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The Virtual Instrumentation Diagram

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Ron Claghorn

- Not very good at operating computers. Therefore, he has a real passion for automation.
- Before Six—Sigma became popular, his father characterized him as someone “always looking for the easy way”. Now Ron makes a living at it.
- His favorite cooking utensil is the microware because it can be operated with just one button

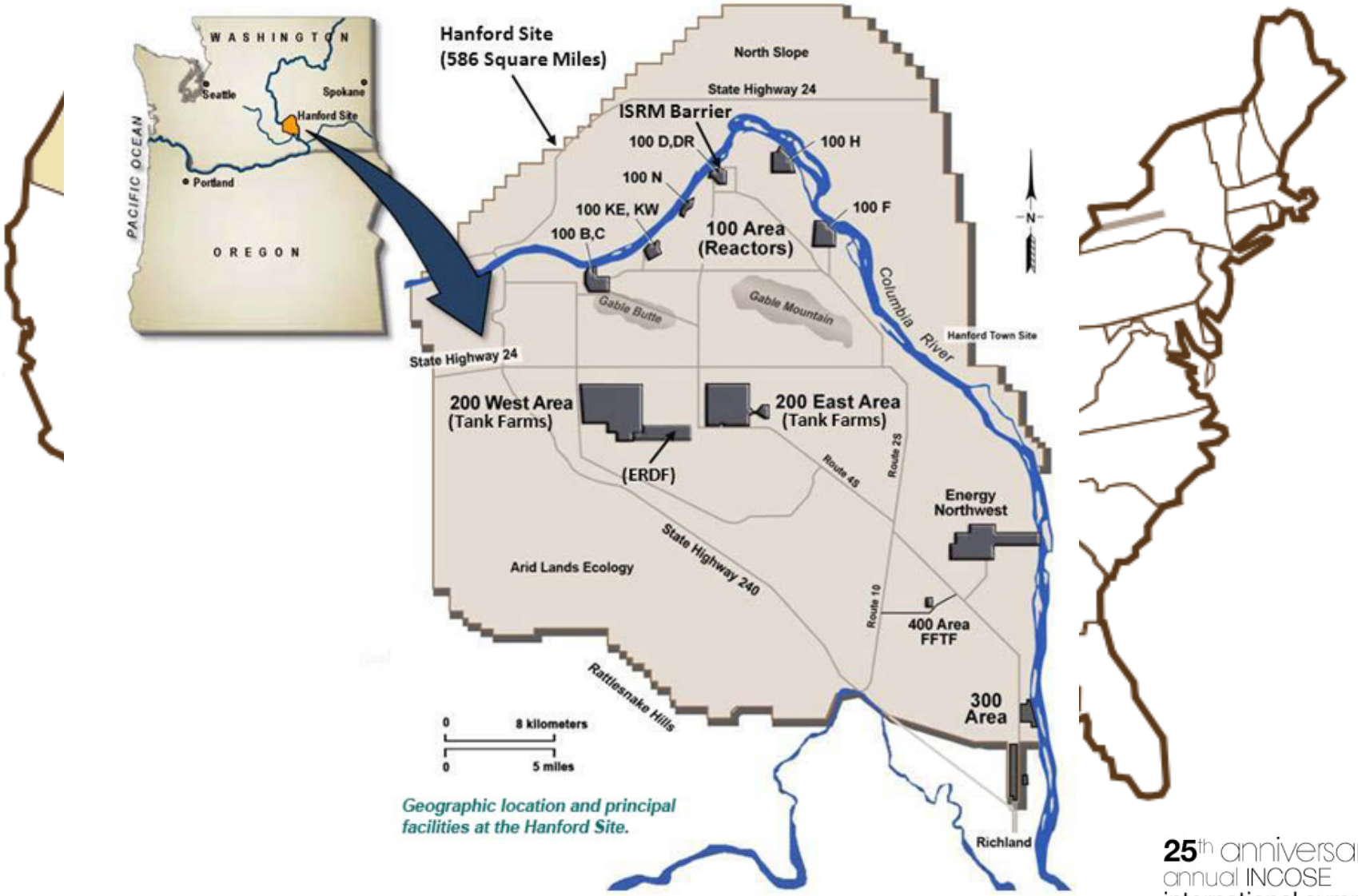
Agenda

- Motivation for this work
- The promise of model-based systems engineering (MBSE)
- MBSE implementation issues
- Proposed resolution

Author Experience

- Chemical engineer by degree
- 34 years at Hanford Site, Washington
- Primarily Engineering, Procurement, and Commissioning (EPC)
- 12 years Systems Engineering supervisor
- Currently involved in updating the flowsheet for disposition of Hanford tank waste

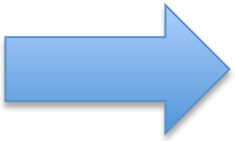
Hanford Site



Geographic location and principal facilities at the Hanford Site.

Inherent Risks

- Chemical and nuclear waste materials
- Some materials soluble in water
- Proximity to a very important river
- Selected disposition of waste includes high pressure and high temperature processes

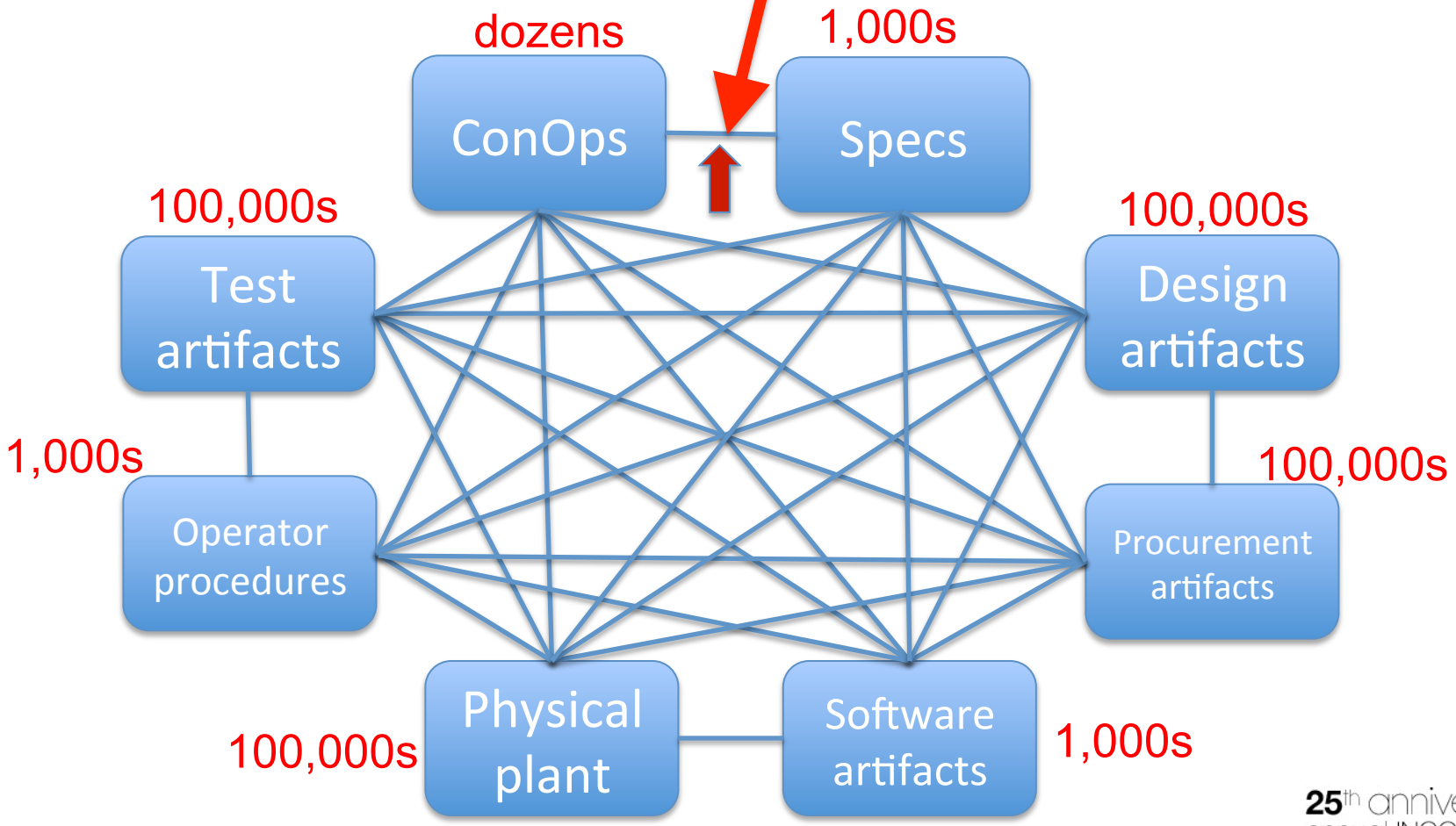


High expectations for high quality work to minimize risks

Challe

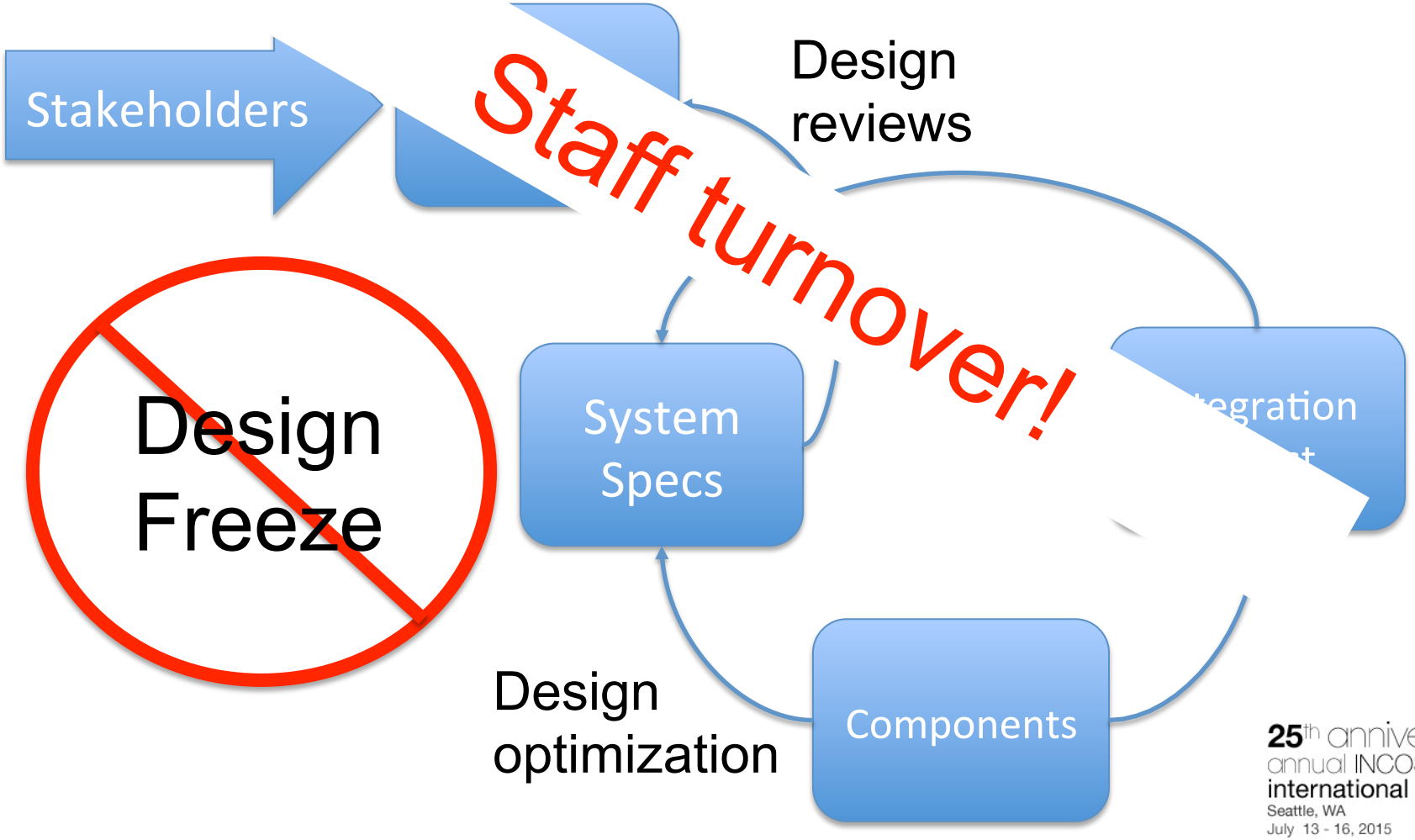
> 100,000 links!

Configuration Management (CM) = Consistency



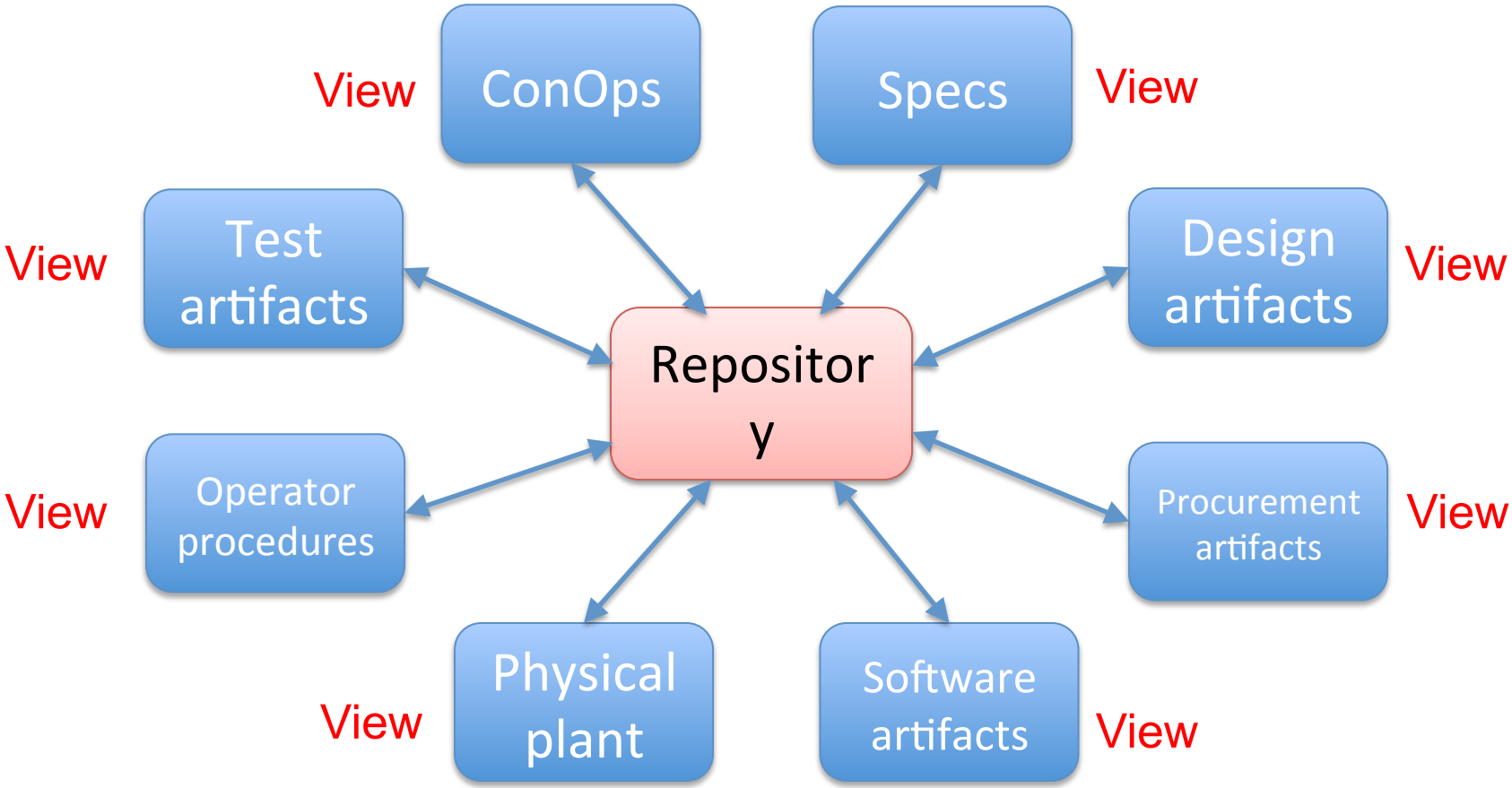
Document Instability

EPC ' '·· constant change



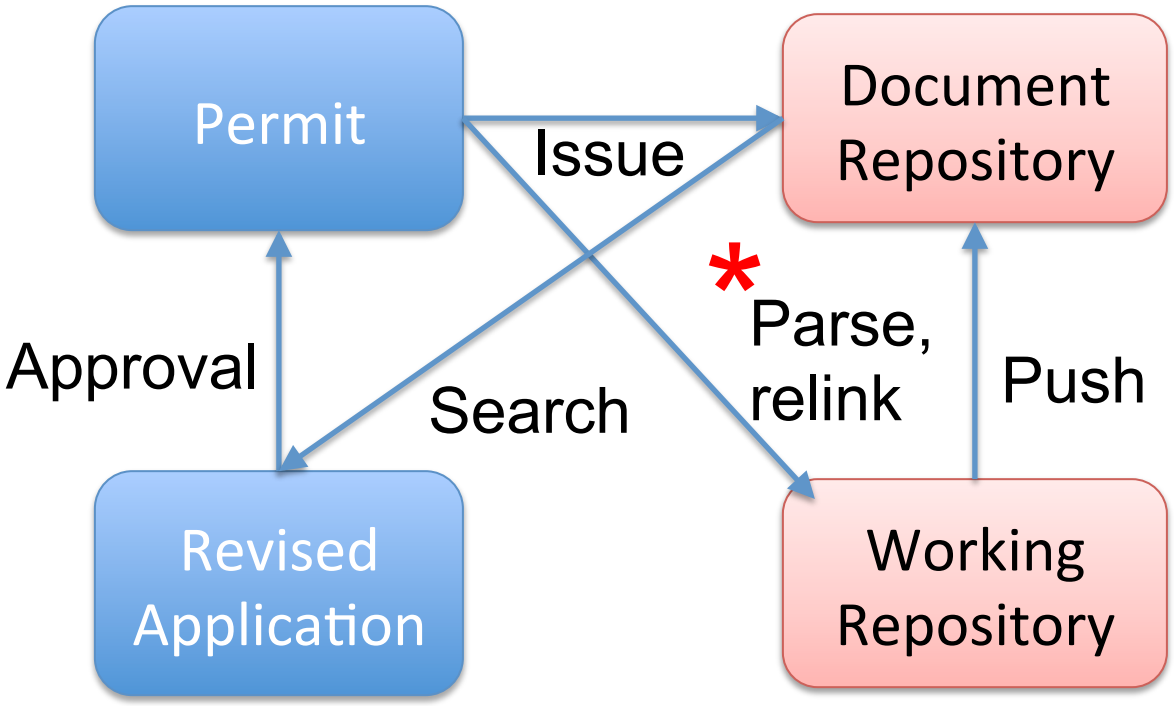
The Promise of MBSE

One repository → Dynamic views → Problem solved?



MBSE Issue #1

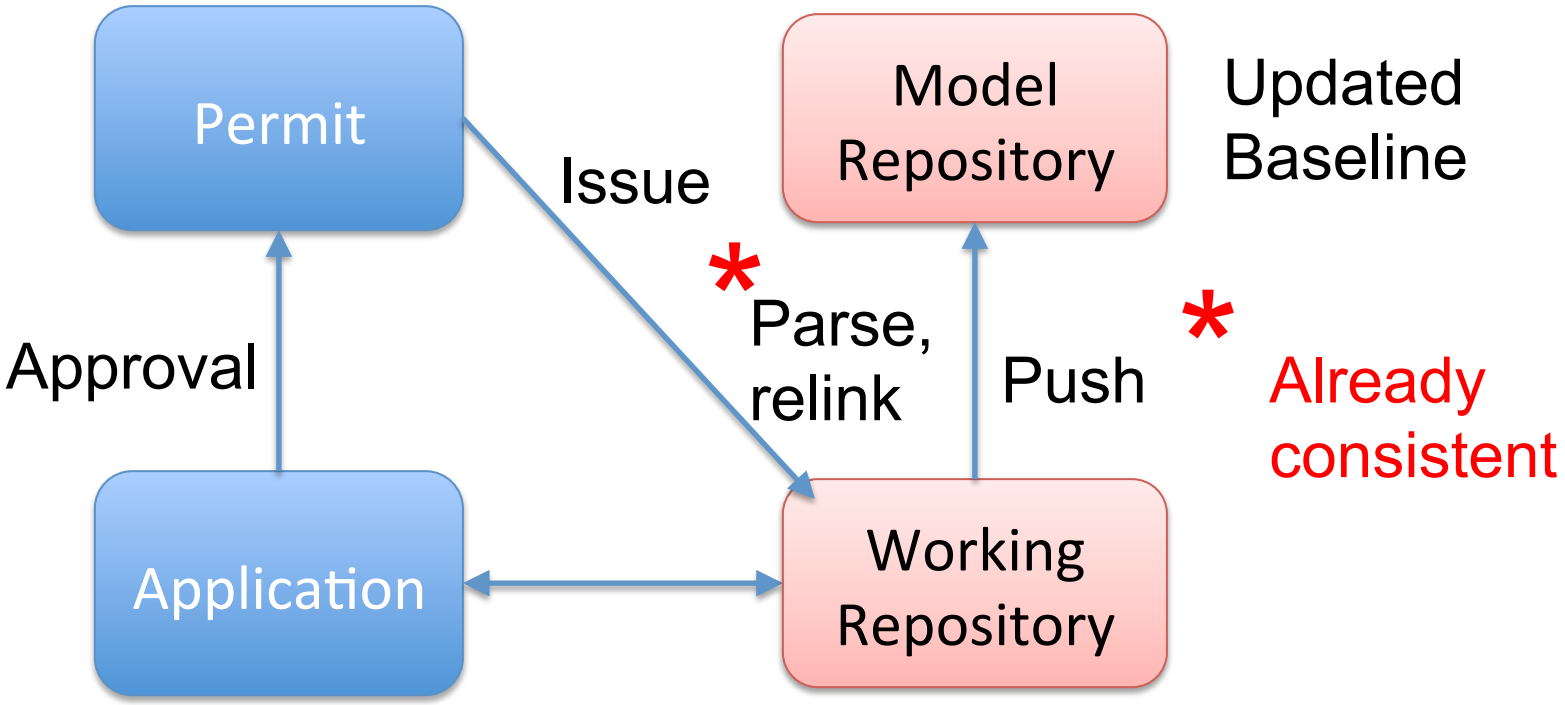
Some documents won't have two-way communication with the repository



*Problem solved with US Patent 7890486

MBSE-like Approach

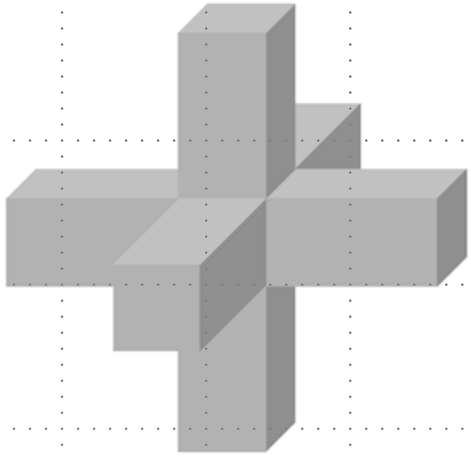
Two-way updates



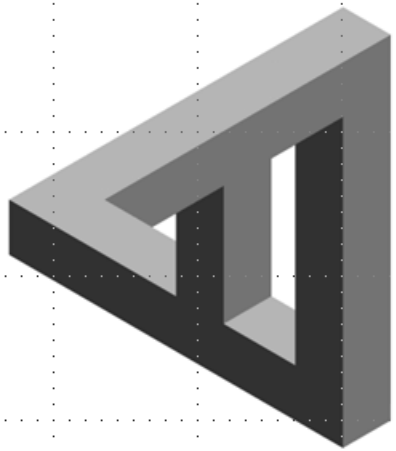
MBSE Issue #2

Complexity of the graphics*

"A picture paints a thousand words"



or ...



"A thousand readable words could have been put in the space of this one unreadable drawing"

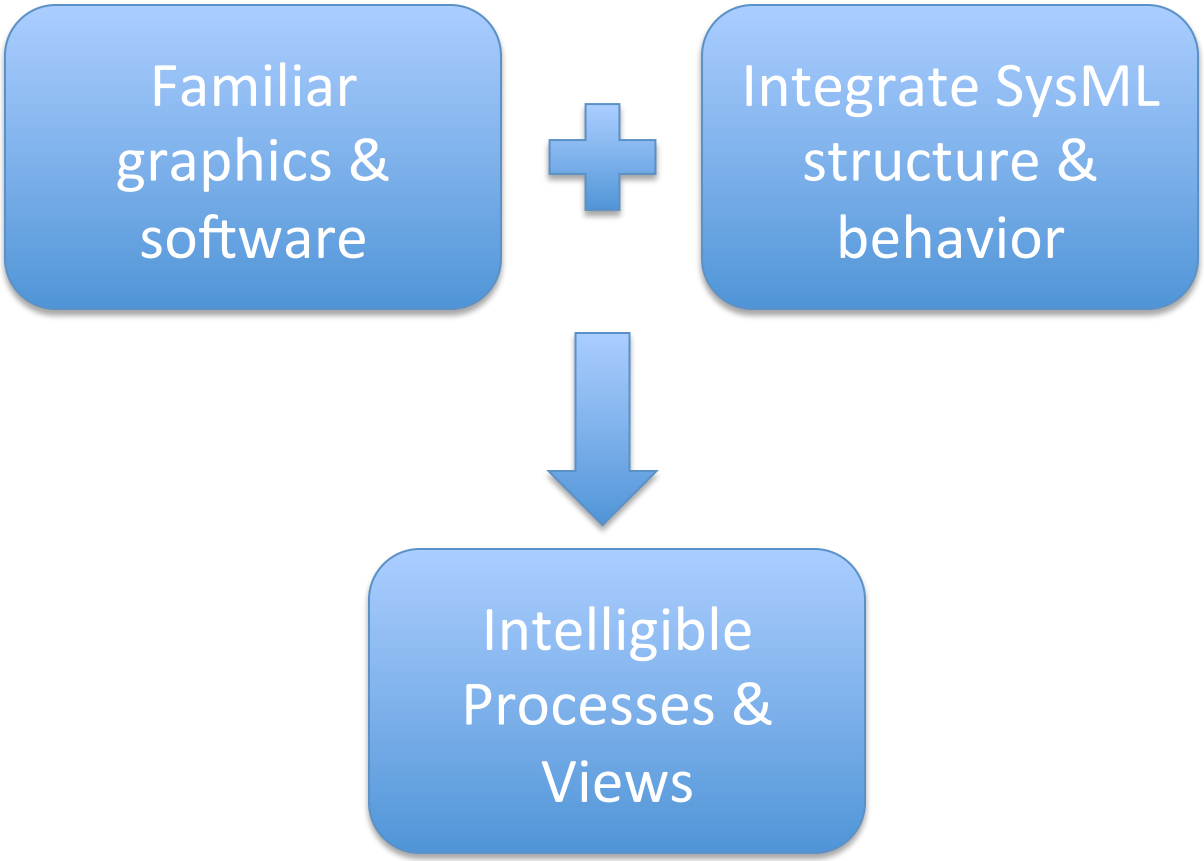
*Andy Gurd, IBM Requirements Management blog, July 31 2012

MBSE Issues

Complexity of the tools

- Huge learning curve
- Helps to have background in computer programming (SysML Block ~ Software Class)
- Requires ~months for the average user to become proficient (Internet: many give up and go back to spreadsheets)

Gentle MBSE Implementation



Instrumentation Diagrams

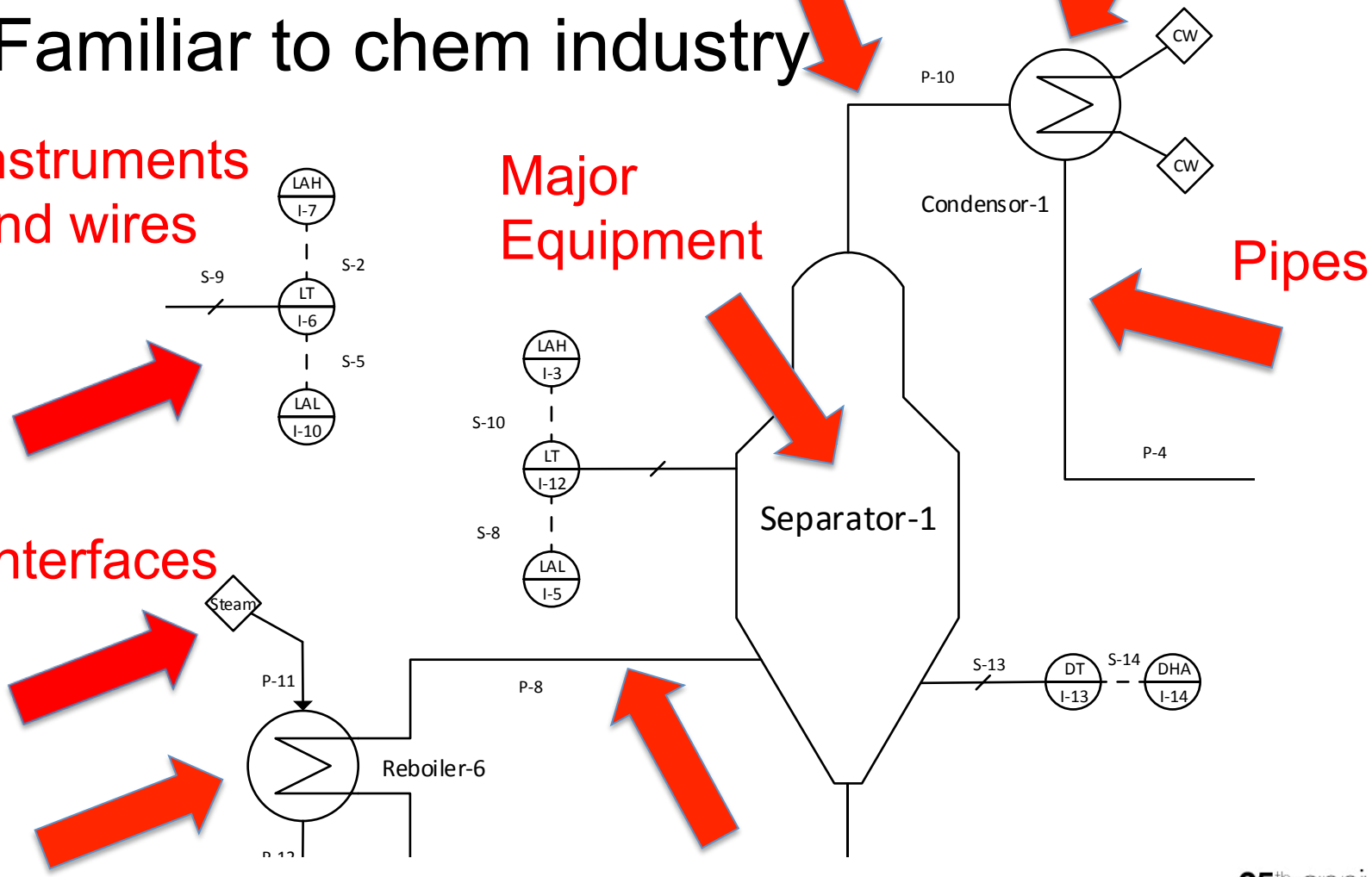
Familiar to chem industry

Instruments and wires

Major Equipment

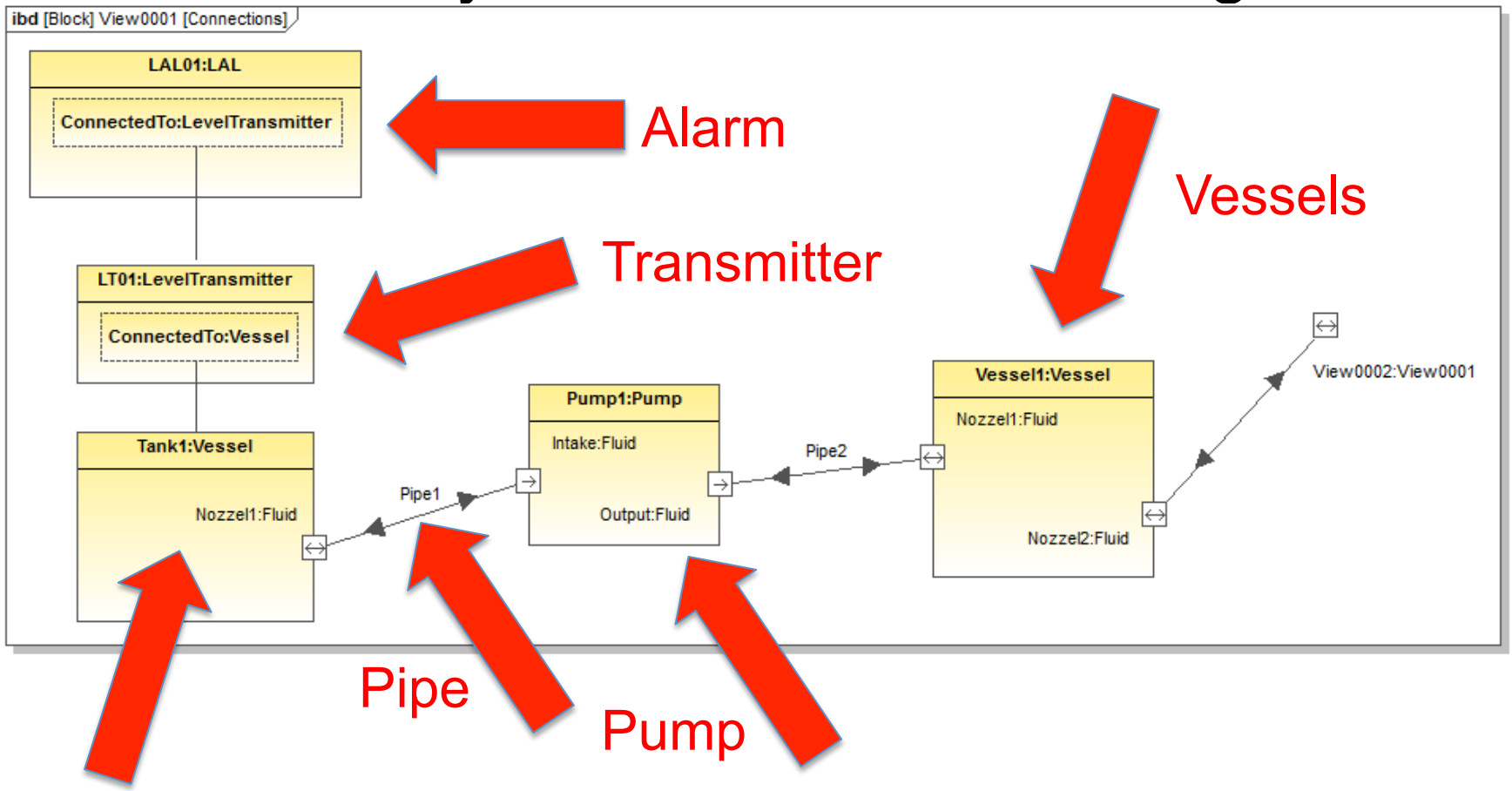
Pipes

Interfaces



Instrumentation Diagrams

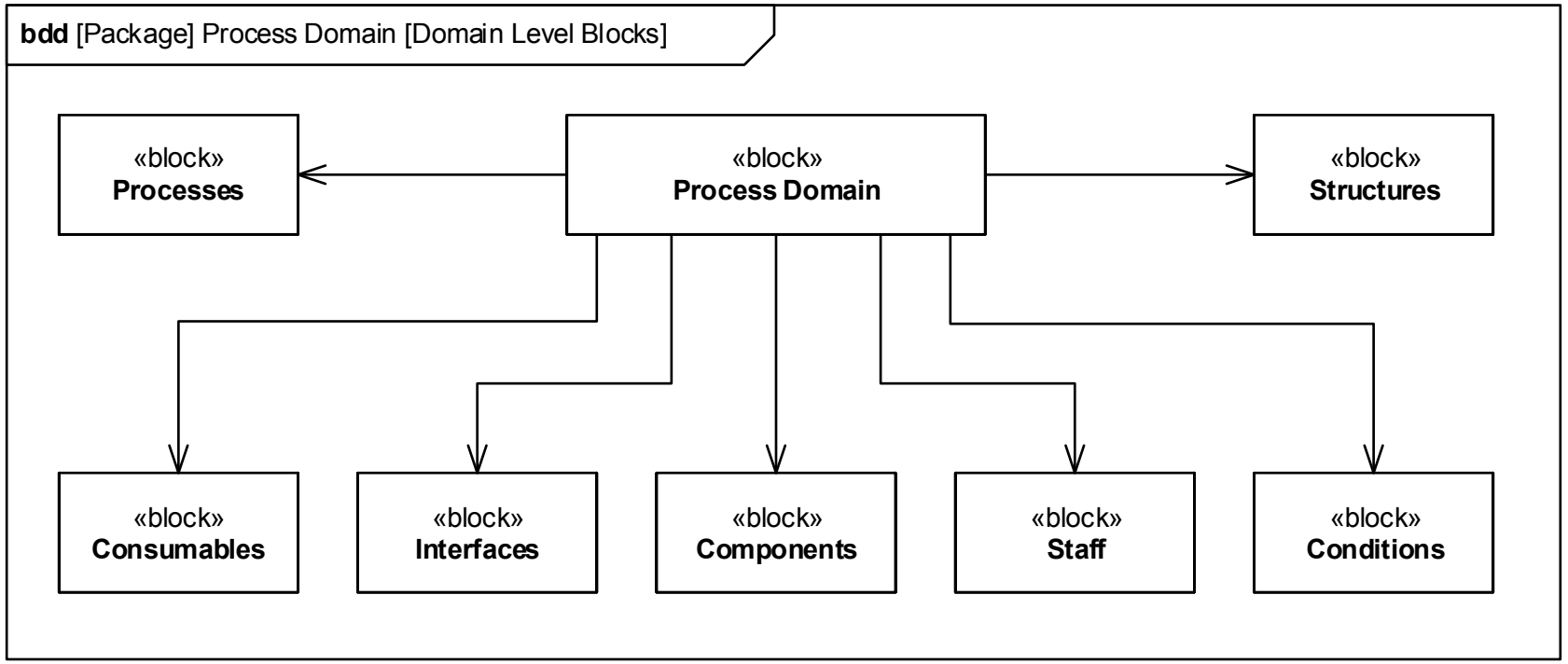
Similar to a SysML internal block diagram



Instrumentation Diagrams

- Multiple uses:
  - Trade studies
  - Hazard analysis
  - Basis for layouts and isometrics
- Requires collaboration of multiple disciplines: process; instrumentation, controls, mechanical

P&ID Coverage



Selection of Modeling Tool

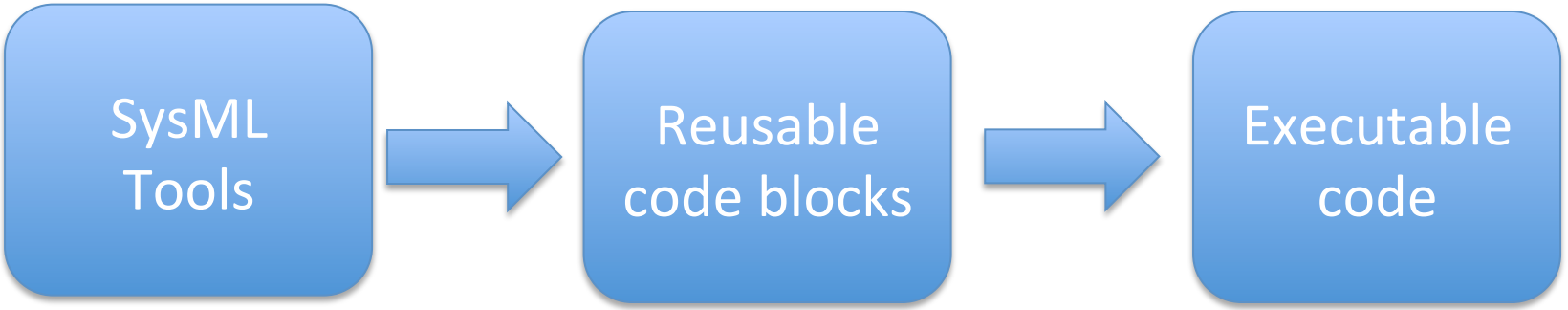
Criteria

- Syntax – Correct use of SysML
- Semantics – Reflect reality
- Pragmatics – Understood by stakeholders
- Two-way communication with the repository
- Other features such as easy to use

Syntax

- SysML modeling tools evaluated for this paper (UModel and Rhapsody) are very good at enforcing SysML syntax vs Visio stencil

Perfect syntax!



Semantics

The model must mimic reality:

- In actuality, components are specified, created, tested, integrated, and then tested as part of the system
- Components react to conditions independant of other components

Pragmatics

The model must be understood by all stakeholders

Other Criteria

- Ease of use (e.g. symbol library)
- Cost ($300 to $10,000)
- Schedule (time to produce)
- Searchable repository for casual users
- Bi-directional code:

SysML – code – SysML

Selection of MBSE Tool

- Survey at SysMLtools.org provides a summary but also warns:

  the “Muddle-Driven Marketecture” vendor hype and tool featuritis associated with commercial SysML tools can overwhelm even savvy engineers

- In other words: try before you buy
- Evaluated UModel (inexpensive) and Rhapsody (for advanced simulation)

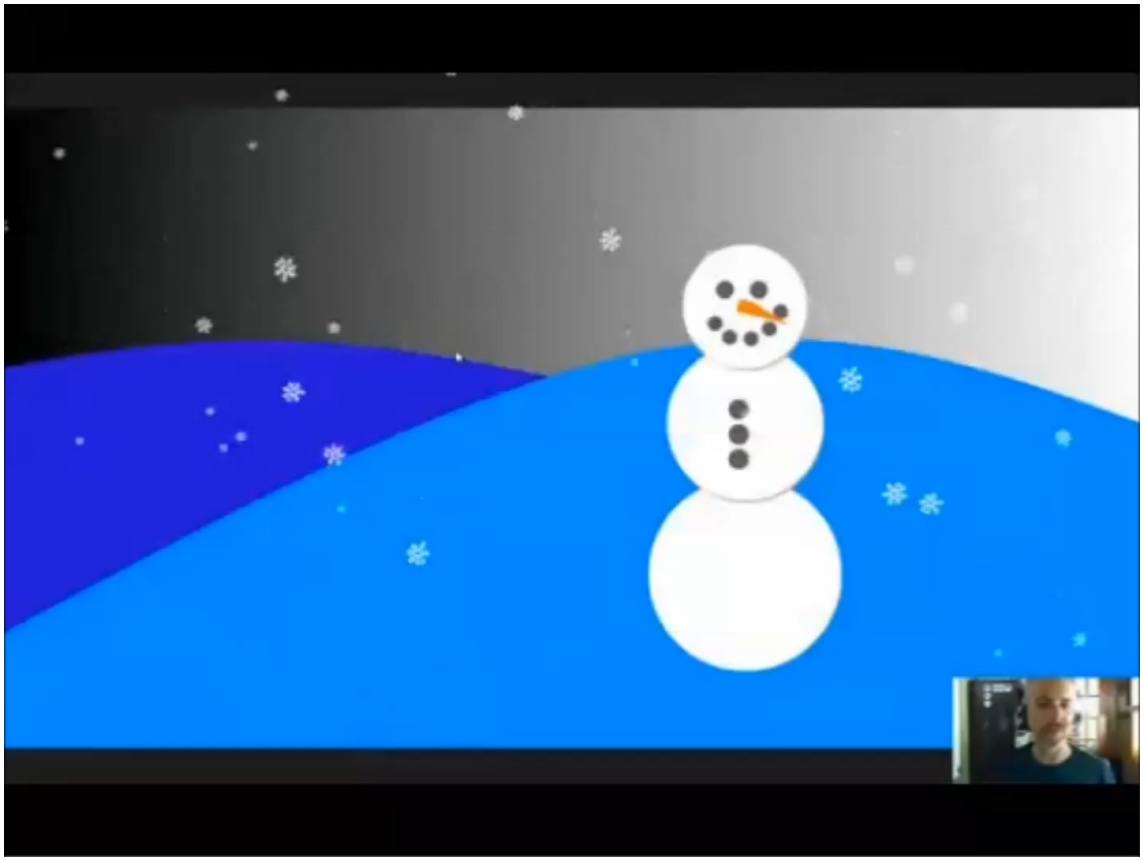
Tool Test Results

- Each good at enforcing SysML syntax
- Each good at creating reusable software objects
- Each capable of creating executables from those objects
- Animation is a differentiator: none to some. All tools would need coding to animate a P&ID.

What code to use?

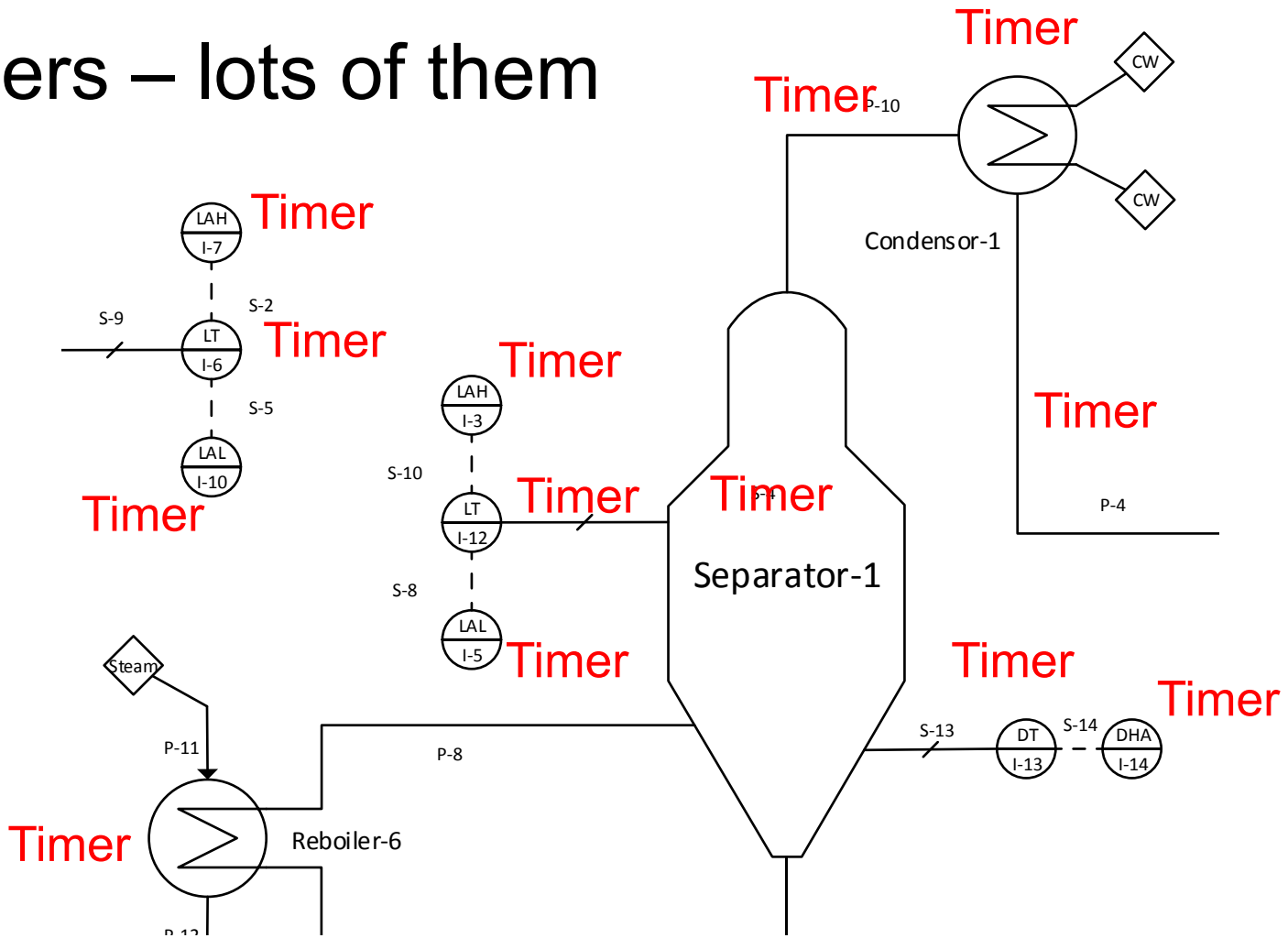
Animation Technology

Windows Presentation Foundation specially created to facilitate animation.



Animation Requirements

Timers – lots of them

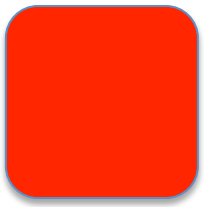


WPF Animation Toolbox

Examples (of many):

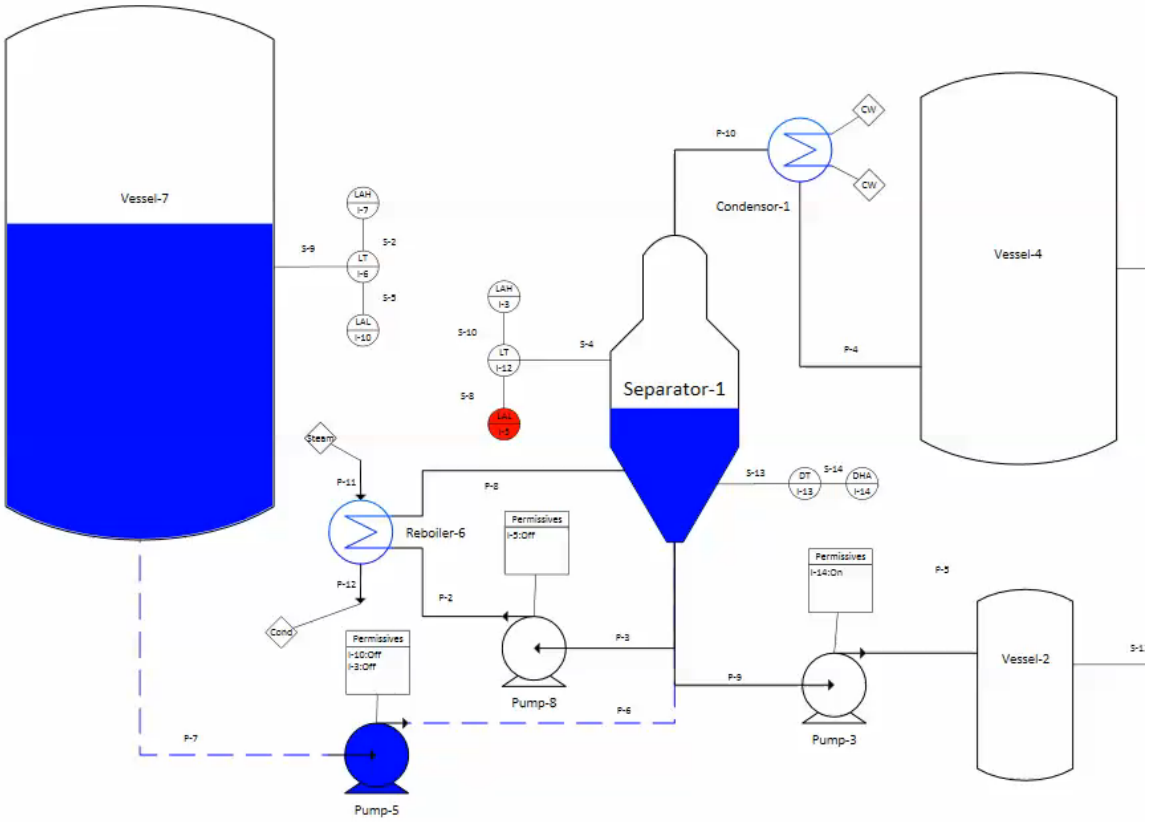
Color change to indicate temperature

Opacity to indicate decontamination



Animation Requirement

Pan and zoom vector-based graphics

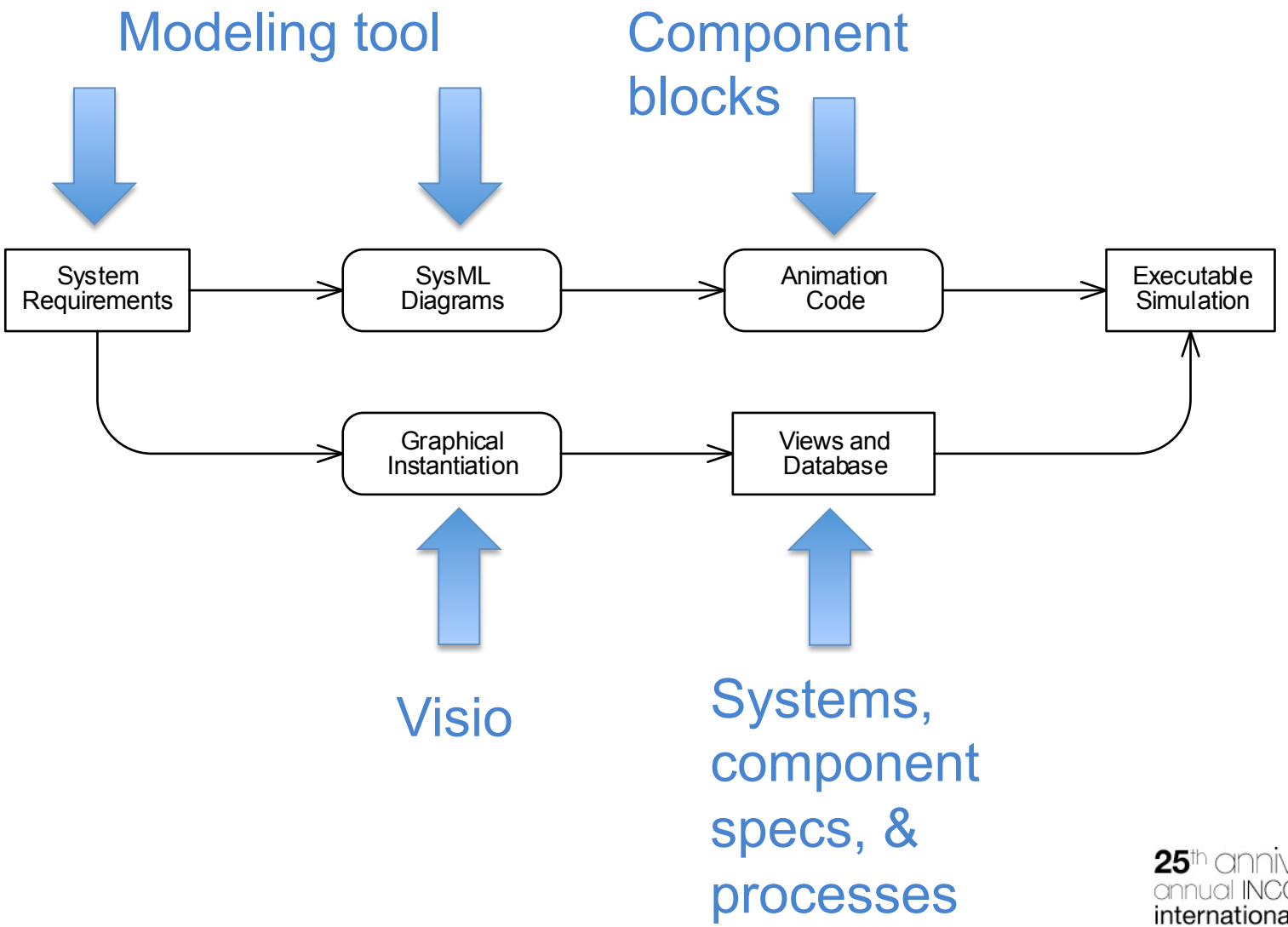


XAML Drawing Tool

WPF uses Extensible Application Markup Language (XAML an instance of XML)

- Hard to find drawing tools that generate XAML
- Found that Visio will create XAML in when saved as a web page. And the professional version has a P&ID library!

Selected Approach



Draw the View in Visio

Drag & drop

Tag each component

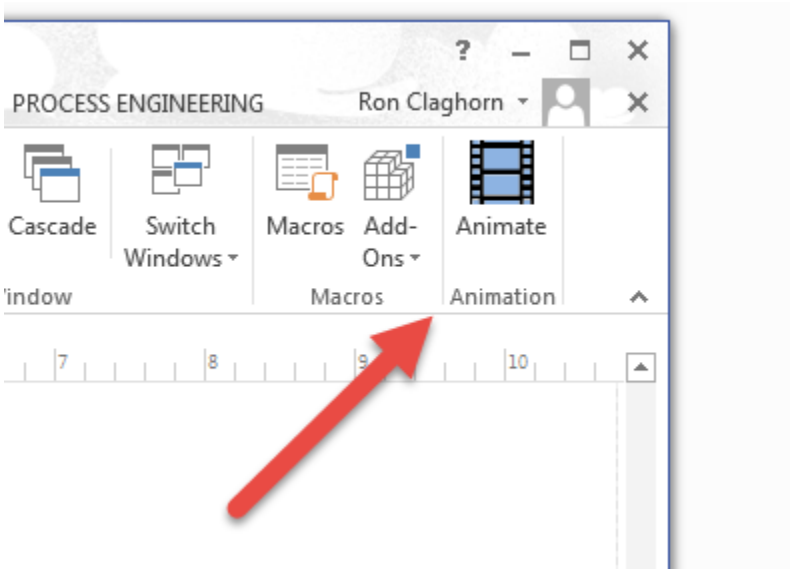
Right-click to add values

- Drag and drop components to instantiate the component blocks and the associations created using the MBSE tool
- Give each component a unique tag name
- Right-click on components to quantify properties and initial values

Start the Animation

Command button in Visio ribbon:

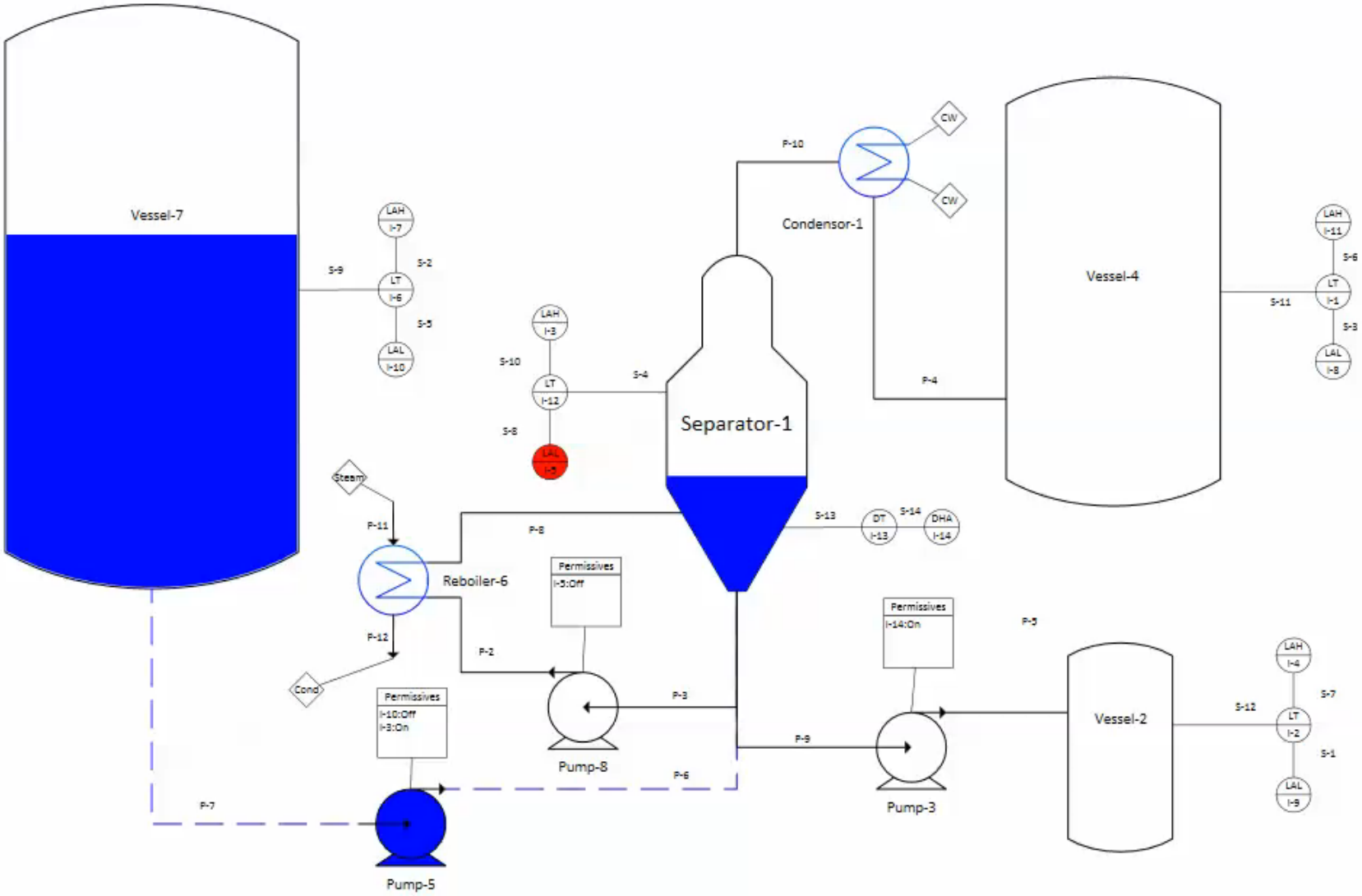
- Inserts details into the repository
- Creates XAML



Application Startup

- Reads the repository
- Pulls in the XAML from Visio output
- Create instances of components and associations

MainWindow


Vessel-7
LAH I-7
LT I-6
LAL I-10
S-9
S-2
S-5
LAH I-3
LT I-12
LAL I-8
S-10
S-4
S-8
Separator-1
P-10
CW
CW
Condensor-1
P-4
Vessel-4
LAH I-11
LT I-1
LAL I-8
S-6
S-11
S-3
Steam
P-11
Reboiler-6
P-8
S-13
DT I-13
S-14
DHA I-14
Permissives
I-5:Off
P-12
Cond
P-2
Permissives
I-10:Off
I-3:On
Pump-8
P-3
P-6
P-7
Pump-5
Permissives
I-14:On
P-5
P-9
Pump-3
Vessel-2
LAH I-4
LT I-2
LAL I-9
S-12
S-7
S-1

Net Result

Minimal pain for the gain in adopting the MBSE approach:

- Maximum engineer participation in model development
- Quality based on established metrics
- Meaningful presentation to a wide range of stakeholders
- Repository for creating consistent artifacts