

# **Streamlined Electronic Process for Generating RELAP5-3D Model Input**

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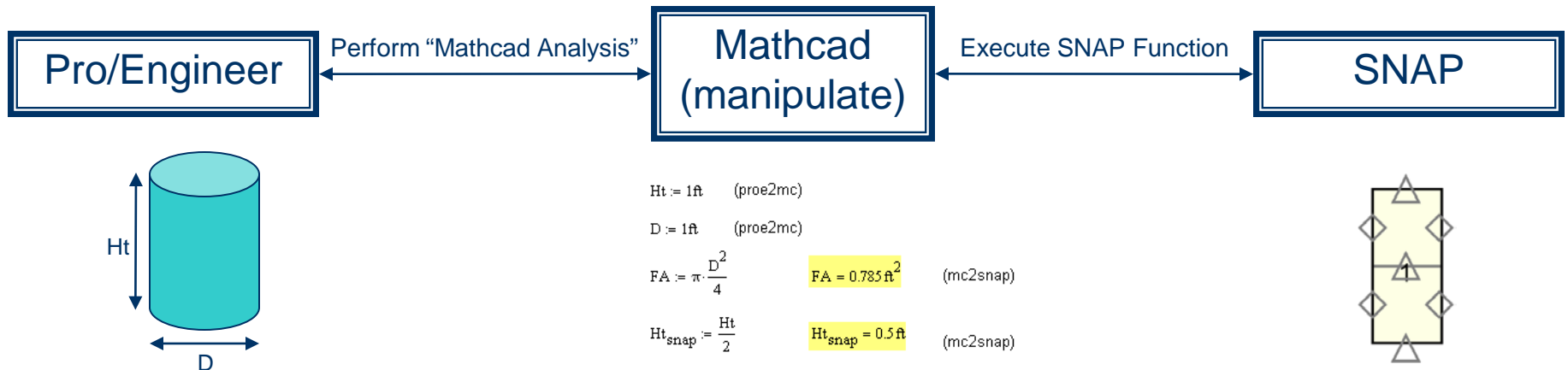
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# Outline

- Introduction
- Software Programs
  - Pro/Engineer
  - Mathcad
  - Symbolic Nuclear Analysis Package
- Piping Example
- Current Process Limitations
- Conclusions

# Introduction

- Process for creating RELAP5-3D model input generated from Pro/Engineer models.
- Utilizes Mathcad as an intermediate program
  - Receives, modifies and relays dimensional values/calculations from Pro/Engineer to SNAP.

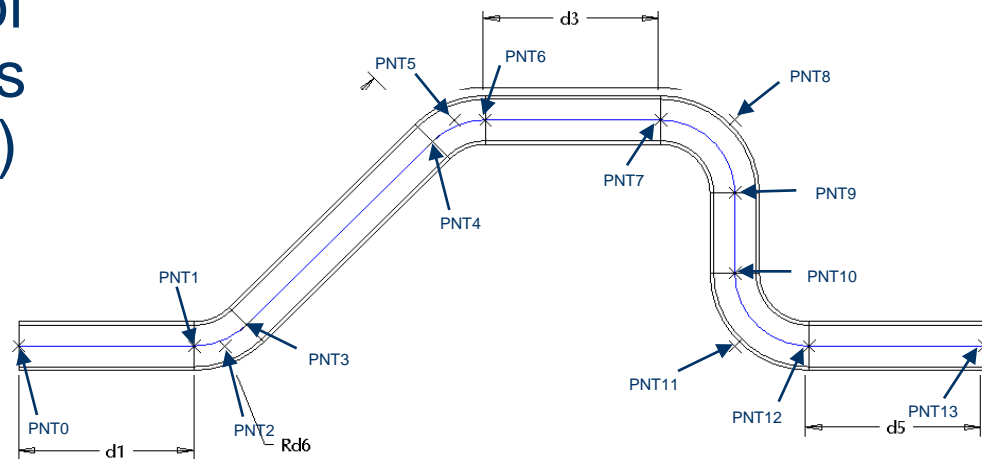
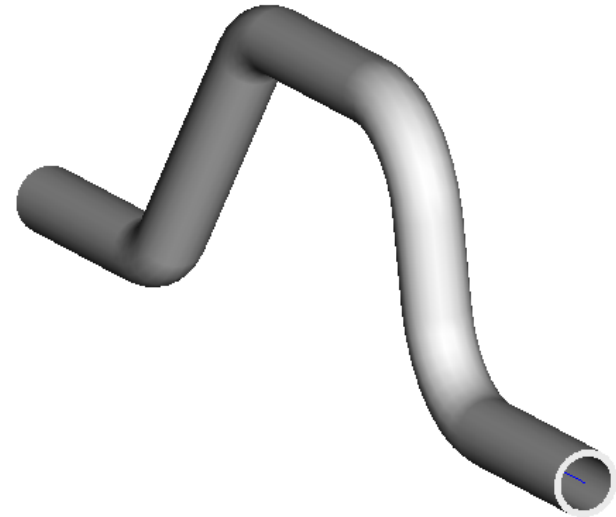


# Software Programs

	<u>Pro/Engineer</u>	<u>Mathcad</u>	<u>SNAP</u>
Product Vendor	PTC	PTC	APT
Product Version	Wildfire 3.0 (or later)	V.13.1 (or later)	V.1.1.1 (or later)
Interface Capability	Bidirectional		Bidirectional
Data Transfer Requirements	Manual Linking (initially), Requires Unit Agreement		Automatic Linking, Requires Variable/Name & Unit Agreement

# Pipe Example – Pro/Engineer

- Define a 3D Pro/Engineer model with piping dimensions (segment lengths, angles, ID, OD, etc.)
  - Alternatively, a set of defined datum points (X, Y, Z coordinates) could be used, but requires a more complex Mathcad worksheet.



# Pipe Example – Mathcad Analysis

“Mathcad feature provides capability to use data

1. Manual dimensions parameter Mathcad

2. Require agreement ft., Ang

3. Option automatic Pro/E with Mathcad variable name a

4. Create additional

5. Save a later call model (avoids variable times)

The screenshot shows the Pro/ENGINEER interface with a 3D model of a pipe. The pipe has several dimensions and angles labeled: 48.000, 72.000, 45.000° REF, 90.000° REF, 20.153 REF, 90.000° REF, and R21.750. The Mathcad Analysis dialog box is open, showing a table of variables and units.

Pro/E	Unit	Mathcad	Unit
ANGLE_D7.PIP...	rad	A_pipe_d7	rad
ANGLE_D8.PIP...	rad	A_pipe_d8	rad
ANGLE_D9.PIP...	rad	A_pipe_d9	rad
ANGLE_D10.PIP...	rad	A_pipe_d10	rad

The dialog box also shows a 'Results' section with columns for Variable, Value, and Units. Below this is a 'Saved Analyses' section with a list containing 'PROETOSNAP'. The 'Name' field is set to 'PROETOSNAP'. Buttons for 'Compute', 'Info', 'Retrieve', and 'Delete' are visible.

Red annotations on the image include:

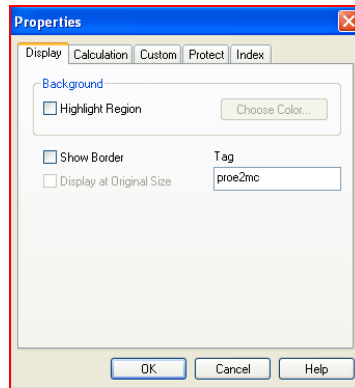
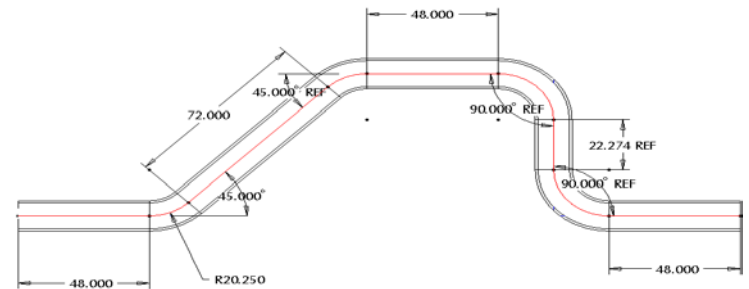
- Circle 1: Points to the 'Mathcad Analysis' dialog box.
- Circle 2: Points to the 'Auto-mapping' checkbox.
- Circle 3: Points to the 'Add Dimension' button.
- Circle 4: Points to the 'Execute Mathcad analysis' option in the 'Analysis' menu.
- Circle 5: Points to the 'PROETOSNAP' entry in the 'Saved Analyses' list.

Execute Mathcad analysis

Select FEATURE or DIMENSION.  
Select FEATURE or DIMENSION.

# Pipe Example – Mathcad

- Modify Pro/Engineer input and develop output to send to SNAP as model inputs.
  - Link tagged variables with Pro/Engineer dimensions
  - Modify Pro/Engineer data into SNAP input parameters (flow area, metal thickness, volume lengths, etc.)



$L_{pipe\_d1} := 1in$	$A_{pipe\_d7} := 1rad \quad 534rad$
$L_{pipe\_d2} := 1in$	$A_{pipe\_d8} := 1rad \quad 534rad$
$L_{pipe\_d3} := 1in$	$A_{pipe\_d9} := 1rad \quad 268rad$
$L_{pipe\_d4} := 1in$	$A_{pipe\_d10} := 1rad \quad 3268rad$
$L_{pipe\_d5} := 1in$	
$PipeID\_d11 := 1in$	$PipeID\_d11 = 0.083ft$
$PipeOD\_d12 := 1in$	$PipeOD\_d12 = 0.083ft$
$R_{elbow\_d6} := 1in$	$R_{elbow\_d6} = 0.083ft$
$L_{pipe\_proe} := 1in$	$L_{pipe\_proe} = 0.083ft$
$FA := \pi \cdot \frac{PipeID\_d11^2}{4}$	$FA = 0.721ft^2 \quad -3ft^2$
$IR_{pipe} := \frac{PipeID\_d11}{2}$	$IR_{pipe} = 0.042ft$

# Pipe Example – Mathcad to SNAP

- Link (automatic) Mathcad output variables with SNAP user defined Numerics
  - Requires variable/name & unit agreement (matching variable key stroke operations)
    - Ex. Mathcad's "IR<sub>pipe</sub>" is equivalent to SNAPs "IR.pipe"
  - Each numeric is assigned to a pre-established pipe parameter
  - Mathcad exports values in S.I. units
    - SNAP handles the conversion from S.I. to British

$$L_{seg1} = \frac{L_{pipe0,0}}{3} \quad L_{seg2} = \frac{L_{pipe1,0}}{2}$$

$L_{seg1} = 1.333 \text{ ft}$        $L_{seg2} = 0.712 \text{ ft}$

$$L_{seg3} = \frac{L_{pipe2,0}}{3} \quad L_{seg4} = \frac{L_{pipe3,0}}{2}$$

$L_{seg3} = 2 \text{ ft}$        $L_{seg4} = 0.712 \text{ ft}$

$$L_{seg5} = \frac{L_{pipe4,0}}{3} \quad L_{seg6} = \frac{L_{pipe5,0}}{2}$$

$L_{seg5} = 1.333 \text{ ft}$        $L_{seg6} = 1.424 \text{ ft}$

$$FA = \pi \cdot \frac{PipeID_{d11}^2}{4} \quad FA = 0.721 \text{ ft}^2$$

$$IR_{pipe} = \frac{PipeID_{d11}}{2} \quad IR_{pipe} = 0.479 \text{ ft}$$

The screenshot displays the MCADtoSNAP software interface. On the left, a tree view shows the project structure. The main window is divided into several panes:

- General:** Shows the model name 'MCADtoSNAP' and various options like 'Execute Pipe Calculations'.
- MCADtoSNAP - External Function:** A dialog box for mapping Mathcad variables to SNAP numerics. It lists input variables (A.seg1 through A.seg13, IR.pipe, FA) and output variables (K.seg1 through K.seg6).
- Hydrocomponent Input:** Lists pipe segments with their lengths, such as L.seg1 : 1.333333 ft.
- Heat Structure Input:** Lists pipe diameters, such as IR.pipe 0.47916667 ft.
- Set Initial Conditions:** Shows temperature (300.0 F) and pressure (500.0 psi).
- Geometry - PIPE 1:** A window showing a 3D schematic of a pipe network and a table of cell data.

Cell Number	Volume (ft³)	Length (ft)	Area (ft²)
1	1.515043e-4	L.seg1(1.333333)	FA(0.721185)
2	1.515043e-4	L.seg2(0.711769)	FA(0.721185)
3	1.515043e-4	L.seg3(2.0)	FA(0.721185)
4	2.272604e-4	L.seg4(0.711769)	FA(0.721185)
5	2.272604e-4	L.seg5(1.333333)	FA(0.721185)
6	1.515043e-4	L.seg6(1.423534)	FA(0.721185)
7	1.515043e-4	L.seg7(1.333333)	FA(0.721185)
8	1.515043e-4	L.seg8(0.711769)	FA(0.721185)
9	2.272604e-4	L.seg9(0.711769)	FA(0.721185)
10	2.272604e-4	L.seg10(1.333333)	FA(0.721185)
11	1.515043e-4	L.seg11(1.333333)	FA(0.721185)
12	1.515043e-4	L.seg12(1.333333)	FA(0.721185)
13	1.515043e-4	L.seg13(1.333333)	FA(0.721185)

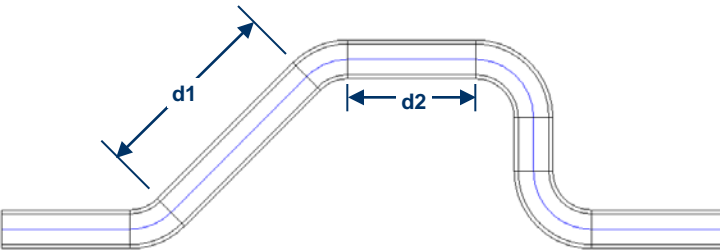


# Pipe Example – Iterative Process

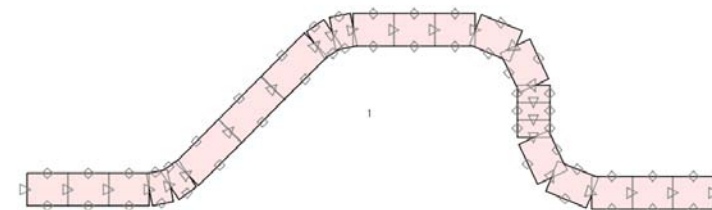
Pro/Engineer

SNAP/NUPAC

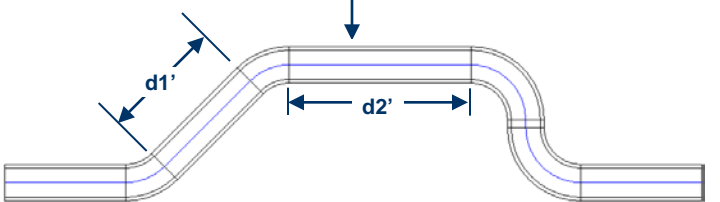
Mathcad



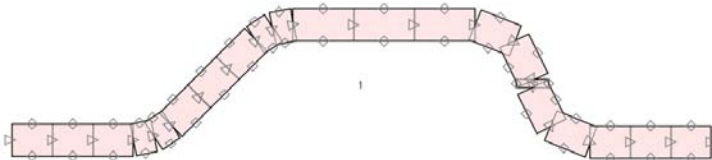
Manipulate



Alter Piping Geometry



Manipulate



# Current Process Limitations

- Requires caution when matching variables/units
  - Angles represented in degrees need to be in radians (Pro/Engineer to Mathcad).
  - Angles represented in degrees/radians need to be unitless (Mathcad to SNAP).
- Re-nodalization requires updates to both Mathcad & SNAP
- Not ideal for major design changes
  - Adding/removing features and/or dimensions.
- SNAP limitations/bugs
  - Unable to transfer Mathcad tables into SNAP and use them as input to the model.
  - Unable to apply a numeric for angle geometry.

# Conclusions

- Successfully demonstrated model building capability from Pro/Engineer to SNAP
- Good for performing simple design iterations
- Improved Quality Assurance
  - Eliminates errors associated with manually inputting values.
  - Easily trace the origins of a particular input.
- Bidirectional capability allows the design to be driven by the hydraulic model
  
- Extensive up-front work effort
  - Process requires fully established work files (Pro/Engineer (.prt/.asm), Mathcad worksheet & SNAP).
- Software improvements are required to make the process efficient