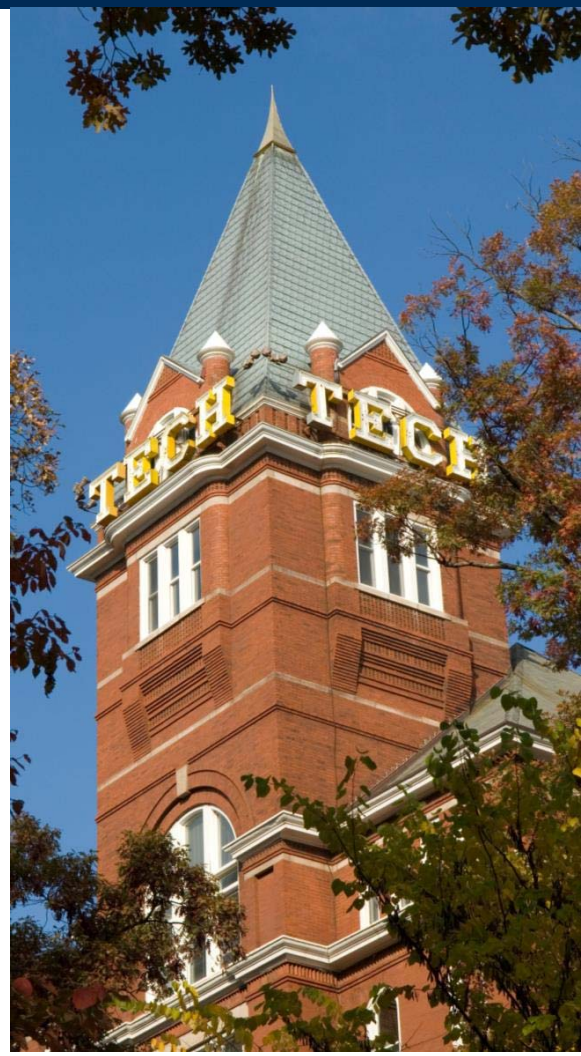
Georgia Tech Research Institute

Rapid Model Building with Patterns



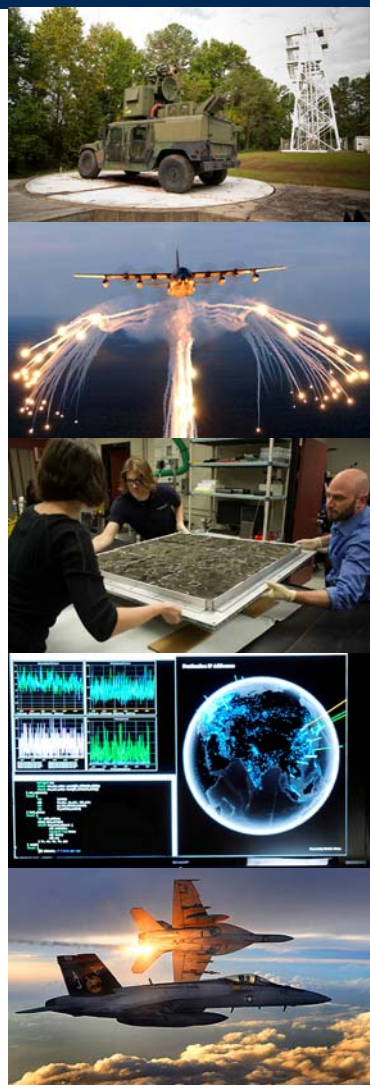
October 23, 2019

Bjorn Cole, PhD

Shane Connelly

Outline

- Conceptualization of Ingrid Nerdman
  - Common MBSE Workflows
  - Motivation for Ingrid Nerdman
- Overview of Ingrid Nerdman
  - Ingrid Nerdman
- Employment of Ingrid Nerdman
  - Demonstration



Common MBSE Workflows

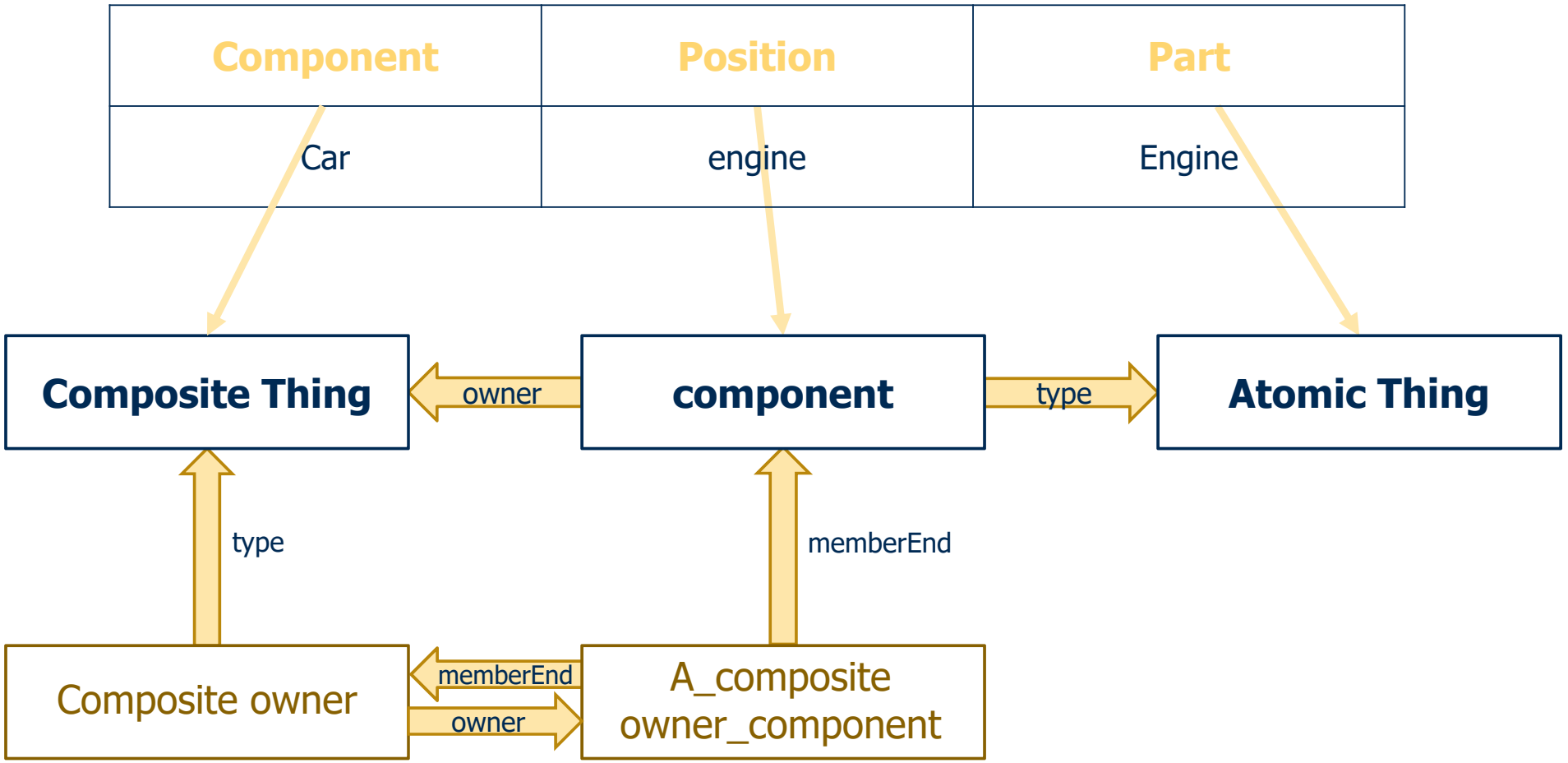
- Customer approaches late in their development having decided they want MBSE support
- Customer and other engineers provide you with a large amount of lightly structured data relating to model components
- In both cases, the customer expects to rapidly gain insights and understandings about their complex system

Motivation for Ingrid Nerdman

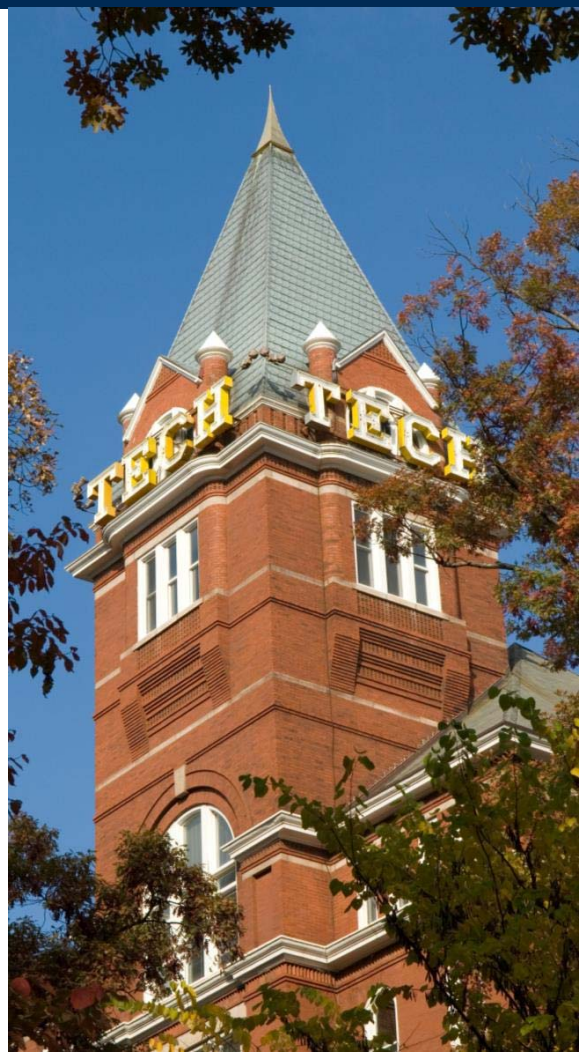
- Reduce the impact of the Big Data problem
- Provide rapid, dynamic, and flexible model instantiation
- Curtail the "long tail" of infrequent contributors to MBSE work
- Increase speed
  - Modelers become more responsive
  - Save skilled laborers for skilled labor

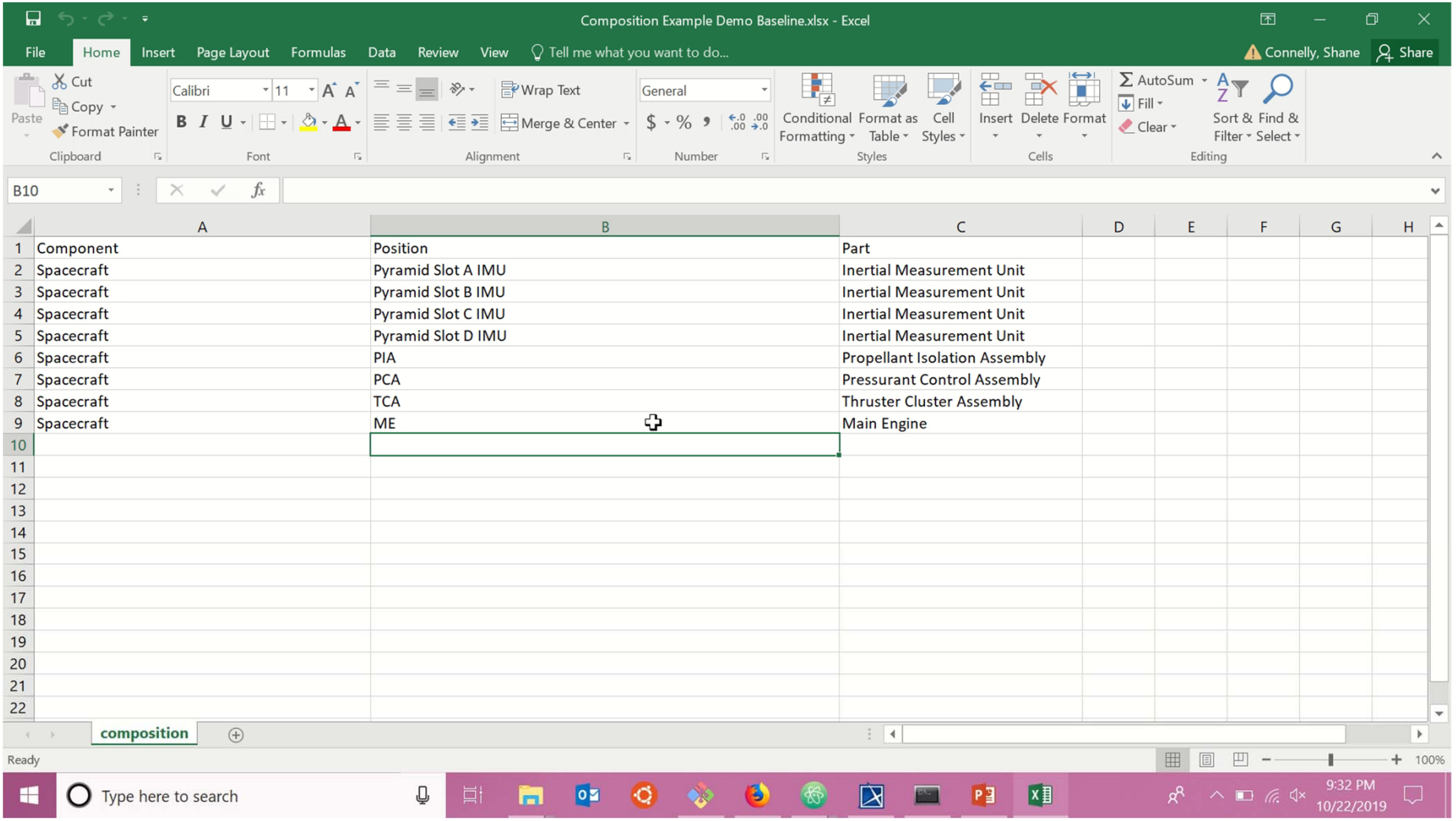
Ingrid Nerdman

- Spreadsheet based graph interpretation of a SysML modeling pattern to construct a new SysML model or update an existing one
- Reaches beyond the Cameo Excel/CSV Import
  - Supports full model creation
- Goes beyond Maple MBSE
  - Local change detection before touching the authoritative model
- Employs user predefined model patterns and meta data for all of its capabilities

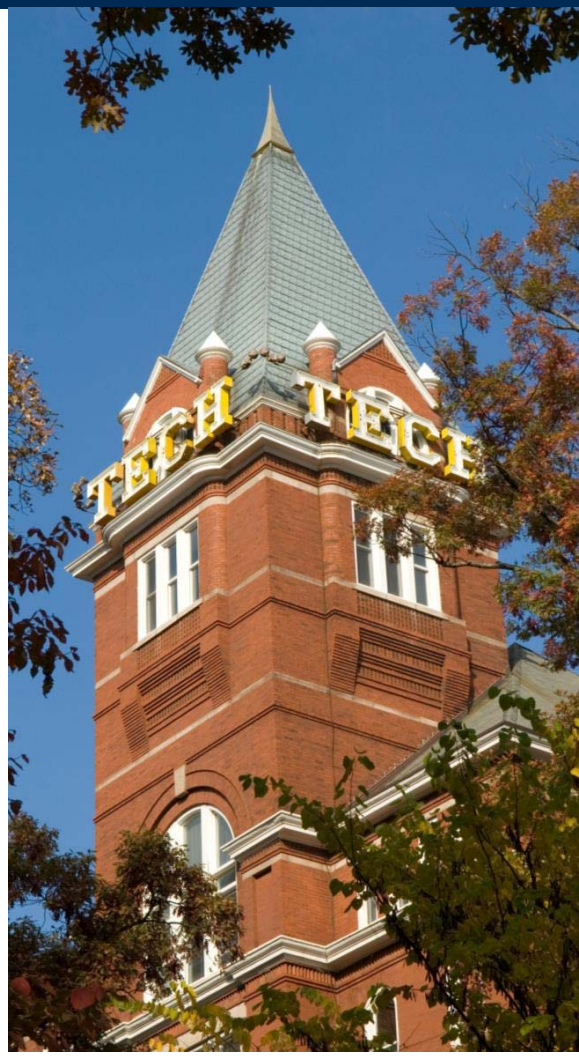

Component
Position
Part
Car
engine
Engine
Composite Thing
owner
component
type
Atomic Thing
type
memberEnd
Composite owner
memberEnd
owner
A_composite
owner_component

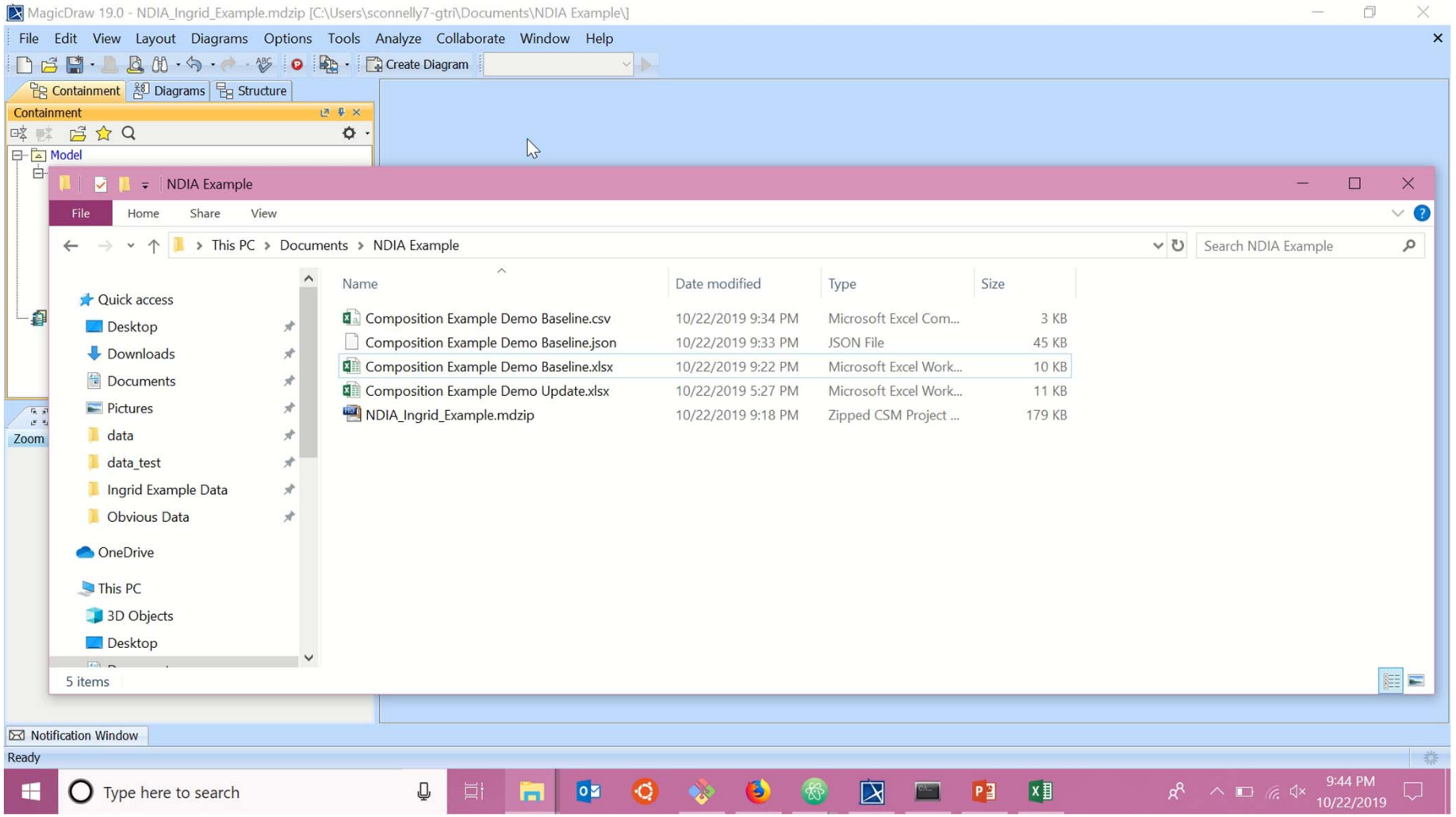
Ingrid Nerdman: Model Creation Demo




Composition Example Demo Baseline.xlsx - Excel
File Home Insert Page Layout Formulas Data Review View Tell me what you want to do...
Connelly, Shane Share
Cut Copy Format Painter Paste
Calibri 11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Cell Styles
Insert Delete Format
AutoSum Fill Clear
Sort & Filter Find & Select
Clipboard Font Alignment Number Styles Cells Editing
B10
A B C D E F G H
1 Component Position Part
2 Spacecraft Pyramid Slot A IMU Inertial Measurement Unit
3 Spacecraft Pyramid Slot B IMU Inertial Measurement Unit
4 Spacecraft Pyramid Slot C IMU Inertial Measurement Unit
5 Spacecraft Pyramid Slot D IMU Inertial Measurement Unit
6 Spacecraft PIA Propellant Isolation Assembly
7 Spacecraft PCA Pressurant Control Assembly
8 Spacecraft TCA Thruster Cluster Assembly
9 Spacecraft ME Main Engine
10
11
12
13
14
15
16
17
18
19
20
21
22
composition
Ready
100%
Type here to search
9:32 PM
10/22/2019

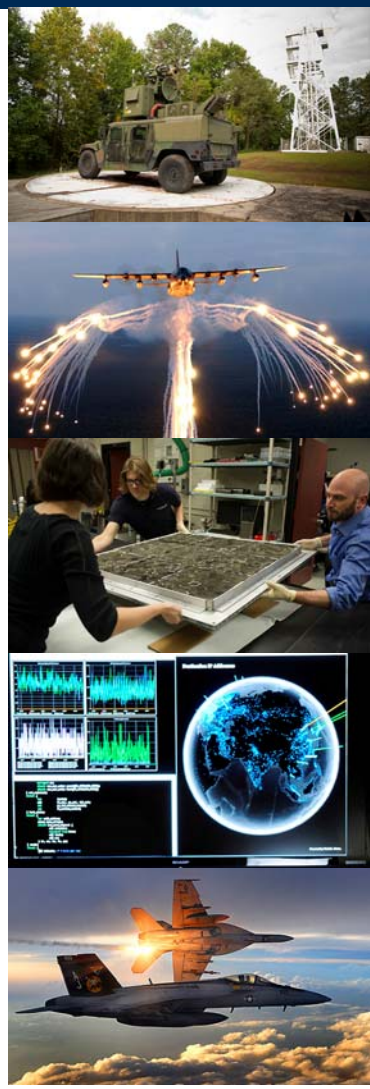
Ingrid Nerdman: Model Update Demo




MagicDraw 19.0 - NDIA_Ingrid_Example.mdzip [C:\Users\sconnelly7-gtri\Documents\NDIA Example\]
File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help
Create Diagram
Containment Diagrams Structure
Containment
Model
Zoom
NDIA Example
File Home Share View
This PC › Documents › NDIA Example
Search NDIA Example
Quick access
Desktop
Downloads
Documents
Pictures
data
data_test
Ingrid Example Data
Obvious Data
OneDrive
This PC
3D Objects
Desktop
Name
Date modified
Type
Size
Composition Example Demo Baseline.csv 10/22/2019 9:34 PM Microsoft Excel Com... 3 KB
Composition Example Demo Baseline.json 10/22/2019 9:33 PM JSON File 45 KB
Composition Example Demo Baseline.xlsx 10/22/2019 9:22 PM Microsoft Excel Work... 10 KB
Composition Example Demo Update.xlsx 10/22/2019 5:27 PM Microsoft Excel Work... 11 KB
NDIA_Ingrid_Example.mdzip 10/22/2019 9:18 PM Zipped CSM Project ... 179 KB
5 items
Notification Window
Ready
Type here to search
9:44 PM
10/22/2019

Questions

- We are in the process of open sourcing this tool
  - Email ingrid-nerdman@gtri.gatech.edu with requests for access



MBSE Workflow Tools

- The following analysis applies to any specialized CAD tool, but focus on SE tools today
- CAD tool for specialized operator that does complex SE tasks every day at high speed
- CAD tool leaves out "long tail" (tail is especially long in SE) of infrequent contributors, commenters, and editors

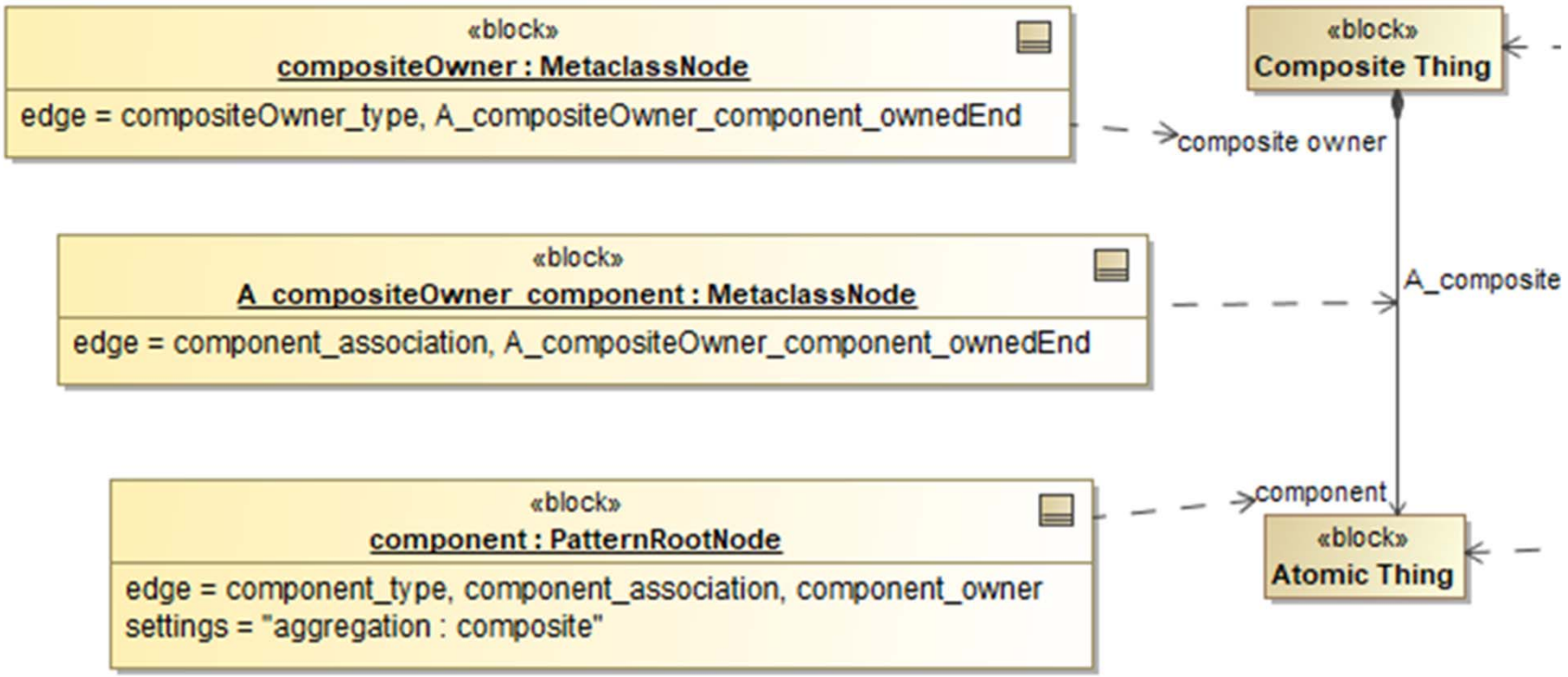
MBSE Workflow Tools - Need More Speed

- Many customers currently come to us later than they should, but the tools also make us slow to respond
- Hard to start with a lot of architectural work already done (or "done") and a need to build up a model quickly
- Just raw data ingestion tools would help

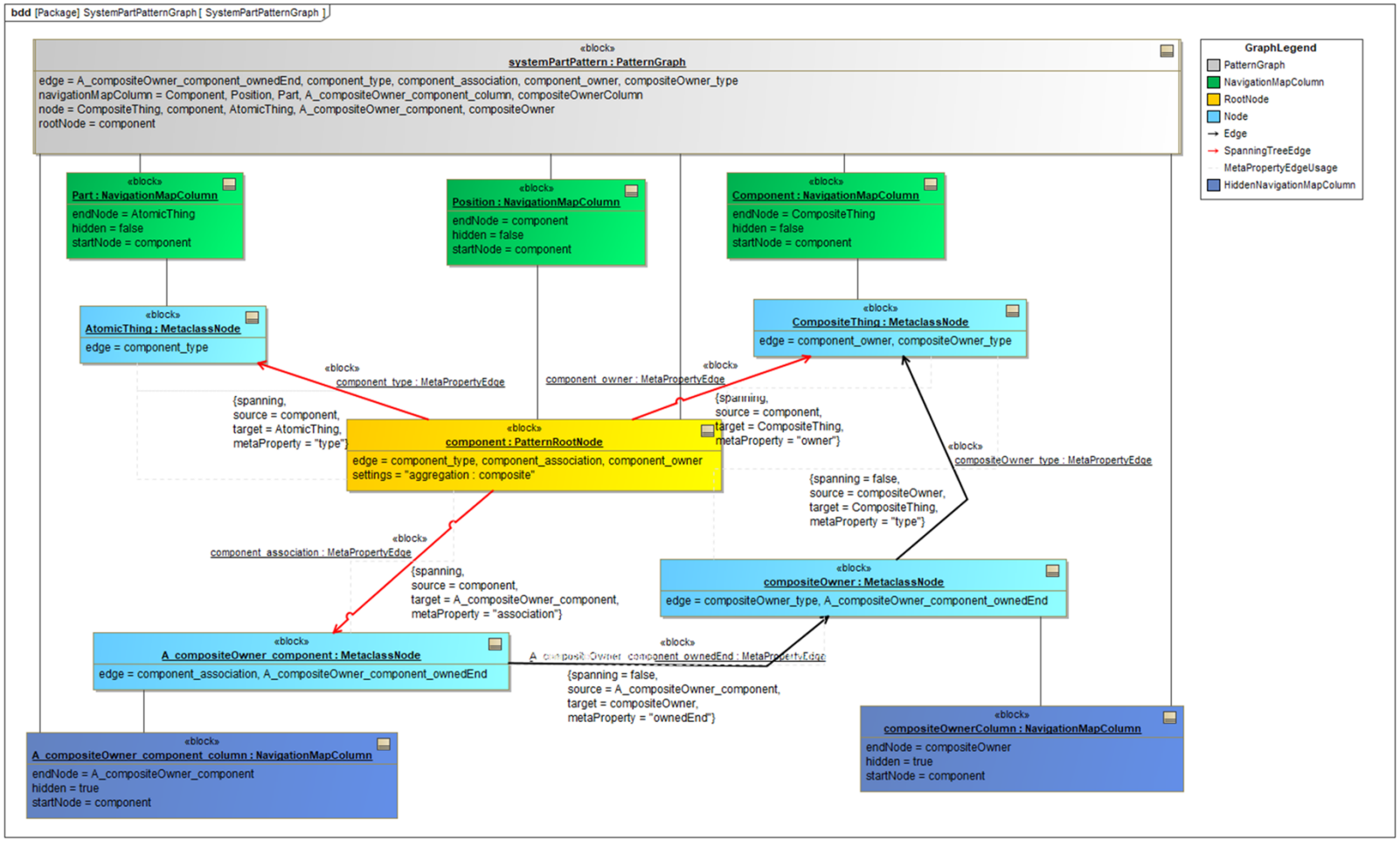
Ingrid Nerdman Concept

- Goal is to support bulk data entry by non-modelers
- Goes beyond Cameo Excel / CSV Import because it supports full model creation
- Goes beyond Maple MBSE due to doing change detection before touching authoritative model
- Uses predefined model pattern metadata to support above

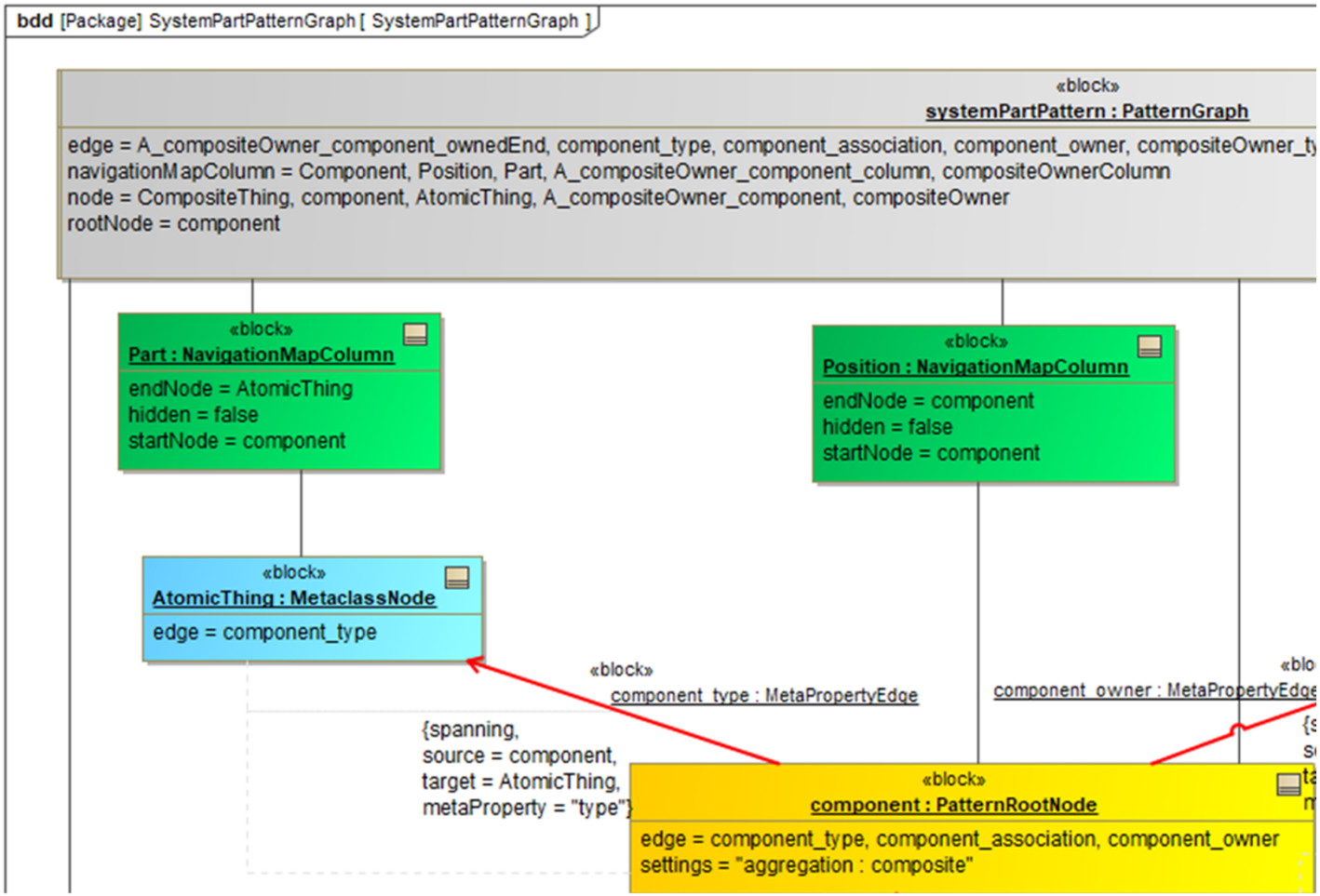
Pattern Templates Defined in Cameo



Pattern Templates Defined in Cameo



Pattern Templates Defined in Cameo



Ingrid Nerdman Process

- Pattern Sheet
  - Column titles represent particular model concepts with significance defined in the Pattern JSON
  - Each cell interpreted as a graph node and by extension a SysML item
- IDs
  - Assigned by Ingrid Nerdman if missing
  - Associates the nodes to their known MagicDraw IDs to facilitate model ingestion
- Renames
  - User specifies desired name changes to elements of the model
  - Helps Ingrid Nerdman interpret user intent

Ingrid Nerdman Process

- Excel File loaded in through command line
  - Pattern matched by sheet name
  - If provided, IDs and renames parsed
- Columns correspond to node type in subgraph
  - Columns added to complete the subgraph
  - Excess columns interpreted as annotations

Component	Position	Part
Car	engine	Engine

Ingrid Nerdman Process

- Original compared to Change
  - Model type consistent
    - Edge attributes constant
  - Edges describe complete set of connections in model

- Change detection inspired by stable marriage algorithm applied to edges

Original Edge → Change Edges

{ (Car, engine, owner): [((Vehicle, engine, owner), 2), ((Engine, engine, owner), 1), (Drivetrain, drivetrain, owner), 0) …] }

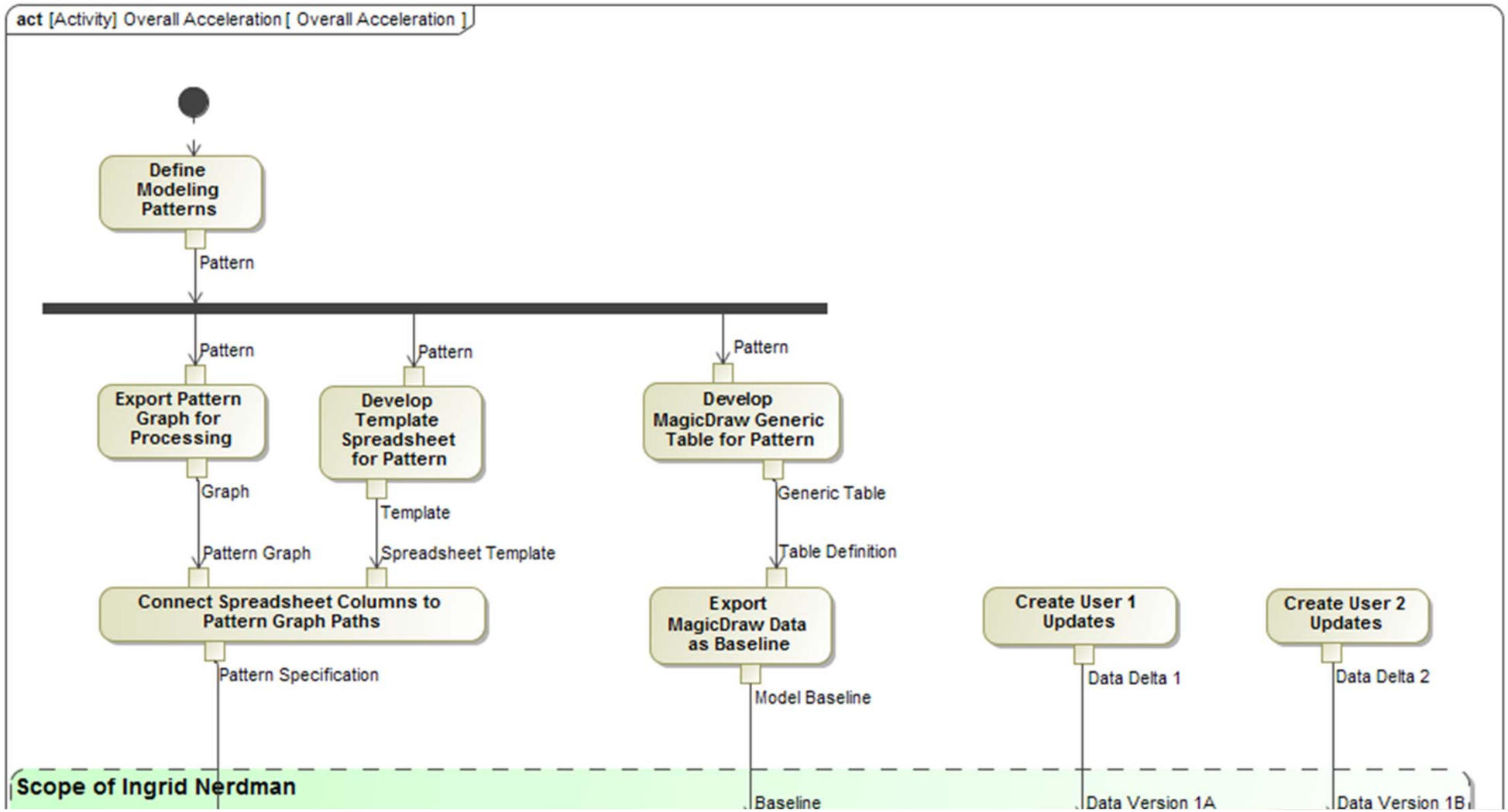
Ingrid Nerdman Process

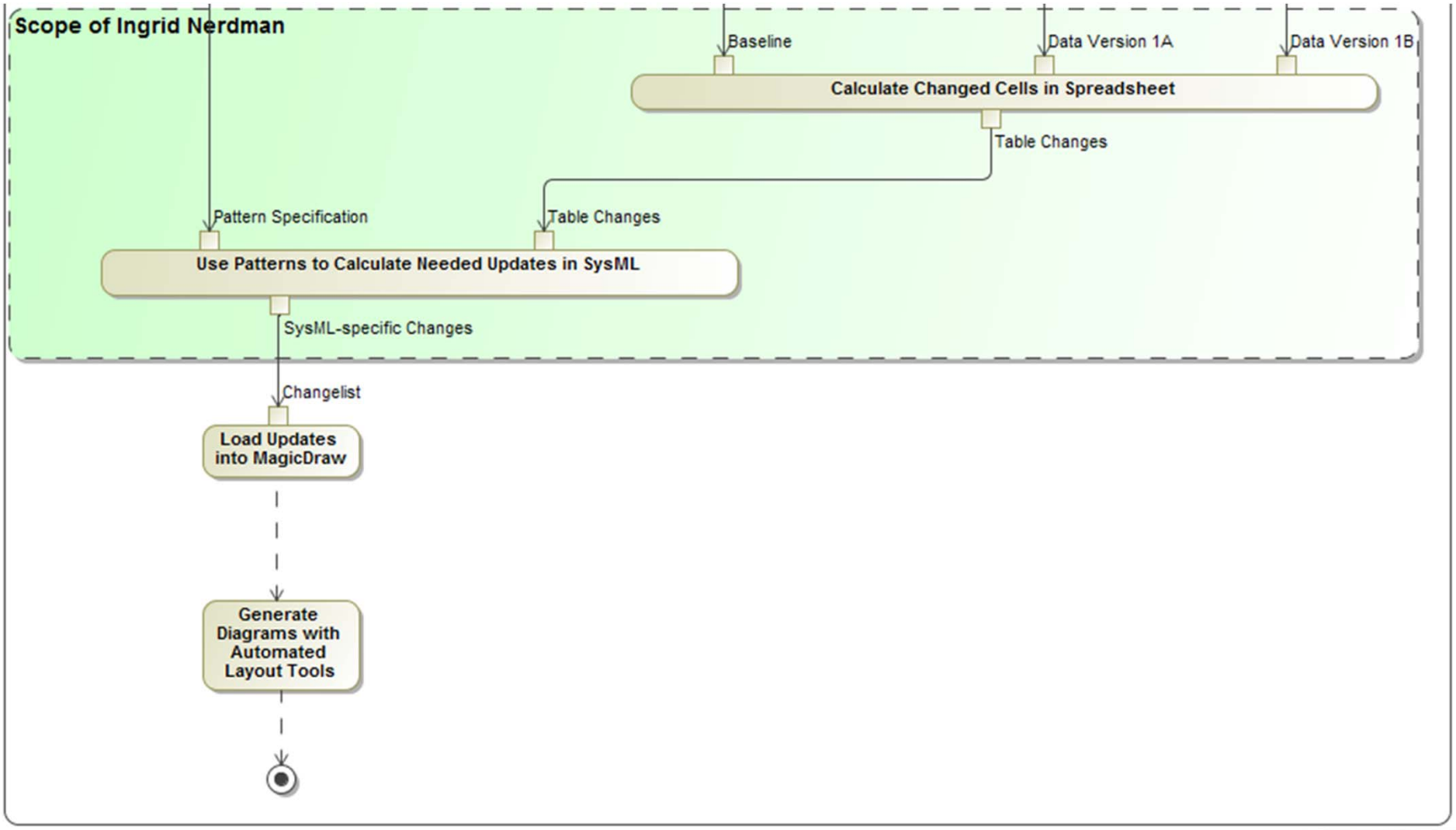
- High confidence changes and model creation written to JSON for SysML digestion
- Reusable JSON template for nodes and edges
  - Model creation or update changes the values passed to the template and operation communicated to Magic Draw
  - Patterns Template provides the SysML object specifications and Ingrid Nerdman passes the objects role relative to neighbors

Ingrid Nerdman Process

- Spreadsheet view
  - First two columns show JSON changes
  - Unstable Columns let the user know of the changes that the computer was unsure of

Edit 1	Edit 2	Unstable Matches Original	Unstable Matches Change
('ME', 'Spacecraft', 'owner')	('ME', 'Space Ship', 'owner')	('spacecraft qua me context', 'Spacecraft', 'type')	('space ship qua me context', 'Space Ship', 'type')
('Thruster-1', 'Small Thruster', 'type')	('Thruster-1', 'Big Thruster', 'type')	('spacecraft qua me context', 'Spacecraft', 'type')	('propellant isolation assembly qua sv-5 context', 'Propellant Isolation Assembly', 'type')
		('spacecraft qua me context', 'Spacecraft', 'type')	('SV-5', 'Solenoid Valve', 'type')
		('spacecraft qua me context', 'Spacecraft', 'type')	('Thruster-1', 'Big Thruster', 'type')


act [Activity] Overall Acceleration [Overall Acceleration]
Define Modeling Patterns
Pattern
Pattern
Pattern
Pattern
Export Pattern Graph for Processing
Develop Template Spreadsheet for Pattern
Develop MagicDraw Generic Table for Pattern
Graph
Template
Generic Table
Pattern Graph
Spreadsheet Template
Table Definition
Connect Spreadsheet Columns to Pattern Graph Paths
Export MagicDraw Data as Baseline
Create User 1 Updates
Create User 2 Updates
Pattern Specification
Model Baseline
Data Delta 1
Data Delta 2
Scope of Ingrid Nerdman
Baseline
Data Version 1A
Data Version 1B


Scope of Ingrid Nerdman
Baseline
Data Version 1A
Data Version 1B
Calculate Changed Cells in Spreadsheet
Table Changes
Pattern Specification
Table Changes
Use Patterns to Calculate Needed Updates in SysML
SysML-specific Changes
Changelist
Load Updates into MagicDraw
Generate Diagrams with Automated Layout Tools