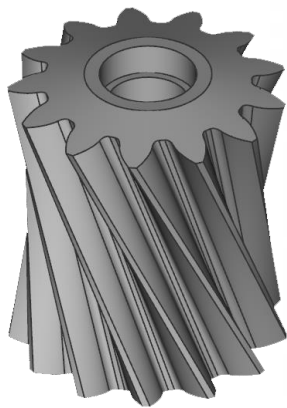
Simulation  
Result



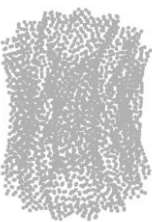
Experimental  
Data



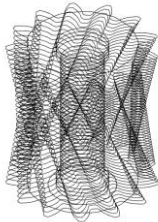
Surface Mesh



CAD Surfaces



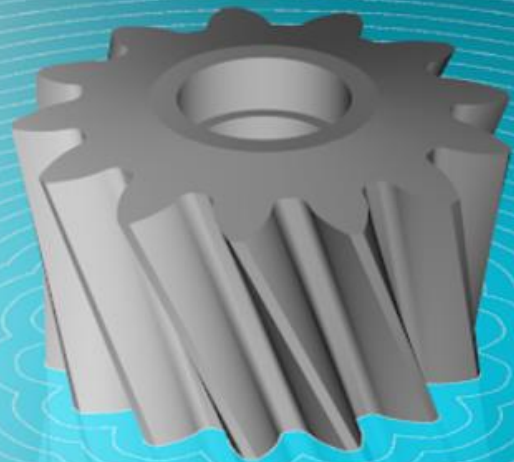
Scan Data  
(Point Cloud)



Manufacturing  
Data



Lattice  
(Beams / Shells)



Implicit Field  
(nTop Model)

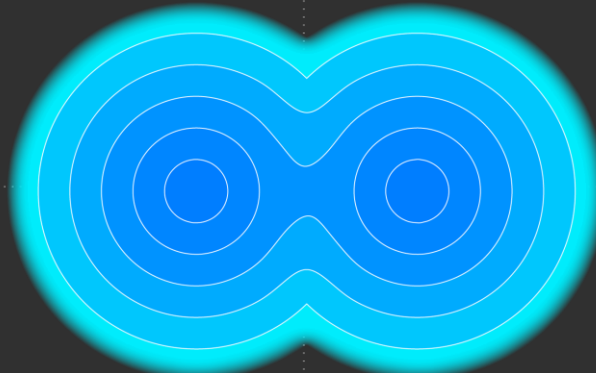
# Implicit geometry overview

One Circle (Implicit)



$$f(x, y) = \sqrt{x^2 + y^2} - r = 0$$

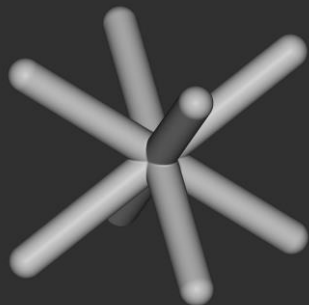
Boolean Union of two circles (Implicit)



$$f(x, y) = \min(\text{CircleA}, \text{CircleB})$$

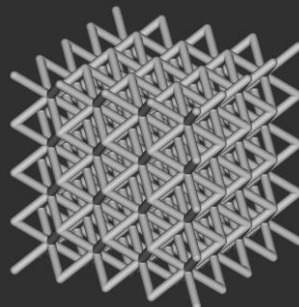
# Implicit geometry overview

Implicit



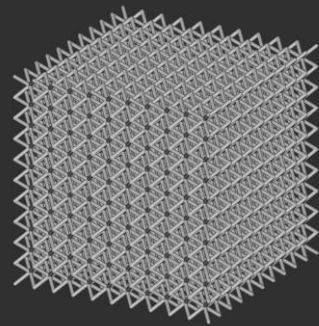
~12 kB

1 Implicit Equation



~12 kB

1 Implicit Equation



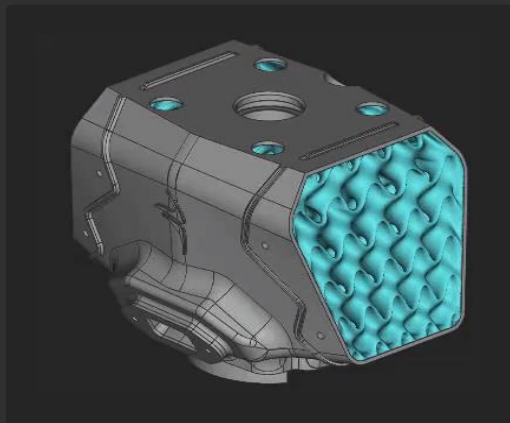
~12 kB

1 Implicit Equation

# Implicit geometry benefits

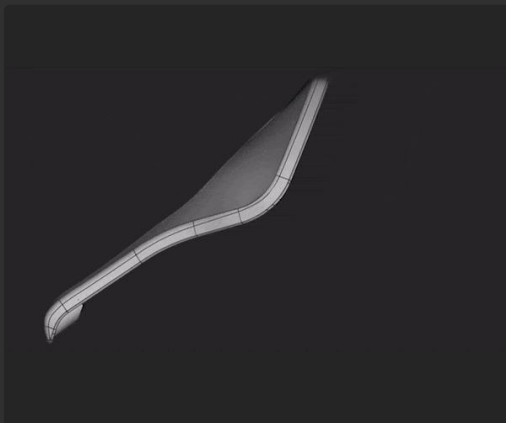
## Modeling capabilities

A fundamentally different and unbreakable modeling technology that delivers unprecedented **speed**, **scalability**, and **reliability**.



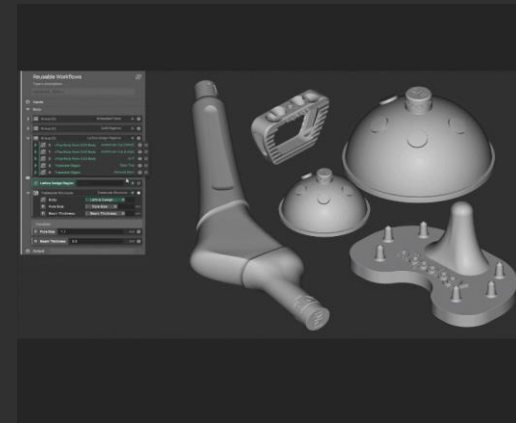
## Field-Driven Design

A new design approach that enables you to control parameters at every point directly from simulations, test data, and engineering formulas.



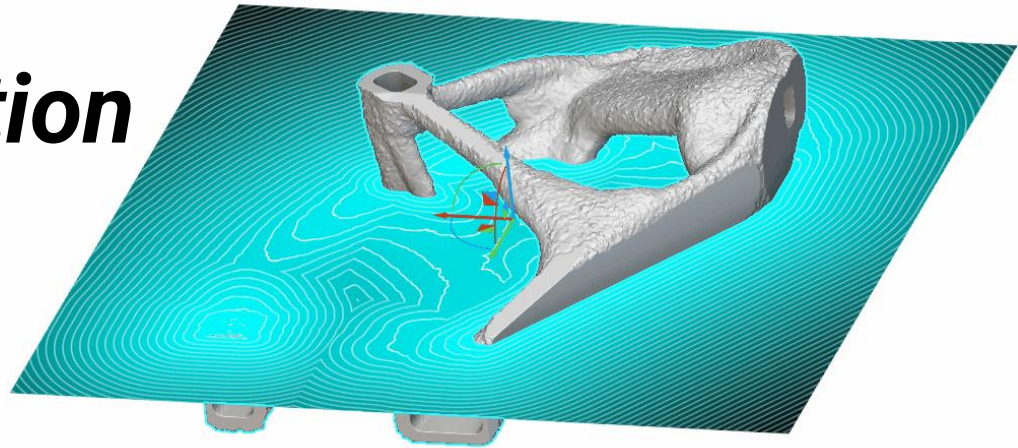
## Blocks & Codeless Automation

A block-based approach to design automation that allows you to reuse workflows, speed up design iterations, and package engineering processes.



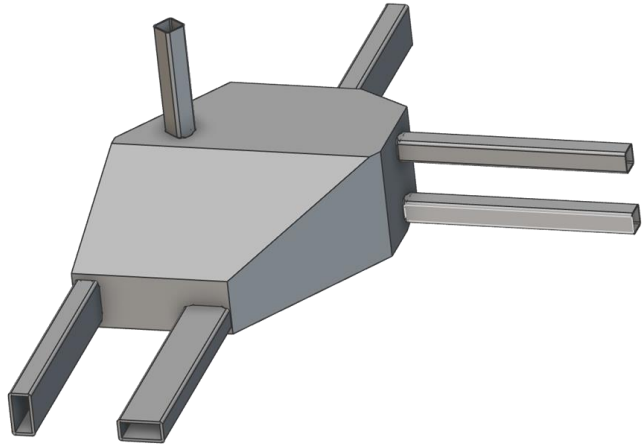


# *Implicit Fields & Topology Optimization*

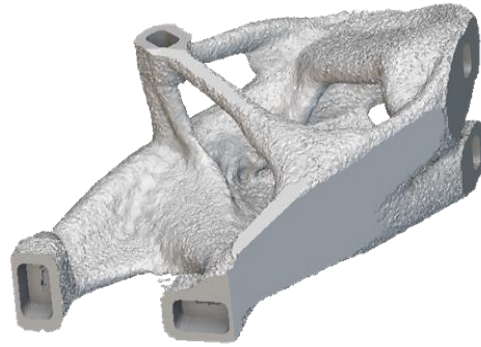




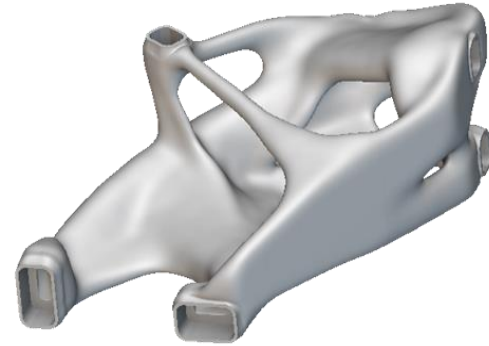
# Geometry recovery: Implicit smoothing



Design Space

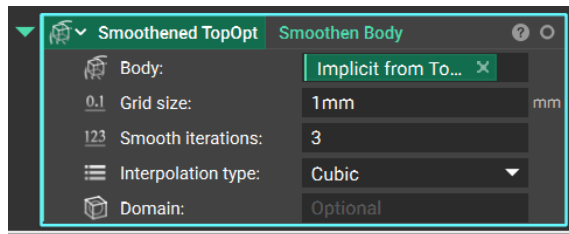


Topology Optimization Result  
(Isocontour)

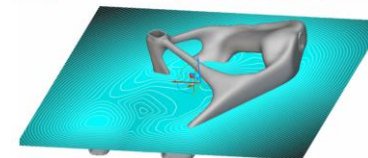
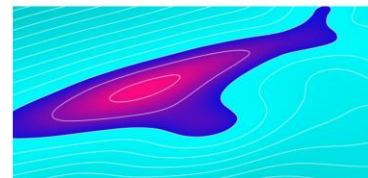
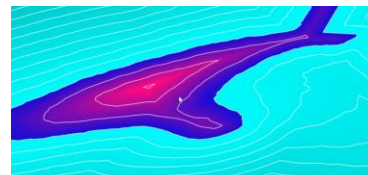
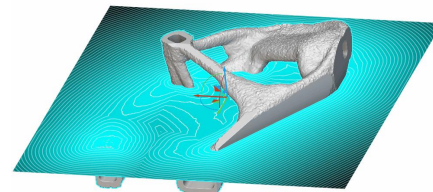


Smooth TopOpt Result

# Geometry recovery: Implicit smoothening



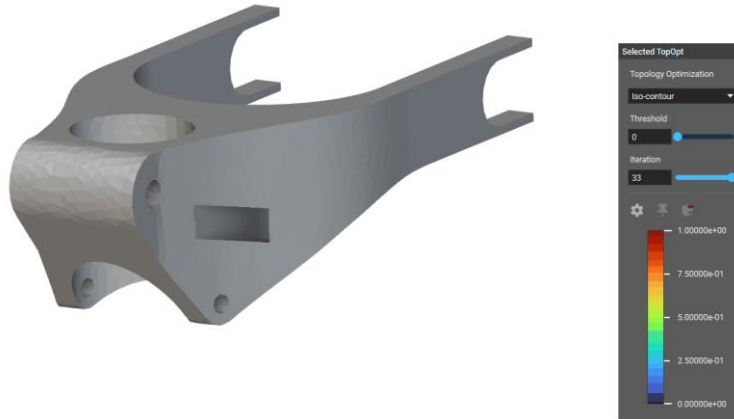
Gaussian Blur function to smooth values in the field



# Further lightweighting: field-driven design

In some cases, it is **difficult or impossible to further lightweight a component using topology optimization**

- Aggressive Volume Fraction/Density threshold leading to disconnected components

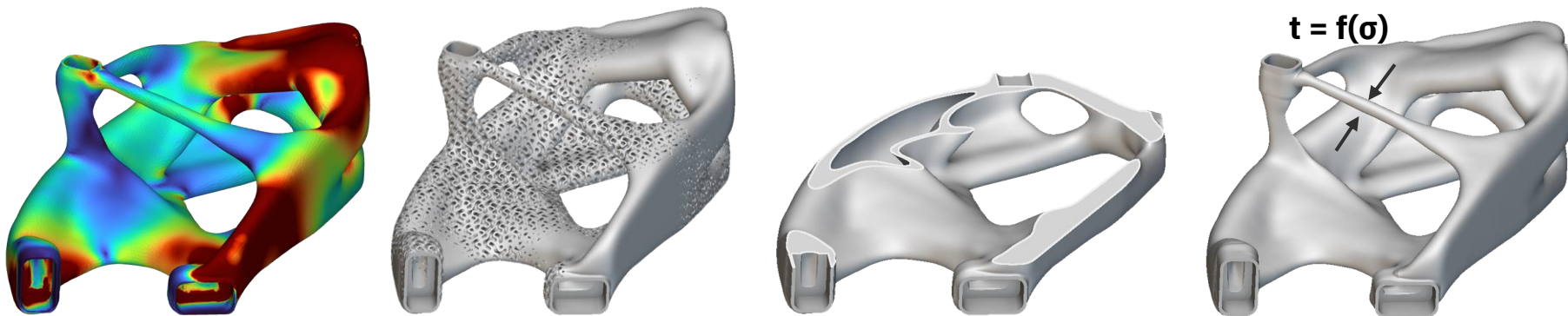


# Further lightweighting: field-driven design

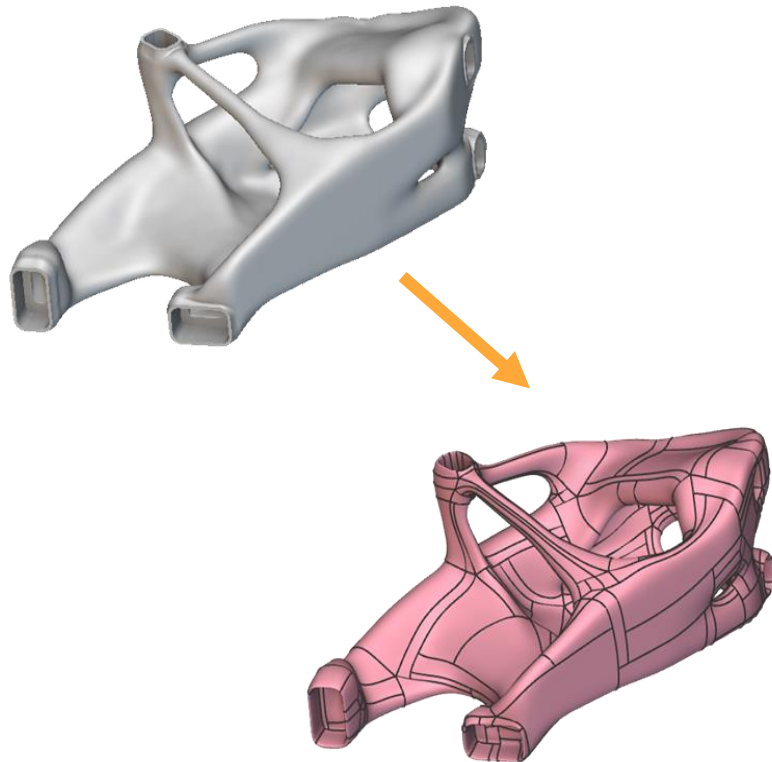
What can be done after topology optimization?

Use data to reduce weight intelligently – **only remove material where you can afford to do so**

## Field-driven design



# ***Topology optimization from Implicit to CAD***



# Exporting CAD and Mesh data

## Imported Formats

### CAD Data

CATIA (.CATPart)  
Solidworks (.sldprt)  
Creo (.prt)  
NX (.prt)  
Inventor (.ipt)

### CAE Data

Abaqus (.inp, .odb)  
ANSYS (.cdb, .rst, .rth)  
ANSYS Fluent (.msh)  
LS-DYNA (.k)  
Nastran (.bdf, .dat, .nas)  
Patran (.pat)  
Universal (.unv)

### CAD kernel/neutral

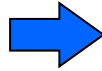
STEP (.step)  
Parasolid (.x\_t, .x\_b)  
ACIS (.sat and .sab)

### Mesh Data

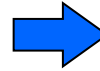
STL (.stl)  
OBJ (.obj)  
3MF mesh (.3MF)

### Other

Points/vectors (.csv)  
3MF beam lattice  
Voxels (.vdb)



nTop  
Implicit  
modeller



## Exported Formats

### CAD kernel/neutral

STEP (.step)  
Parasolid (.x\_t, .x\_b)

### Mesh Data

STL (.stl)  
OBJ (.obj)  
3MF mesh (.3MF)

### Other

Points/vectors (.csv)  
3MF beam lattice  
Voxels (.vdb)

### CAE Data

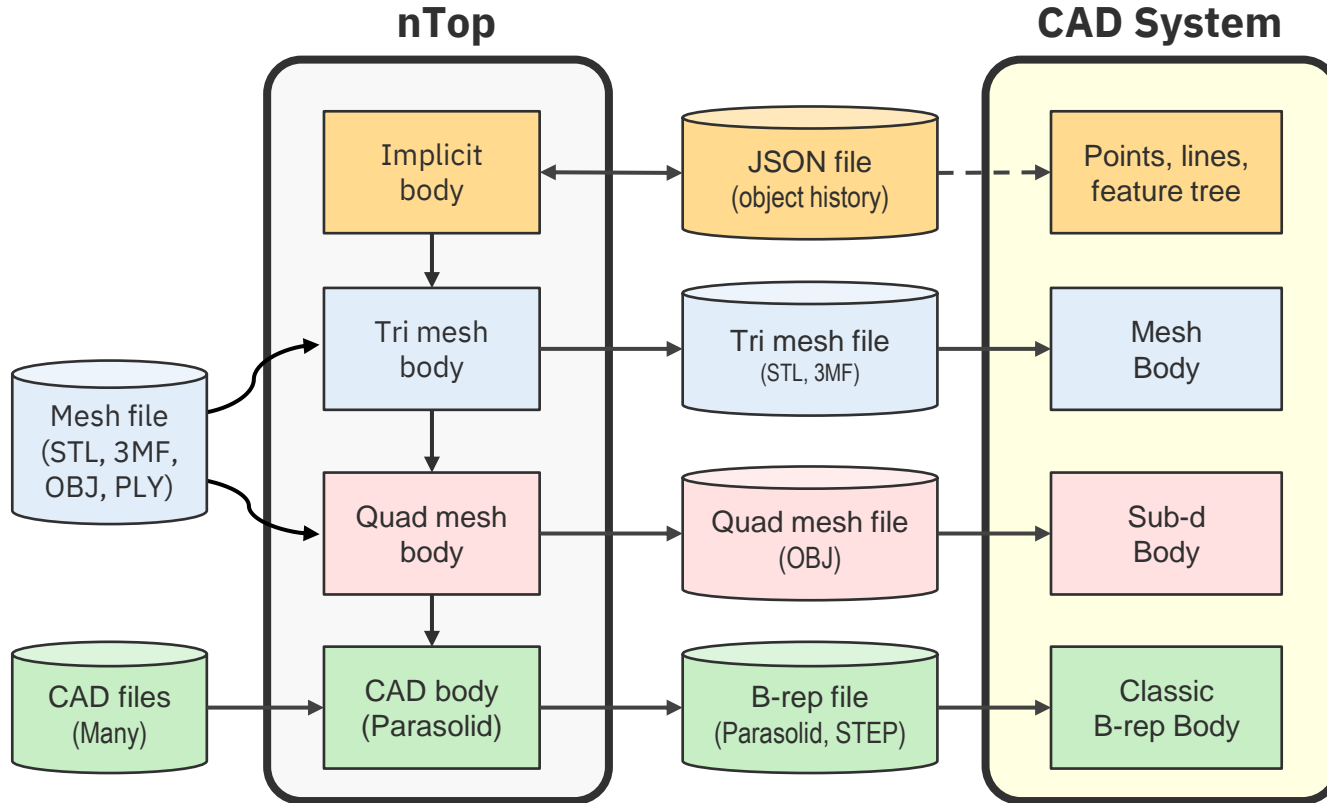
Abaqus (.inp)  
ANSYS (.cdb)  
ANSYS Fluent (.msh)  
LS-DYNA (.k)  
Nastran (.bdf)  
Patran (.pat)  
Universal (.unv)

### Slice Data

Common Layer I/F (.cli)  
Common Layer File (.clf)  
Renishaw Points (.csv)  
Arcam ABF (.abf)  
Stratasys Layer (.ssl)



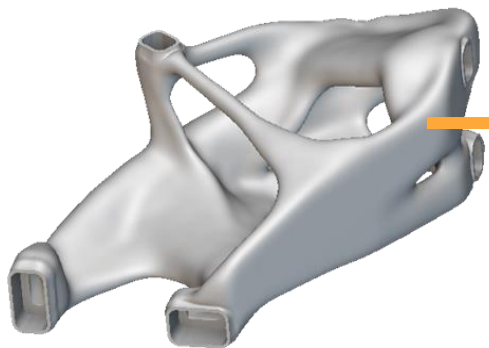
# Import/Export paths



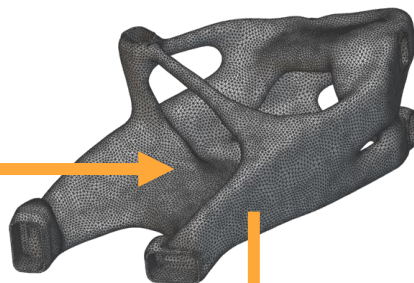
## Applications

- Simple pt-to-pt CAM
- History-based editing
- Archiving
  
- Digital mockup
- Visualization
- CAE
- Some modeling
  
- Modeling
- Assemblies
- Drafting
- Complex CAM
- Archiving

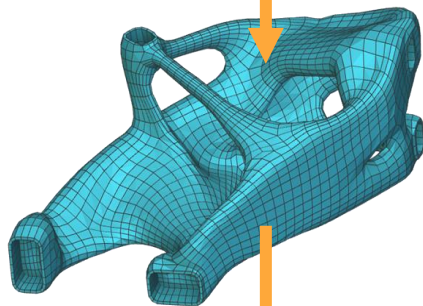
# Automotive bracket example



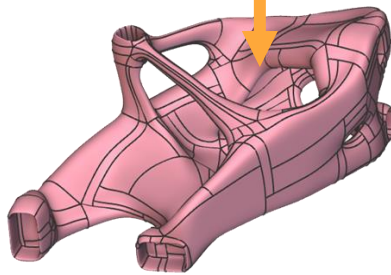
Smooth TopOpt Result (Implicit)



Tri-mesh (STL, 3MF)



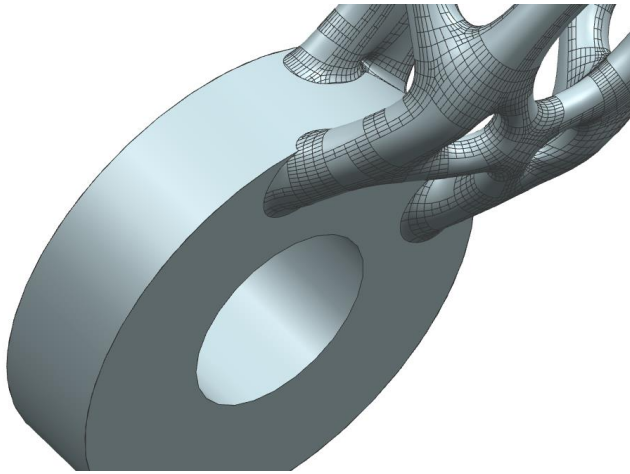
Sub-d (OBJ)



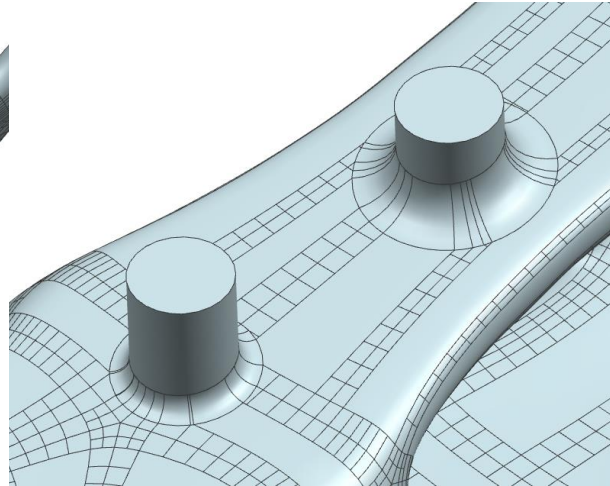
Smooth B-Rep (STEP, Parasolid)

# Usability of models

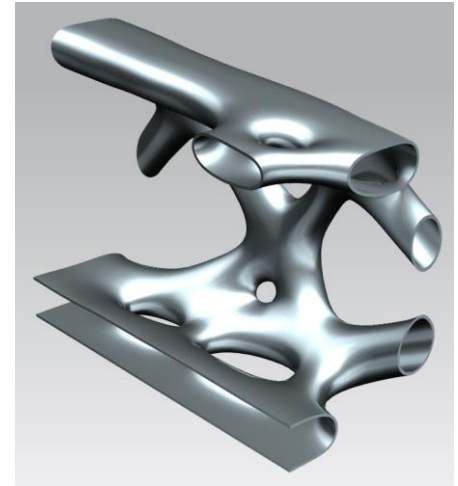
Models generated in nTop are usable in downstream CAD operations



Boolean operations



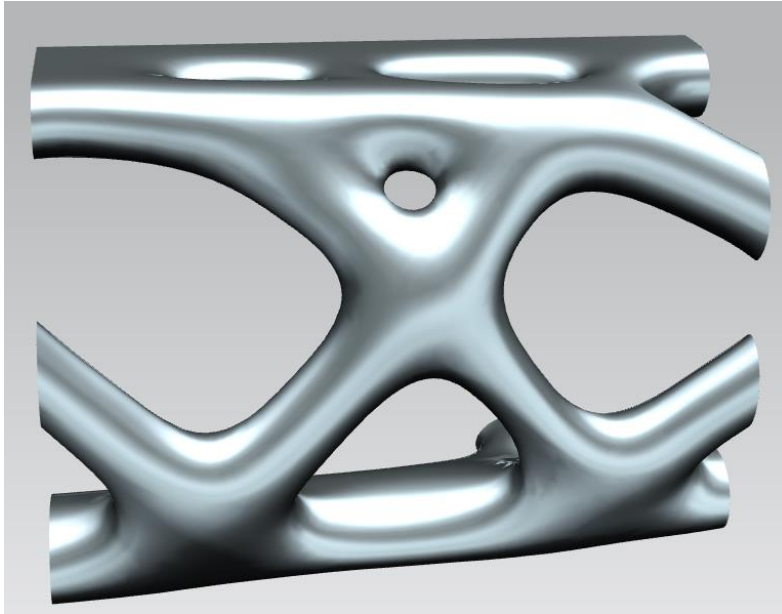
Booleans & blending



Shelling

# Surface quality

Organic regions of models are high quality smooth surfaces (C2)



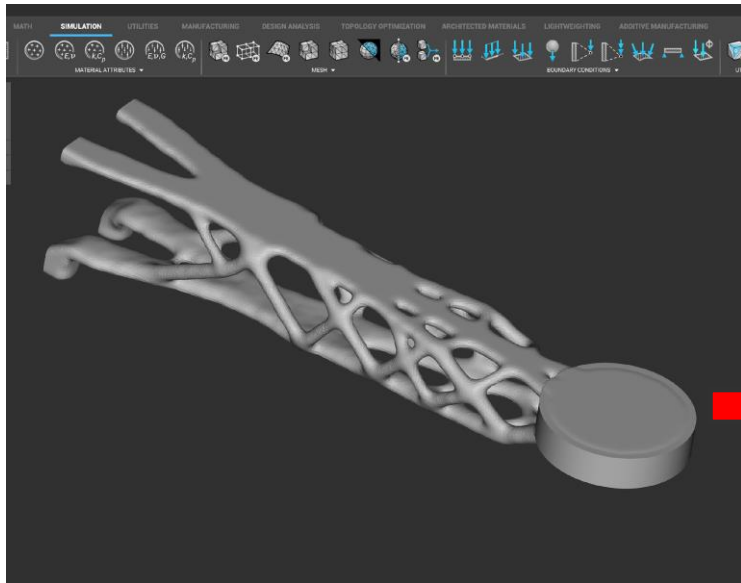
Shaded image



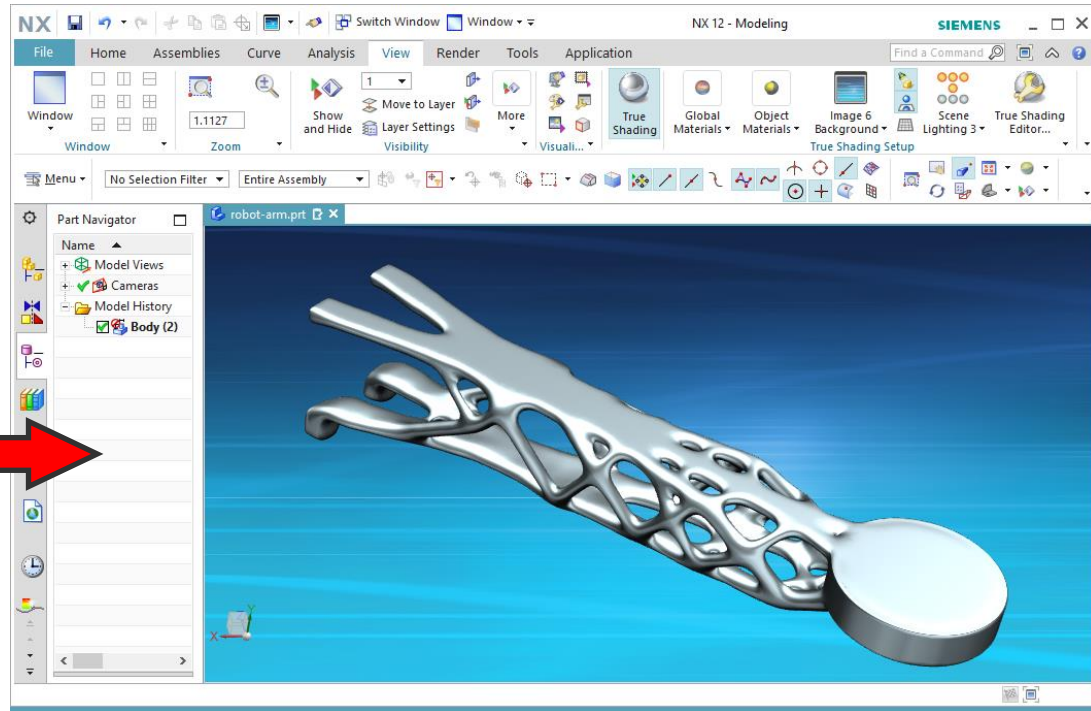
Reflection lines

# nTop to Parasolid (XT) to NX

Implicit body in nTop

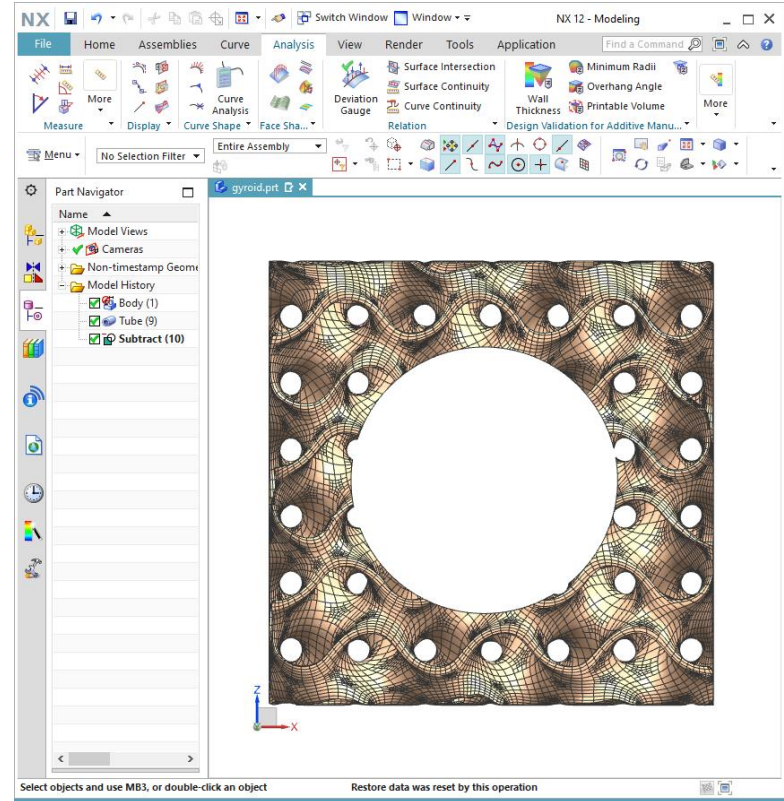
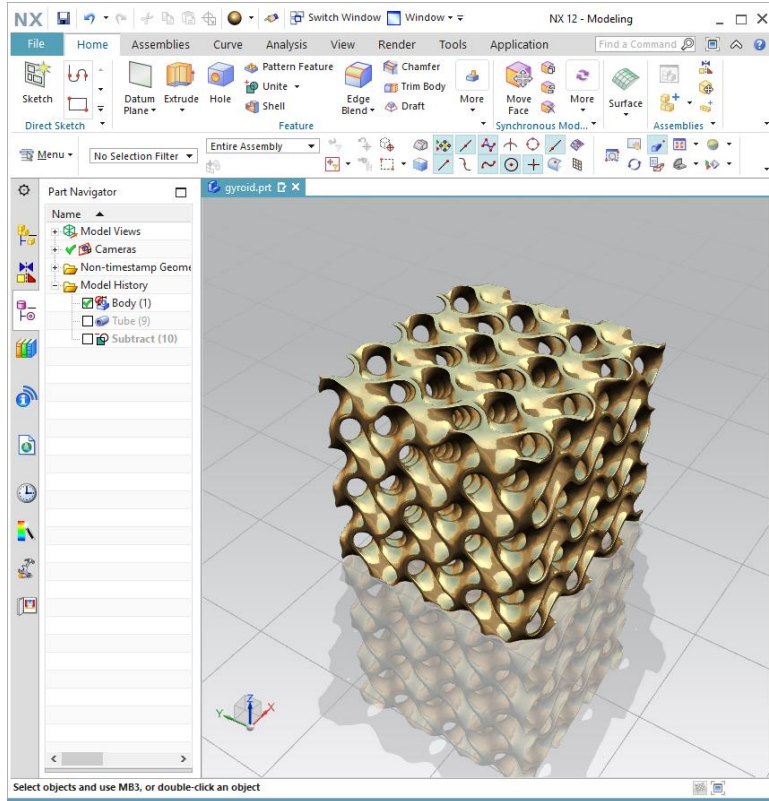


Standard (classic) solid body in NX





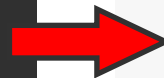
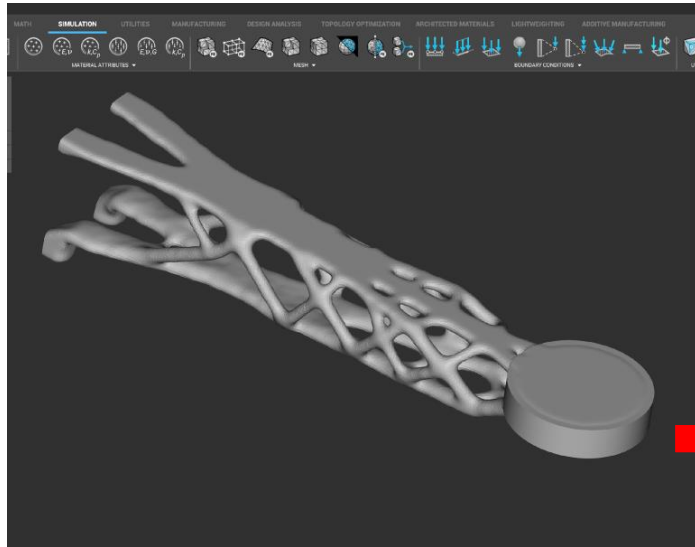
# nTop Gyroid exported to NX



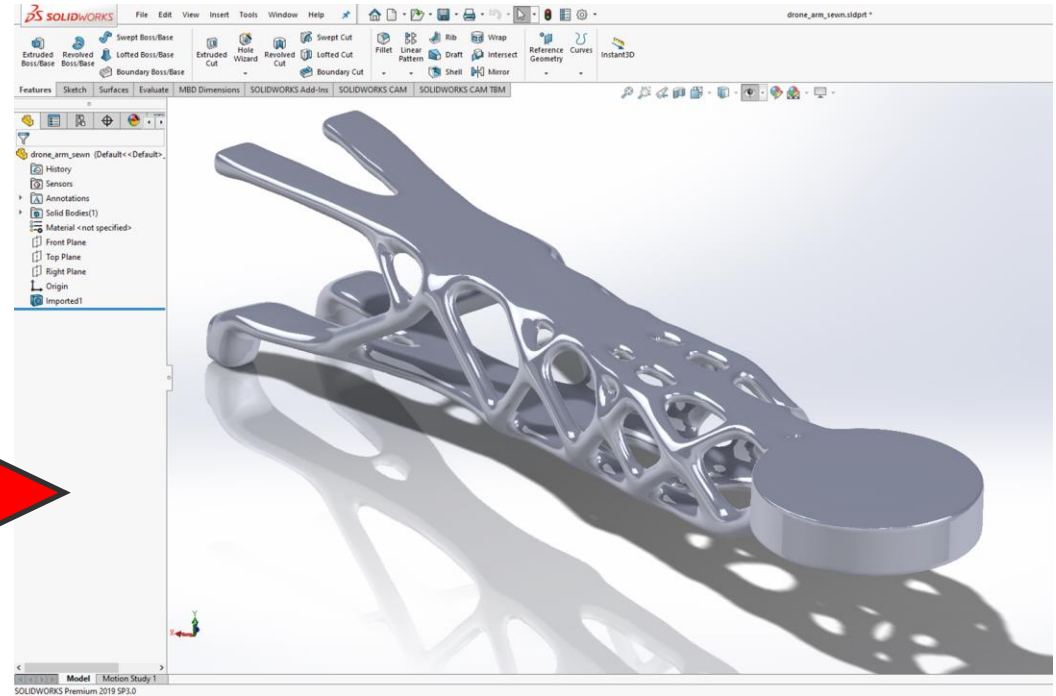


# nTop to Parasolid (XT) to Solidworks

Implicit body in nTop



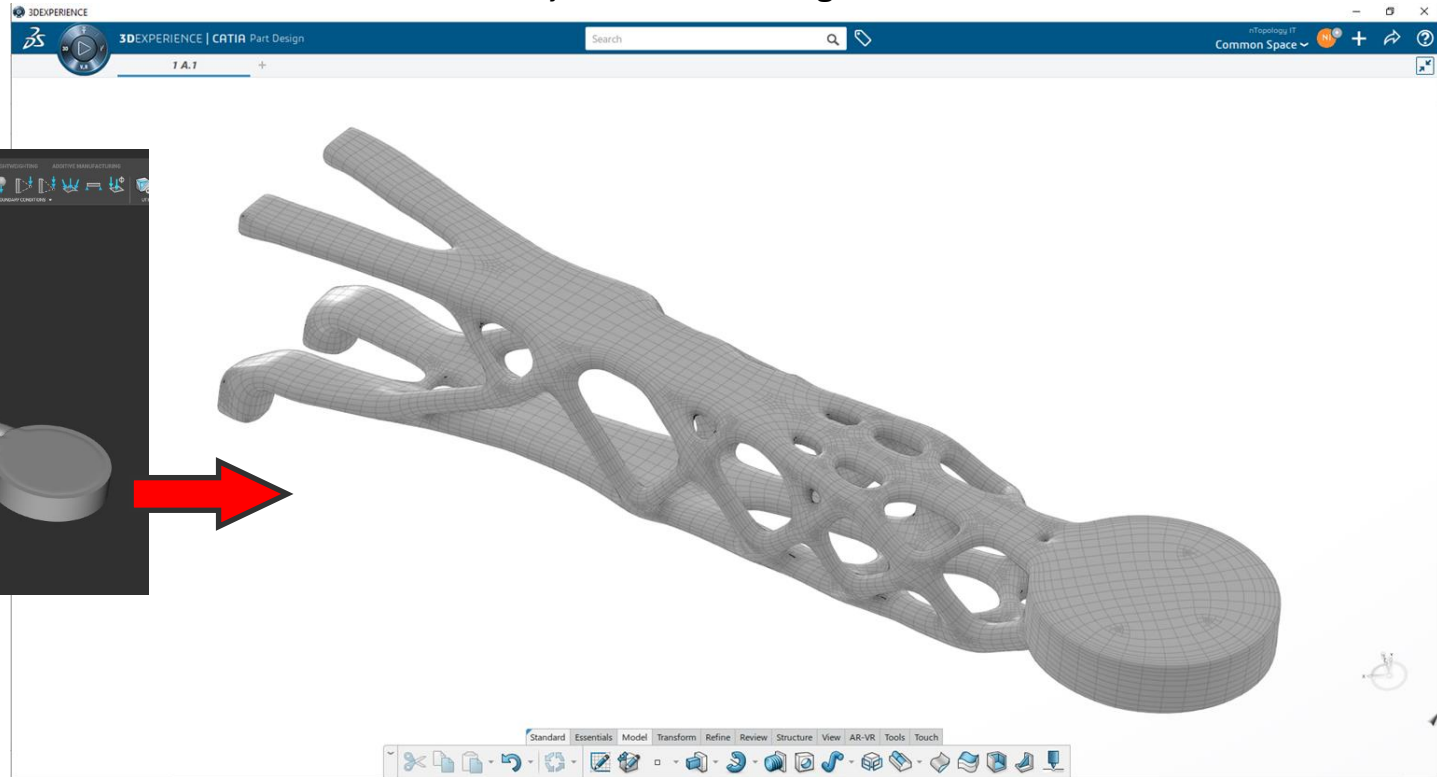
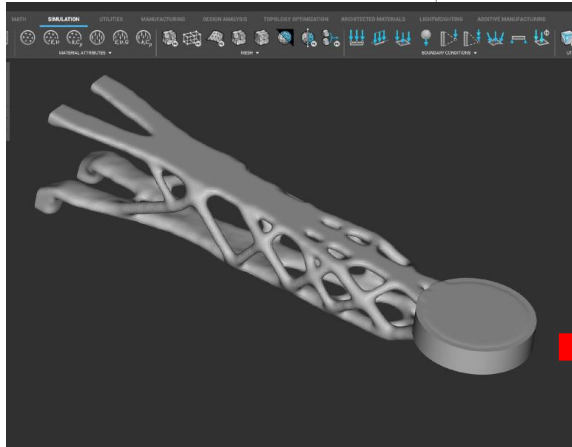
Solid body in SolidWorks



# nTop to STEP to CATIA

Solid body in Catia Part Design

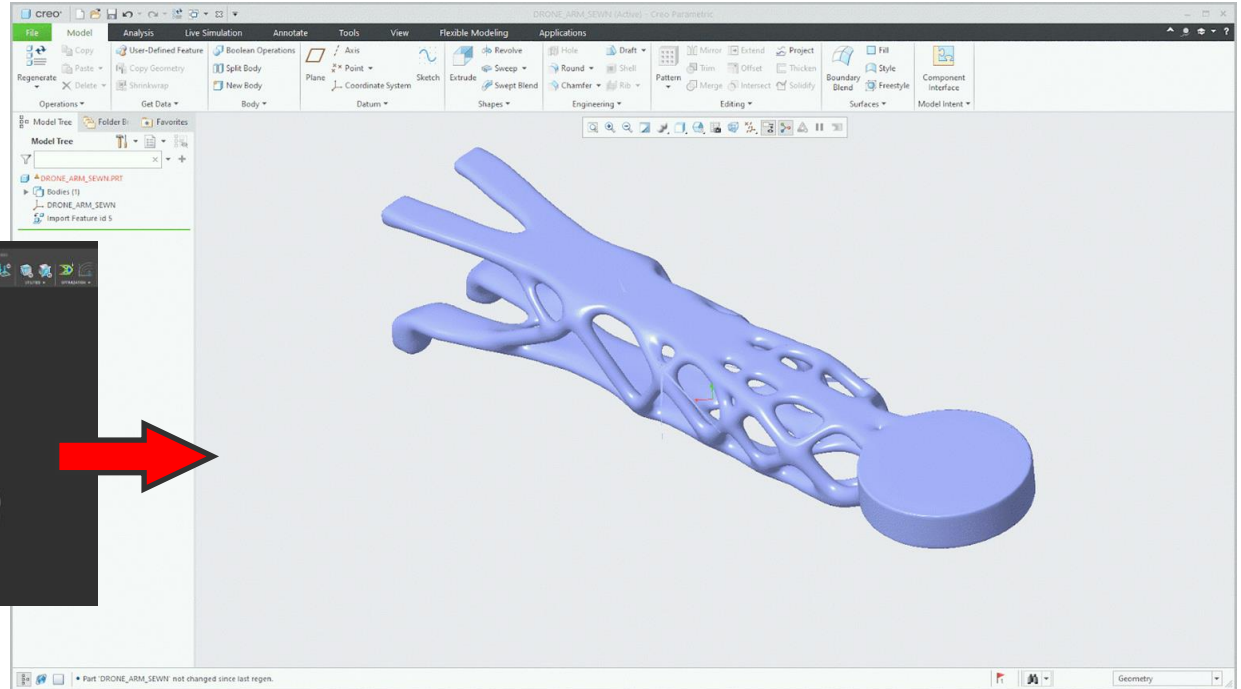
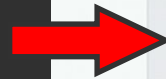
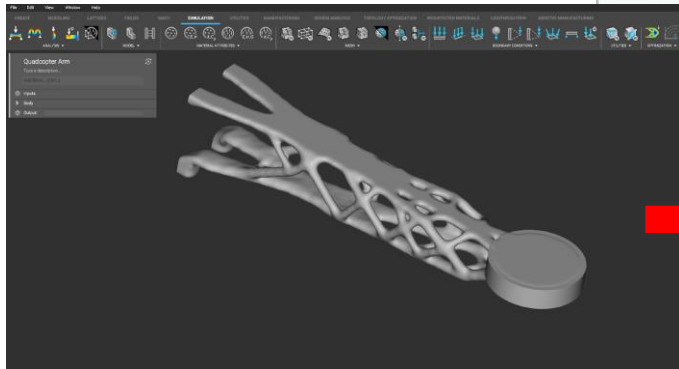
Implicit body in nTop



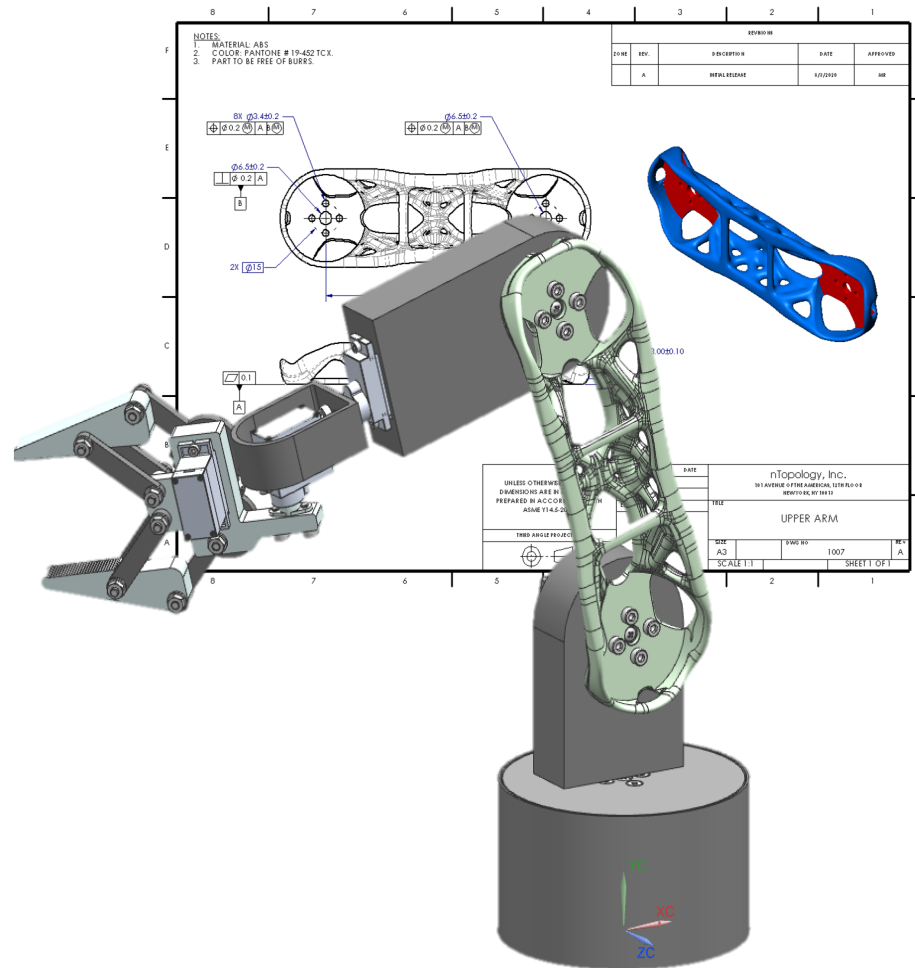
# nTop to STEP to CREO

## Solid body in Creo

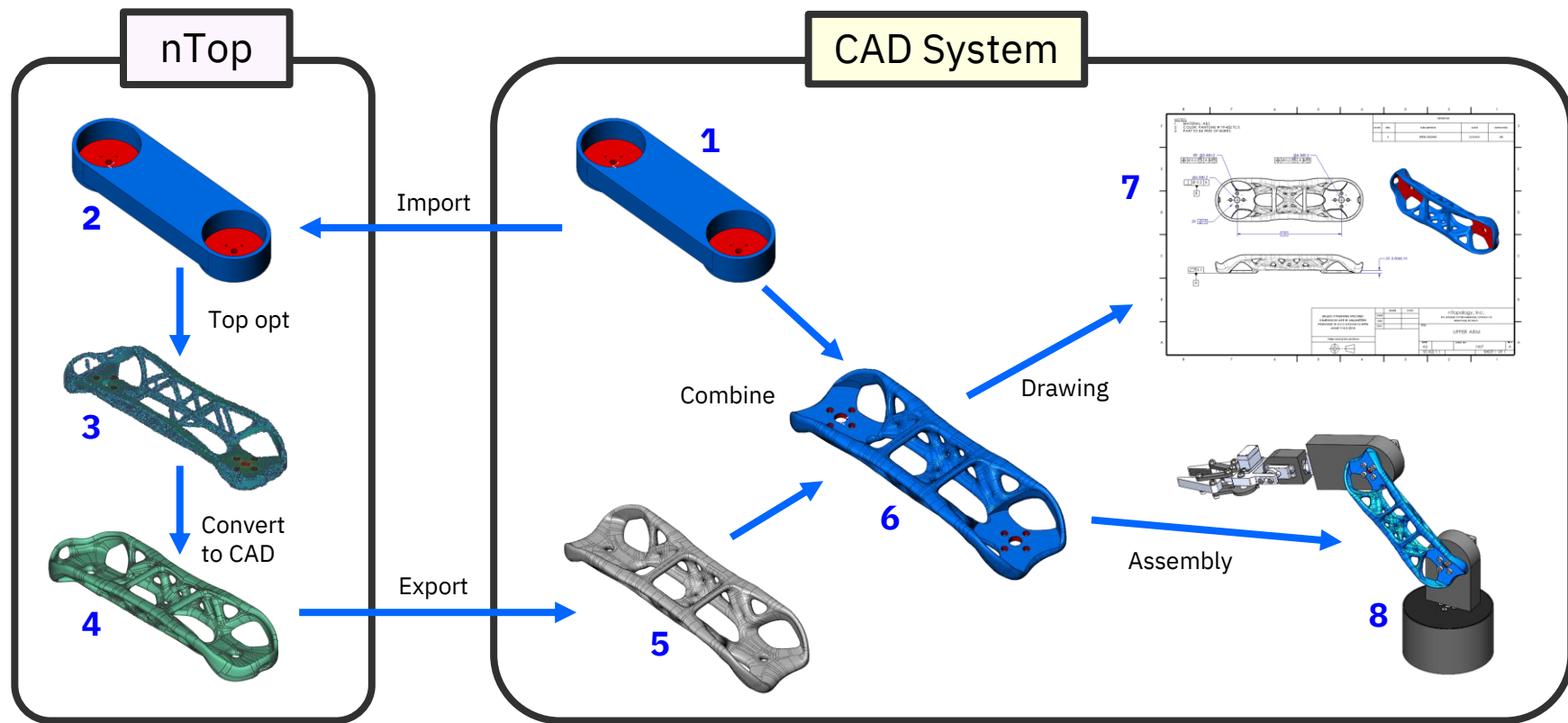
### Implicit body in nTop



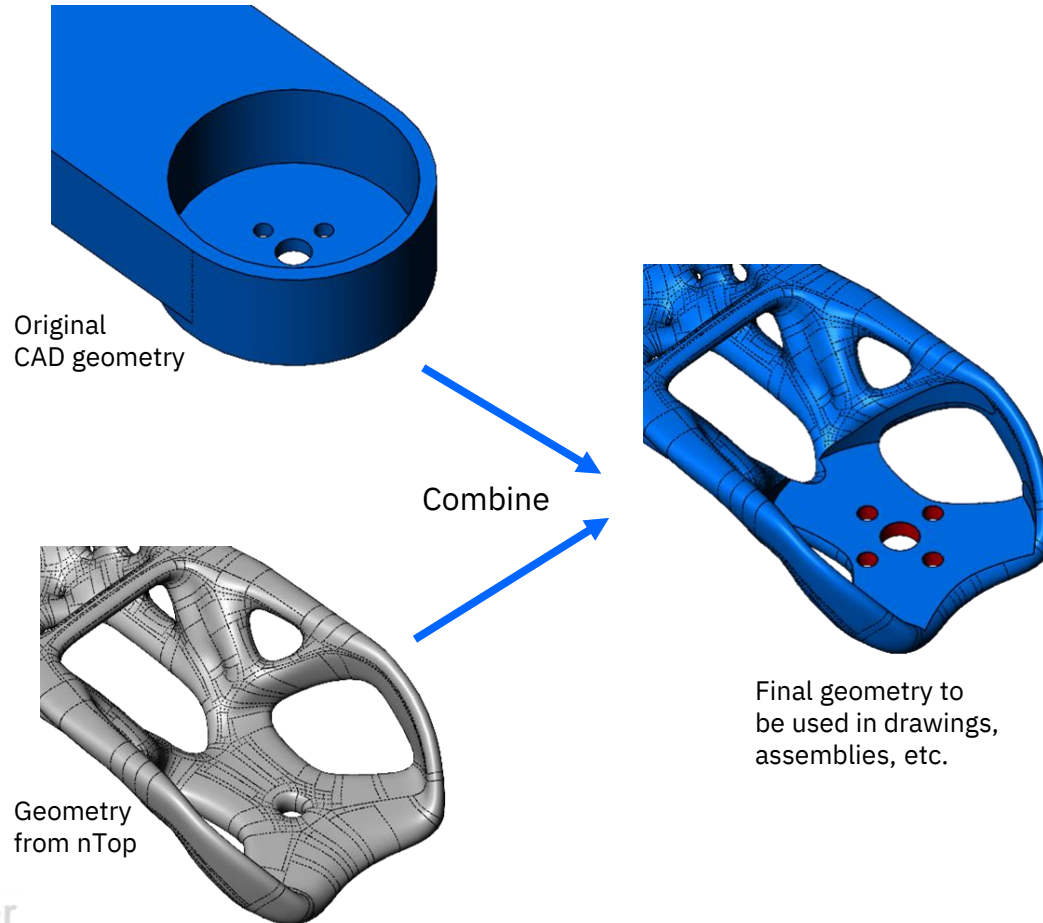
# TopOpt integration into CAD systems



# Using an nTop Model in CAD Applications



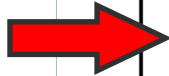
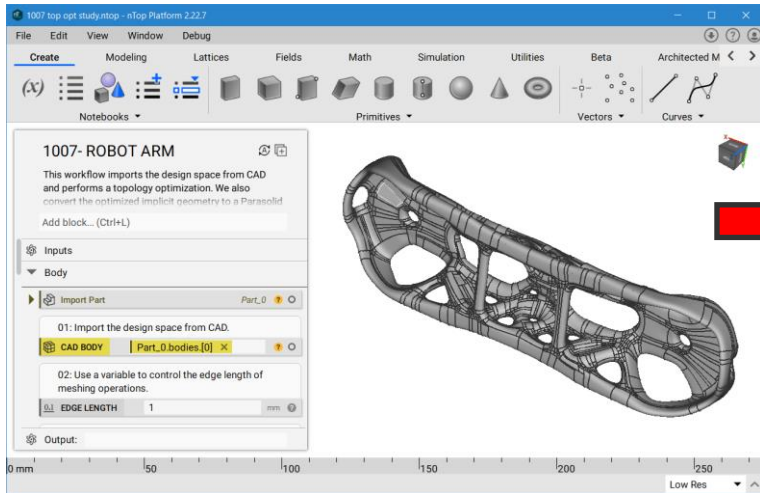
# The “Combine” Step



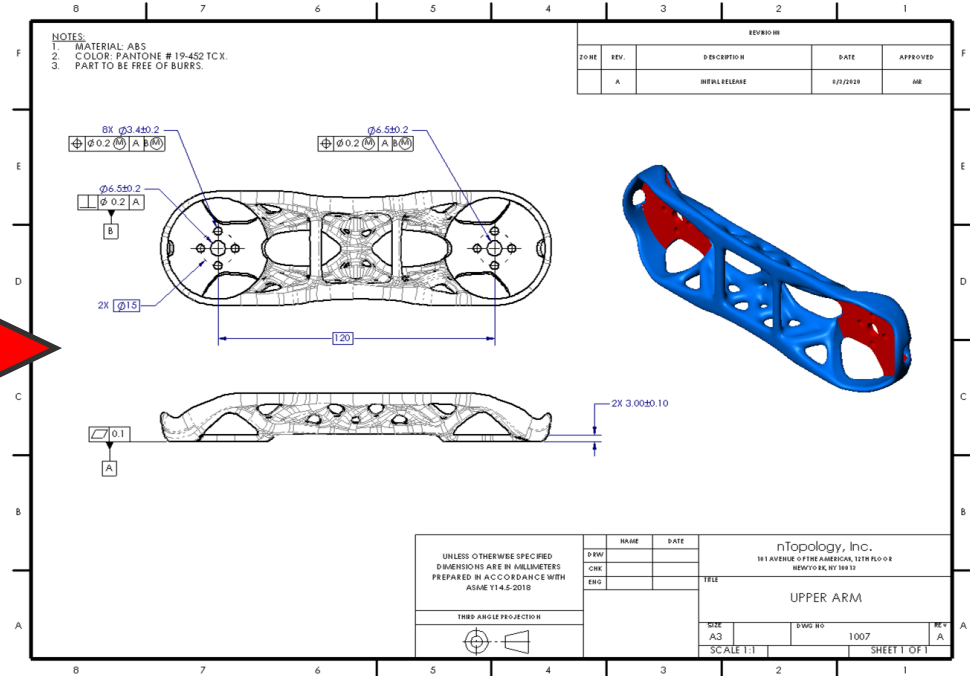


# Creating Drawings

## Model in nTop

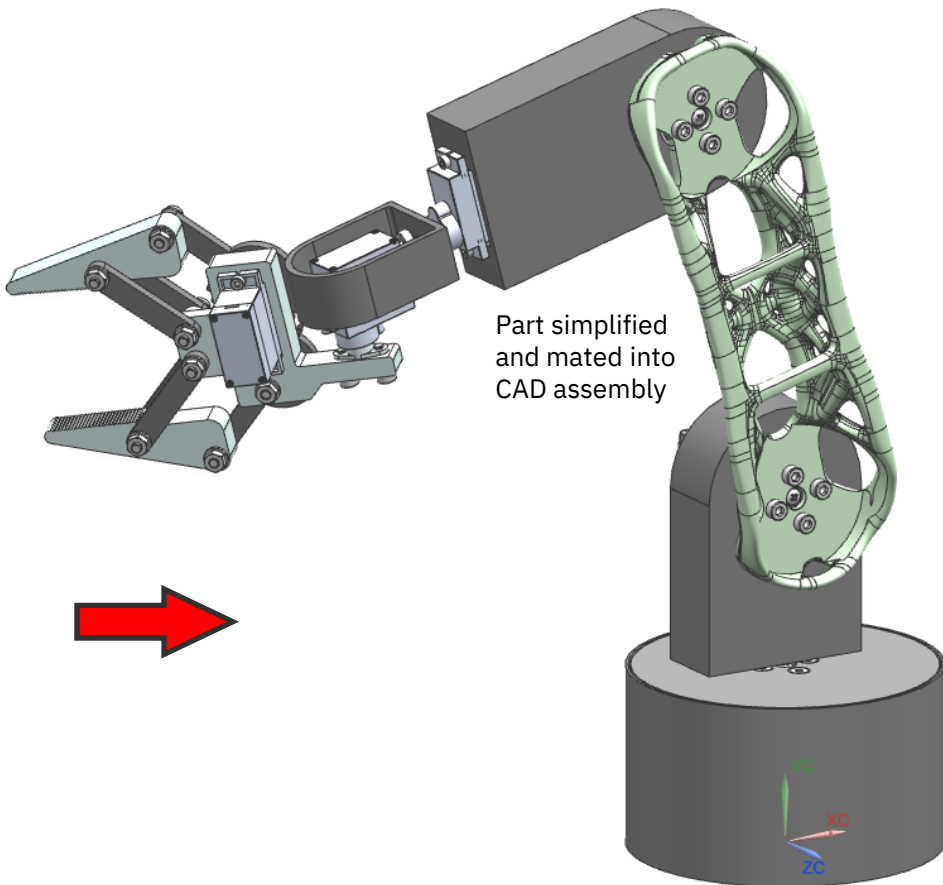
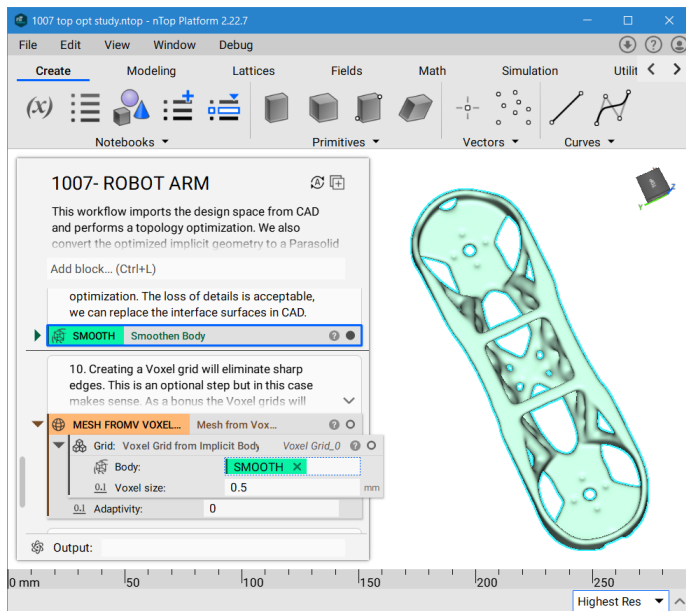


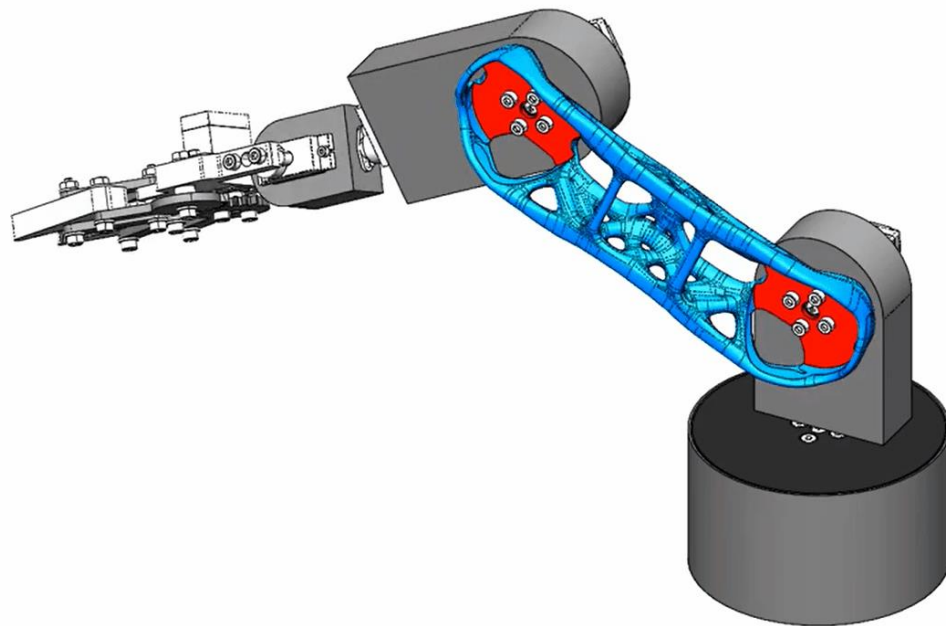
## Drawing (SolidWorks)



# Creating Assemblies

Part model in nTop





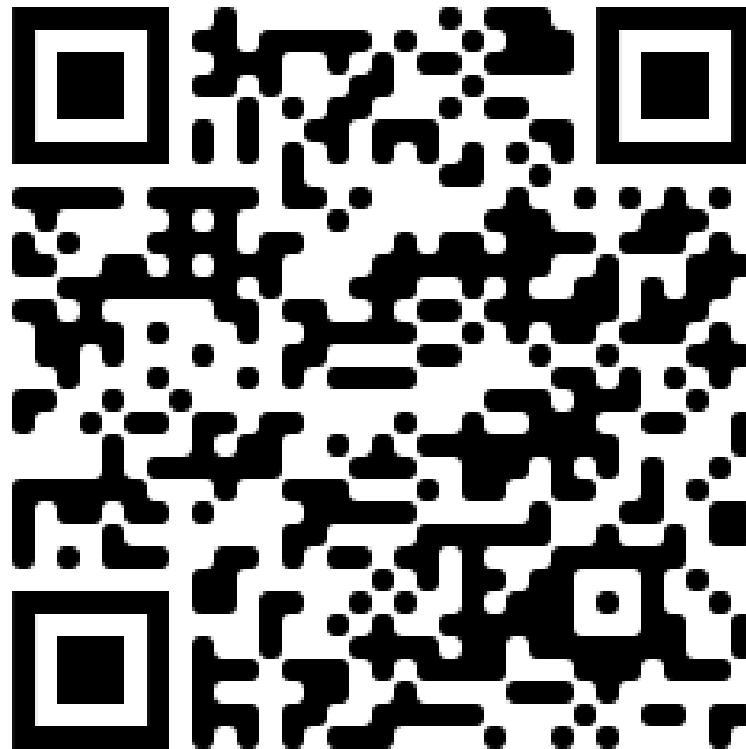
# Summary

- Implicit geometry offers valuable benefits:
  - Lightweight, robust format for complex geometry and boolean operations
  - Topology optimization smoothing (Gauss filter) – fast and automated
  - Further lightweighting capabilities: field-driven design
- Conversion from Implicit to CAD readable formats is possible:
  - Tri mesh (STL, 3MF, OBJ, PLY)
  - Sub-d body (OBJ)
  - B-Rep (STEP, PARASOLID)
- CAD exported from nTop:
  - passes model and Surface quality checks
  - can be re-modified in CAD (e.g. to get analytical interfaces)
  - can be integrated in an assembly and used to produce e.g. GD&T drawings

# Let's connect!

By scanning the QR code you'll find:

- My contact information
- This presentation
- More information about nTop – Whitepapers, use cases, etc.



Thank you!  
Any questions?