Streamlined Electronic Process for Generating RELAP5-3D Model Input

S.B. Casey

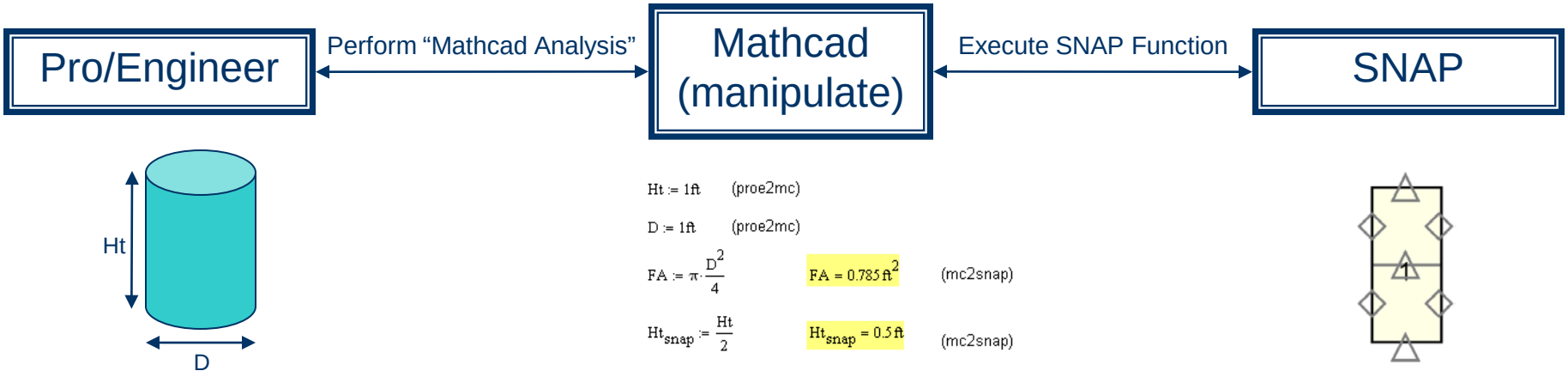
Bechtel Marine Propulsion Corporation
P.O. Box 1072
Schenectady, NY 12301-1072

Outline

- Introduction
- Software Programs
  - Pro/Engineer
  - Mathcad
  - **S**ymbolic **N**uclear **A**nalysis **P**ackage
- 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.

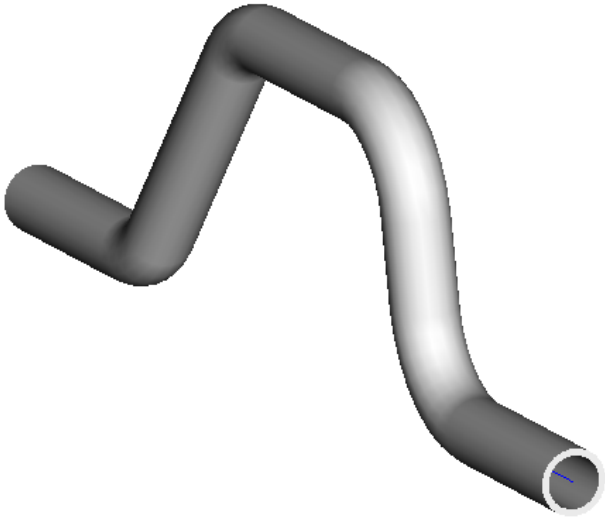


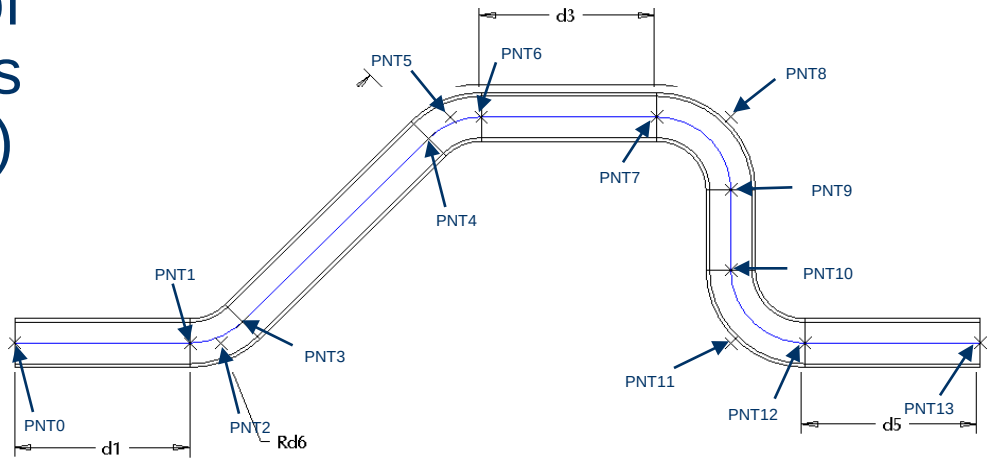
Software Programs

	Pro/Engineer	Mathcad	SNAP
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.

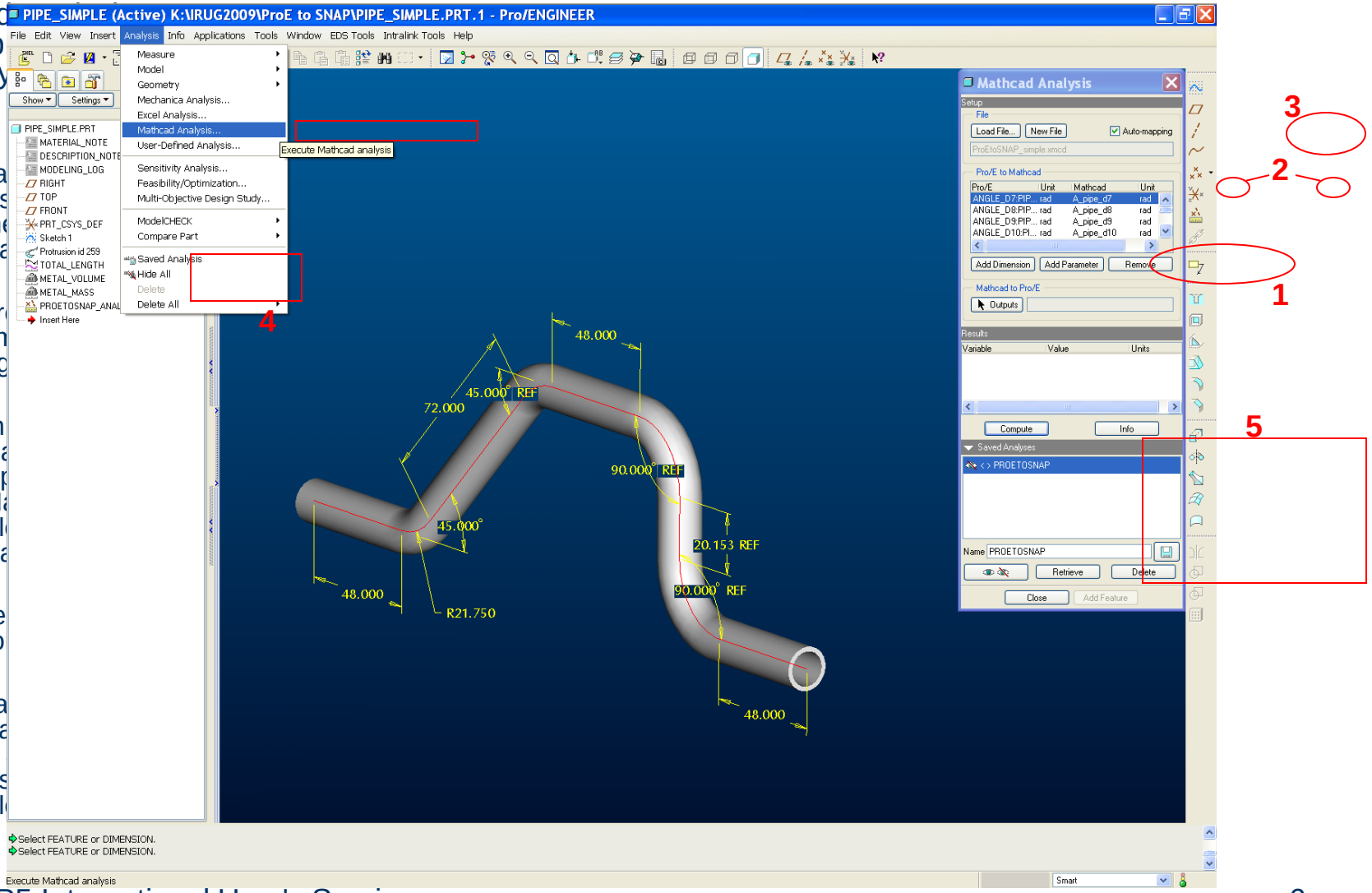




Pipe Example – Mathcad Analysis

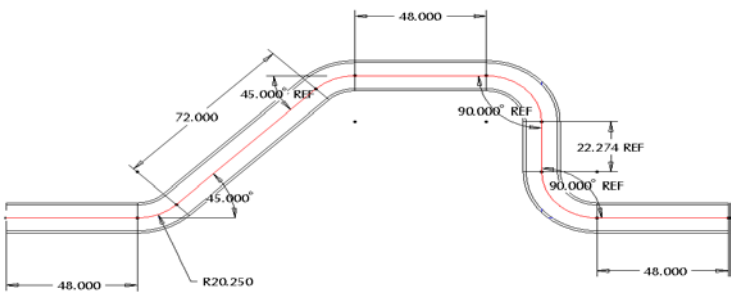
- "Mathcad
  feature p
  capability
  data

1. Manua
   dimens
   parame
   Mathca
2. Requir
   agreen
   ft., Ang
3. Option
   automa
   Pro/E p
   with Ma
   variabl
   name a
4. Create
   additio
5. Save a
   later ca
   model
   (avoids
   variabl
   times)



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.)



$L_{pipe\_d1} := 1\,in$ $A_{pipe\_d7} := 1\,rad$ $534\,rad$

$L_{pipe\_d2} := 1\,in$ $A_{pipe\_d8} := 1\,rad$ $534\,rad$

$L_{pipe\_d3} := 1\,in$ $A_{pipe\_d9} := 1\,rad$ $268\,rad$

$L_{pipe\_d4} := 1\,in$ $A_{pipe\_d10} := 1\,rad$ $3268\,rad$

$L_{pipe\_d5} := 1\,in$

$Pipe_{ID\_d11} := 1\,in$ $Pipe_{ID\_d11} = 0.083\,ft$

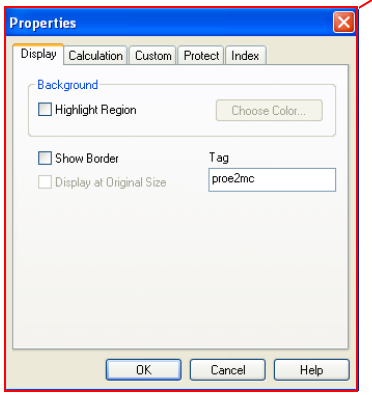
$Pipe_{OD\_d12} := 1\,in$ $Pipe_{OD\_d12} = 0.083\,ft$

$R_{elbow\_d6} := 1\,in$ $R_{elbow\_d6} = 0.083\,ft$

$L_{pipe\_proe} := 1\,in$ $L_{pipe\_proe} = 0.083\,ft$

$FA := \pi \cdot \frac{Pipe_{ID\_d11}^2}{4}$ $FA = 0.721\,ft^2$ $\cdot 3\,ft^2$

$IR_{pipe} := \frac{Pipe_{ID\_d11}}{2}$ $IR_{pipe} = 0.042\,ft$



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_{pipe}" 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

$$L_{seg1} := \frac{L_{pipe_{0,0}}}{3} \qquad L_{seg1} = 1.333\,ft$$

$$L_{seg2} := \frac{L_{pipe_{1,0}}}{2} \qquad L_{seg2} = 0.712\,ft$$

$$L_{seg3} := \frac{L_{pipe_{2,0}}}{3} \qquad L_{seg3} = 2\,ft$$

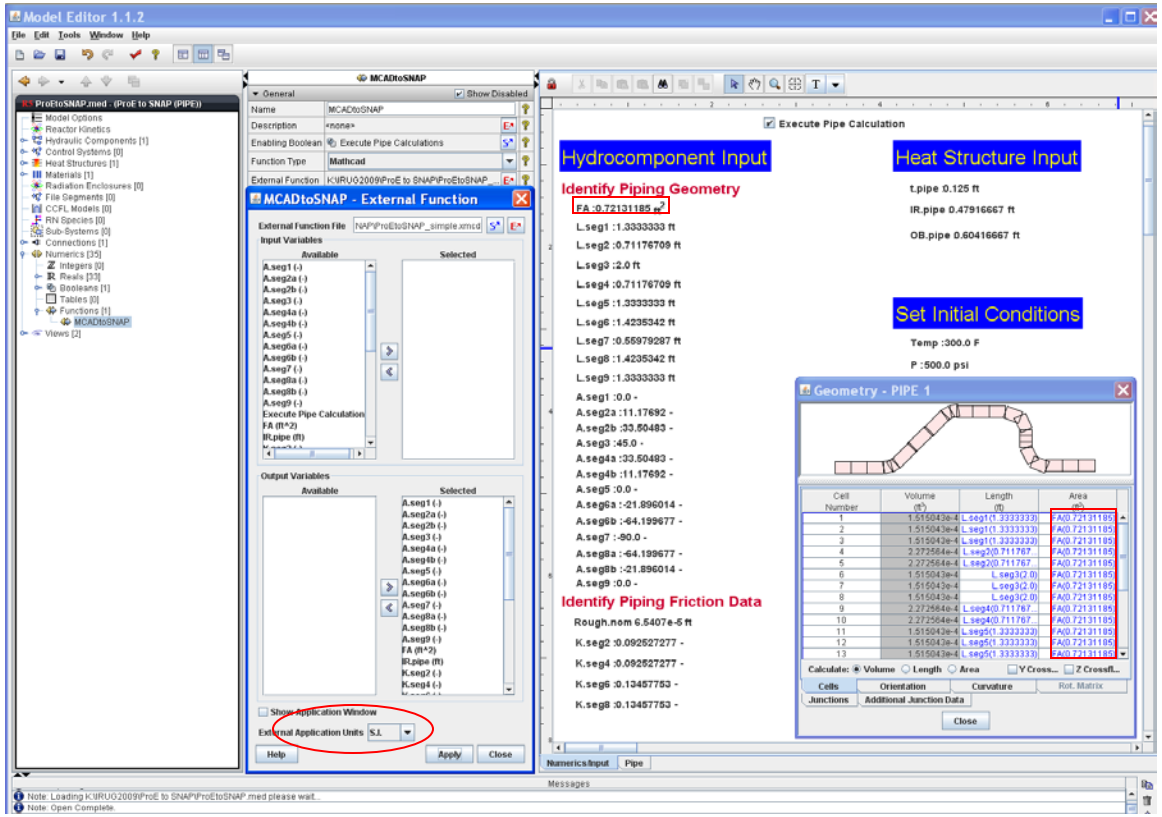
$$L_{seg4} := \frac{L_{pipe_{3,0}}}{2} \qquad L_{seg4} = 0.712\,ft$$

$$L_{seg5} := \frac{L_{pipe_{4,0}}}{3} \qquad L_{seg5} = 1.333\,ft$$

$$L_{seg6} := \frac{L_{pipe_{5,0}}}{2} \qquad L_{seg6} = 1.424\,ft$$

$$FA := \pi \cdot \frac{Pipe_{ID\_d11}^{2}}{4} \qquad FA = 0.721\,ft^2$$

$$IR_{pipe} := \frac{Pipe_{ID\_d11}}{2} \qquad IR_{pipe} = 0.479\,ft$$

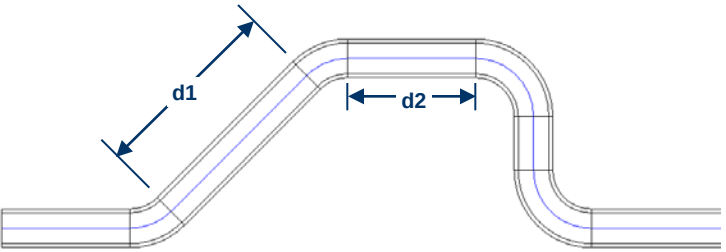


Pipe Example – Iterative Process

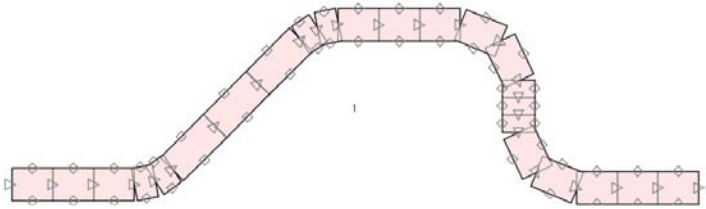
Pro/Engineer

SNAP/NUPAC

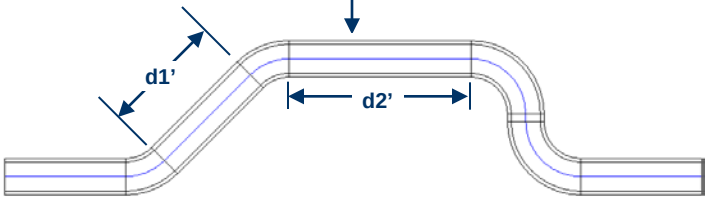
Mathcad



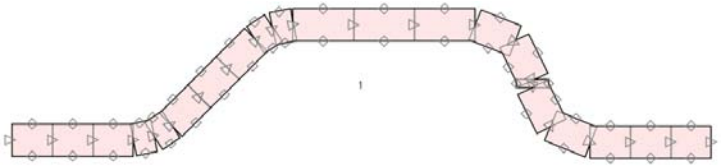
Manipulate



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