

PTC Mathcad: Product Update and Roadmap

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- Why PTC Mathcad?
- What is PTC Mathcad?
- Release Schedule
- PTC Mathcad Express
- PTC Mathcad Prime 3.0
- Beyond Prime 3.0

Why PTC Mathcad?

Some primary themes

Symptom

Failures across extended /
diverse engineering teams

Slow / inaccurate development
of *new* designs

Inefficiency / duplication during
derivative designs

Loss of expertise / competitive
advantage

Possible root cause

Unit errors between
heterogeneous design tools

Inefficient application of design
best-practices

Limited re-use of previous,
proven engineering analyses

Analyses are trapped in
intangible / unusable forms

- Possible root cause

- Unit errors due to exchanging values without units across tools and team

$$fx = A2 * B2$$

D

	A	B	C
1	F	l	T
2	2800	7	19600
3			

$$fx = A2 * B2 * 0.0254$$

D E

	A	B	C
1	F (kN)	l (in)	T (kN*m)
2	2800	7	497.84
3			

- PTC Mathcad solution

- Explicit unit handling throughout calculations with automatic unit conversion

$$F := 2800 \text{ kN}$$

$$F = (6.295 \cdot 10^5) \text{ lbf}$$

$$l := 7 \text{ in}$$

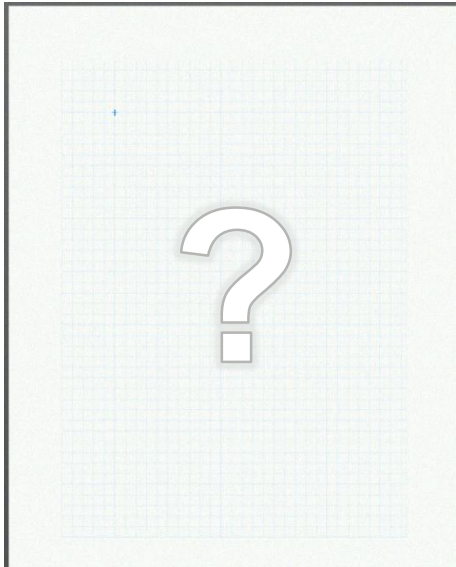
$$l = 17.78 \text{ cm}$$

$$T := l \cdot F$$

$$T = (3.672 \cdot 10^5) \text{ ft}\cdot\text{lbf}$$

$$T = 497.84 \text{ kN}\cdot\text{m}$$

- Possible root cause
 - Inefficient application of design best-practice



- PTC Mathcad solution
 - New design best-practice using standard design procedure implemented as PTC Mathcad example worksheets and templates

Compression Spring Design

Wire Dia. Mean Dia.
Wire Dia. Mean Dia.
Wire Dia. Mean Dia.
Wire Dia. Mean Dia.

Compression Spring Design

A helical spring is made up of a wire coiled in the form of a helix and primarily intended for compressive or tensile loads. The cross-section of the wire from which the spring is made may be circular, square or rectangular.

The major stresses produced in helical springs are shear stresses due to twisting. The load applied is parallel to or along the axis of the spring. In open coiled helical springs, the spring wire is coiled in such a way that there is a gap between the two consecutive turns, as a result of which the helix angle is large.

Spring variable definitions:

Number of Active Coils:	$N_{coil} = 20$	$N_{coil} = 20$
Diameter of the wire:	$d_{wire} = 6.1 \text{ mm}$	$d_{wire} = 6.1 \text{ mm}$
Coil diameter:	$D_{coil} = 29.9 \text{ mm}$	$D_{coil} = 29.9 \text{ mm}$
Outer diameter:	$D_{outer} = D_{coil} + d_{wire} = 36 \text{ mm}$	
Shear modulus:	$G = 77.2 \cdot GPa = (1.12 \cdot 10^7) \text{ psi}$	
Force on the spring:	$F_{spring} = \frac{1}{2} (250 \text{ kg} \cdot g) = 1.226 \text{ kN}$	

- Possible root causes

- Limited re-use of previous, proven engineering analyses
- Analyses are trapped in intangible / unusable forms

$$= (\$B\$1 * \$D\$1 / 2) * ((\text{PI}()) * \$F\$1 * \$D\$1 - \$H\$1) / (\text{PI}() * \$D\$1 + \$F\$1 * \$H\$1) + \$B\$1 * \$F\$2 * \$D\$2 / 2$$

```

47 L:=2*pi*r*tau_d/2/G from F (-x direction)
48 f:=M/L: %moment at G caused by applied force          %2.2E in
49 M=F*L: %moment at G caused by applied force          %5.0E lbf
50 f:=M/L: %moment at G caused by applied force          %2.2E in
51 disp('N.B. Moment is positive, thus counterclockwise'),
52 tau_d:=F/(A1+A2): %direct Shear stress
53 f:=M/L: %moment at G caused by applied force          %2.2E in
54 tau_t1=M*r1/J: %torsional shear stress on bolt one
55 f:=M/L: %moment at G caused by applied force          %2.2E in
56 tau_t2=M*r2/J: %torsional shear stress on bolt two
57 f:=M/L: %moment at G caused by applied force          %2.2E in
58 tau_R1:=sqrt(tau_d^2+tau_t1^2): %R
59 f:=M/L: %moment at G caused by applied force          %2.2E in
60 tau_R2:=sqrt(tau_d^2+tau_t2^2): %R
61 f:=M/L: %moment at G caused by applied force          %2.2E in
62 if tau_R2>tau_R1 %resultant shear
63   tau_R:=tau_R2:
64 else tau_R:=tau_R1:
65 end;

```

```

if (Cancel(worker, e)) return;
int x = (int)((p.X - args.axesBounds.Left) * scaleX);
int y = (int)(args.imageBounds.Height - (p.Y - args.axesBounds.Top) * scaleY);
int index = (y * offset + x);
if (index < pixels.Length)
{
  UInt32 alpha = ((pixels[index] & 0xFF000000) >> 24) + args.alpha;
  if (alpha > 0xFF) alpha = 0xFF; // limit to max
  UInt32 rgba = (args.rgb & 0x00FFFFFF) | (alpha << 24); // redo
  pixels[index] = rgba;
  pixelCount[index]++;
  if (pixelCount[index] > maxPixelCount) maxPixelCount = pixelCount[index];
}
};
if (Cancel(worker, e)) return;
Parallel.For(0, pixels.Length - 1, index =>
{
  if (Cancel(worker, e)) return;
  if (pixelCount[index] > 0)

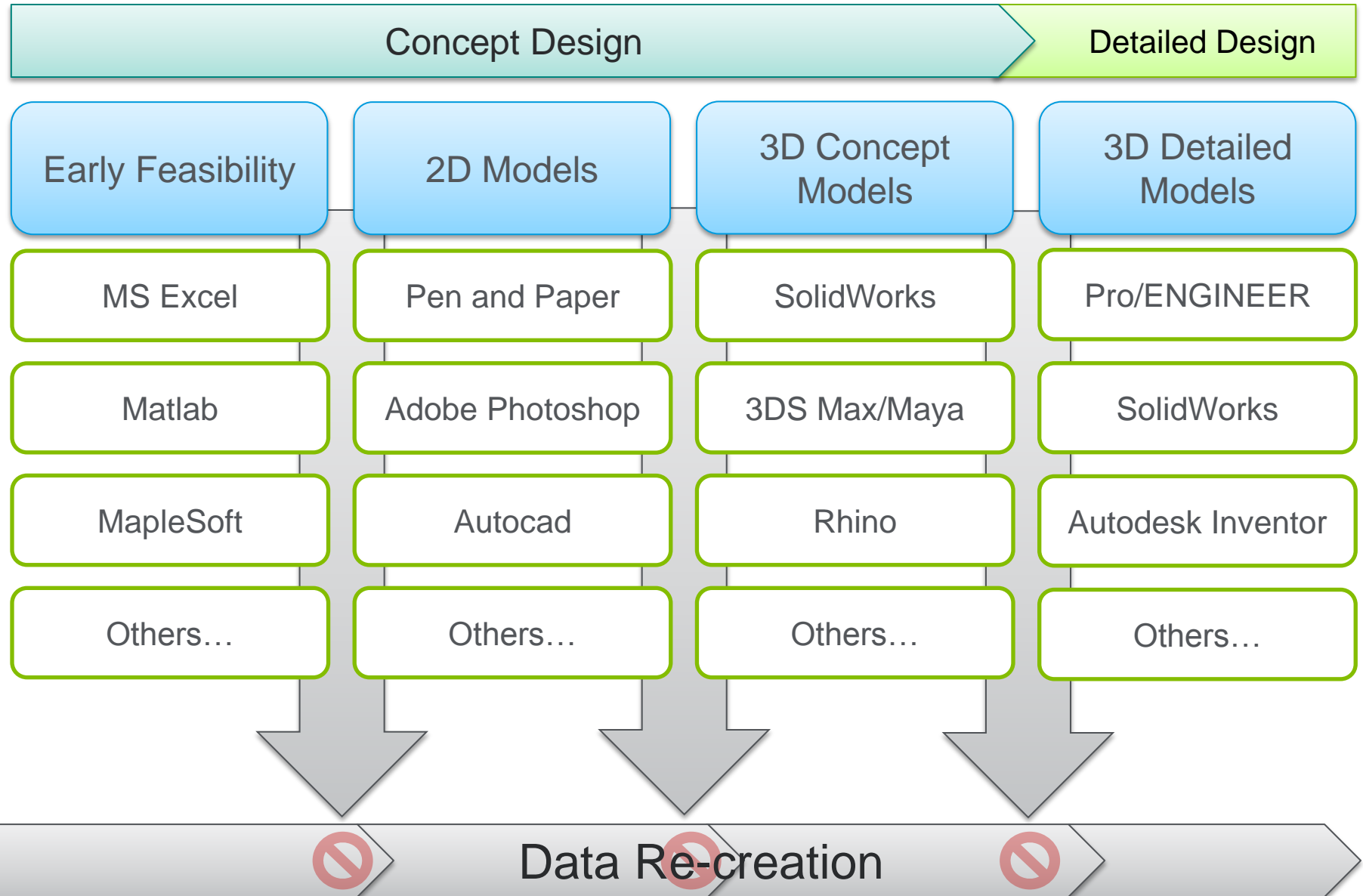
```

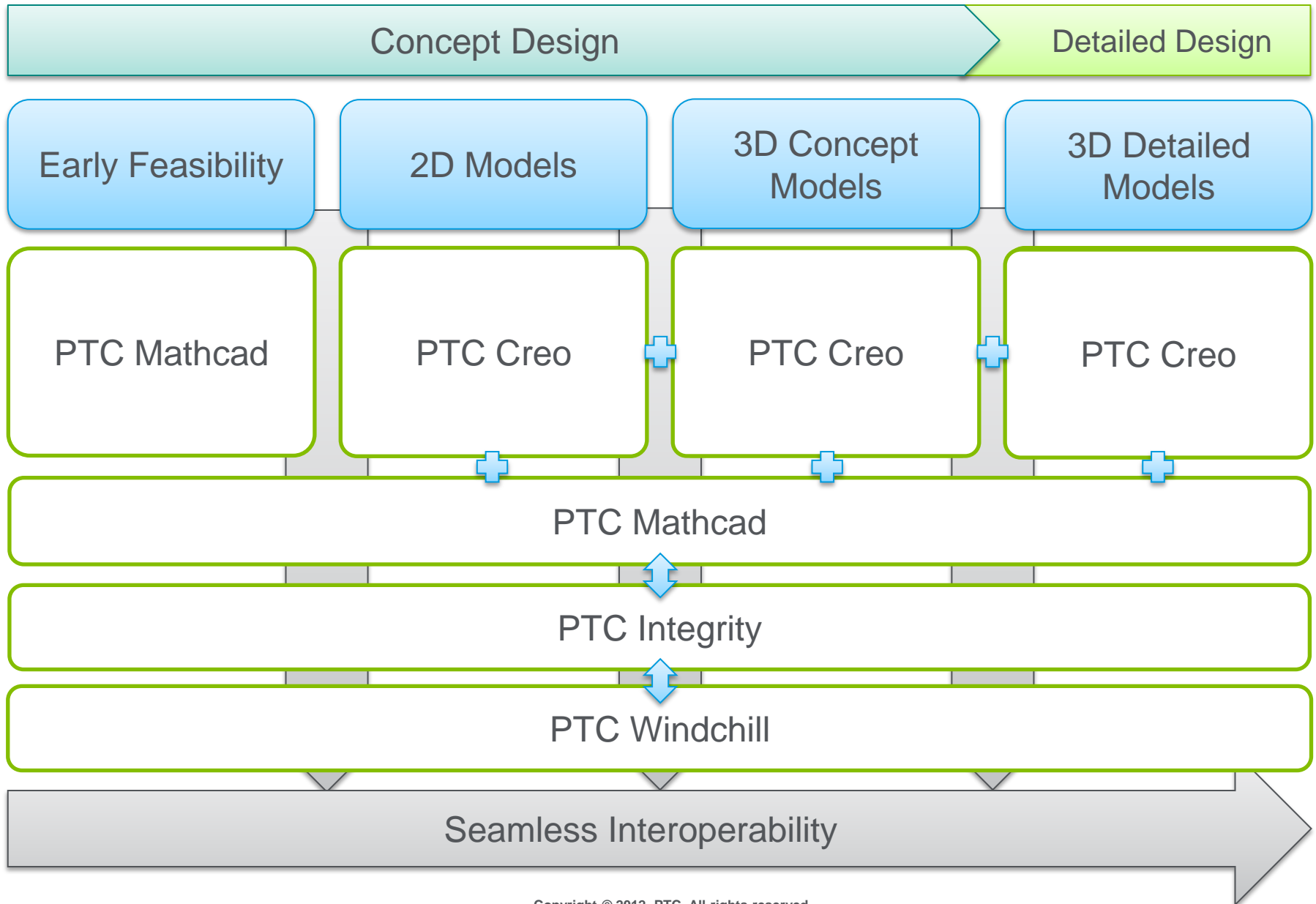
- PTC Mathcad solution

- Live, calculating, *readable* documents
- Use of natural math notation
- Inclusion of text, math and graphics in single document

The screenshot displays a PTC Mathcad document titled "DATA ANALYSIS Example". It includes a table of data points, a graph showing a fitted curve to the data, and a table of material properties for A36 steel. The graph plots stress (σ) in MPa against thickness (t) in cm. The table lists properties for A36 steel, including yield strength (σ_y = 250 MPa), ultimate strength (σ_u = 415 MPa), and modulus of elasticity (E = 200 GPa).

Property	Value
Yield Strength (σ _y)	250 MPa
Ultimate Strength (σ _u)	415 MPa
Modulus of Elasticity (E)	200 GPa
Yield Strength (σ _y)	36.2 ksi
Ultimate Strength (σ _u)	59.8 ksi
Modulus of Elasticity (E)	29.0 Msi





A system engineering view of a product development timeline

Challenge #1

Can we solve these market requirements?

Challenge #2

Does detailed CAD design meet subsystem requirements?

Challenge #3

How can I re-apply complex design theory actively to my CAD geometry?

Challenge #4

After the 3D modeling is done, do we know that it will uphold the system level requirements?

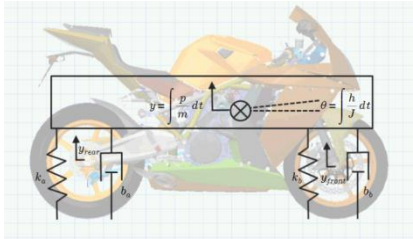
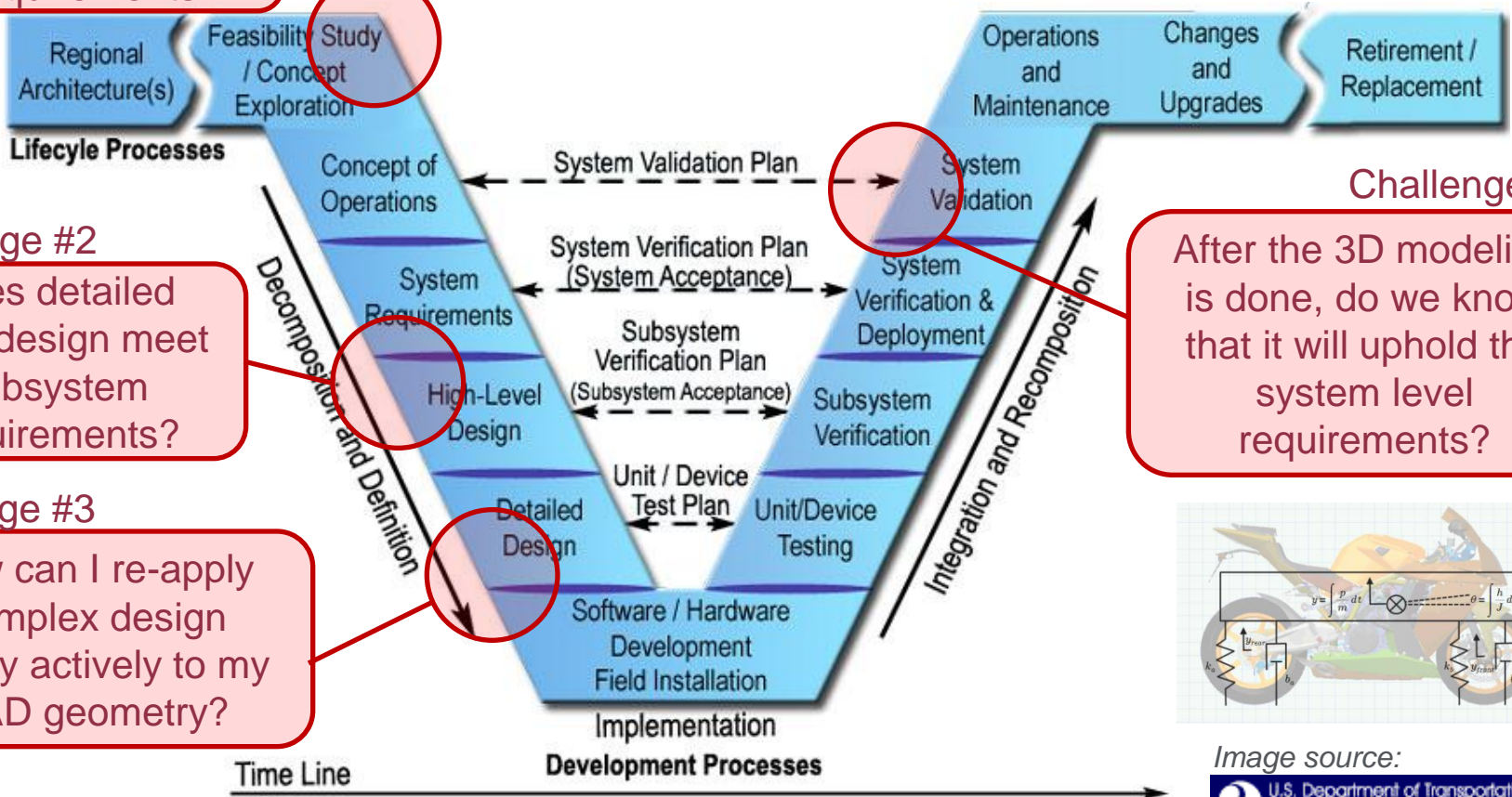


Image source:

A system engineering view of a product development timeline

Scenario #1

Perform early feasibility studies

Scenario #2

Verify subsystem operation, using CAD geometry

Scenario #3

Re-apply design guidelines to create known-good CAD configurations

Scenario #4

System validation performed on entire CAD assembly to ensure operational requirements are met

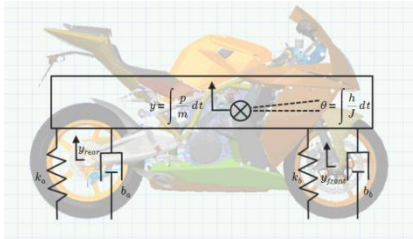
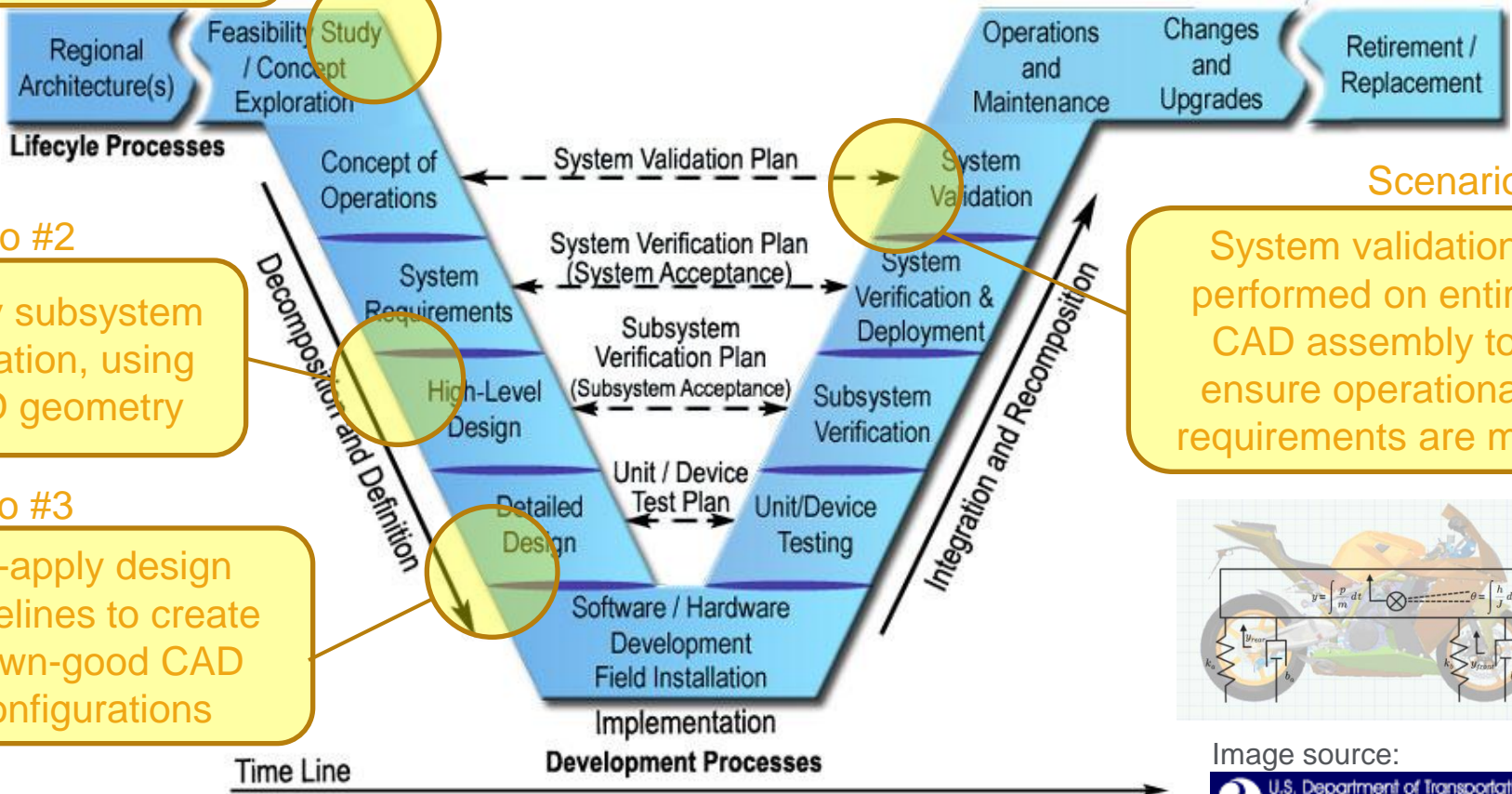


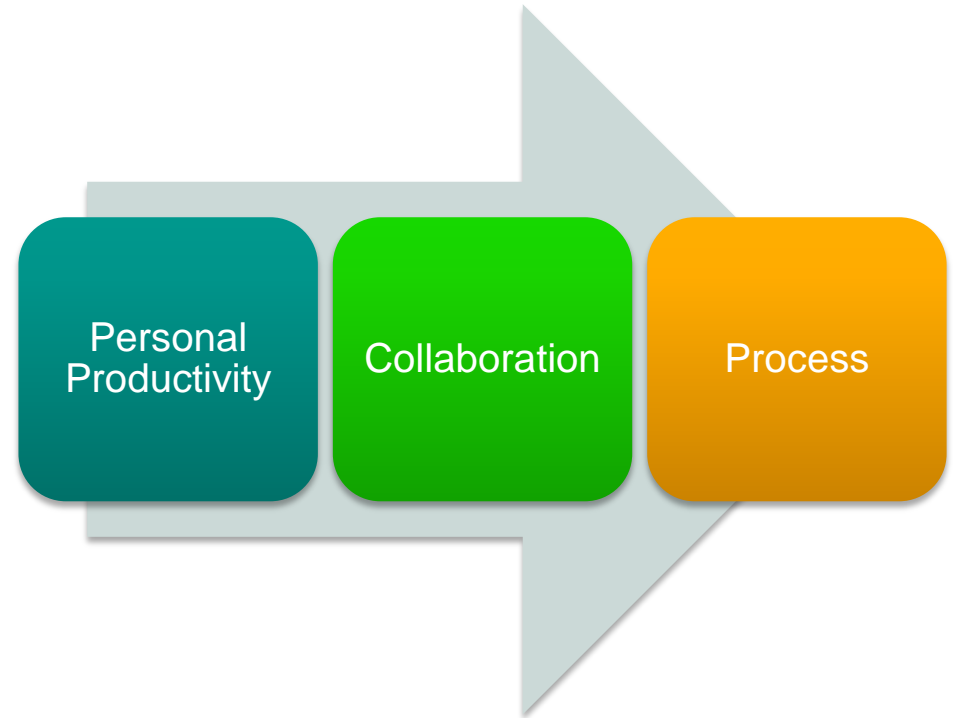
Image source:

PTC Mathcad Prime

Product Strategy Review

PTC Mathcad has been an established product in the market since late 80's. Why re-invent it?

- **PTC Mathcad as de-facto standard for engineering calculations**
 - Personal productivity
 - Collaboration
 - Process
- **Market trends**
 - Support IP capture and standardization
 - New workforce
- **User expectations**
 - Modern UI
 - Easy to learn
 - Focus on engineering (not programming)
- **Technology Trends**
 - Keeping up with Microsoft technology
- **Challenge**
 - Satisfy needs of existing and new users



- **User Experience: New User Interface (UI)**

- Completely rewritten UI (15 minute problem)

- Modern look and feel
- Usability, discovery, learnability
- Task oriented
- Document centric

ISO 261 specifies a detailed list of preferred combinations of outer diameter D and pitch P for ISO metric screw threads

$$A_{\text{surface}} = \frac{2 \pi (D-d) \cdot l}{p \cdot \cos\left(\frac{A}{2}\right)}$$

Note: Preferred combinations of Nominal Diameter and Thread Pitch are defined in the collapsed area below:

Expand the area to view its contents. Press F1 for help.

$l := 100 \text{ mm}$ l = Length of threaded part of bolt

$A := 60 \text{ deg}$ A = Thread angle (60deg for ISO)

D_{nom} Nominal diameter(m) and coarse thread pitch (unitless) values are used from hidden table above:

P_{coarse}

Total surface area is calculated for each bolt combination and plotted:

$$SA(i) := \frac{2 \pi \cdot (D_{\text{nom}_i} - d) \cdot l}{P_{\text{coarse}_i} \cdot \cos\left(\frac{A}{2}\right)}$$

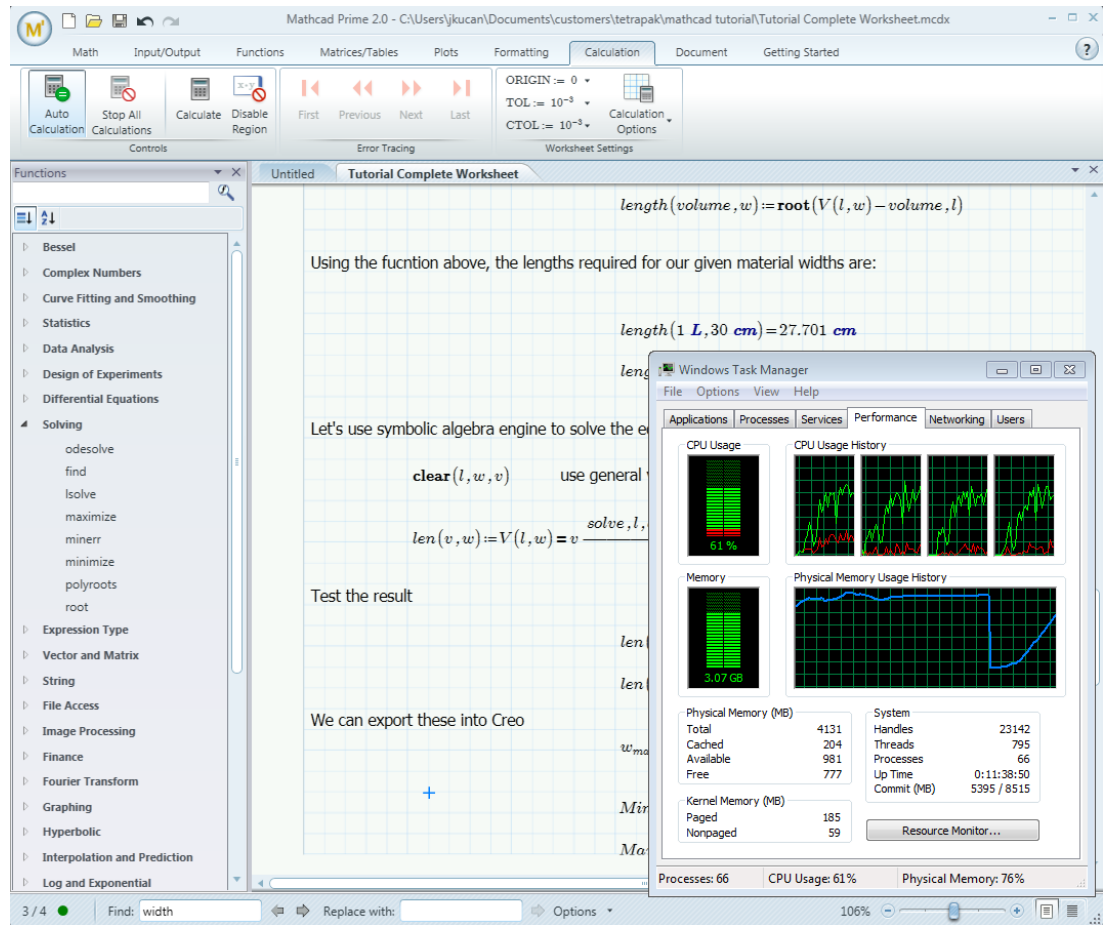
For example, set: $ex := 8$

Nominal diameter:
 $D_{\text{nom}_{ex}} = 4 \text{ mm}$

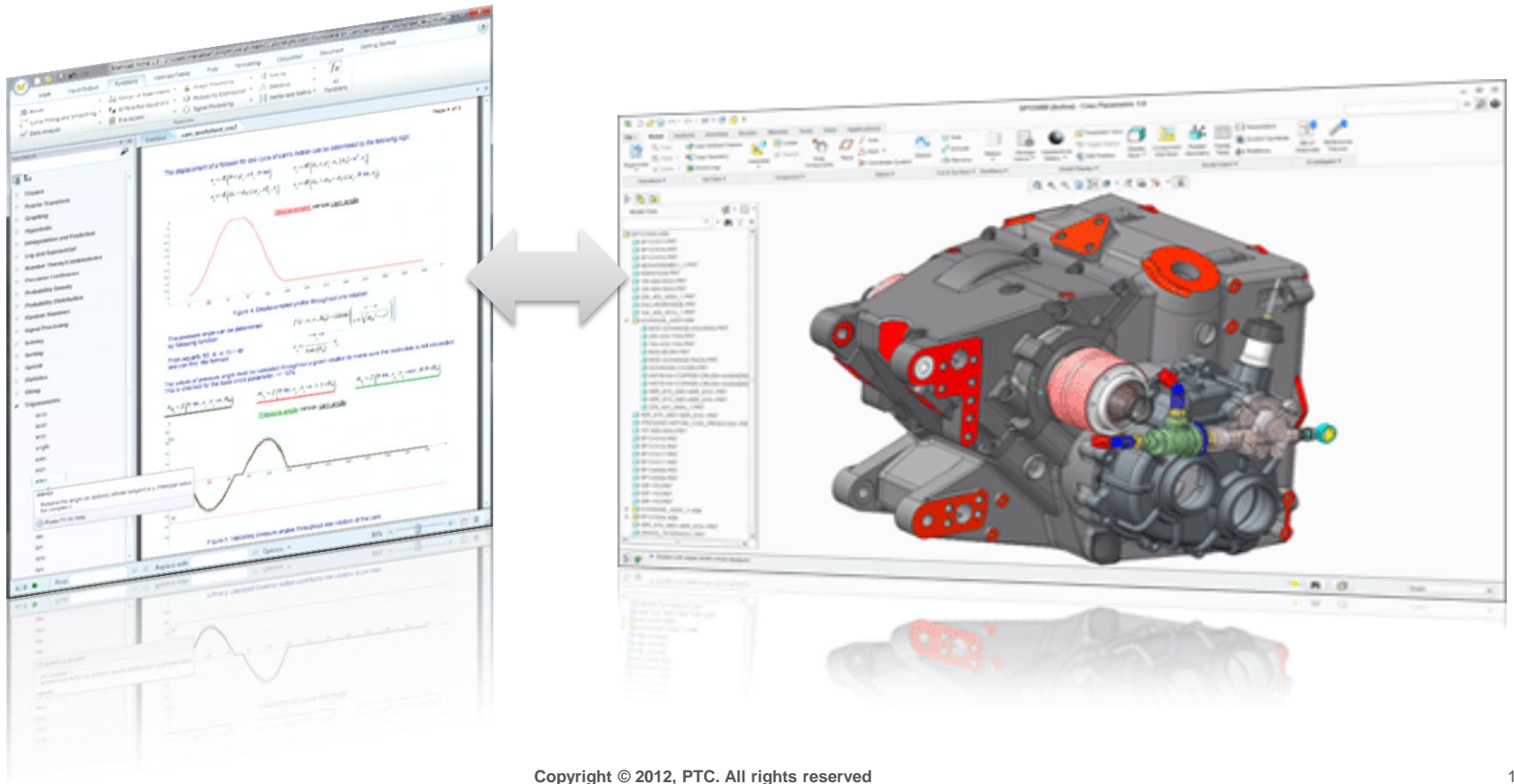
Thread pitch:
 $P_{\text{coarse}_{ex}} = 0.7$

Total surface area:
 $SA(ex) = 32.545 \text{ cm}^2$

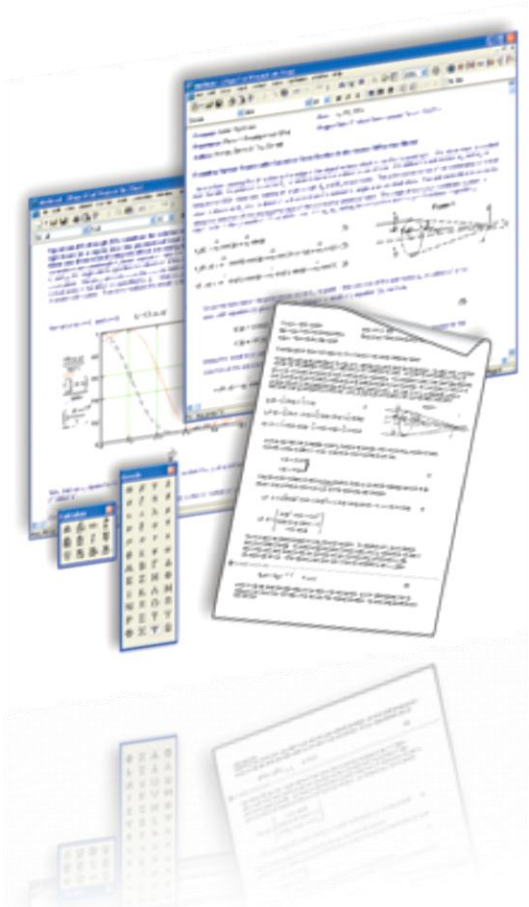
- Computational Power: PTC Mathcad Calculation Engine
 - Major improvements the PTC Mathcad calculation engine
 - Robust and flexible unit checking
 - 64bit
 - Multi-threading
 - Enhanced to numerics



- Integration: Working within Engineering Ecosystem
 - Integrating with CAD (e.g. PTC Creo)
 - Integrating with requirements management (e.g. PTC Integrity)
 - Open architecture



- Content: Preserving Intellectual Property
 - Standards-based format
 - Conversion from prior versions



Mathcad Prime interface showing a technical diagram with flow variables (F1, F2, F3, W1, W2, W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13, W14, W15, W16, W17, W18, W19, W20, W21, W22, W23, W24, W25, W26, W27, W28, W29, W30, W31, W32, W33, W34, W35, W36, W37, W38, W39, W40, W41, W42, W43, W44, W45, W46, W47, W48, W49, W50, W51, W52, W53, W54, W55, W56, W57, W58, W59, W60, W61, W62, W63, W64, W65, W66, W67, W68, W69, W70, W71, W72, W73, W74, W75, W76, W77, W78, W79, W80, W81, W82, W83, W84, W85, W86, W87, W88, W89, W90, W91, W92, W93, W94, W95, W96, W97, W98, W99, W100) and associated equations.

Mathcad Prime interface showing mathematical derivations and equations, including a differential equation: $\frac{d^2x}{dt^2} + \frac{d^2y}{dt^2} = 0$.

Данные по численности популяций взяты из http://www.rohan.sdsu.edu/~mahaffy/courses/100/math122/lectures/qual_de2/qualde2.html

data	0	1	2
0	0	5939	30610
1	1	7310	47513

$$t_m := \text{data}^{(0)} \quad h_m := \text{data}^{(1)} \quad h_m := \text{data}^{(2)}$$

$$i := 0 \dots \text{rows}(t_m) - 1$$

$$F_1 := H \quad \text{fitF}_1(x) := \text{interp}(\text{pspline}(t_m, F_1), t_m, F_1, x)$$

$$F_2 := (H, L) \quad \text{fitF}_2(x) := \text{interp}(\text{cspline}(t_m, F_2), t_m, F_2, x)$$

$$F_3 := L \quad \text{fitF}_3(x) := \text{interp}(\text{cspline}(t_m, F_3), t_m, F_3, x)$$

$$\psi_1 := \text{IntF}_1(t_m) \quad \psi_2 := \text{IntF}_2(t_m) \quad \psi_3 := \text{IntF}_3(t_m)$$

$$\begin{pmatrix} k_1 \\ k_2 \\ k_3 \end{pmatrix} := \begin{pmatrix} 0.543832626812794 \\ 2.37764607122829 \times 10^{-5} \\ 0.881264030691851 \end{pmatrix} \quad \text{Given } H = k_1 \psi_1 - k_2 \psi_2 + H_0 \quad L = k_2 \psi_2 - k_3 \psi_3 + L_0$$

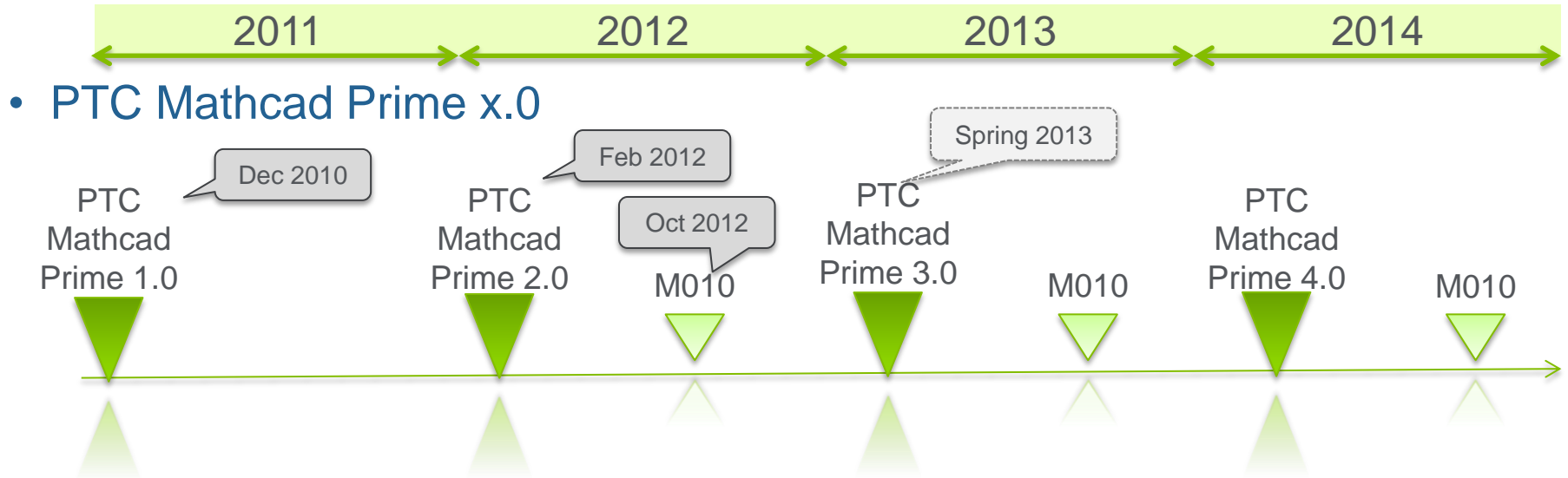
$$\begin{pmatrix} k_1 \\ k_2 \\ k_3 \end{pmatrix} := \text{Minerr}(k_1, k_2, k_3) \begin{pmatrix} k_1 \\ k_2 \\ k_3 \end{pmatrix} = \begin{pmatrix} 0.543832626812794 \\ 2.37764607122829 \times 10^{-5} \\ 0.881264030691851 \end{pmatrix}$$

$$f(t, x) := \begin{pmatrix} k_1 x_0 - k_2 x_0 x_1 \\ k_2 x_0 x_1 - k_3 x_1 \end{pmatrix} \quad S_m := \text{rkfwd}((H_0, L_0)^T, 0, \max(t_m), \max(t_m) - 10, f)$$

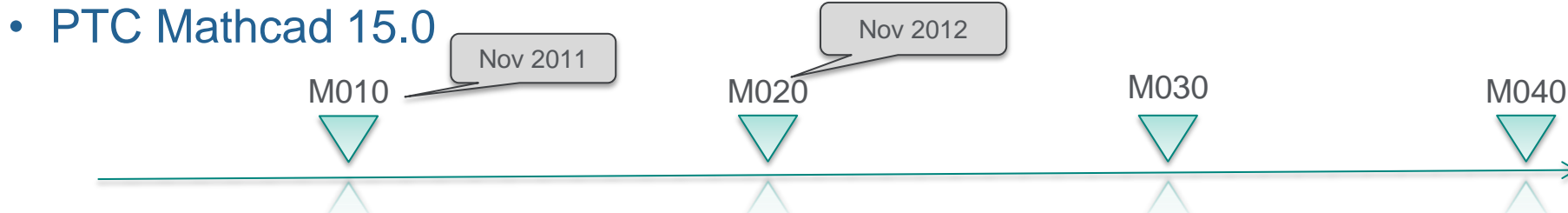
Product Schedule

Milestones

- 
- Nov 2011: PTC Mathcad 15.0 M010
 - Feb 2012: PTC Mathcad Prime 2.0
 - Oct 2012: PTC Mathcad Express/PTC Mathcad Prime 2.0 M010
 - Nov 2012: PTC Mathcad 15.0 M020
 - Planned...
 - Jan 2013: PTC Mathcad Prime 3.0 *alpha*
 - Spring 2013: PTC Mathcad Prime 3.0
 - ...



- Yearly major releases with new functionality
- Maintenance releases to address customer-reported issues



- Maintenance releases to address customer-reported issues
- No new features

Roadmap

Tools for engineers

- Integration with Excel
- Performance
- Enhanced Numerics
- Symbolics
- Document Organization

The screenshot displays the Mathcad Prime 2.0 interface. The main window shows a table titled "Universal Beams to BS4 Part 1 1993" with columns for ID, Mass per metre (M), Section Depth (h), Section Width (b), Thickness of Web (s), Thickness of Flange (t), Root Radius (r), and Depth between fillets (d). Below the table, there is a 3D plot of a beam cross-section with dimensions: $t = 100 \text{ mm}$, $r = 145 \text{ mm}$, $h = 500 \text{ mm}$, $d = 10 \text{ mm}$, and $s = 200 \text{ mm}$. The plot shows a rectangular cross-section with a fillet at the bottom corners. To the right of the plot, the moment of inertia is calculated as $I = \frac{b \cdot h^3 - (d + 2r)^3 (b - d)}{12} = (6.983 \cdot 10^8) \text{ cm}^4$. The length is given as $L = (1 \cdot 10^4) \text{ mm}$ and the height as $h = 500 \text{ mm}$.

The screenshot shows a Microsoft Excel spreadsheet with the same data as the Mathcad interface. The table is titled "Universal Beams to BS4 Part 1 1993" and contains the following data:

ID	Mass per metre M kg/m	Section Depth h mm	Section Width b mm	Thickness of Web s mm	Thickness of Flange t mm	Root Radius r mm	Depth between fillets d mm
419388	388	921	420.5	21.4	36.6	24.1	799.6
419343	343.3	911.8	418.5	19.4	32	24.1	799.6
305289	289.1	926.6	307.7	19.5	32	19.1	824.4
305253	253.4	918.4	305.5	17.3	27.9	19.1	824.4
305224	224.2	910.4	304.1	15.9	23.9	19.1	824.4
305201	200.9	903	303.3	15.1	20.2	19.1	824.4
292226	226.5	850.9	293.8	16.1	26.8	17.8	761.7
292194	193.8	840.7	292.4	14.7	21.7	17.8	761.7
292176	175.9	834.9	291.7	14	18.8	17.8	761.7
267197	196.8	769.8	268	15.6	25.4	16.5	686
267173	173	762.2	266.7	14.3	21.6	16.5	686
267147	146.9	754	265.2	12.8	17.5	16.5	686
267134	133.9	750	264.4	12	15.5	16.5	686
254170	170.2	692.9	255.8	14.5	23.7	15.2	615.1
254152	152.4	687.5	254.5	13.2	21	15.2	615.1

The screenshot shows a 3D plot of a sphere with a radius of 10 units, centered at the origin of a 3D coordinate system. The axes are labeled x, y, and z. Below the 3D plot, there is a 2D plot of a sine wave with a period of 2π and an amplitude of 1. The plot shows the function $\sin\left(\frac{a}{1.5}\right)$ and $\cos\left(\frac{a}{3}\right)$. The sine wave is plotted against a from $-\pi$ to π . The cosine wave is plotted against a from $-\pi$ to π . The sine wave is labeled $\sin\left(\frac{a}{1.5}\right)$ and the cosine wave is labeled $\cos\left(\frac{a}{3}\right)$. The sine wave is plotted against a from $-\pi$ to π . The cosine wave is plotted against a from $-\pi$ to π . The sine wave is labeled $\sin\left(\frac{a}{1.5}\right)$ and the cosine wave is labeled $\cos\left(\frac{a}{3}\right)$. The sine wave is plotted against a from $-\pi$ to π . The cosine wave is plotted against a from $-\pi$ to π . The sine wave is labeled $\sin\left(\frac{a}{1.5}\right)$ and the cosine wave is labeled $\cos\left(\frac{a}{3}\right)$.

Personal Productivity

Collaboration

Process

PTC Mathcad Express

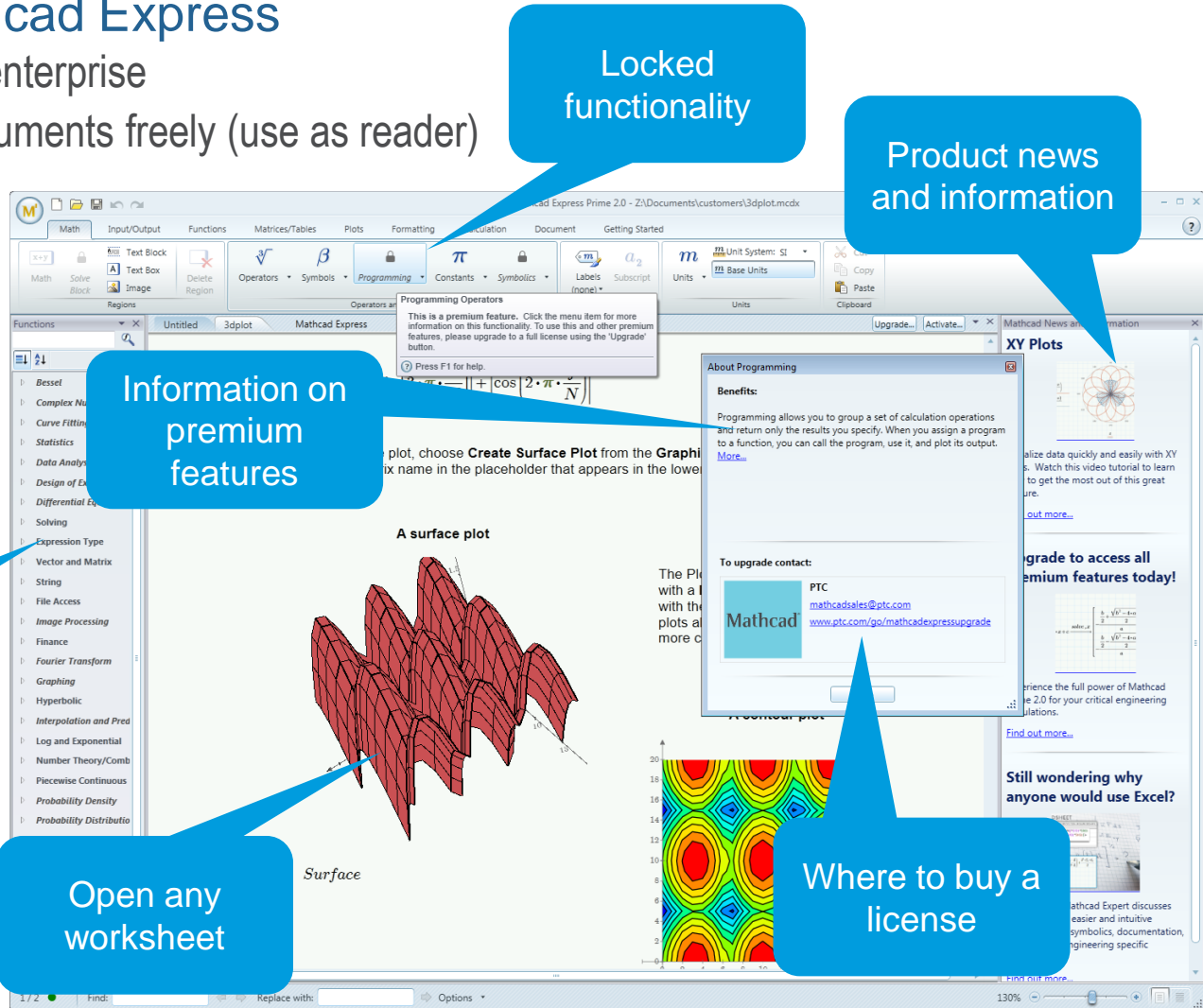
GET IT FREE

	Math Equation Editing	
	Comprehensive Documentation	
	Basic Numeric Functions and Operators	
	Units	
	X-Y Plots	
	Advanced Numeric Functions	
	Programming	
	Symbolics	
	Excel Integration	
	Advanced Plot Types	

PTC Mathcad Prime 2.0

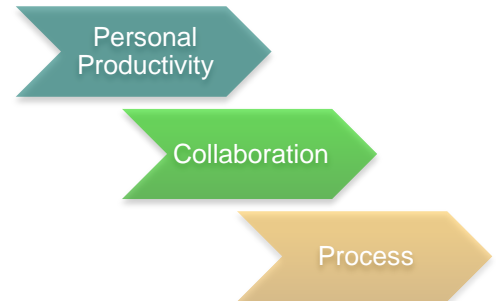
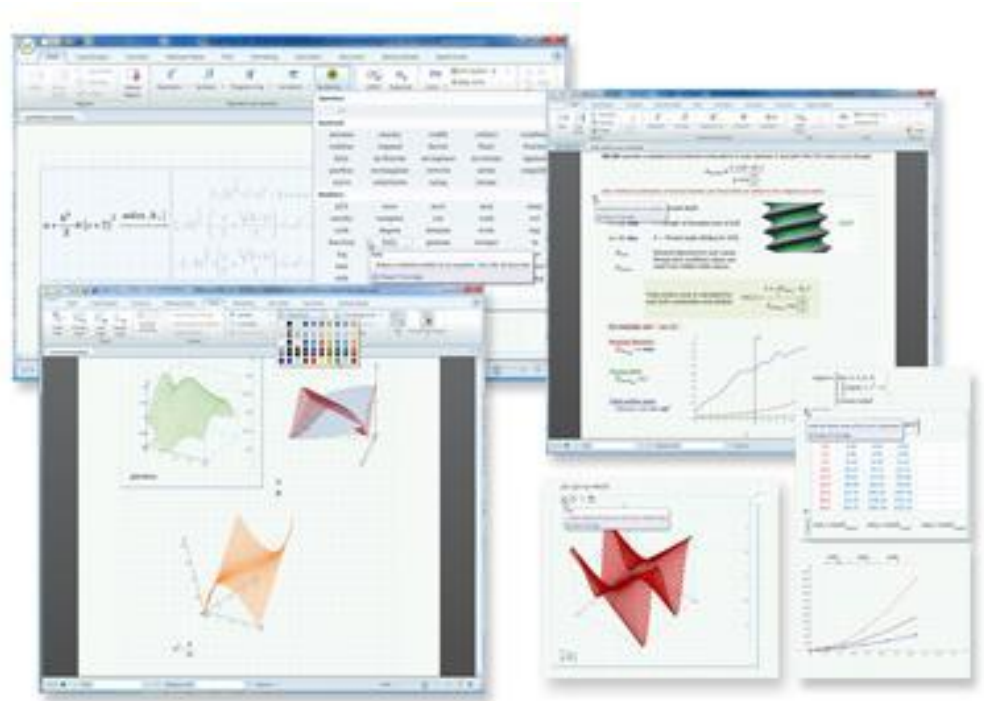
	Math Equation Editing	
	Comprehensive Documentation	
	Basic Numeric Functions and Operators	
	Units	
	X-Y Plots	
	Advanced Numeric Functions	
	Programming	
	Symbolics	
	Excel Integration	
	Advanced Plot Types	

- Leveraging PTC Mathcad Express
 - Helps adoption across enterprise
 - Exchange Mathcad documents freely (use as reader)
- Benefits of upgrading
 - Advanced features
 - Maintenance
 - Standardization



Designed to...

- **Capture Knowledge**
 - Enhanced document formatting
 - Better conversion fidelity
- **Standardize**
 - Templates
- **Integrate**
 - PTC Creo integration
 - Extension functions (user DLL's)
- **Do more**
 - Enhanced numeric functions
- **Release: Spring 2013**



Detailed feature list

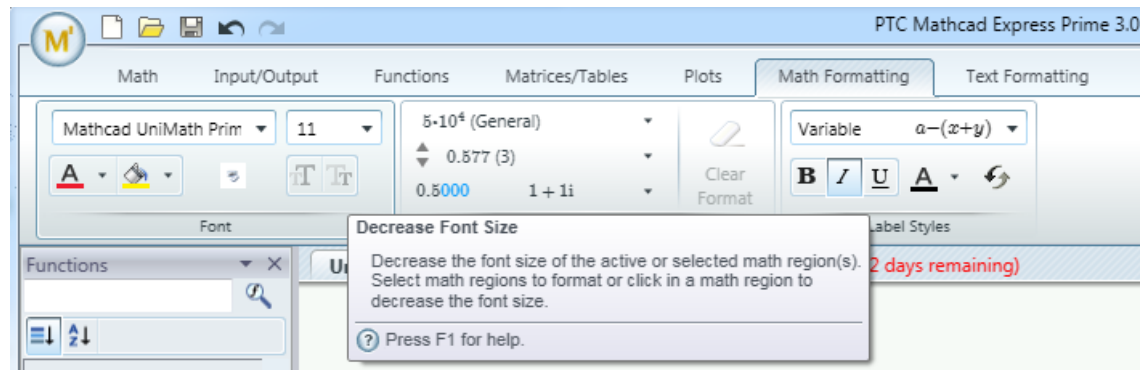
- New features

- Templates
- Inclusion of equations in flowing text
- Formatting of equations (font, color, etc.)
- Global definition operator
- Unconstrained optimization
- LU, QR and Cholesky decomposition functions
- Extension functions (user DLL's) *
- Integration with PTC Creo *

$$k \equiv 37 \frac{N}{m}$$

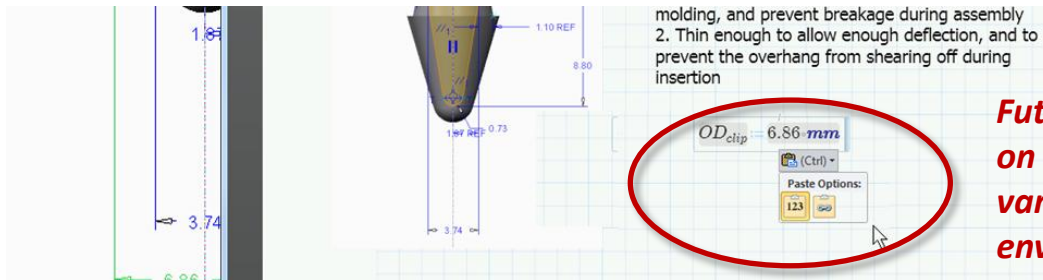
$$f(x) := a \cdot \sin(x)$$

$$g(x) := b \cdot \cos(x)$$



The goal: Tie ‘why’ (PTC Mathcad) to ‘what’ (PTC Creo) data

- PTC Mathcad deployed as a PTC Creo-aware applet (e.g. like the Learning Connector)
- One (or none) embedded PTC Mathcad scratchpad per savable PTC Creo object
- Similar to an OLE object (e.g. like PTC Mathcad’s Excel component)
- PTC Creo Mathcad *is* PTC Mathcad
- PTC Creo Mathcad opens embedded scratchpads *and* external worksheets
- PTC Creo Mathcad can be started and exited independently of PTC Creo
- Awareness: PTC Mathcad indicators in PTC Creo, PTC Creo differentiators in PTC Mathcad
- Ad-hoc copy paste between PTC Creo and PTC Creo Mathcad



Future: create relationships on the fly as results or variables are pasted in either environment

- Building and maintaining parametric model integration will come!

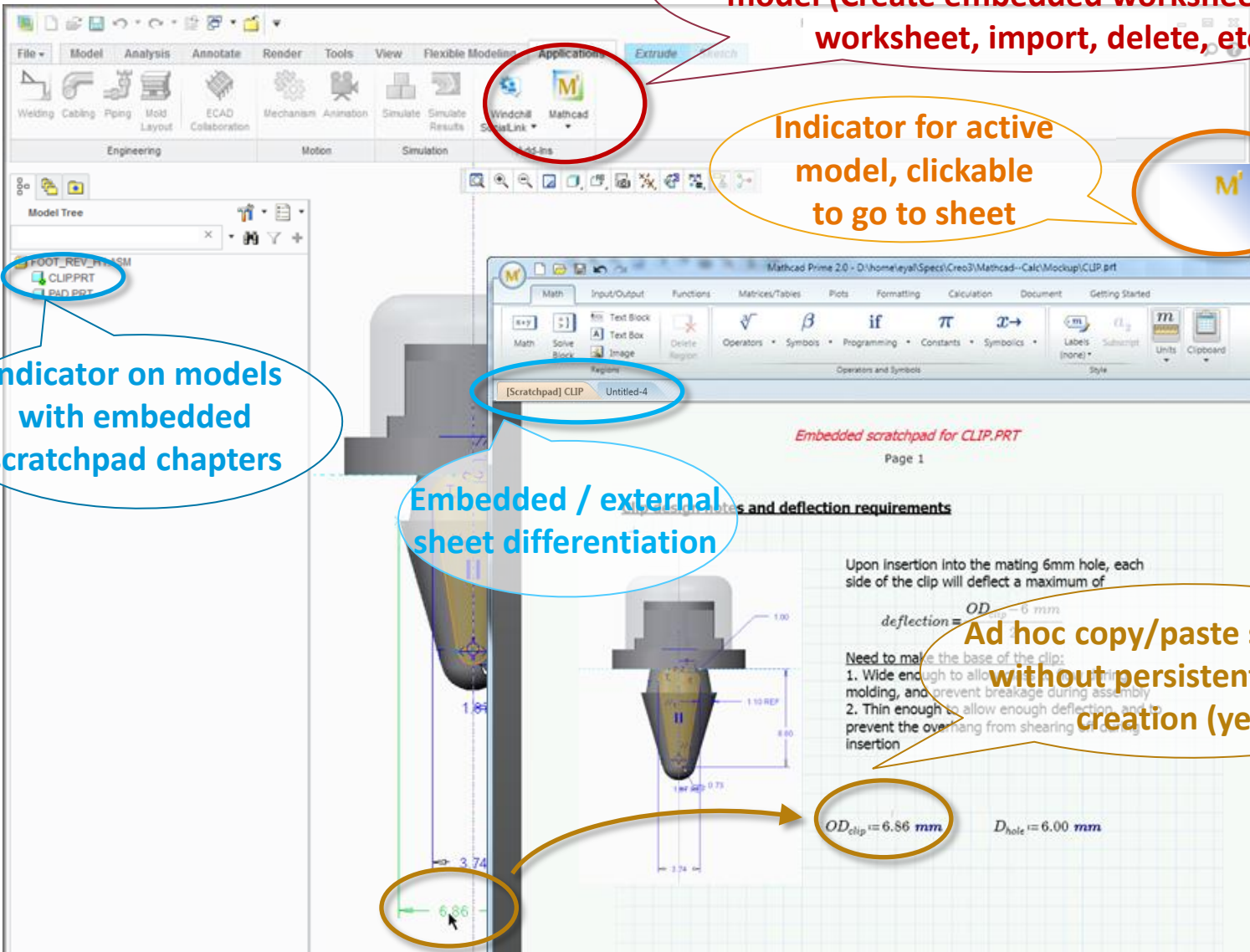
Perform PTC Mathcad operations for the active model (Create embedded worksheet, go to worksheet, import, delete, etc)

Indicator for active model, clickable to go to sheet

Indicator on models with embedded scratchpad chapters

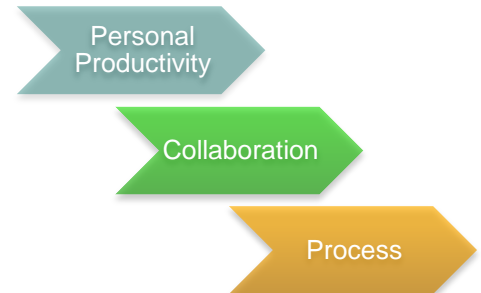
Embedded / external sheet differentiation

Ad hoc copy/paste supported, without persistent relation creation (yet!!)



Designed to...

- **Communicate effectively**
 - Plot improvements
 - Sketching
- **Standardize**
 - Input controls
- **Integrate**
 - API
- **Do more**
 - Enhanced numerics
 - Better conversion fidelity



Candidate detailed feature list

- **New features**
 - Plot layout and other improvements
 - Text styles
 - Input controls
 - Spell checker
 - API
 - Extension functions (user DLL's) *
 - Scripting
 - Sketching

PTC[®]

PRODUCT & SERVICE
ADVANTAGE