

# SIMULATION AND ANALYSIS

Jose Coronado and Andrew McGough  
CAD Product Management

November 2016



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**PTC Forum Europe**  
Stuttgart, Germany

# AGENDA

1. PTC Mathcad
2. Creo Simulate

# SIMULATION AND ANALYSIS: PTC MATHCAD PRIME 4.0

Andrew McGough  
Product Manager

November 2016



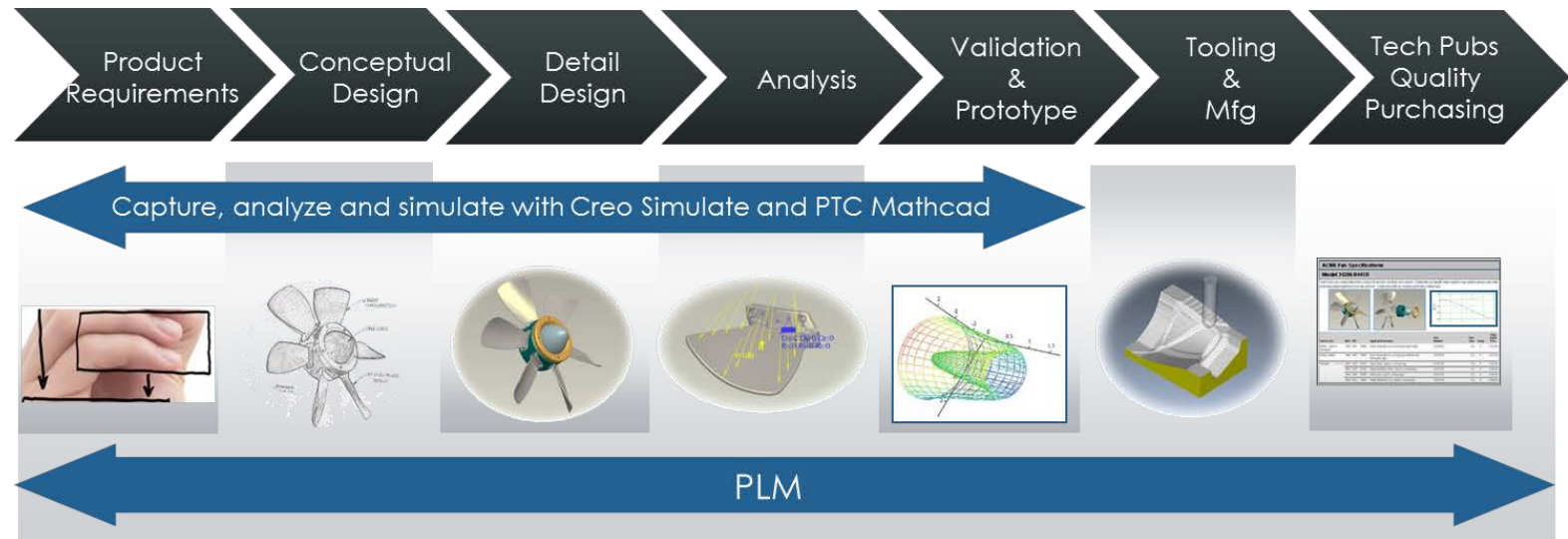
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**PTC Forum Europe**  
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Creo and PTC Mathcad offer a seamless integration of simulation, analysis and modeling.

- With Creo simulate designers are empowered to easily analyze parts and assemblies, and optimize designs.

## ENGINEERING KNOWLEDGE



- PTC Mathcad combines the ease and familiarity of an engineering notebook with the powerful features of a dedicated engineering calculations application.

# AGENDA

1. What is PTC Mathcad?
2. PTC Mathcad Prime 4.0
3. Creo Engineering Notebook

# AGENDA

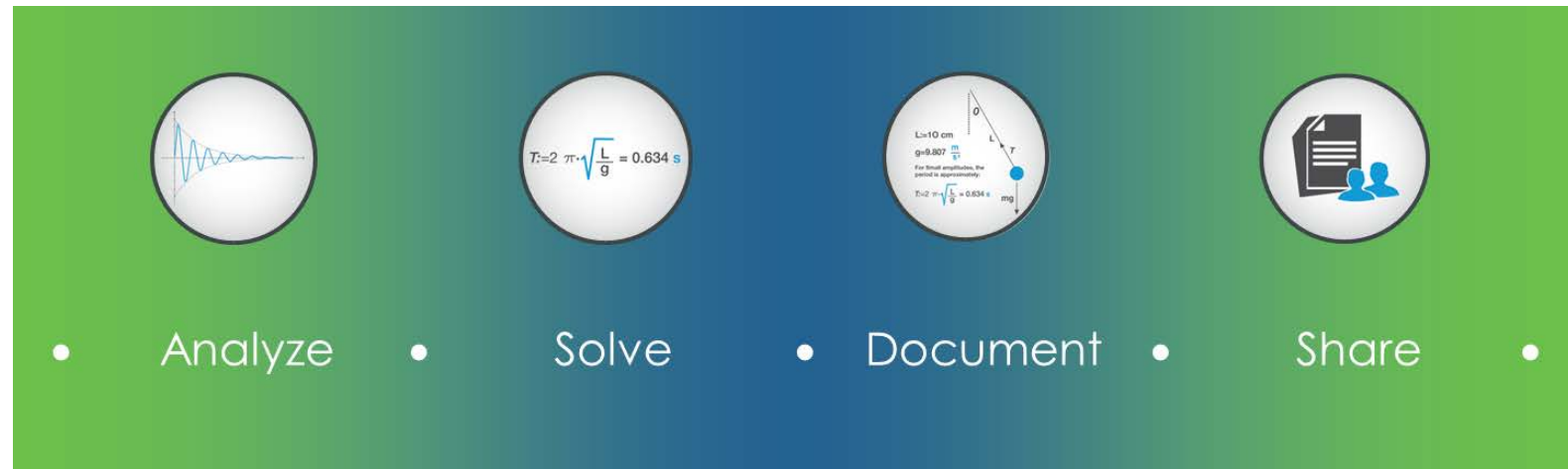
- 1. What is PTC Mathcad?**
2. PTC Mathcad Prime 4.0
3. Creo Engineering Notebook

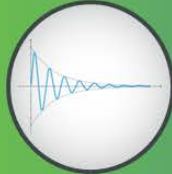
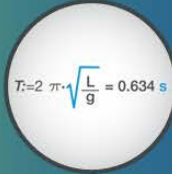
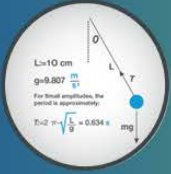

# ENGINEERING CALCULATIONS: TYPICAL ISSUES



A **digital engineering notebook** to perform your engineering **calculations** and manage your **design intent**

# PTC MATHCAD



-   
 • Analyze •
-   
 • Solve •
-   
 • Document •
-   
 • Share •

PTC Mathcad combines the ease and familiarity of an **engineering notebook** with a powerful **mathematical engine**



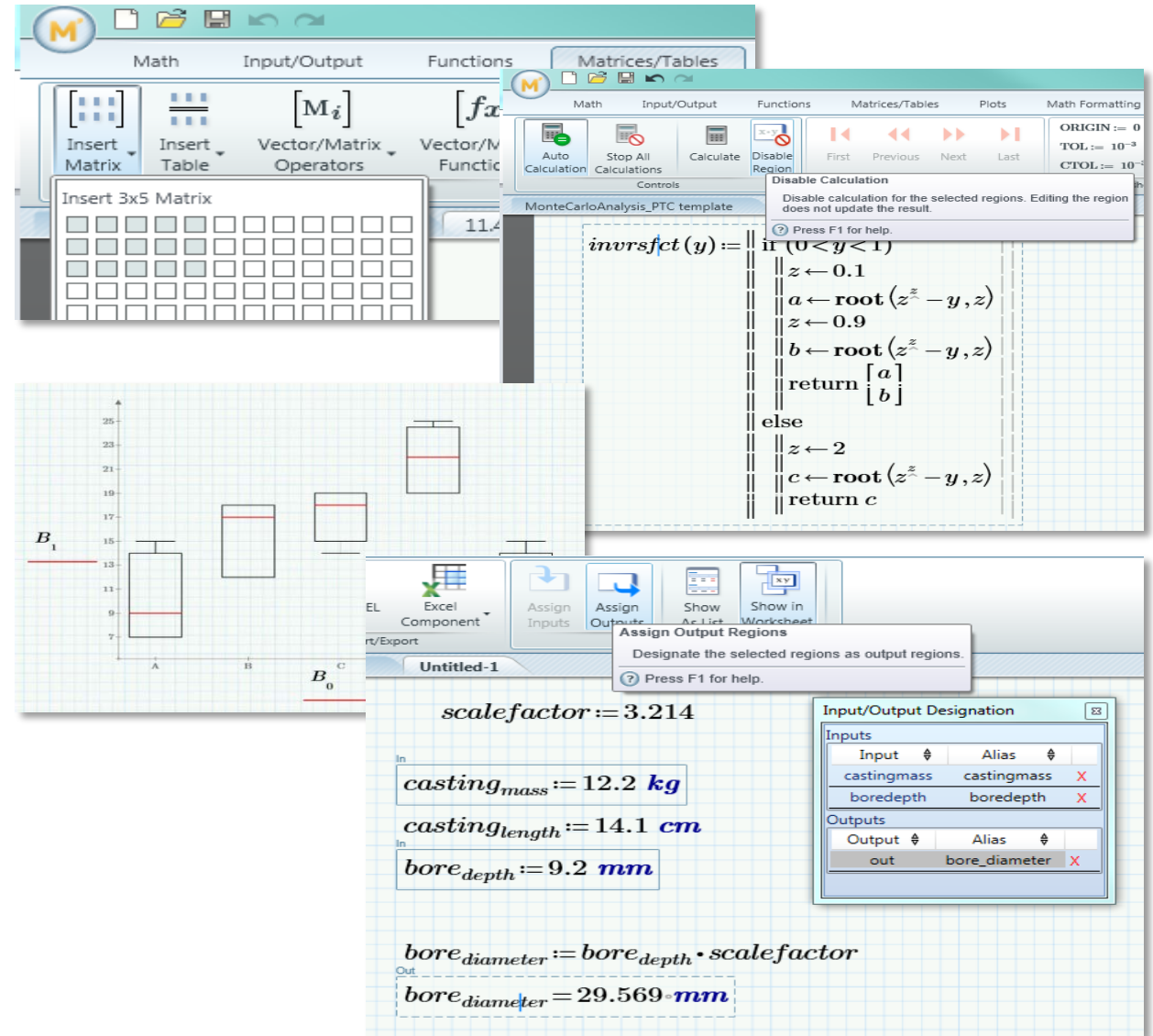
- Document-oriented approach
  - Multi-document, task-oriented UI
  - WYSIWYG document editing
  - Page/draft (whiteboard) modes
  - Document formatting and control
- Visual presentation features
  - Fully formatted text and images
  - Full control over Math formatting
  - 2D, 3D, polar, and contour plots
  - Collapsible Areas
- Powerful math engine
  - Numeric and Symbolic calculation
  - Rich function library
  - Comprehensive support for units

The screenshot displays several key features of PTC MathCAD:

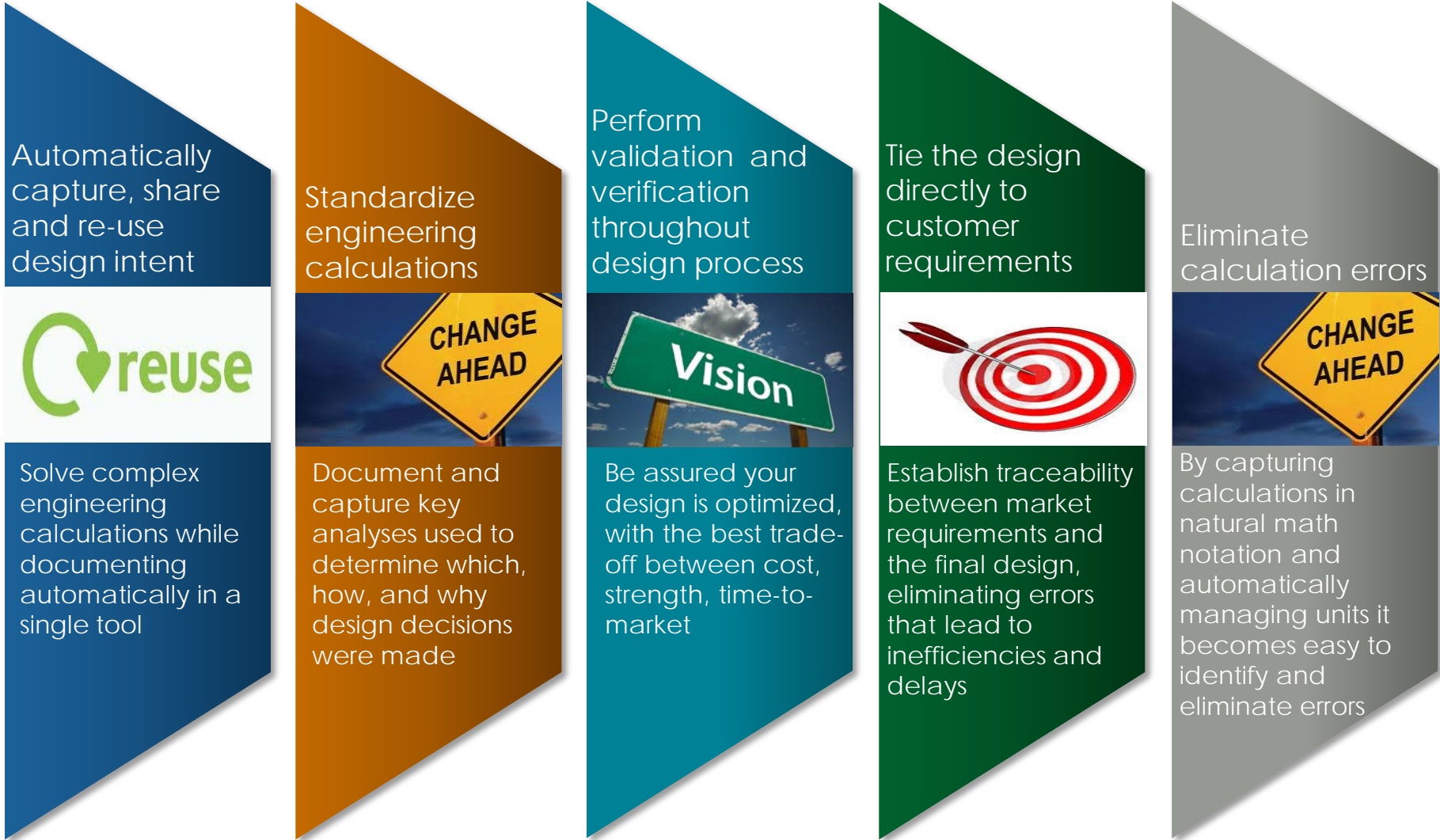
- Polar Plot:** A plot of a closed curve on a polar coordinate system with angles from 0 to 330 degrees and radii from 0 to 1.6.
- Contour Plot:** A 2D contour plot of the function  $contour(x, y) := \cos\left(\frac{x}{4}\right) + \sin\left(\frac{y}{4}\right)$ . The plot shows concentric contour lines with a color scale from blue (low values) to red (high values).
- Function Definition:** The equation  $contour(x, y) := \cos\left(\frac{x}{4}\right) + \sin\left(\frac{y}{4}\right)$  is shown in the document.
- Help Window:** A tooltip for the `localmax` function is visible, stating: "localmax(M, [w]) Takes a matrix and returns the n adjacent values. The optional window value w determines the margin for points to be considered maximum. Press F1 for help."
- Calculation Window:** A window titled "Calculation" shows a variable definition:  $X := a - (x + y)$ . The window includes options for Variable, Unit, Constant, Function, System, and Keyword.
- Table:** A table with units is displayed:
 

$g_{moon}$	$v_0$	$\theta$	$h$
$\left(\frac{m}{s^2}\right)$	$(mph)$	$(^\circ)$	$(m)$
1.6	150	32	75

- Advanced engineering math tools
  - Programming
  - Solve blocks
  - Custom functions
  - Matrix math capabilities
- Integrations
  - Creo Engineering Notebook
  - Windchill integration
  - Excel component
  - Multiple format file access
- Process enhancements
  - Default and custom templates
  - Legacy worksheet converter
  - Worksheet Include and caching



# ENGINEERING CALCULATIONS: USING PTC MATHCAD



# AGENDA

1. What is PTC Mathcad?
- 2. PTC Mathcad Prime 4.0**
3. Creo Engineering Notebook

# PTC MATHCAD PRIME 4.0

Design the next generation of products with PTC Mathcad Prime 4.0 - show, solve, and secure your engineering calculations more effectively than ever.

- Performance Enhancements
  - Document performance improvements
- Content Protection
  - Area protection
  - Area locking
- Interoperability with Third Party Applications
  - Mathcad as an OLE container
  - Copy/Paste multiple regions to Word
  - Save as RTF
- Usability Enhancements
  - Equation wrapping
- Windows 10 support
- Critical bug fixes

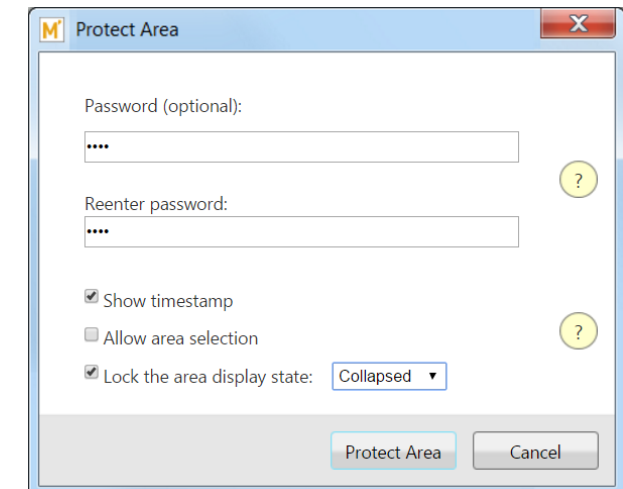
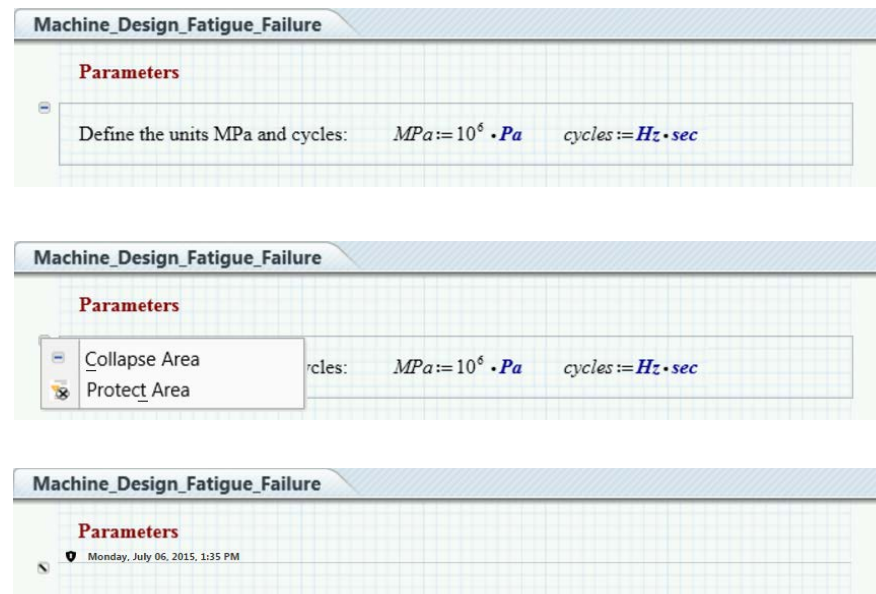
# PTC MATHCAD PRIME 4.0: PERFORMANCE ENHANCEMENTS

- Document Performance Improvements
  - Benefits worksheet-level operations and region-level operations
    - Adding and removing whitespace
    - Separating and moving regions
    - Region selection
    - Text editing
    - Switch to draft mode
    - Pushing regions down
    - Plus additional improvements

Main Improvements	Improvement (Worksheet dependent)
Switching between Page/Draft mode	Improved 10 – 30 times
“Orientation” - Page Orientation change (Portrait/Landscape)	Improved 10 – 100 times
“Letter” - Page size change (change page formats A3, A4, ...)	Improved 10 – 40 times
“Margin” – Margin switch between Standard, Narrow and Wide	Improved 10 – 40 times
“Grid Size” – Grid size switch between Fine and Standard.	Improved 10 – 15 times
“Show Grid”	Improved 5 – 10 times
“Add Space”	Improved 5 – 10 times
“Remove Space”	Improved 5 – 10 times
“Add Page Break”	Improved 1.5 – 2 times
“Separate Regions”	Some improvement
Select All	Improved 10 – 40 times
Un-Select All	Improved 10 – 40 times
Math format changes on selected items	Some improvement
Text format changes on selected items	Some improvement
Collapse Area	Some improvement

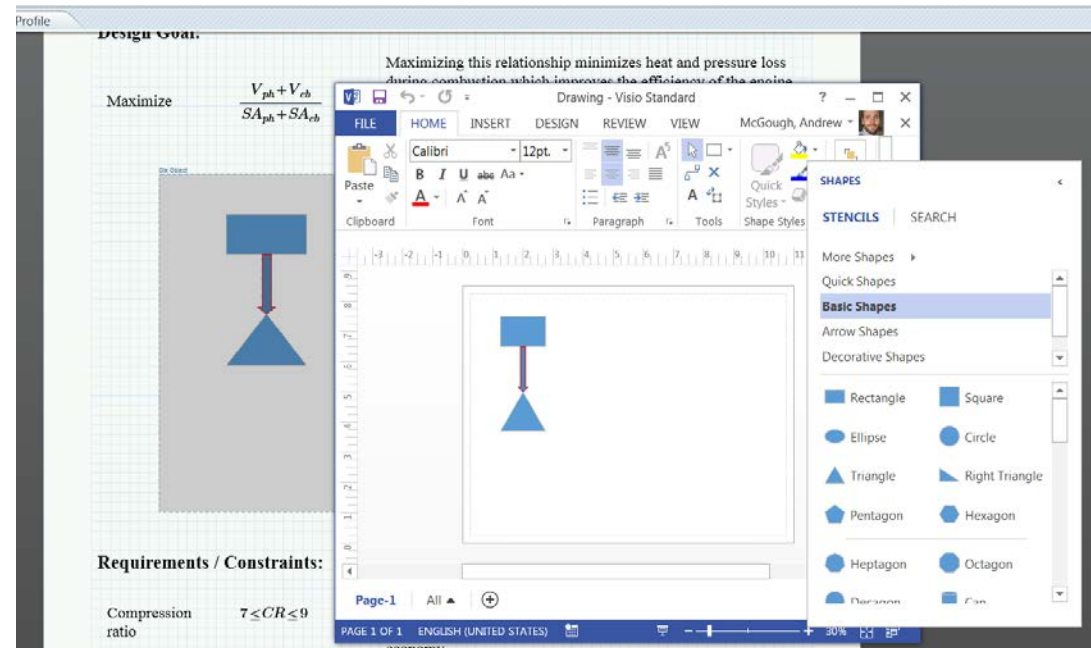
# PTC MATHCAD PRIME 4.0: CONTENT PROTECTION

- Area Protection
  - Protect Area content from edit
  - Password protected or no password
  - Optional timestamp
- Area Locking
  - Lock area display state
    - Open (contents visible), closed (contents hidden) or no lock



- Mathcad as an OLE container
  - Ability to embed applications as OLE objects within the worksheet
  - Any OLE object available on the system
  - Can embed new or from file
  - Can link to file

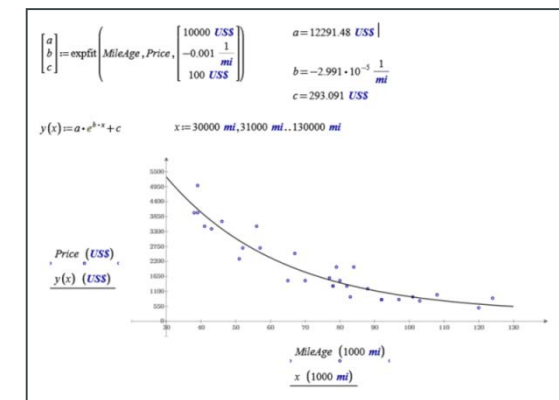
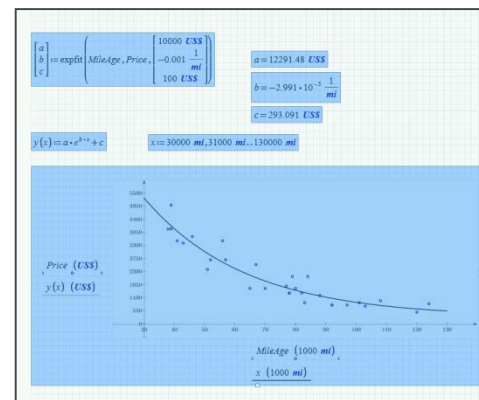
# PTC MATHCAD PRIME 4.0: OLE CONTAINER





# PTC MATHCAD PRIME 4.0: CONTENT PROTECTION

- Copy/Paste multiple regions to Word (3<sup>rd</sup> party apps)
  - User can select multiple regions (contiguous or non-contiguous) and 'copy', making them available on the clipboard for paste:
    - Keep Source Formatting – maintain layout from Mathcad
    - Merge Formatting – pastes regions that can be moved as needed
- Save as RTF
  - Save entire worksheet content directly as single RTF file



# PTC MATHCAD PRIME 4.0: EQUATION WRAPPING

- Equation Wrapping
  - Two ways to enter equation break:
    - Editing an equation
      - » ctrl+shift+enter toggles wrapping on addition, subtraction, multiplication and inline division operators
    - As you type
      - » Keyboard shortcuts to insert wrapped addition, subtraction, multiplication and inline division operators

**For solid cross section**      Change in horizontal diameter (an increase is positive):

$$D_H := \left( \theta \leq \frac{\pi}{2} \right) \cdot \frac{-w \cdot R^4}{6 \cdot E \cdot I_c \cdot \pi} \cdot \left( \pi \cdot k_1 \cdot (s^3 + 3 \cdot \theta \cdot c + 4 - 3 \cdot s) + 3 \cdot k_2 \cdot (\pi - \theta + 2 \cdot \theta \cdot c^2 - s \cdot c) - 6 \cdot k_2^2 \cdot (\pi - \theta + s \cdot c) \right) + \left( \theta > \frac{\pi}{2} \right) \cdot \frac{-w \cdot R^4}{2 \cdot E \cdot I_c}$$

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$$D_H := \left( \theta \leq \frac{\pi}{2} \right) \cdot \frac{-w \cdot R^4}{6 \cdot E \cdot I_c \cdot \pi} \cdot \left( \pi \cdot k_1 \cdot (s^3 + 3 \cdot \theta \cdot c + 4 - 3 \cdot s) + 3 \cdot k_2 \cdot (\pi - \theta + 2 \cdot \theta \cdot c^2 - s \cdot c) - 6 \cdot k_2^2 \cdot (\pi - \theta + s \cdot c) \right) + \left( \theta > \frac{\pi}{2} \right) \cdot \frac{-w \cdot R^4}{2 \cdot E \cdot I_c \cdot \pi} \cdot \left( \pi \cdot k_1 \cdot \left( c \cdot (\pi - \theta) + s - \frac{s^3}{3} \right) + k_2 \cdot ((\pi - \theta) \cdot (2 \cdot s^2 - 1) - s \cdot c) + -2 \cdot k_2^2 \cdot (\pi - \theta + s \cdot c) \right)$$

# AGENDA

1. What is PTC Mathcad?
2. PTC Mathcad Prime 4.0
3. **Creo Engineering Notebook**

# Show Your Work!

# CREO ENGINEERING NOTEBOOK

Spring variable definitions:

Number of Active Coils:  $N_{coil} := 18$

Diameter of the wire:  $d_{wire} := 7 \text{ mm}$

Coil diameter:  $D_{coil} := 28 \text{ mm}$

Outer diameter:  $D_{outer} := D_{coil} + d_{wire} = 35 \text{ mm}$

Shear modulus:  $G := 77.2 \text{ GPa} = (1.12 \cdot 10^7) \text{ psi}$

Force on the spring:  $F_{spring} := \frac{1}{2} (250 \text{ kg} \cdot g) = 1.226 \text{ kN}$

Shear Stress:  $\tau := \frac{8 \cdot F_{spring} \cdot D_{coil}}{\pi \cdot d_{wire}^3} + \frac{4 \cdot F_{spring}}{\pi \cdot d_{wire}^2} = 286.673 \text{ MPa}$

Spring Constant:  $k_{front\_suspension} := \frac{d_{wire}^4 \cdot G}{8 \cdot D_{coil}^3 \cdot N_{coil}} = 58.637 \frac{\text{kN}}{\text{m}}$

Document Design Intent

Coil diameter:  $D_{coil} := 28 \text{ mm}$

Outer diameter:  $D_{outer} := D_{coil} + d_{wire} = 35 \text{ mm}$

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Analysis Driven Design

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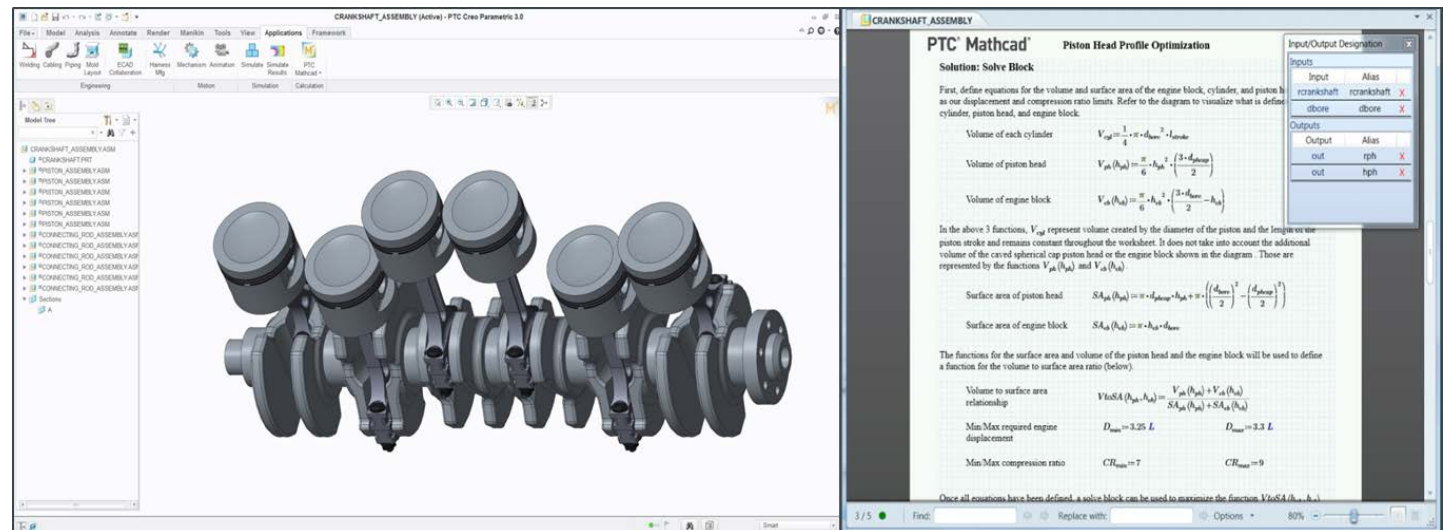
Spring Constant:  $k_{front\_suspension} := \frac{d_{wire}^4 \cdot G}{8 \cdot D_{coil}^3 \cdot N_{coil}} = 58.637 \frac{\text{kN}}{\text{m}}$

Verification and Validation

## Document Design Intent

- **Embed** a Mathcad worksheet directly **within** the Creo model
- Embedded worksheet can be opened, edited and saved within the Creo model
- All design details in the worksheet automatically travel with the Creo model

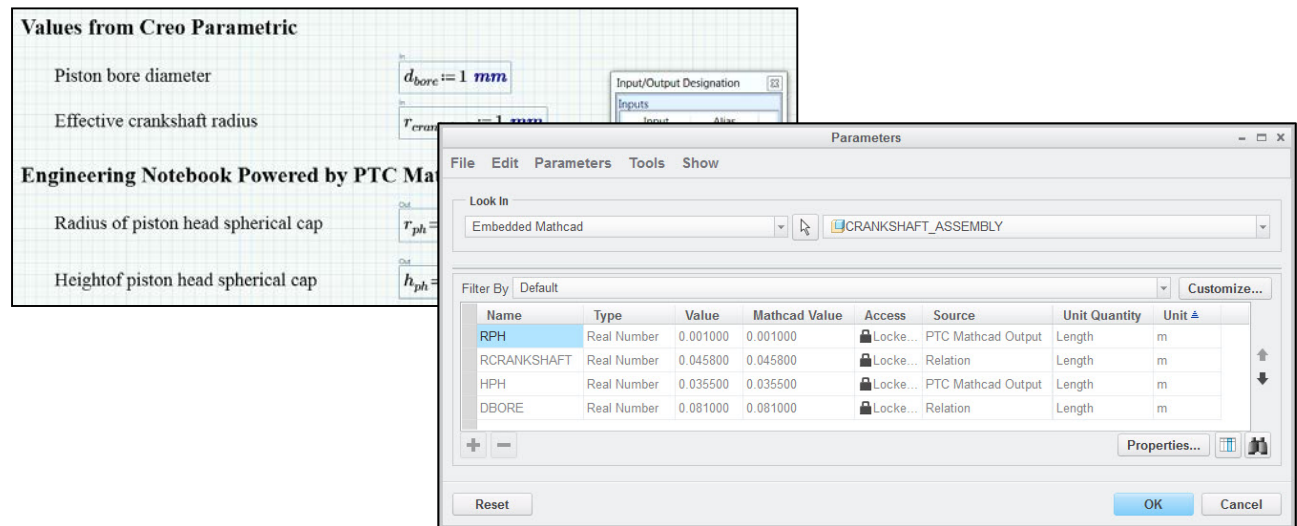
# CREO ENGINEERING NOTEBOOK



## Analysis Driven Design

- Solve calculations and use the results as dimensions within the Creo model.
- Tag parameters as Outputs in the embedded Mathcad worksheet - values from Mathcad to Creo
- Mathcad output evaluations become available in Creo Parameters Table

# CREO ENGINEERING NOTEBOOK



The screenshot displays an Engineering Notebook interface. On the left, a table lists parameters from the Creo Parametric model. On the right, a Mathcad worksheet shows calculations for these parameters. Below the notebook, the 'Parameters' dialog box is open, showing a table of parameter values.

**Values from Creo Parametric**

Piston bore diameter
Effective crankshaft radius
Radius of piston head spherical cap
Height of piston head spherical cap

**Engineering Notebook Powered by PTC Mathcad**

Mathcad calculations shown:

- $d_{bore} := 1 \text{ mm}$
- $r_{crank} := 1 \text{ mm}$
- $r_{ph} :=$
- $h_{ph} :=$

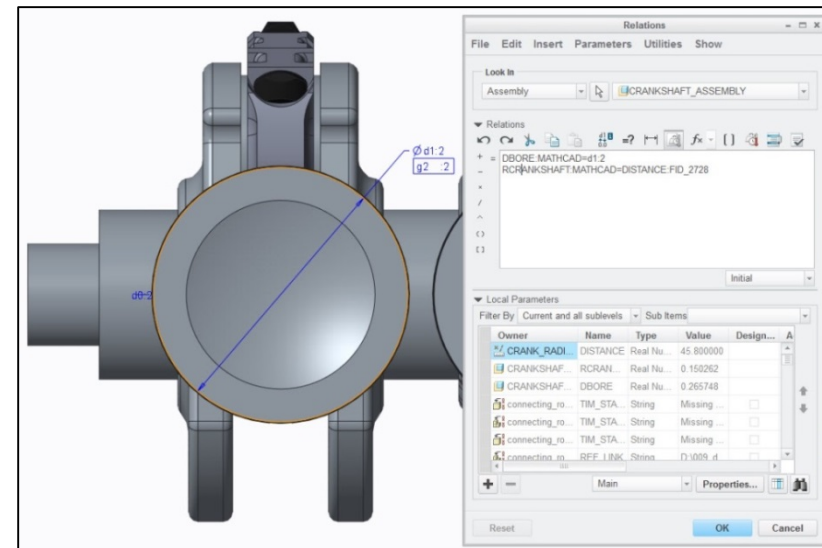
**Parameters Table**

Name	Type	Value	Mathcad Value	Access	Source	Unit	Quantity	Unit
RPH	Real Number	0.001000	0.001000	Locke...	PTC Mathcad Output	Length		m
RCRANKSHAFT	Real Number	0.045800	0.045800	Locke...	Relation	Length		m
HPC	Real Number	0.035500	0.035500	Locke...	PTC Mathcad Output	Length		m
DBORE	Real Number	0.081000	0.081000	Locke...	Relation	Length		m

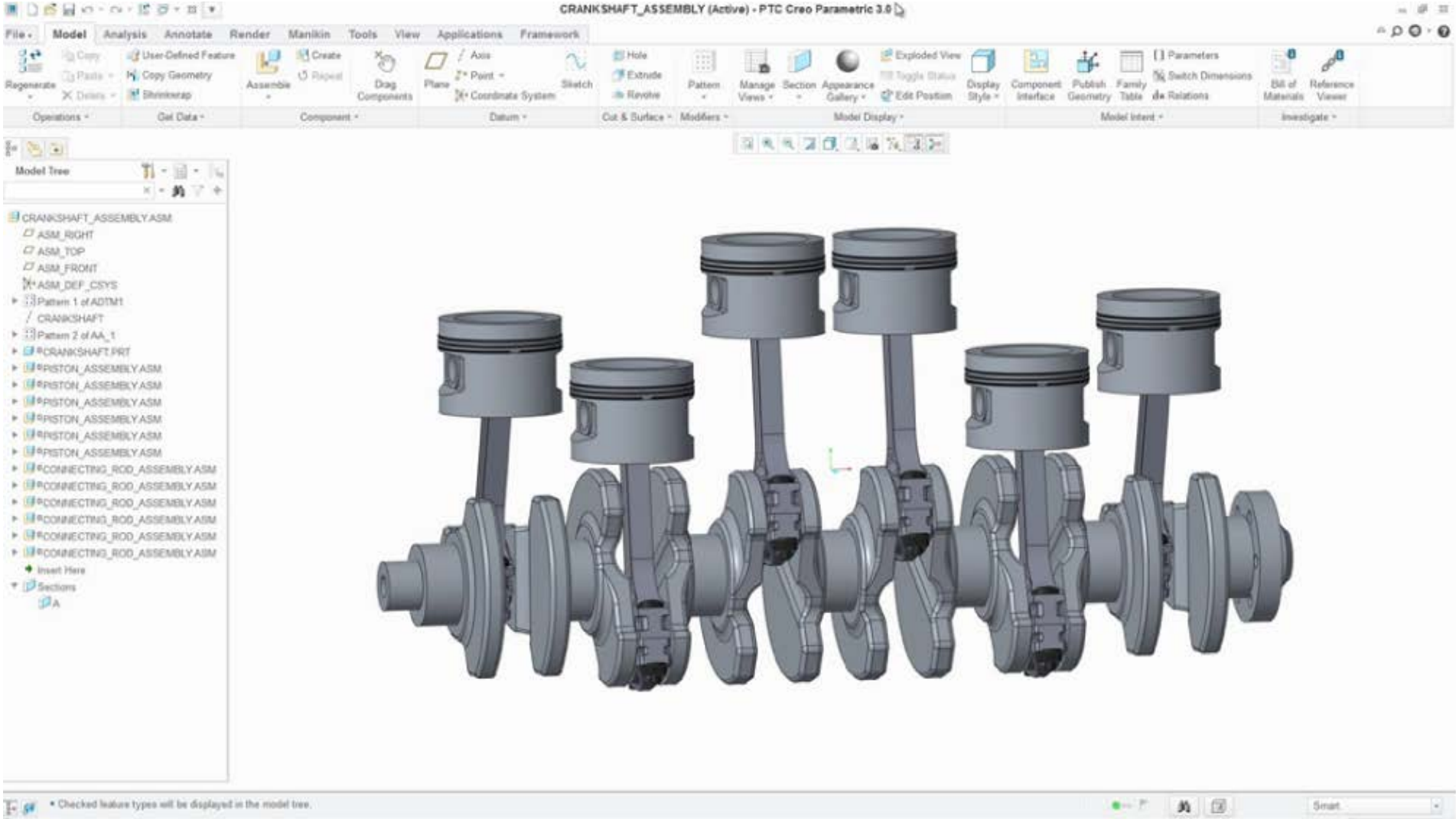
## Verification and Validation

- Creo parameters further analyzed with Mathcad's extensive array of math tools.
- Tag parameters as Inputs in the embedded Mathcad worksheet - values from Creo to Mathcad
- Mathcad output definitions become available in Creo Parameters Table

# CREO ENGINEERING NOTEBOOK



# CREO ENGINEERING NOTEBOOK - DEMO



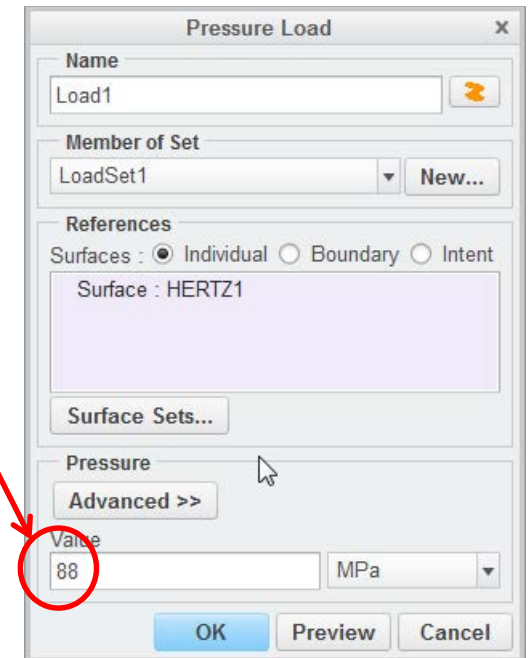


## Why Mathcad Prime belongs *wherever* CAE is used

- Show Your Work!
  - Provide reference/traceability for all loads/numerical input
  - Provide scratchpad for derived inputs
  - Reuse of previous IP for inputs

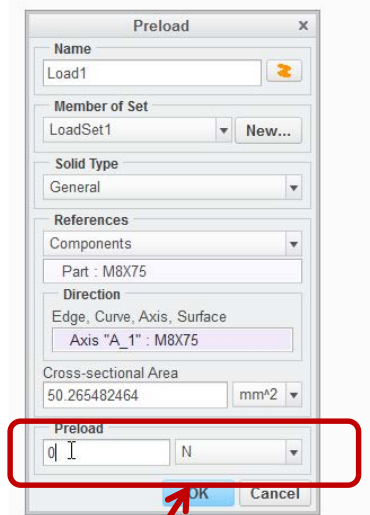
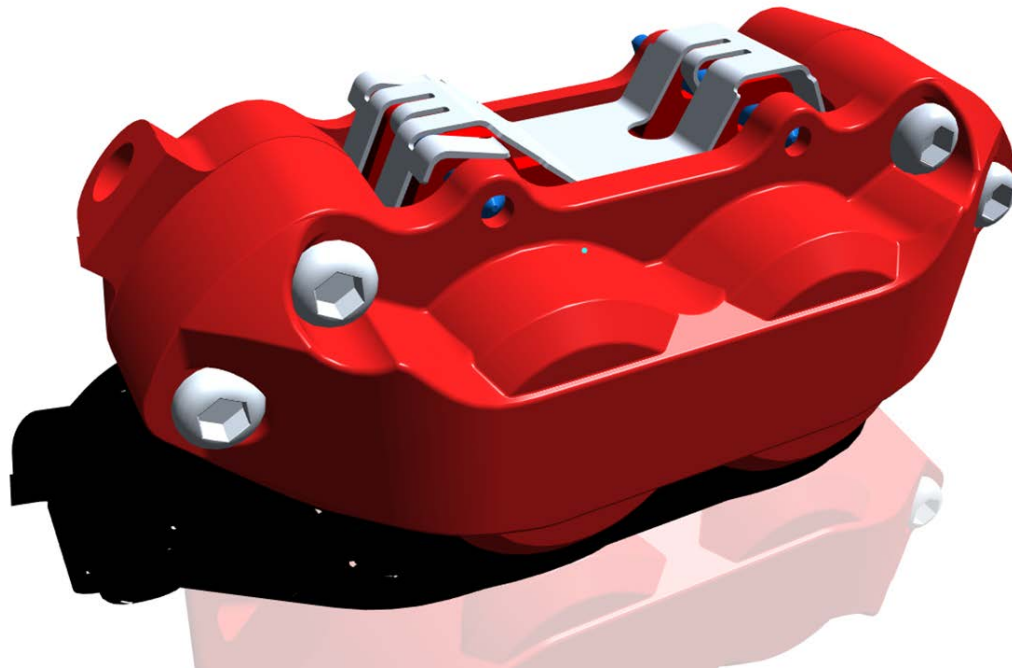
# CREO ENGINEERING NOTEBOOK

Where does this input come from?  
Who calculated it?  
Can it be verified?  
Was it typed correctly?? 8.8? 88? 0.88?



Show Your Work!

For this brake caliper stress analysis we want to apply a preload to this bolt



CREO  
ENGINEERING  
NOTEBOOK

UI requires input of axial force on bolt.  
**What is this number??**

## Show Your Work!

The Bolt axial preload is in fact a complex calculation that can be easily managed in PTC Mathcad.

# CREO ENGINEERING NOTEBOOK

**Bolt Preload**

**Preload (Axial force) on a Bolt for a Given Torque**

Bolt diameter:  $d := 8 \text{ mm}$

Torque applied to bolt:  $\text{torque} := 28 \text{ N}\cdot\text{m}$

Bolt pitch,  $p := 1.0 \text{ mm}$

Thread angle:  $\alpha := 30 \text{ deg}$

Thread lead rate:  $\text{thread\_rate} := 1$

Thread friction:  $\mu_t := 0.4$

Collar friction:  $\mu_c := 0.2$

Calculated quantities:

$d_{\text{mean}} := d - 0.649619 \cdot p$

$d_{\text{collar}} := 1.25 \cdot d$

$\text{thread\_lead} := \text{thread\_rate} \cdot p$

$\tan \lambda := \frac{\text{thread\_lead}}{\pi \cdot d_{\text{mean}}}$

Calculate the bolt pre-tension from torque and bolt properties using the equation:

$T = \text{Thread torque} + \text{Collar torque} = \frac{F_p \cdot d_m}{2} \left( \frac{p + \pi \cdot \mu_t \cdot d_m \cdot \sec \alpha}{\pi \cdot d_m - \mu_t \cdot p \cdot \sec \alpha} \right) + F_p \cdot \mu_c \cdot r_c$

$F_p := \frac{\text{torque}}{\frac{d_{\text{mean}} \cdot (\tan \lambda + \mu_t \cdot \sec(\alpha))}{2 \cdot (1 - \mu_t \cdot \tan \lambda \cdot \sec(\alpha))} + \mu_c \cdot \frac{d_{\text{collar}}}{2}}$

Solution for Preload Force:

$F_p = (7.946 \cdot 10^3) \text{ N}$

$$F_p := \frac{\text{torque}}{\frac{d_{\text{mean}} \cdot (\tan \lambda + \mu_t \cdot \sec(\alpha))}{2 \cdot (1 - \mu_t \cdot \tan \lambda \cdot \sec(\alpha))} + \mu_c \cdot \frac{d_{\text{collar}}}{2}}$$

Solution for Preload Force:

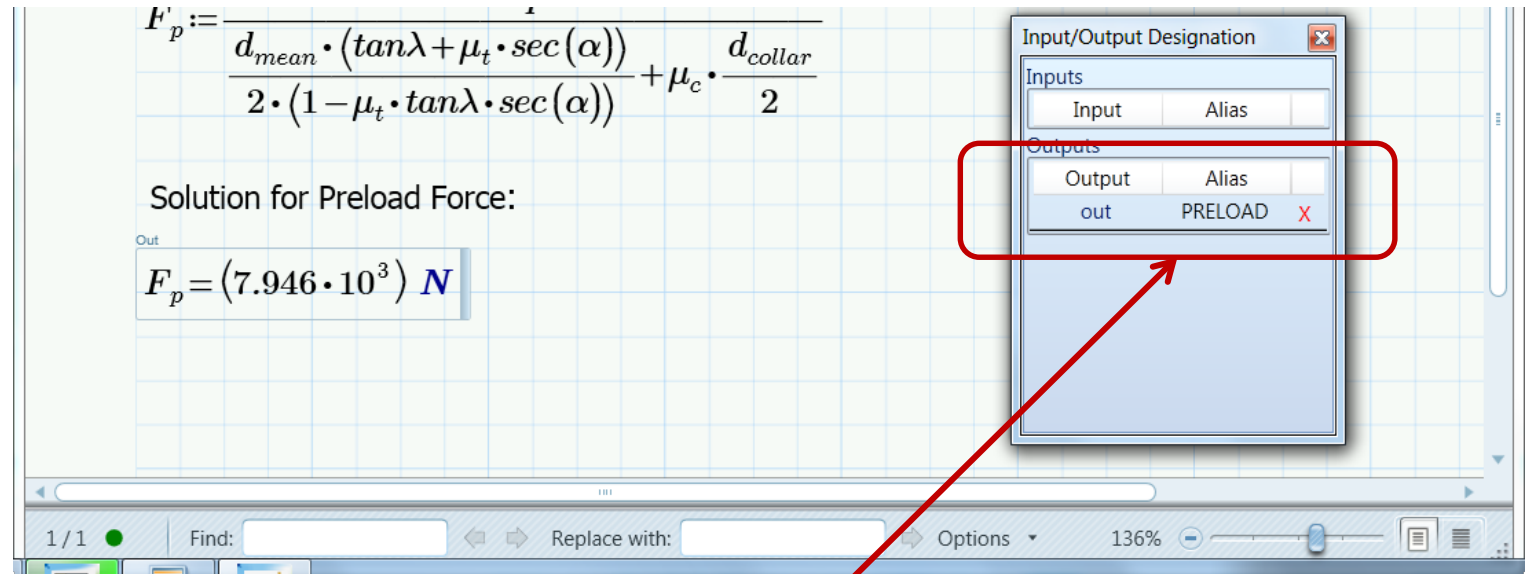
$$F_p = (7.946 \cdot 10^3) \text{ N}$$

Share/Re-use Mathcad worksheet to ensure consistency in calculation

Show Your Work!

Share the calculated result with Creo

# CREO ENGINEERING NOTEBOOK



$$F'_p := \frac{d_{mean} \cdot (\tan\lambda + \mu_t \cdot \sec(\alpha))}{2 \cdot (1 - \mu_t \cdot \tan\lambda \cdot \sec(\alpha))} + \mu_c \cdot \frac{d_{collar}}{2}$$

Solution for Preload Force:

Out

$$F_p = (7.946 \cdot 10^3) \text{ N}$$

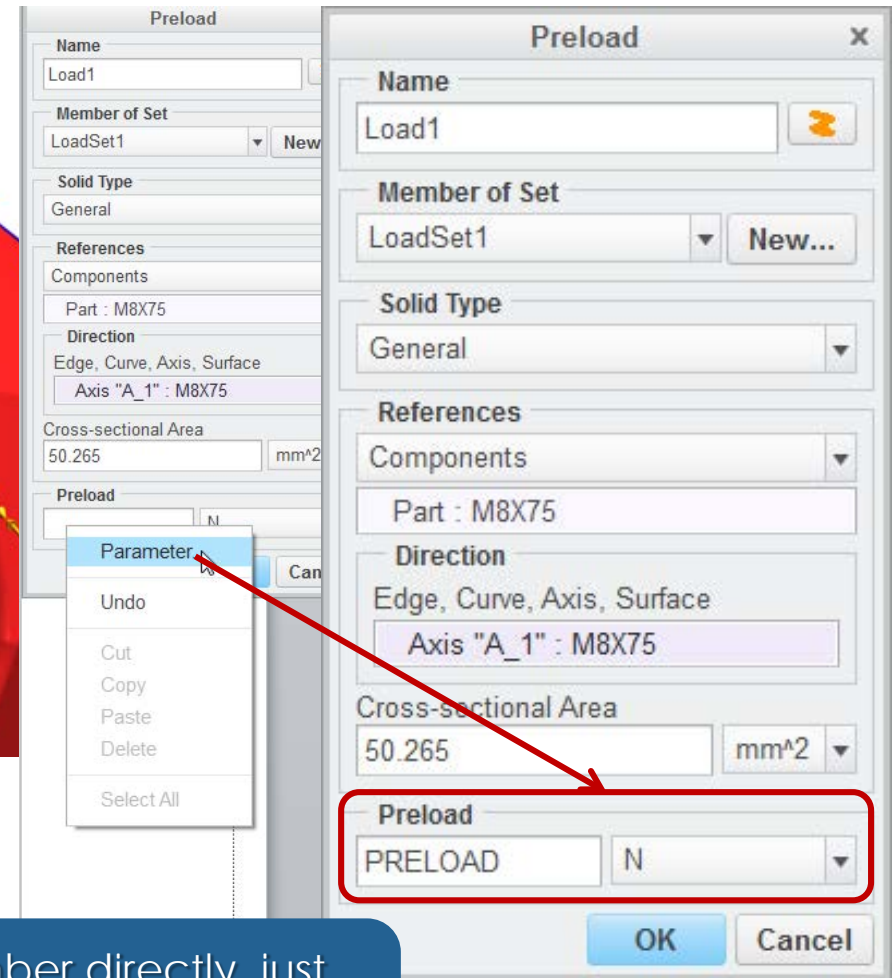
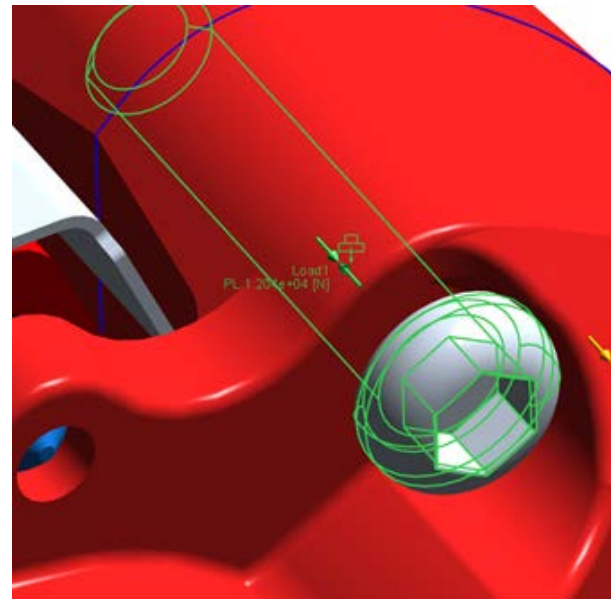
Input/Output Designation	
Inputs	
Input	Alias
Outputs	
Output	Alias
out	PRELOAD X

Parameter "**PRELOAD**" now available in **Creo**:

- Drive geometry in **Creo Parametric**
- Numerical input to loads, material properties in **Creo Simulate**

# Show Your Work!

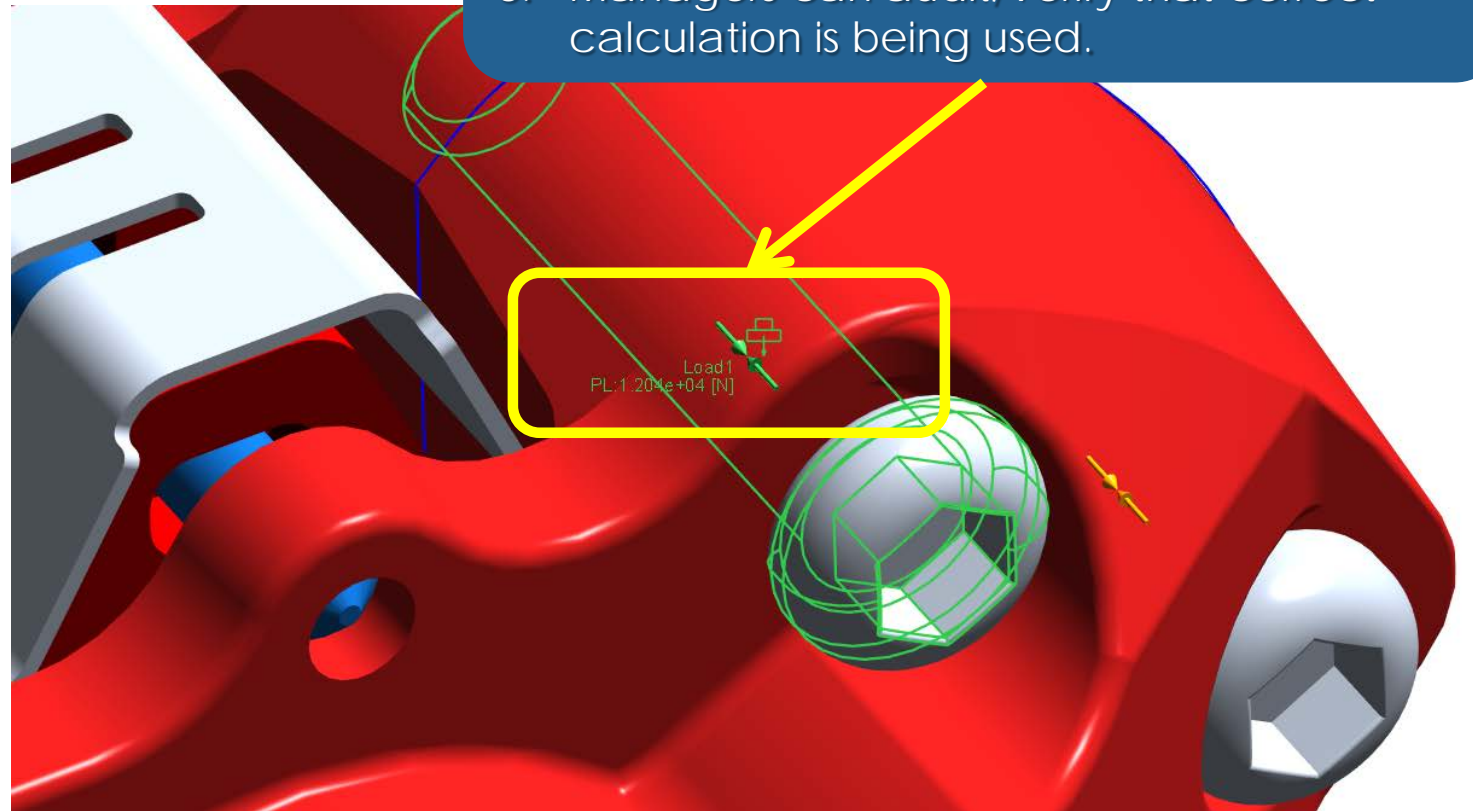
# CREO ENGINEERING NOTEBOOK



Instead of typing in a number directly, just refer to the parameter we correctly calculated and shared from Mathcad!

## Show Your Work!

1. Preload is correctly assigned to bolt.
2. Updates to Mathcad worksheet will be reflected here.
3. Managers can audit/verify that correct calculation is being used.



CREO  
ENGINEERING  
NOTEBOOK

# SIMULATION AND ANALYSIS - CREO SIMULATE 4.0

Jose Coronado  
Product Manager

November 2016



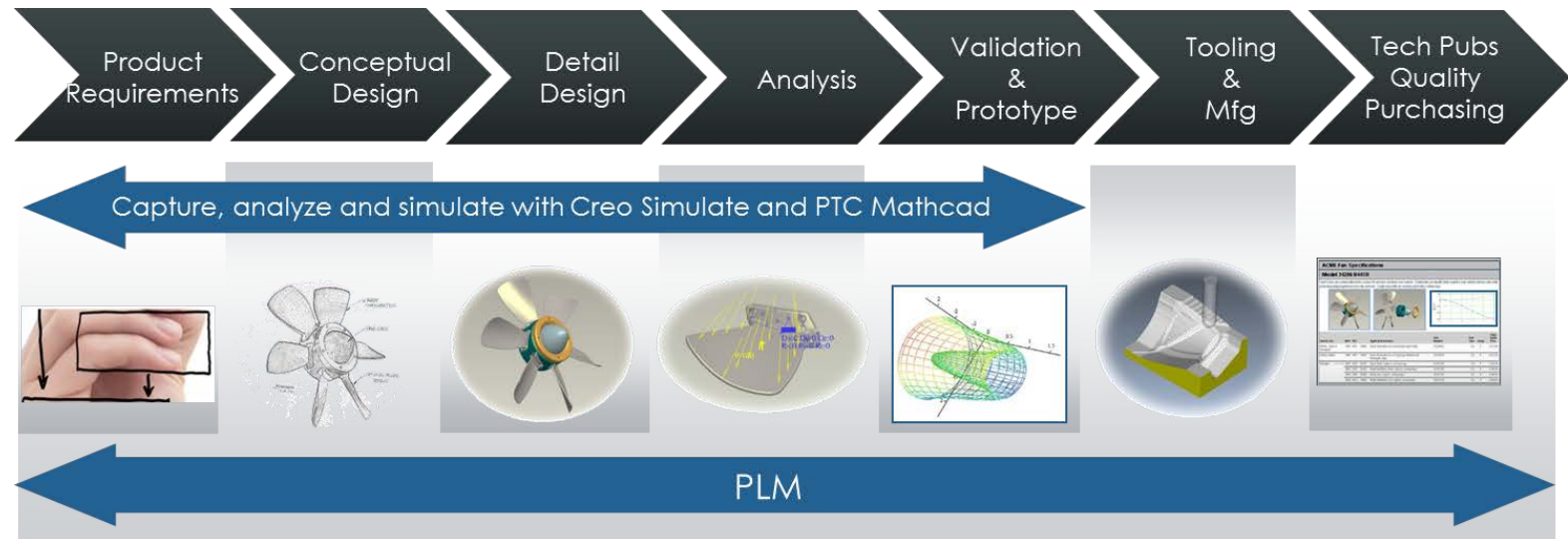
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**PTC Forum Europe**  
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Creo and PTC Mathcad offer a seamless integration of simulation, analysis and modeling.

- With Creo simulate designers are empowered to easily analyze parts and assemblies, and optimize designs.

## ENGINEERING KNOWLEDGE



- PTC Mathcad combines the ease and familiarity of an engineering notebook with the powerful features of a dedicated engineering calculations application.



# AGENDA

1. Usability
2. Process Automation
3. Export
4. Simulation of lattice features

# AGENDA

**1. Usability**

2. Process Automation

3. Export

4. Simulation of lattice features

## Overhaul the Analysis and Design Study Experience

### OVERHAUL THE ANALYSIS AND DESIGN STUDY EXPERIENCE

Revised diagnostic details



- Filtering diagnostic option to show only relevant analysis information
- Dynamic analysis status showing the elapsed time and activity
- Expanding panel to show the analysis run status and convergence plot

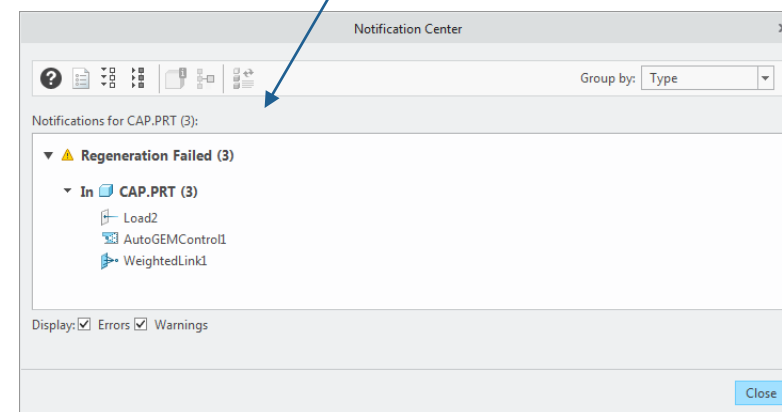
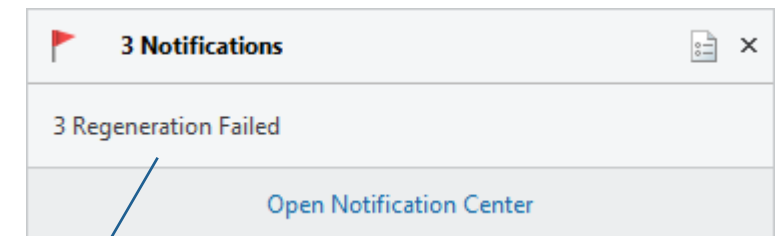
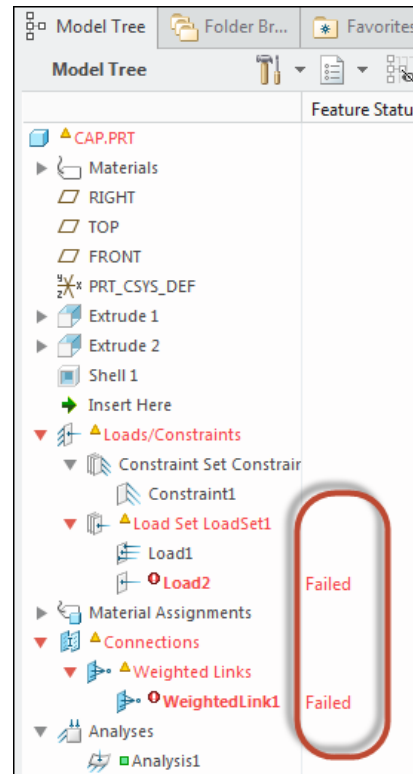


## Notification support for Creo Simulate

- Indications of changes/issues
- Single access-point to quickly identify common model issues
- Support both Simulate objects and features

## NOTIFICATION SUPPORT FOR CREO SIMULATE

Easier way to identify, locate and fix design

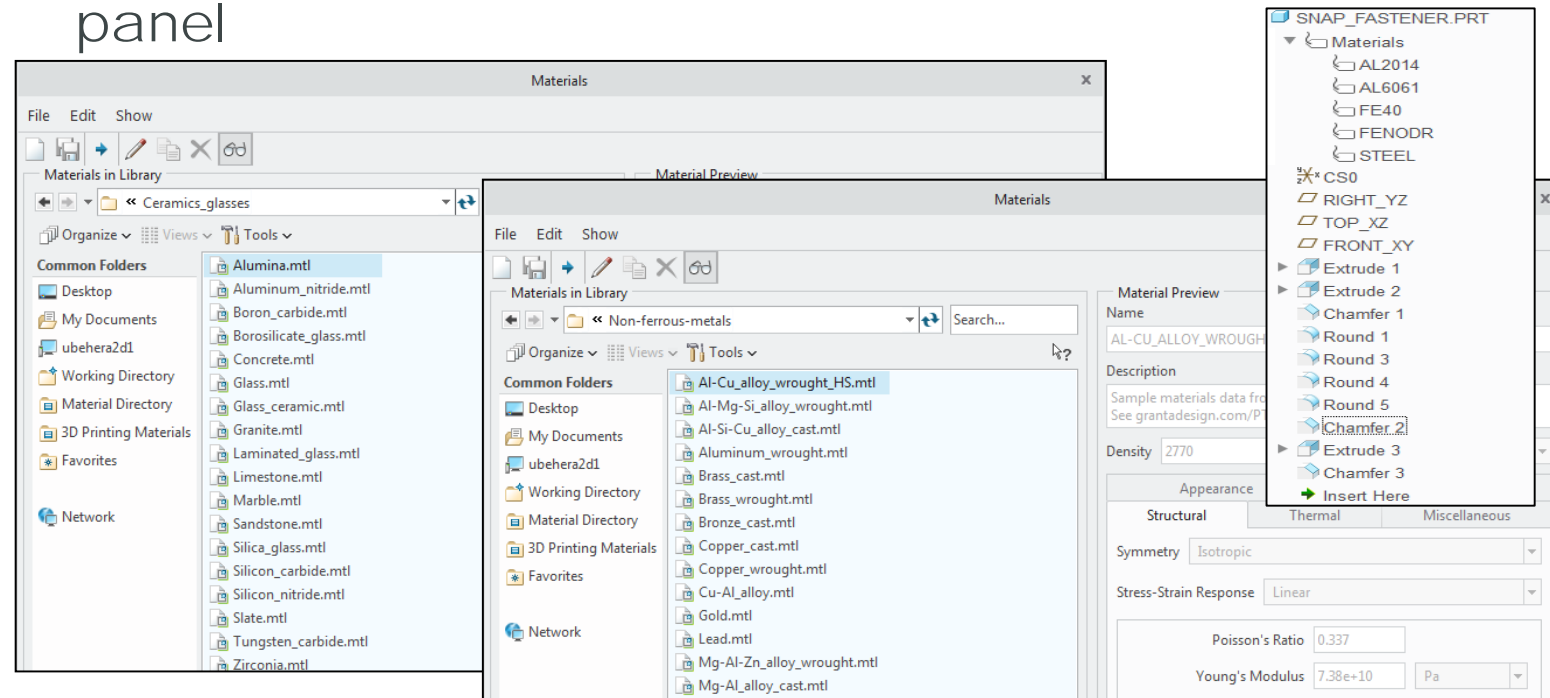


## Material Enhancements

- More than 110 standard materials within the standard install:
  - Ceramics & Glasses, Composites, Elastomers & Rubbers, Ferrous metals, Foams, Non ferrous metals, plastics and woods
- Material Dialog update to show a dynamic properties panel

EASY ASSIGNMENT OF MATERIALS THROUGH A NEW MATERIAL NODE

**GRANTA**  
MATERIAL INTELLIGENCE

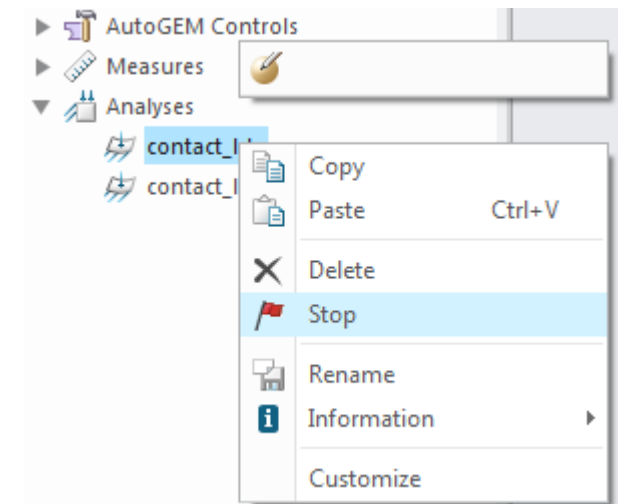
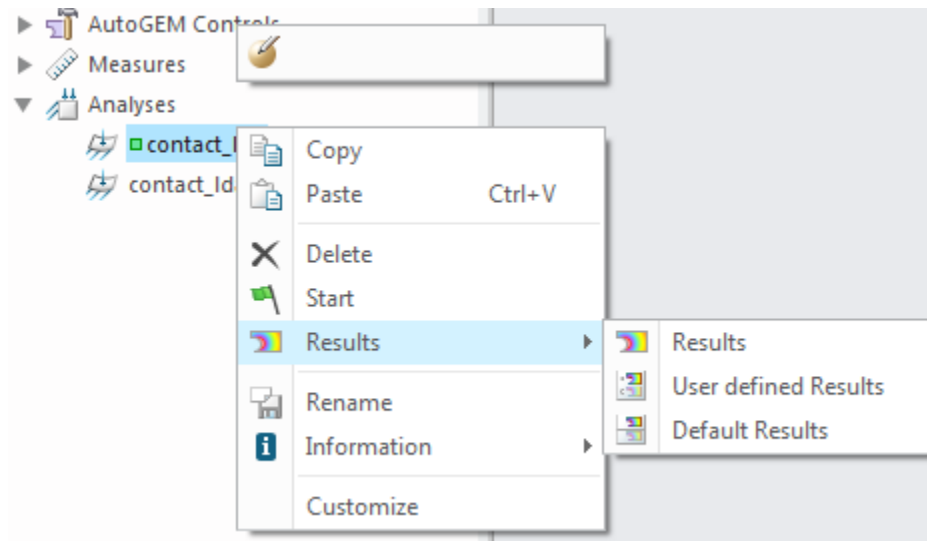
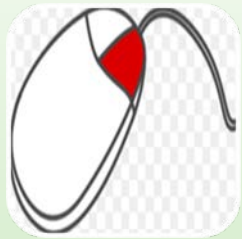


## Analysis Node in Model Tree Enhancements

- Access to additional commands via RMB
- Create new analysis via RMB on the Analyses node
- Updated icons representing the status of a given analysis

### ANALYSIS NODE IN MODEL TREE ENHANCEMENTS

Reduce menu and picks to create, run or review an analysis



Synchronize and lock the orientation of a series of results windows to the active window

## SYNCHRONIZE ORIENTATION CONTROL

Improved results display

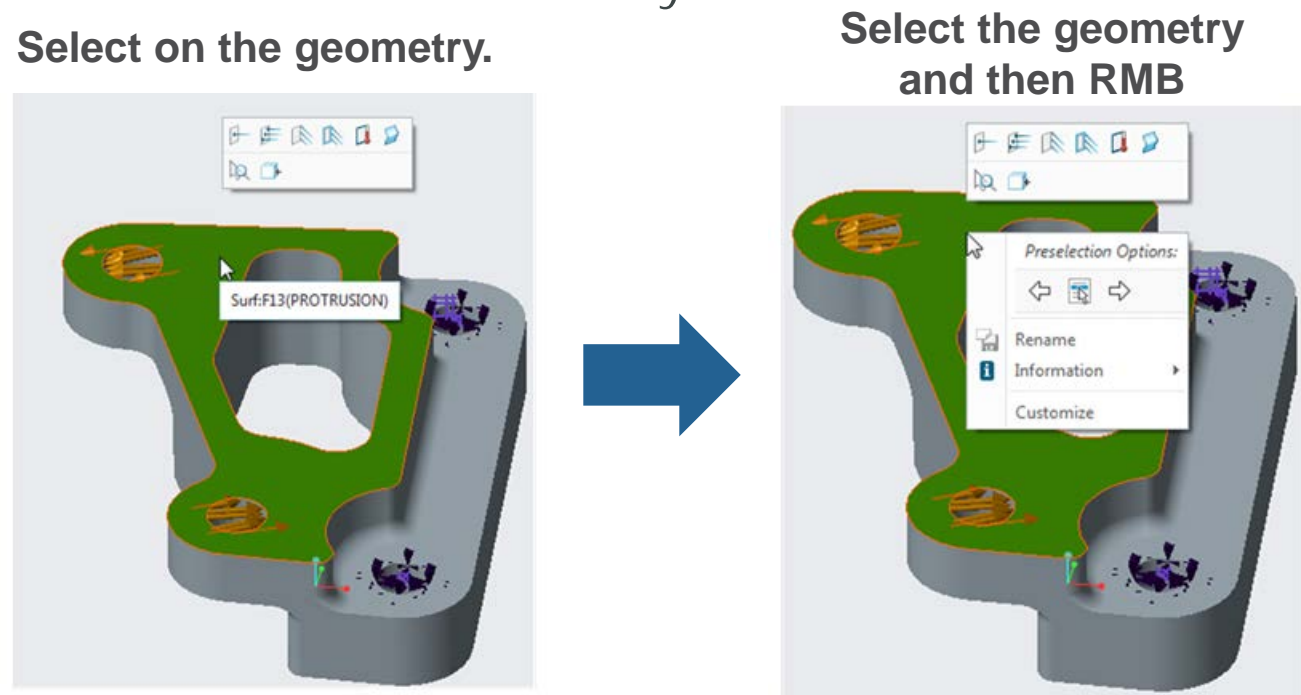


## Better selecting methods

- Access to frequently performed actions (Loads/Constraints)
- When selecting geometry, hovering over or RMB on geometry (Surfaces/Edges)
- Customize the Toolbar to your needs

### MINI-TOOLBAR SUPPORT

Easily apply and edit entities without needing to pick from the ribbon





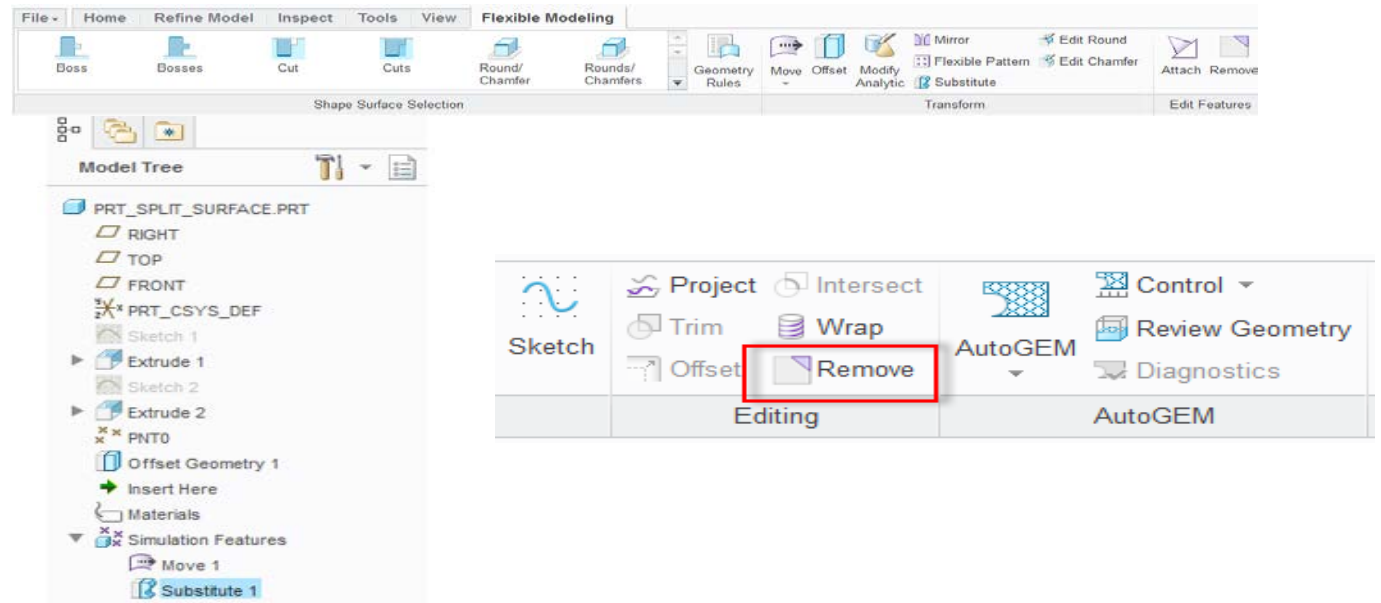
## DATA SIMPLIFICATION IMPROVEMENTS

Explore additional design scenarios easily based on found results



## Improved mechanism to adjust models

- Access to Flexible Modeling tools within Creo Simulate
  - Requires an active license of FMX
  - As a Simulation Feature in the model tree
  - Promote FM features to PMA
- New Remove feature to help simplify the analysis model
  - Does not require a license of FMX



## Better placing of tolerances

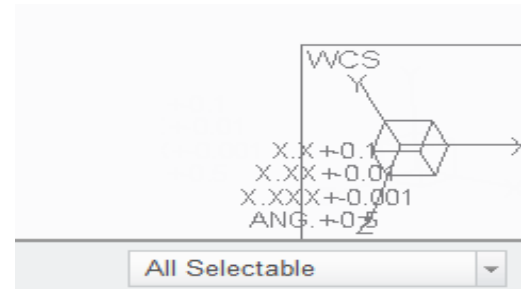
- Relocate tolerance details when in Creo Simulate to avoid overlapping with Simulate Csys
  - Located tolerance to the left of the Csys while in Creo Simulate
  - Move tolerance back to the right corner when in Creo Parametric

### GRAPHIC DISPLAY IMPROVEMENTS

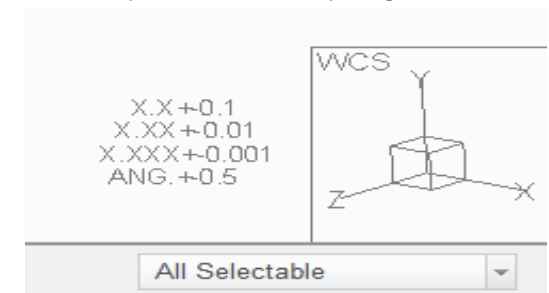
Improved graphic display when tolerances are enabled

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES			
ANGLES	.X	.XX	.XXX
$\pm .5^\circ$	$\pm .02$	$\pm .01$	$\pm .005$

Current Display



Updated Display



# AGENDA

1. Usability

**2. Process Automation**

3. Export

4. Simulation of lattice features

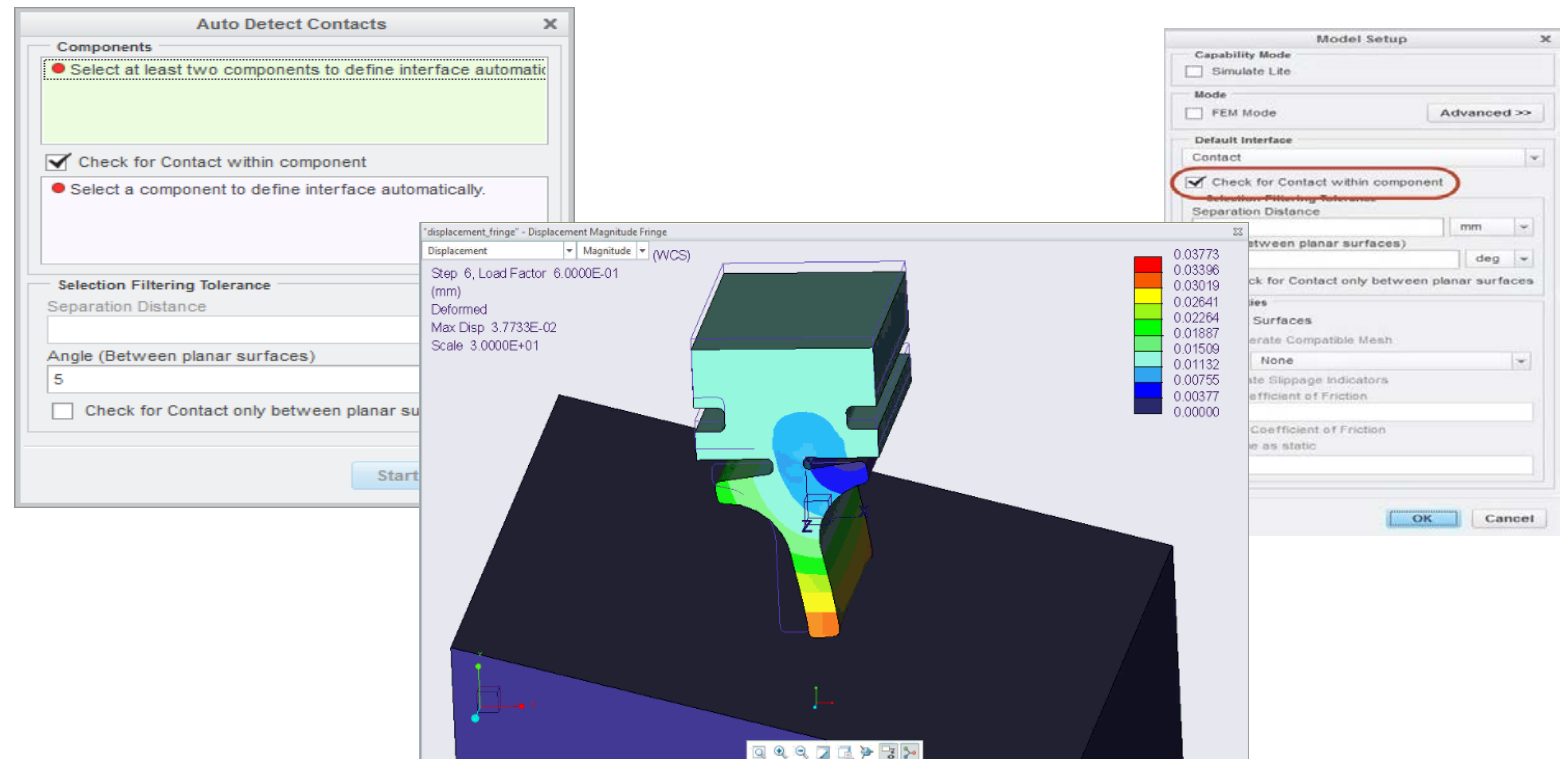
## CONTACT INTERFACE IMPROVEMENTS

Reduces the need to manually create multiple contacts



### Allow detection in part mode

- Auto-detect to detect contacts within a component
- New collector for contact auto-detect when in assembly
- Control contact properties from Model Setup

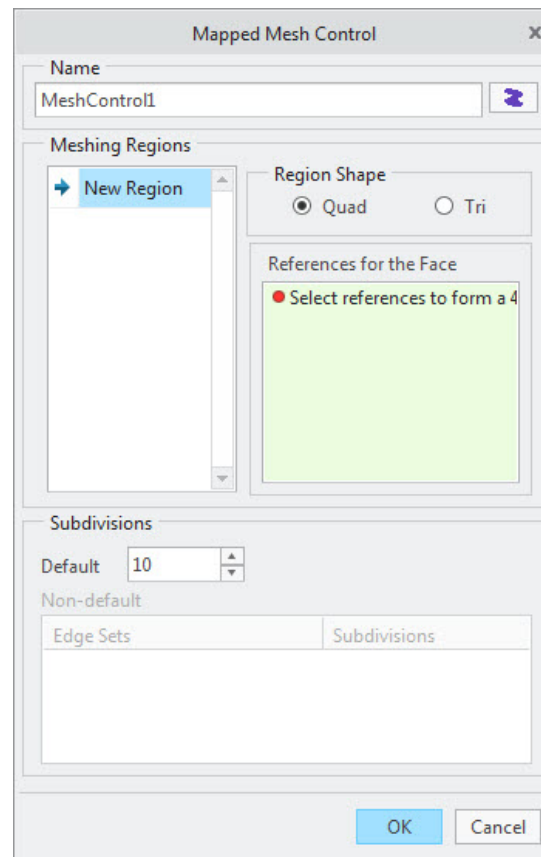


## Reduce the need to manual fix the poor import geometry

- Auto-detect and create thin solid mesh control options
- Enable mapped mesh control option on solid surfaces in FEM mode

## MESH ROBUSTNESS IMPROVEMENTS

Automatically detect and create thin solid mesh control options



AutoGEM Summary			
Entities Created:			
Beam:	0	Edge:	25746
Tri:	0	Face:	35913
Quad:	0	Face-Face Link:	0
<b>Tetra:</b>	<b>15372</b>	Edge-Face Link:	0
Wedge:	0		
Brick:	0		
Criteria Satisfied:			
Angles (Degrees):			
Min Edge Angle: 5.00		Max Edge Angle: 169.81	
Max Aspect Ratio: 11.43			
Elapsed Time: 0.17 min		CPU Time: 0.17 min	
Close			



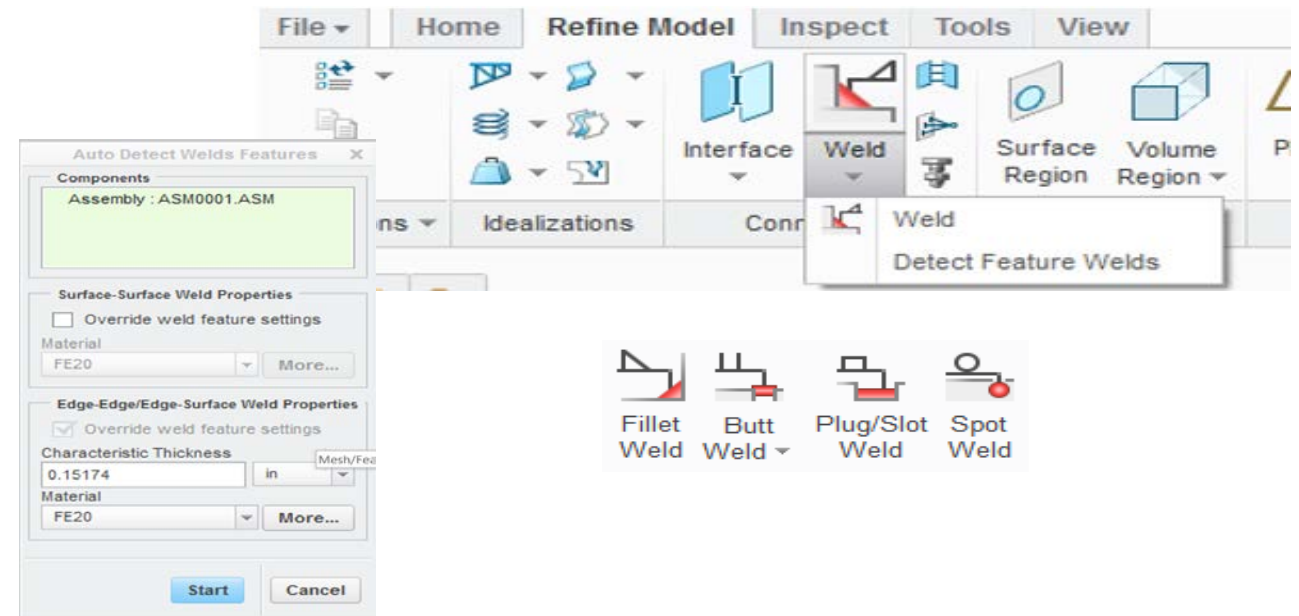
AutoGEM Summary			
Entities Created:			
Beam:	0	Edge:	21244
Tri:	0	Face:	28706
Quad:	0	Face-Face Link:	4800
<b>Tetra:</b>	<b>7007</b>	Edge-Face Link:	0
<b>Wedge:</b>	<b>1932</b>		
Brick:	980		
Criteria Satisfied:			
Angles (Degrees):			
Min Edge Angle: 5.07		Max Edge Angle: 169.27	
Max Aspect Ratio: 11.12			
Elapsed Time: 0.37 min		CPU Time: 0.37 min	
Close			

## Higher quality results when welds features are present

- Enable auto-detection of weld features in the model
- Support solid welds in Creo Simulate
  - Analyze the new weld feature as solid geometry versus surfaces
  - Support the following types of solid welds: Fillet Welds, Plug/Slot Welds, Butt Welds, Spot Welds.

## WELD CONNECTION IMPROVEMENTS

Automated process for creating solid welds



# AGENDA

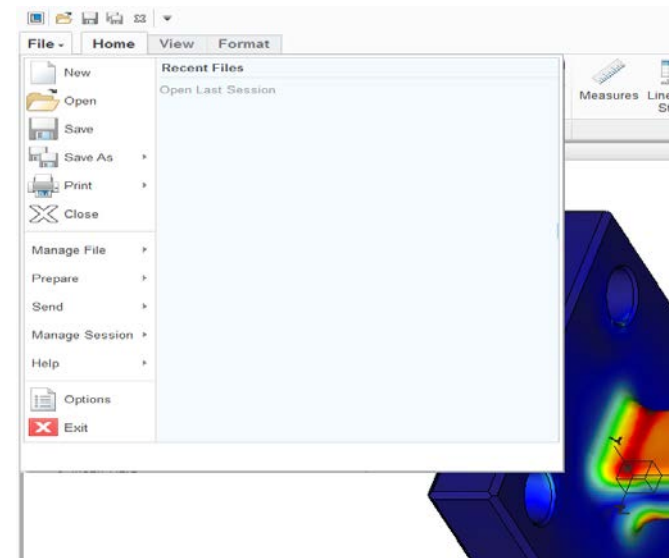
1. Usability
2. Process Automation
- 3. Export**
4. Simulation of lattice features

## Standardized File menu and actions consistent with PMA

- Improved process for saving results to Windchill
  - Publish Creo View file as secondary content for results (\*.mrs) and HTML report (\*.mrp)
  - Ability to vault information to the workspace unlinked from the stored model directly from Simulate Results
- Improve exchange of information with Creo View

## DATA EXCHANGE IMPROVEMENTS

Improve the ability to store and archive results in Windchill





# AGENDA

1. Usability
2. Process Automation
3. Export
4. **Simulation of lattice features**

# CREO – DESIGN FOR ADDITIVE MANUFACTURING, CLOSING THE GAP



Design to print workflow



1

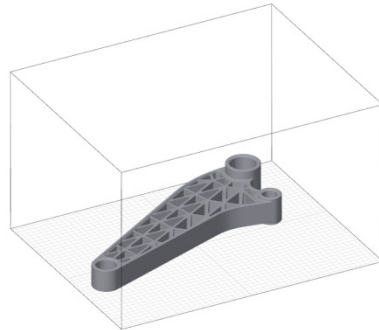
CAD Model



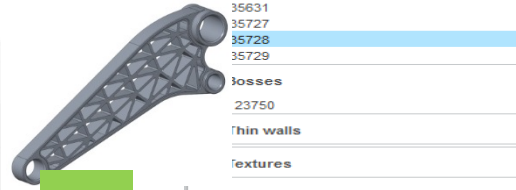
2

Model Preparation  
e.g. define the interior

Optimize



Tray placement



5

Printability Checking  
e.g. thin walls

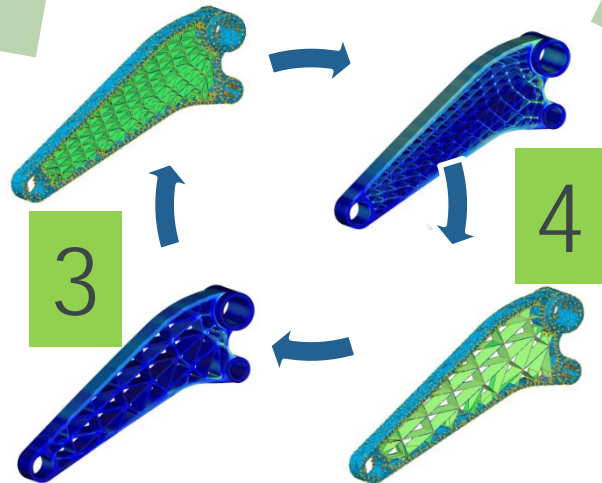
Then Print

Slicing



3D Printer

CAD Domain



Design to print workflow



CAD Model

Users may need up to **4 different types of software** to print 3D models



Slicing



3D Printer

CAD Domain



# DESIGN FOR ADDITIVE MANUFACTURING, CLOSING THE GAP

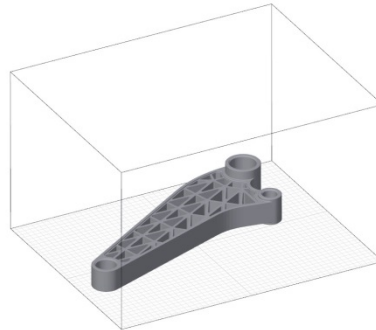
## Design to print workflow



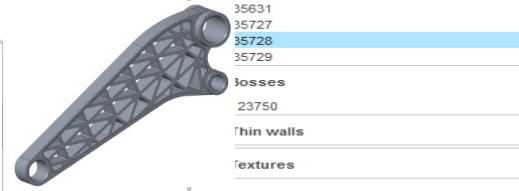
CAD Model



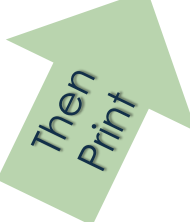
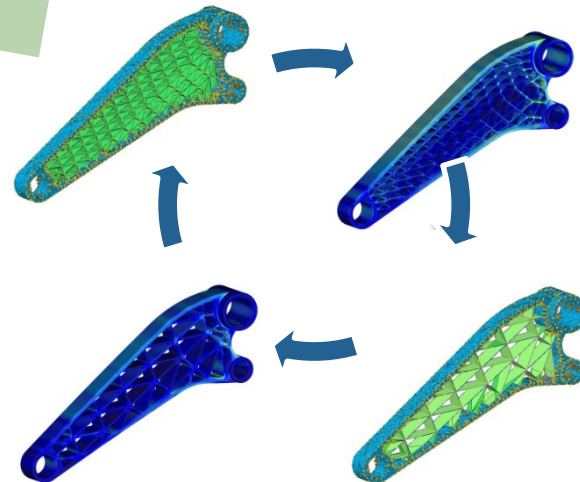
Model Preparation  
e.g. define the interior



Tray placement



Printability Checking  
e.g. thin walls



3D Printer

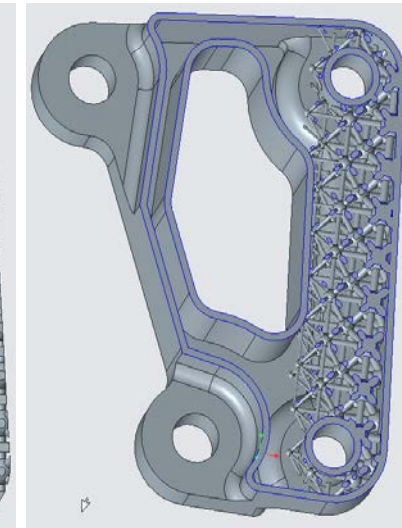
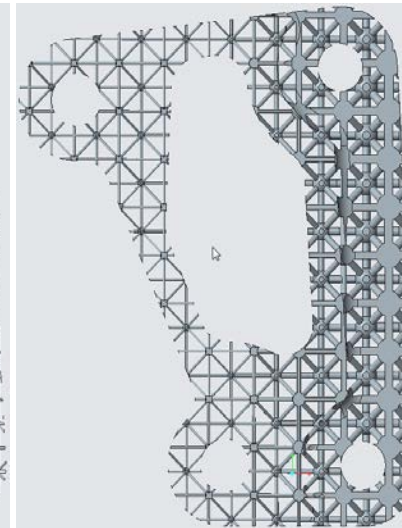
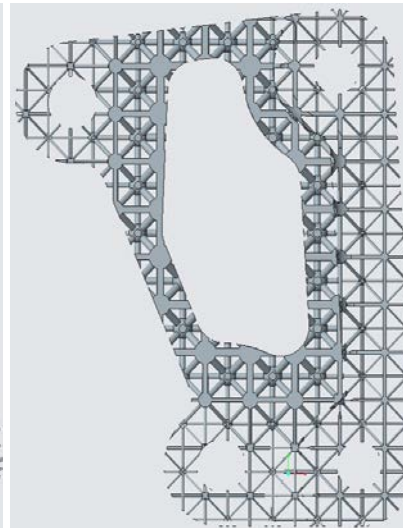
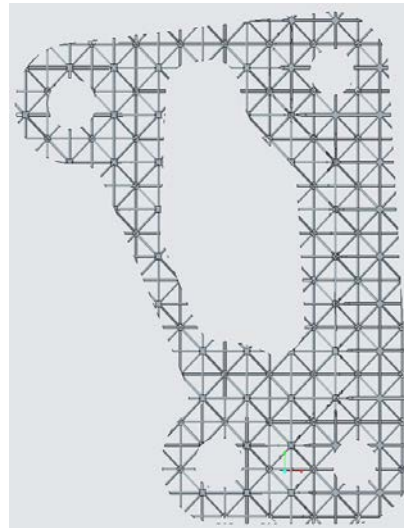
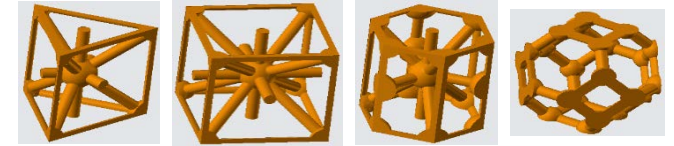
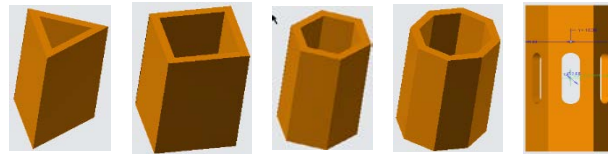
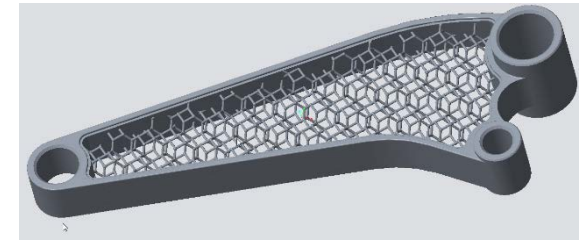
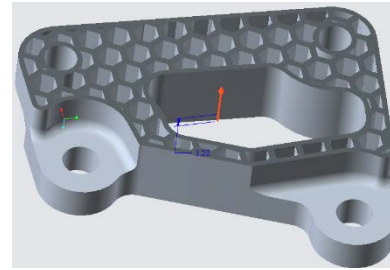
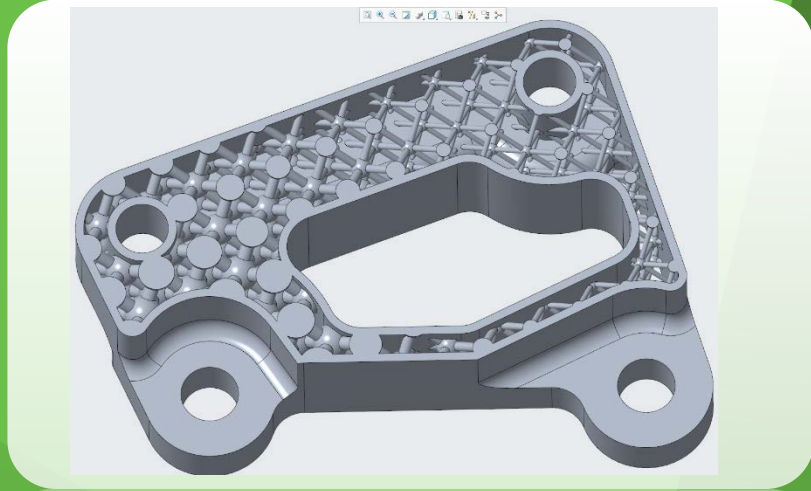
CAD Domain



Goal: To bring the knowledge of **Additive Manufacturing capabilities** early into the design process

# Lattices for 3D printing

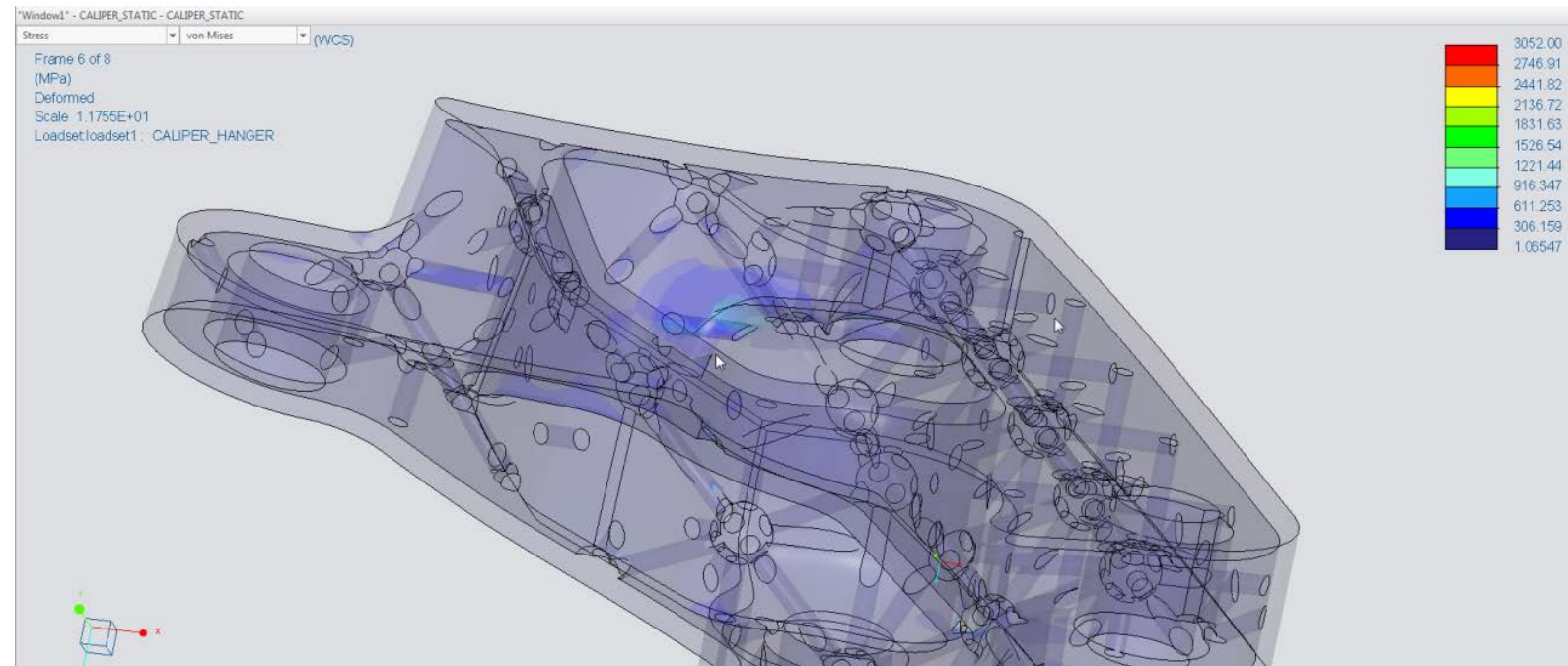
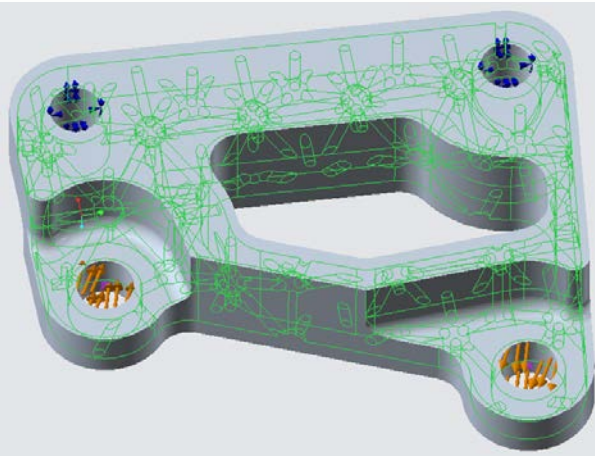
2 ½ D LATTICES  
 3D LATTICES  
 CONTROL ON 3D LATTICES



## Creo Simulate can drive the lattice definition

- The lattice feature can be analyzed and optimized using Creo simulate
- The lattice feature parameters are exposed to be used along Behavioral Modeling experiments

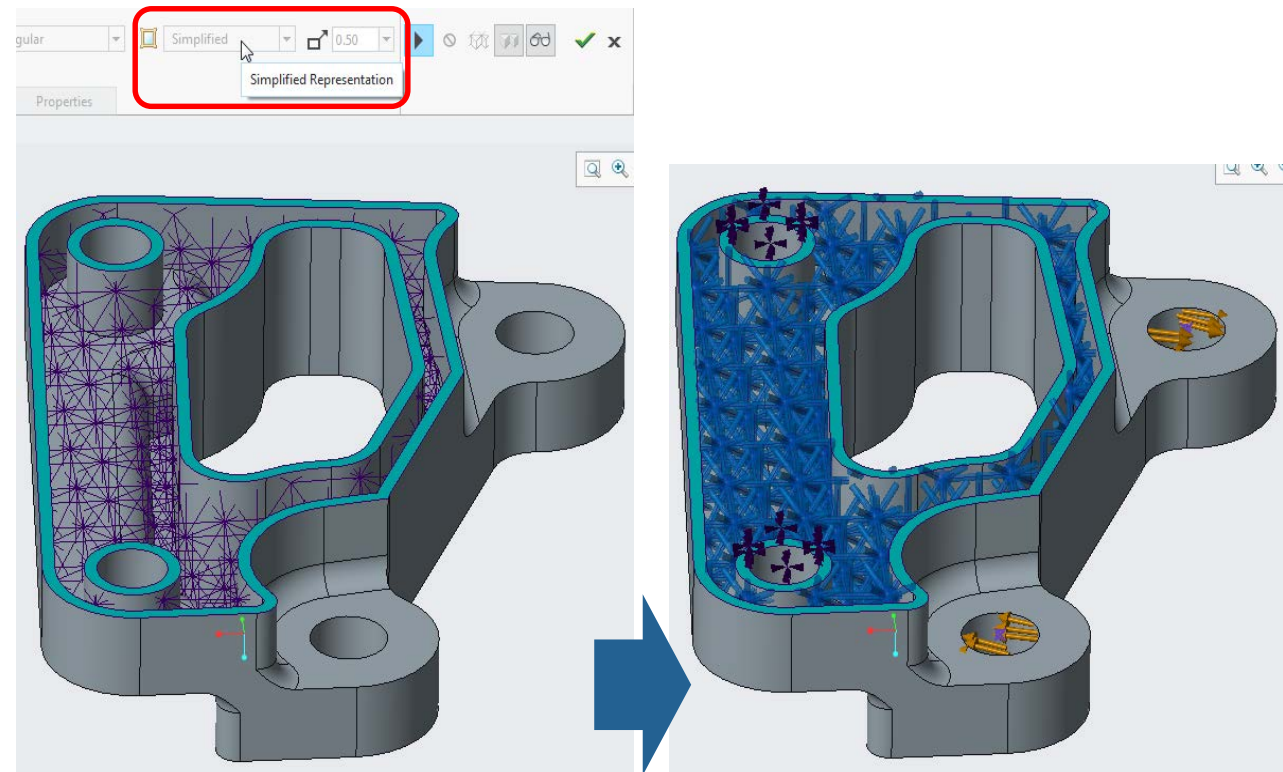
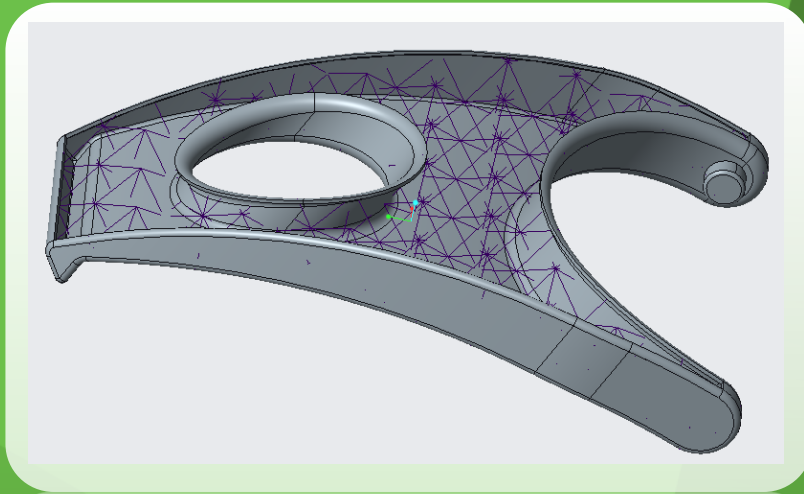
ANALYSIS RESULTS  
IDEALIZED ELEMENTS  
FULL GEOMETRY



## Lattices analysis and optimization

- Idealized elements
  - Automatic conversion of the lattice into beams, masses and shells.
  - Faster results, lightweight geometry transfer to Creo Simulate

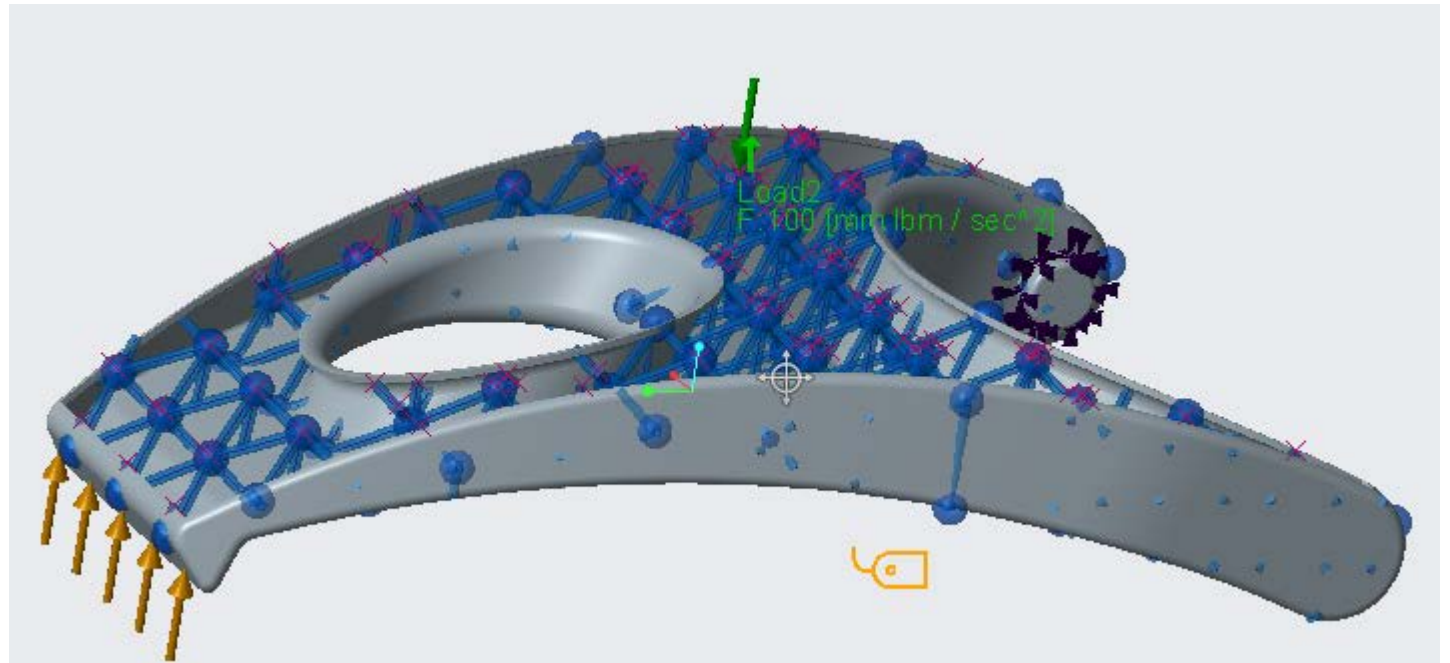
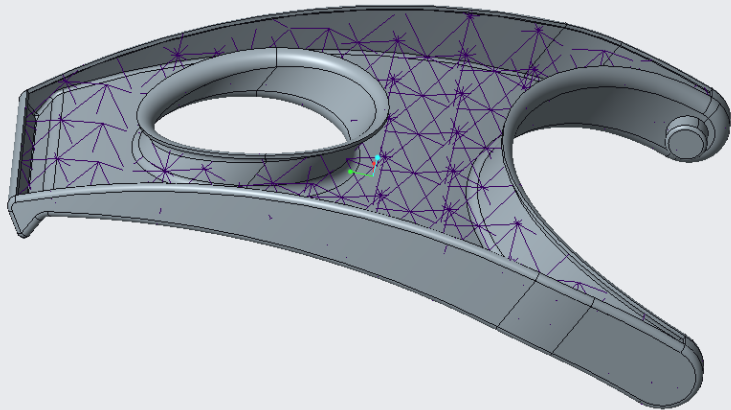
ANALYSIS RESULTS  
 IDEALIZED ELEMENTS  
 FULL GEOMETRY



## Lattices analysis and optimization

- Fine control over where to apply loads and constraints into the Lattice feature
  - Each beam end-point have a datum point assigned on the open side of the lattice
  - Those datum points can be used to define the load and constraints

ANALYSIS RESULTS  
IDEALIZED ELEMENTS  
FULL GEOMETRY

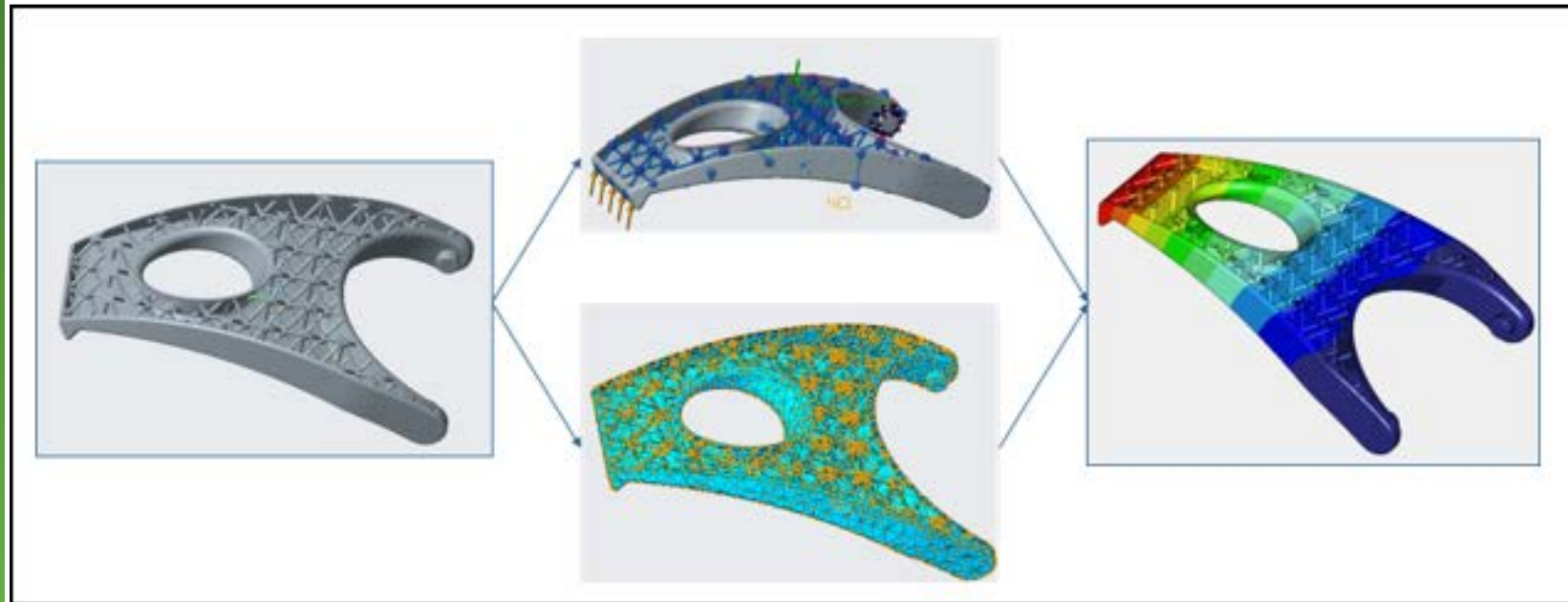
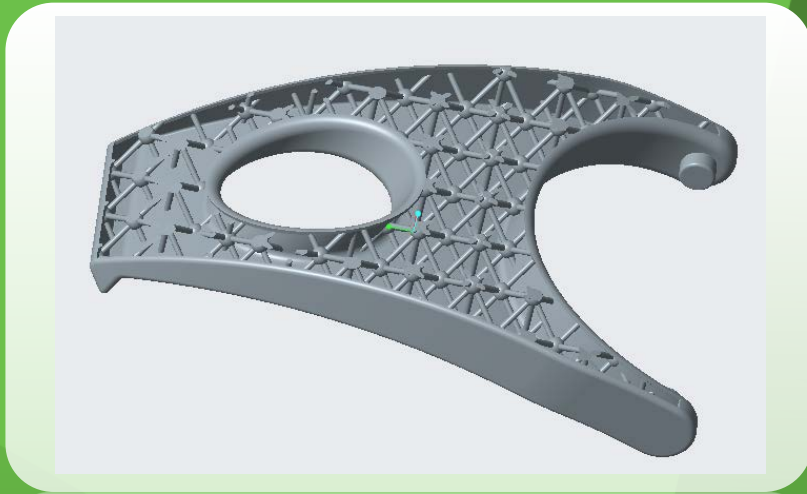




## Lattices analysis and optimization

- Full geometry
  - Use the mesher capabilities of Creo Simulate
  - More refined model, ideal for the final optimization cycle

ANALYSIS RESULTS  
IDEALIZED ELEMENTS  
FULL GEOMETRY





ptc