33rd Annual INCOSE international symposium
hybrid event
Honolulu HI USA

Data Visualization to Address Program and Systems Engineering Problems in Large Projects

Modeling Schedule Logic

Outline

- Problem context
- Data visualization with graphs
- Data visualization for modeling and solving problems
- Data visualization for systems engineering
- Case study
- Process to develop the interactive schedule logic modeling capability
- Importance of interactivity
- Ease of process
- Additional material

Problem Context

Problem Context - Working with large schedules

Unique attributes of large projects
- Extremely large schedules
- Murky picture of work/product relationships
- Changes over time convolute the schedule and understanding of work/product relationships
- Not readily human comprehensible

Types of problems
- Staff/Management/Customer do not have full understanding of schedule
- New staff have difficulty comprehending
- Poor comprehension of risk and impact on other project areas
- Assessment of change is limited – full scope is hard to identify
- Misunderstandings drive unneeded changes – further obscuring schedule structure and resulting in incorrect logic
- Variance Analysis Reports are based on silos of information
- Belief or trust in schedule is deteriorated

Problems impact Program Management and Systems Engineering Efforts
- Earned Value Management
- Management Reserve Allocation
- Risk
- Impact assessments for technical solution feasibility (design, development, integration, verification, validation, production, operation, sustainment)
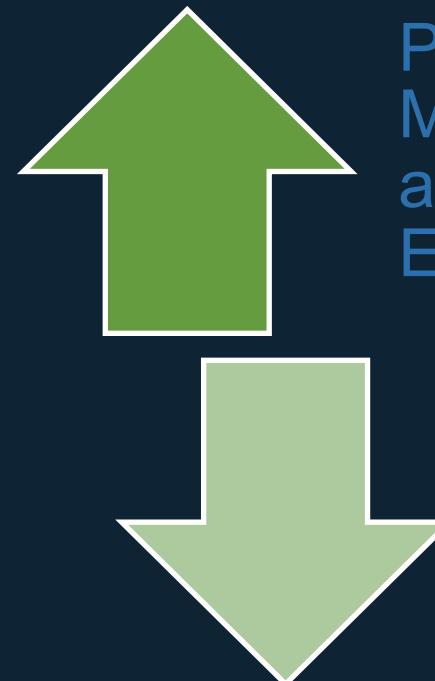
Program Management and Systems Engineering

Poor Comprehension of Schedule Logic

Working with Large Schedules

Current approaches to dealing with large schedules

- Critical path analysis

- Network diagrams (schedule logic diagram) – displays relationships
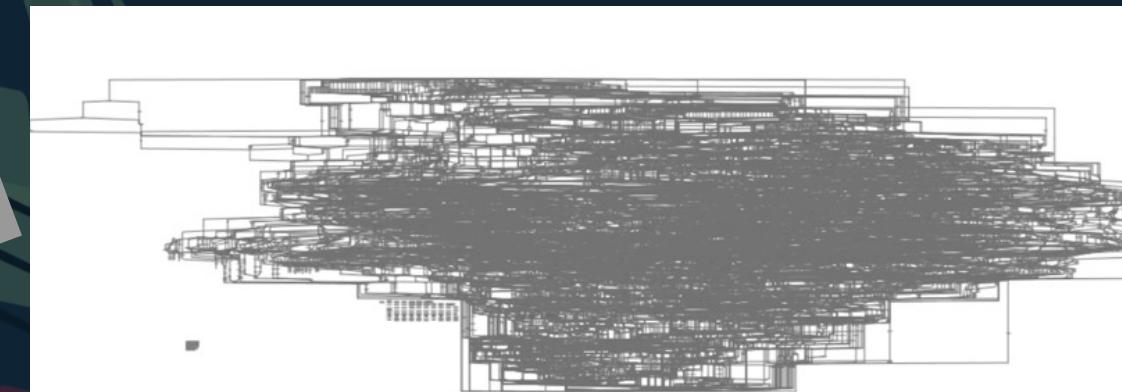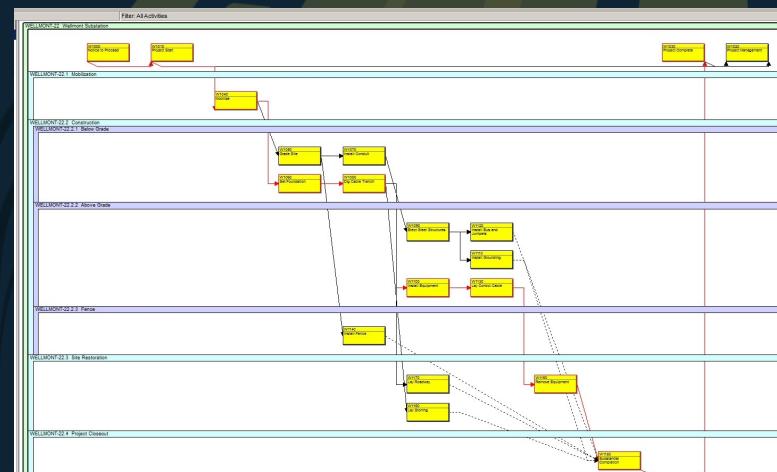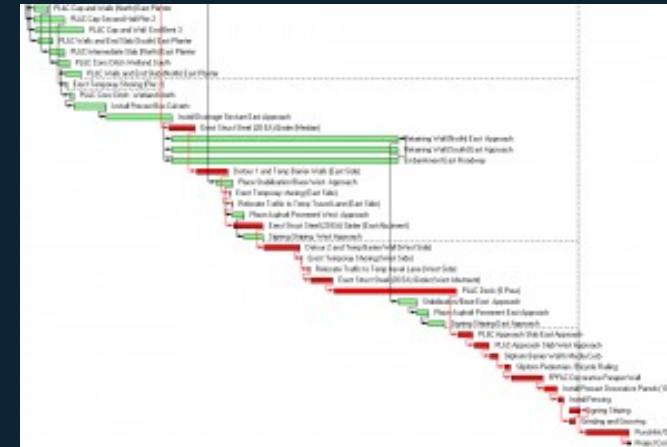
Current State with Large Network Diagrams

Working with Large Schedules

Current approaches to dealing with large schedules

• Critical path analysis

• Network diagrams (schedule logic diagram) – displays relationships
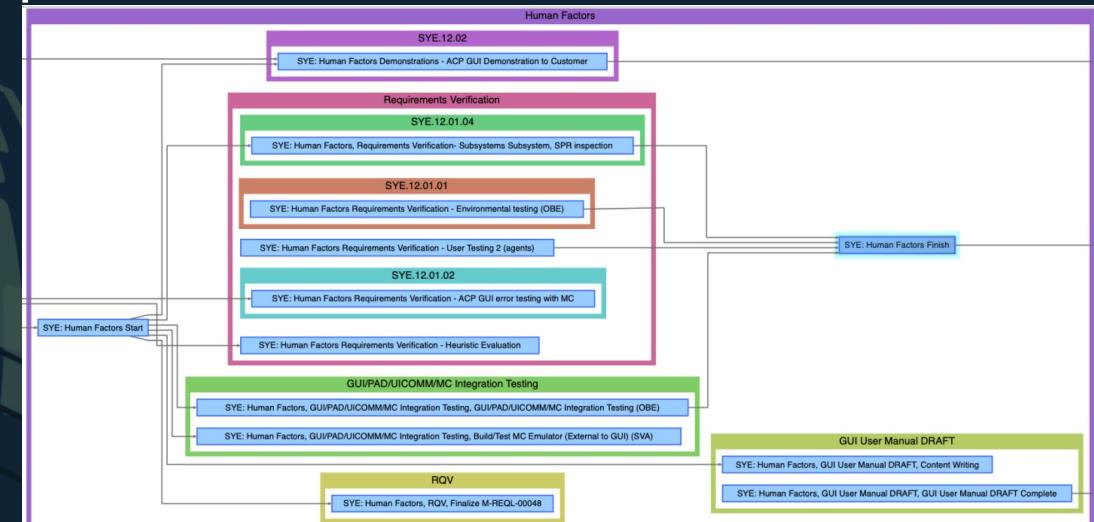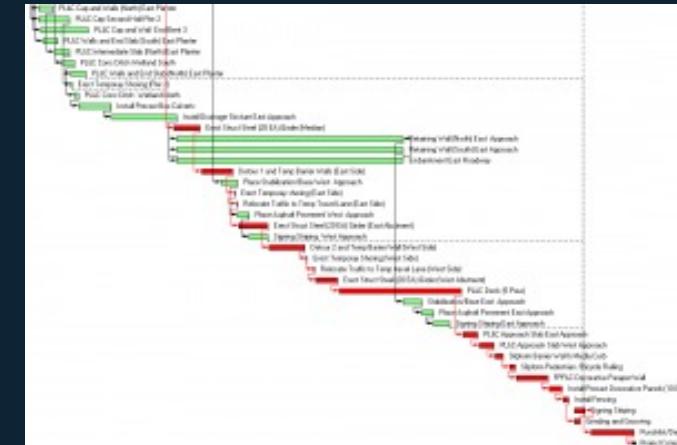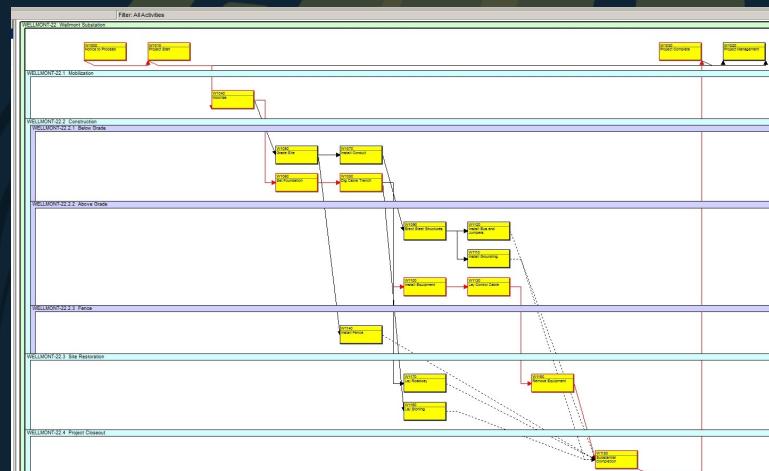

What if we could have this?

Working with Large Schedules

Current app...
large sched...

- Critical p...
- Network ...

  diagram...
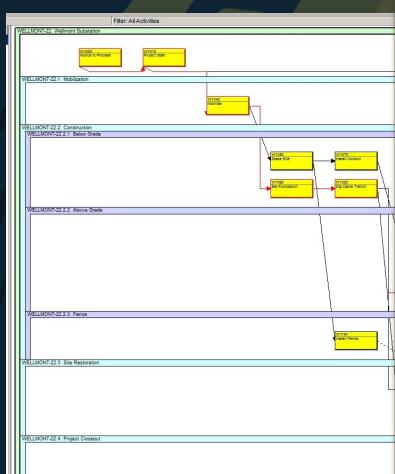
What if you could:

- **Vary the levels of abstraction**
- **Visually consider (individually or combined)**
  - completed tasks
  - in-work tasks
  - work not started
  - work by Product Realization Team (PRT)
  - work by major component
  - work by major project milestone
  - work by float duration, critical path or any number of other project specific needs
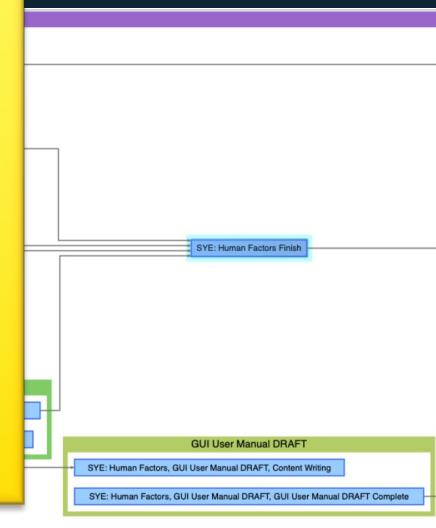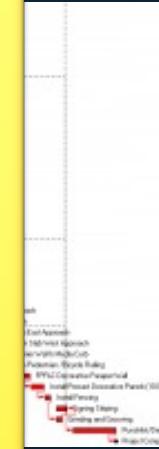
What if we could have this?

Data Visualization with Graphs

Graphs

- Nodes (or vertices)
- Relationships (or edges)
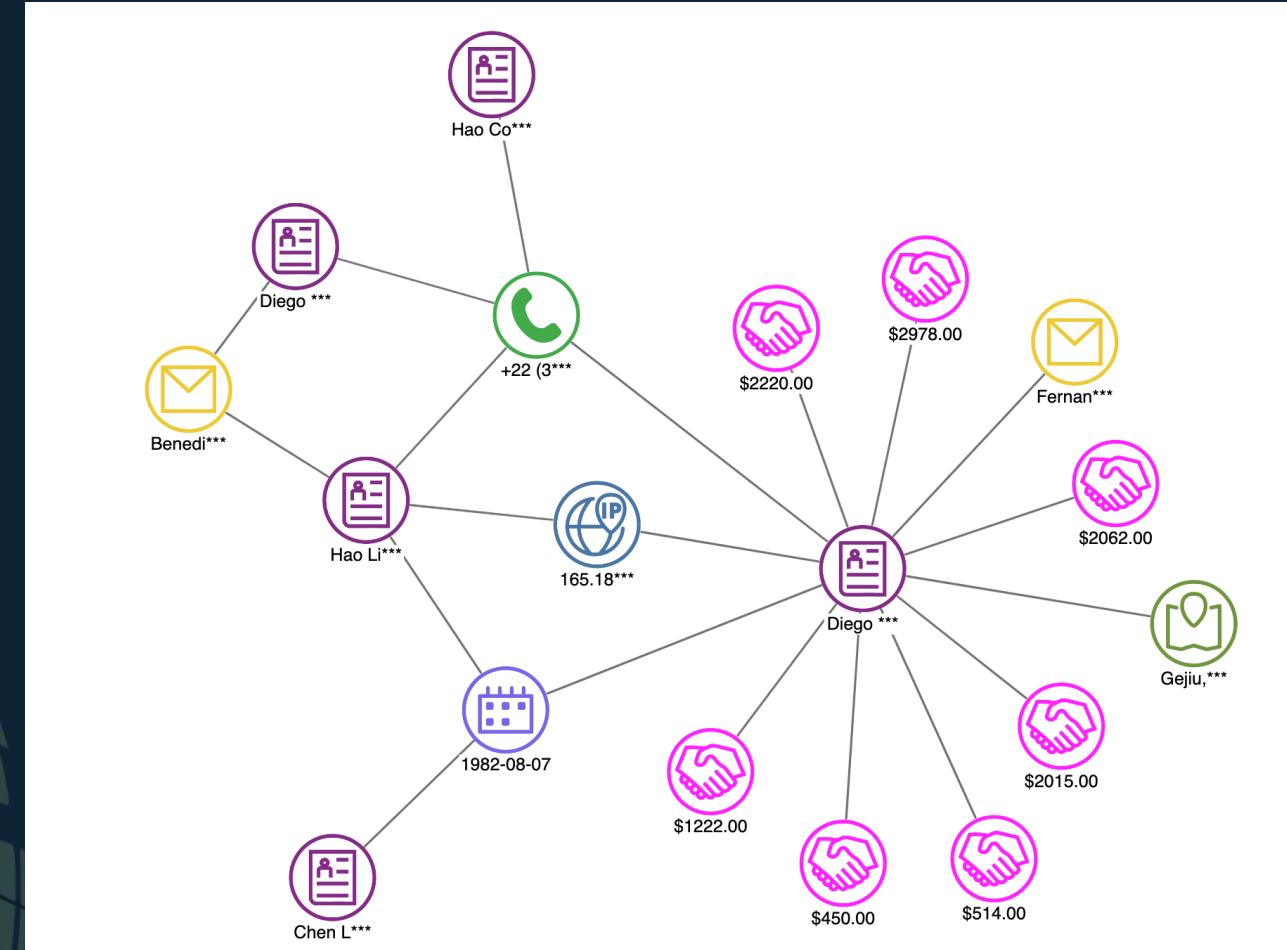
Graphs

- ## Nested Drawings

  – Graph inside a node

  – Graph inside an edge

  – Edges to nodes in other nested drawings
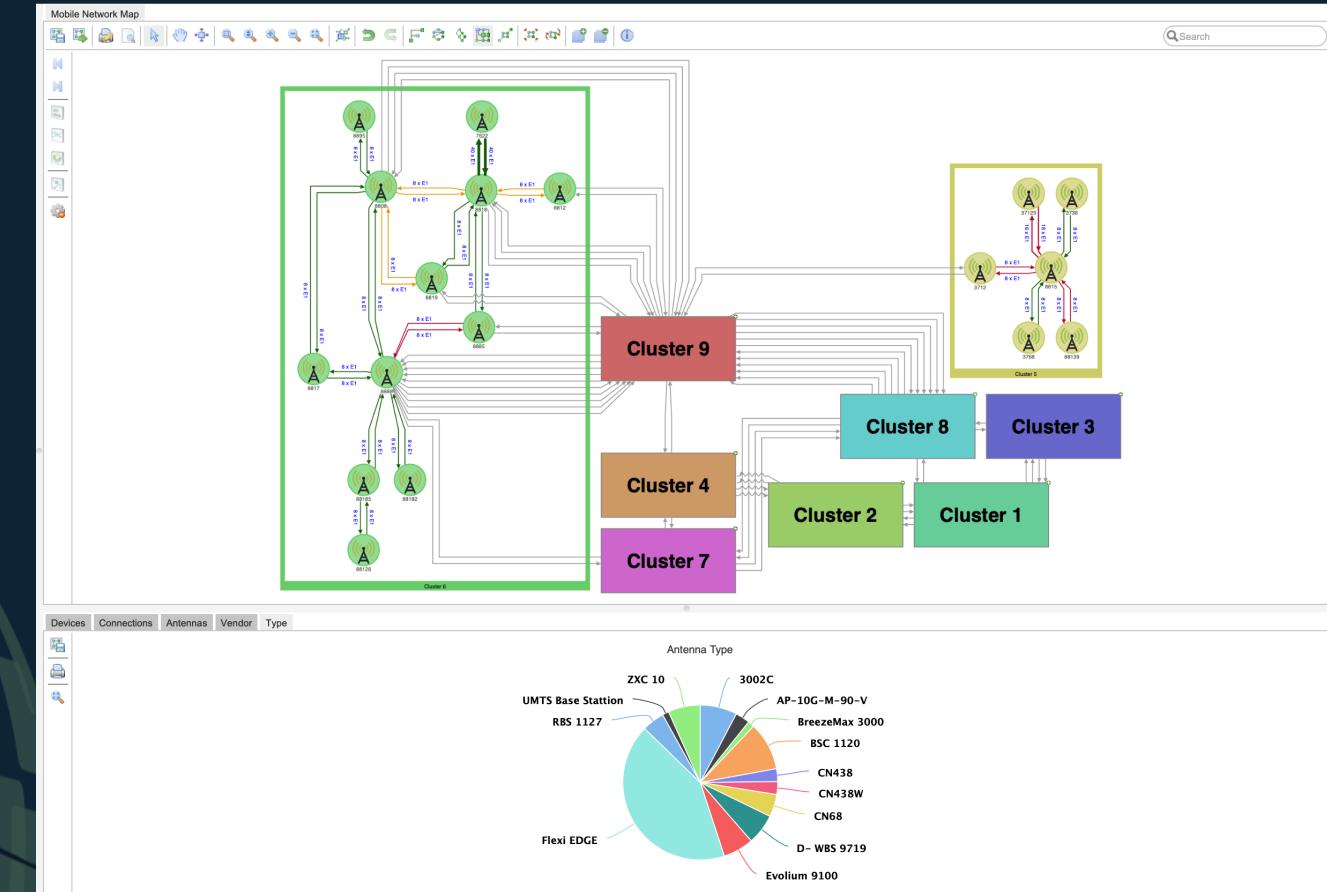
Graphs

- # Nested Drawings

  – Graph inside a node

  – Graph inside an edge

  – Edges to nodes in other nested drawings
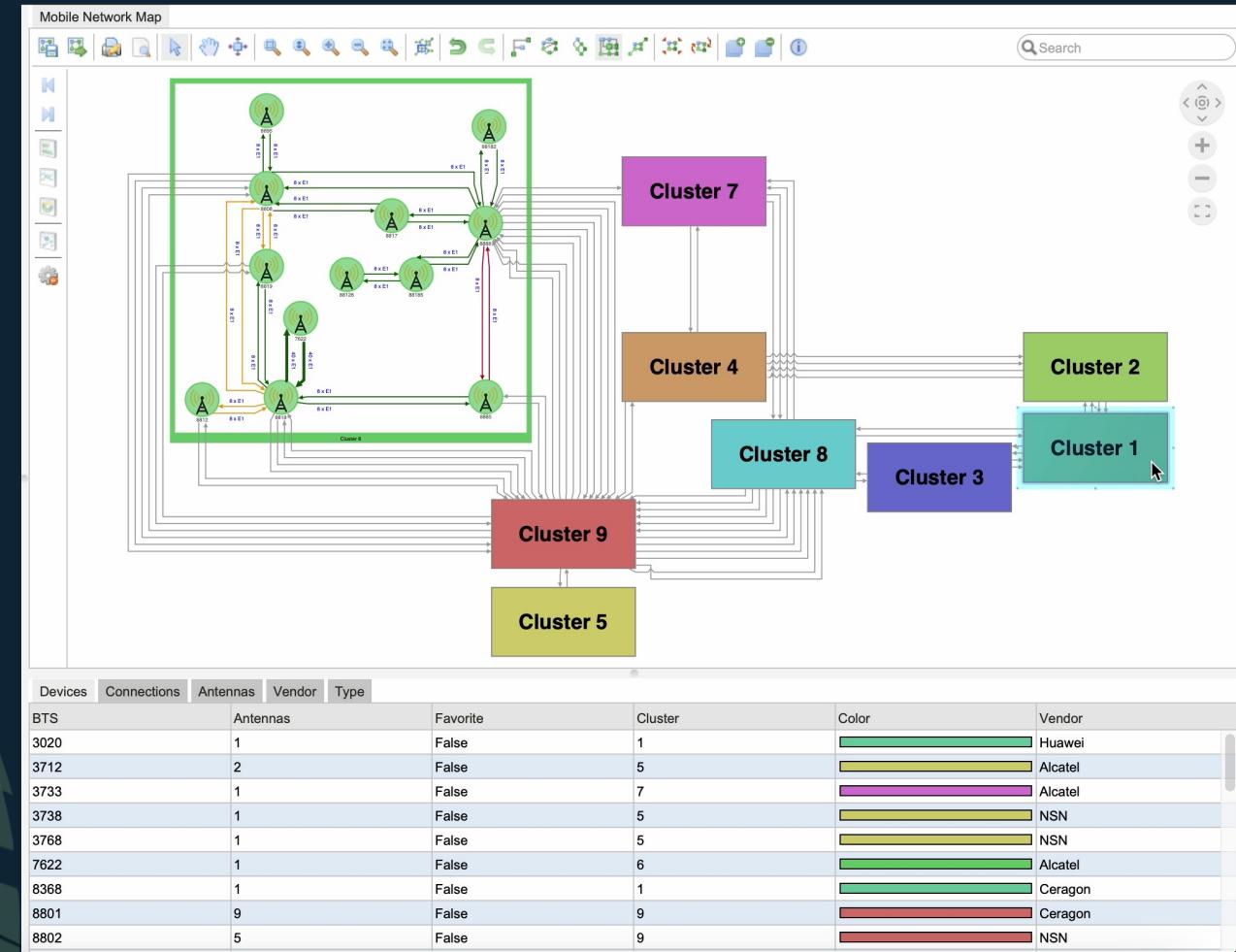
Graphs

- ## Labels
  – Node labels
  – Edge labels
  – Connector labels
  – Edge decoration labels
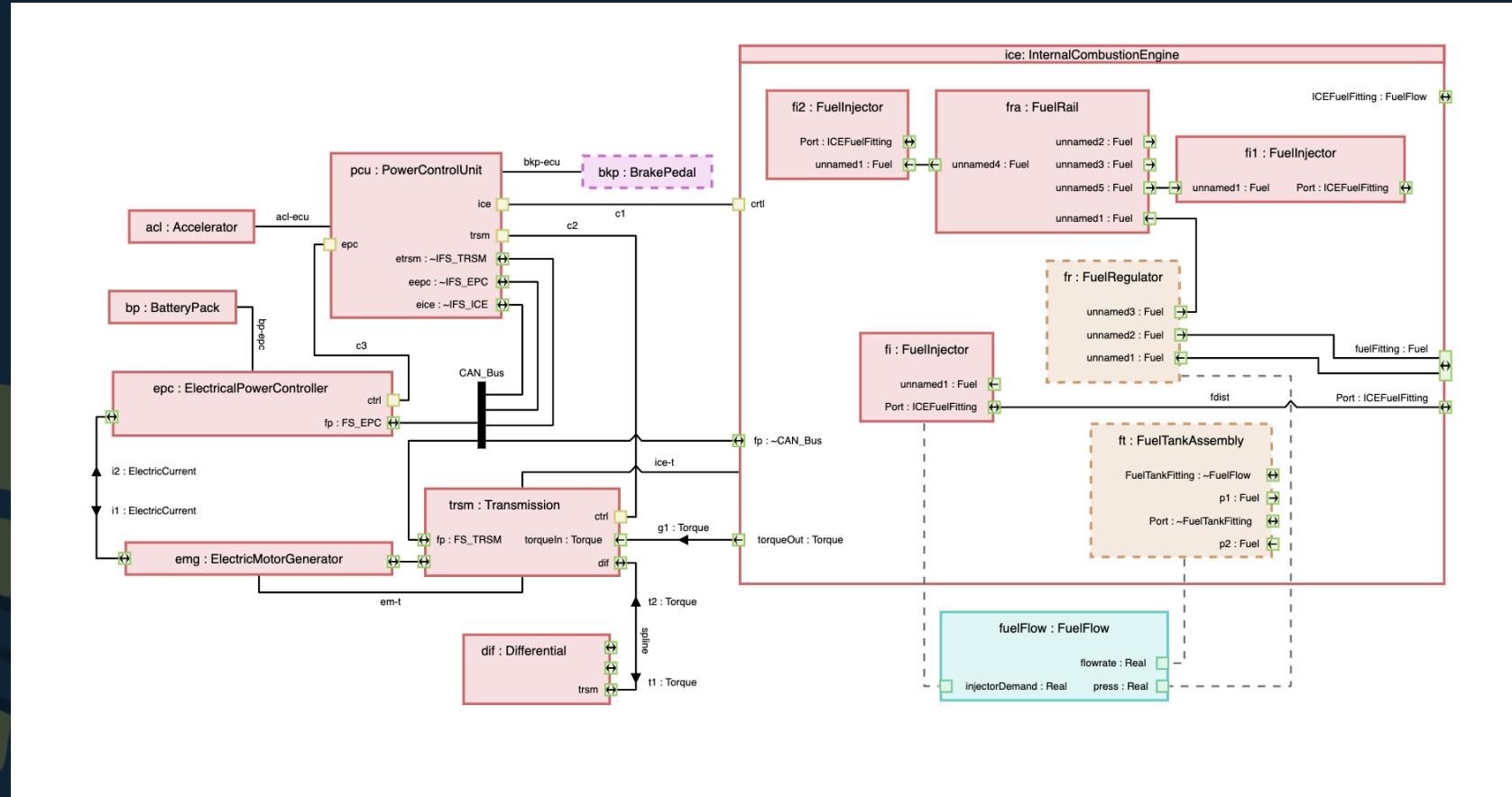
Graphs

- One-Dimensional Swimlanes

- Two-Dimensional Swimlanes
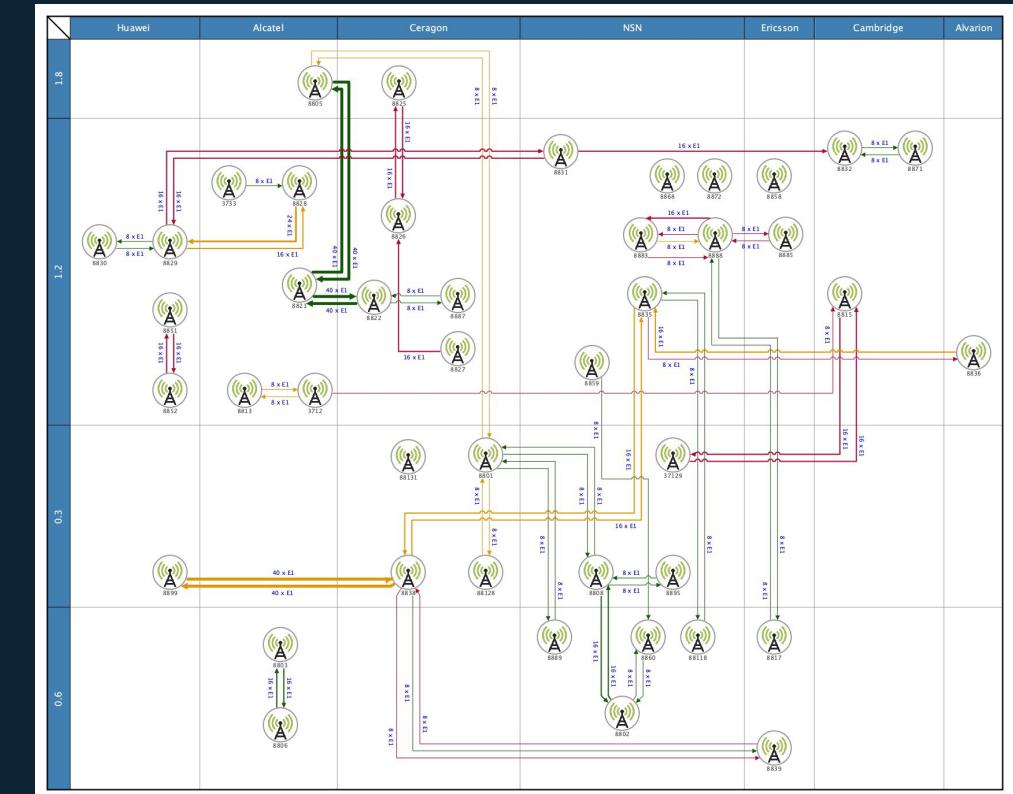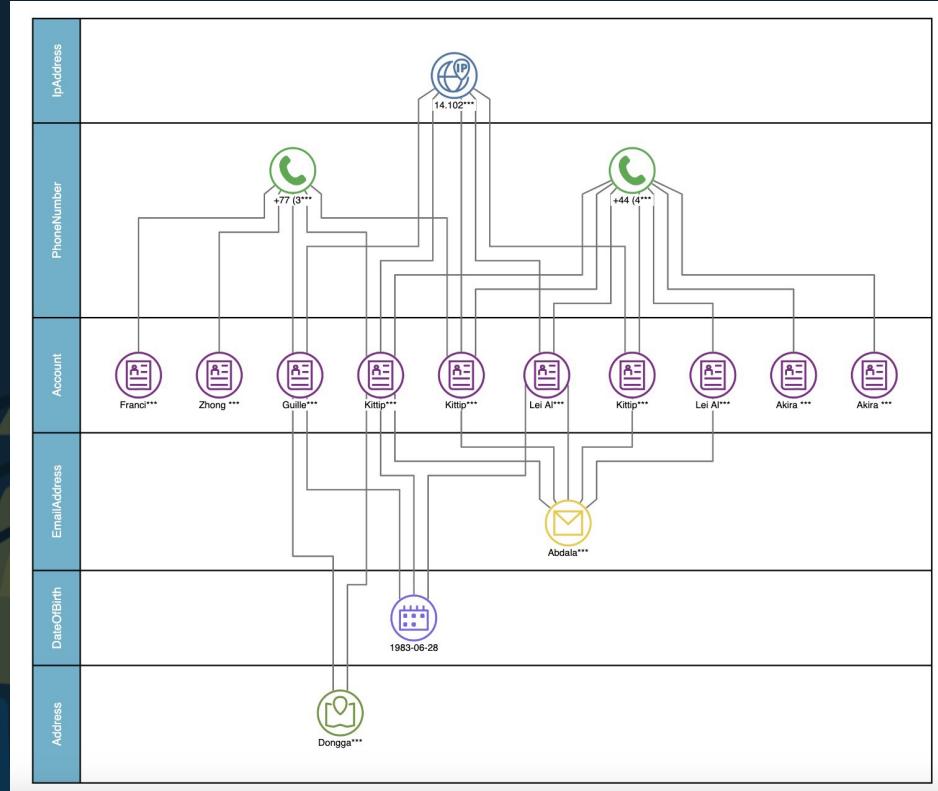
Data Visualization for Modeling and Solving Problems

Graphs for Modeling and Analysis

- Support users in modeling their systems as graphs
- Apply graph visualizations and analyses to discover areas of interest in their data
- Apply graph visualizations and analyses to optimize their systems

Graphs for Modeling and Analysis
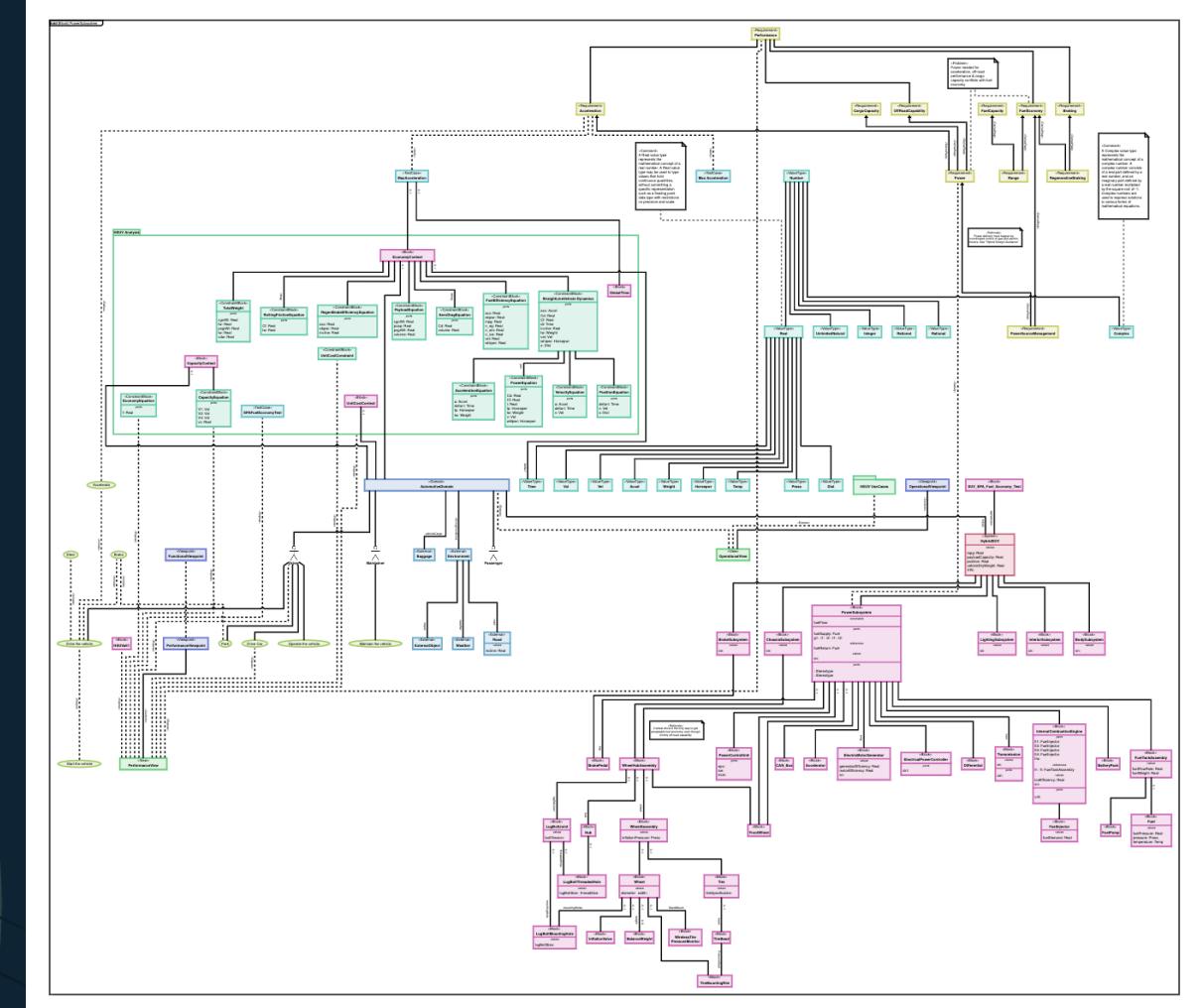
- Support users in modeling their systems as graphs

Graphs for Modeling and Analysis

- Apply graph visualizations and analyses to discover areas of interest in their data
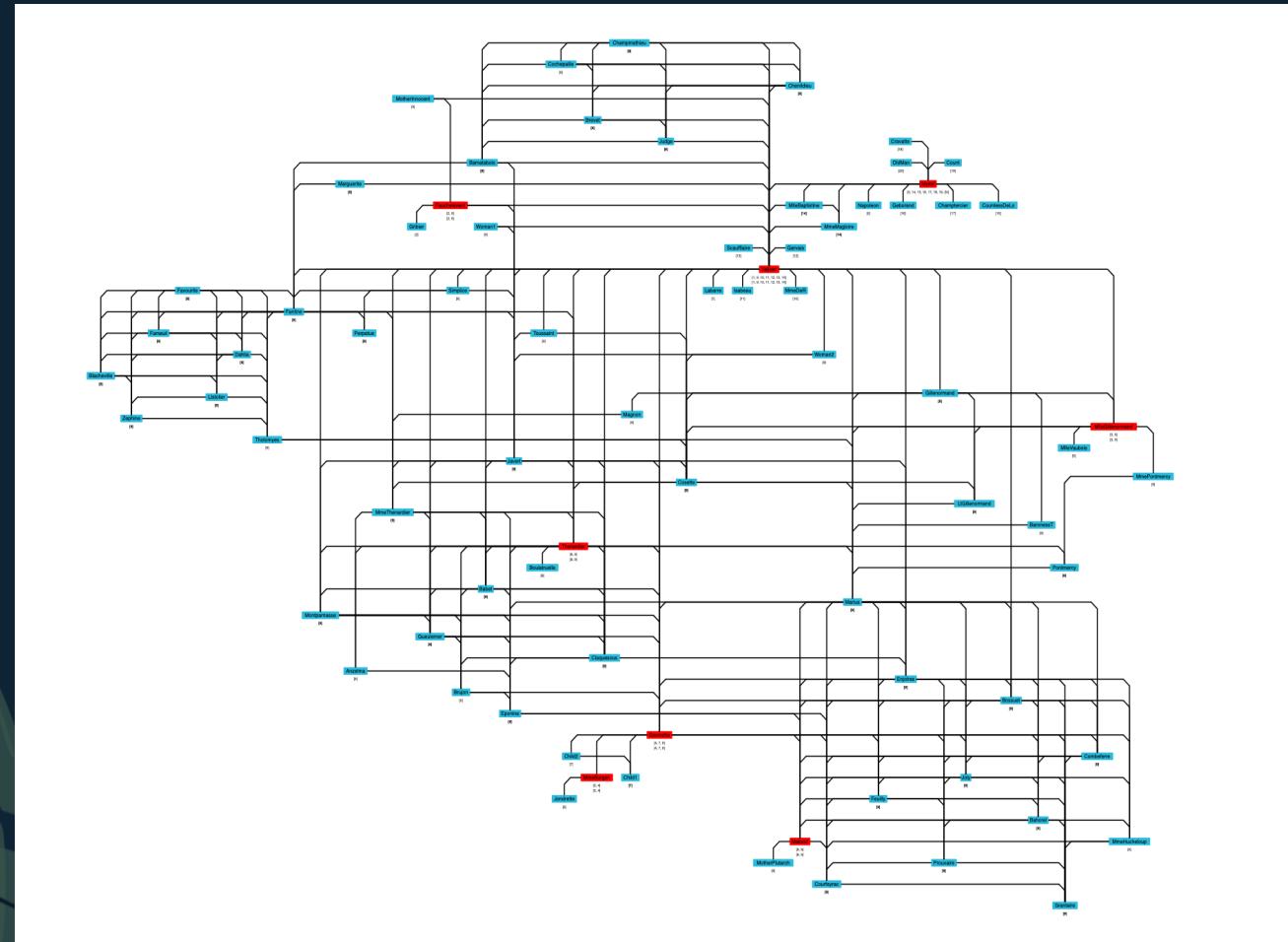
Graphs for Modeling and Analysis

- Apply graph visualizations and analyses to optimize their systems
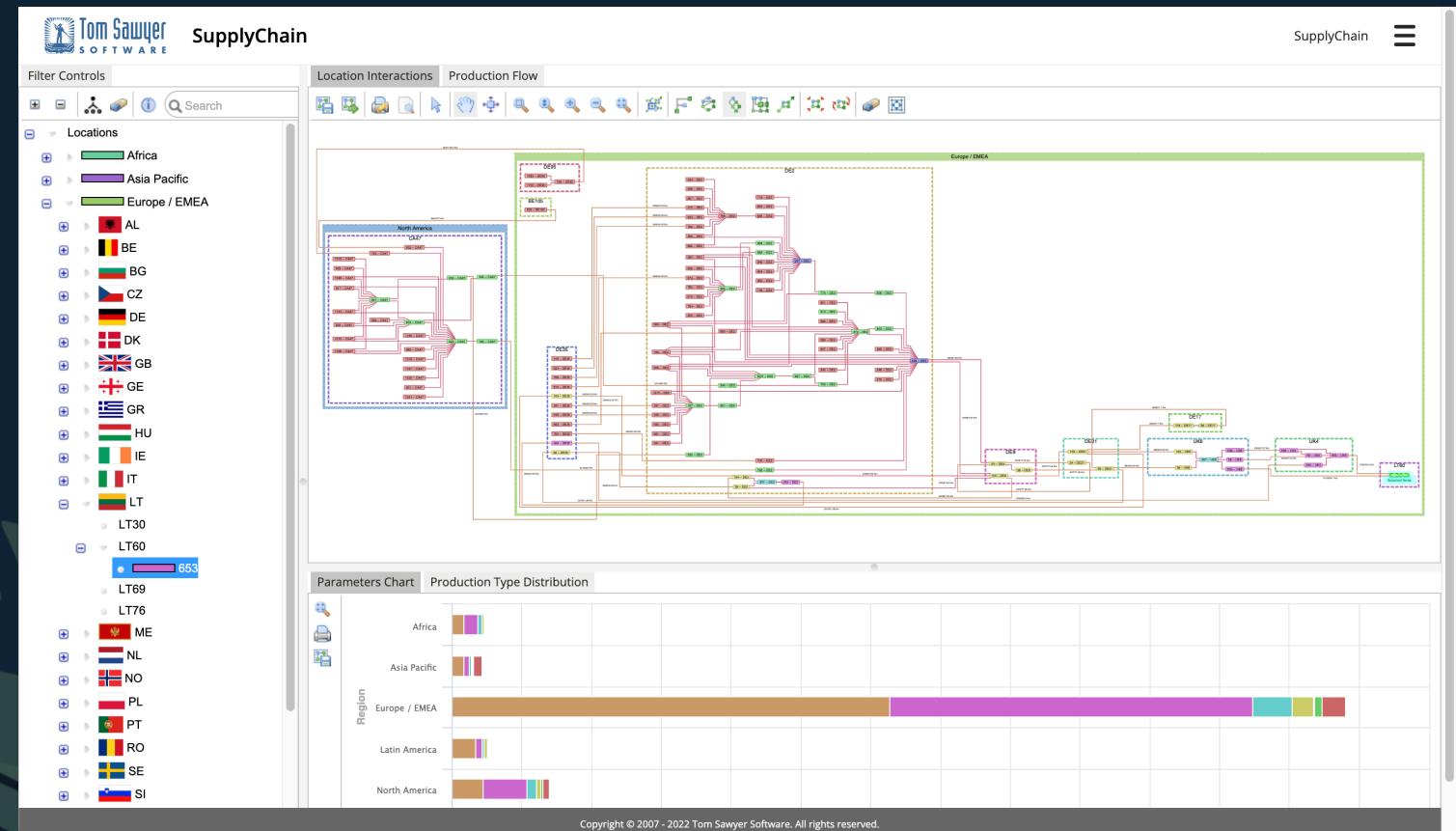
Graphs for Communication

- Deliver pertinent information to decision makers

- Communicate key results to stakeholders

Graphs for Communication

- Deliver pertinent information to decision makers
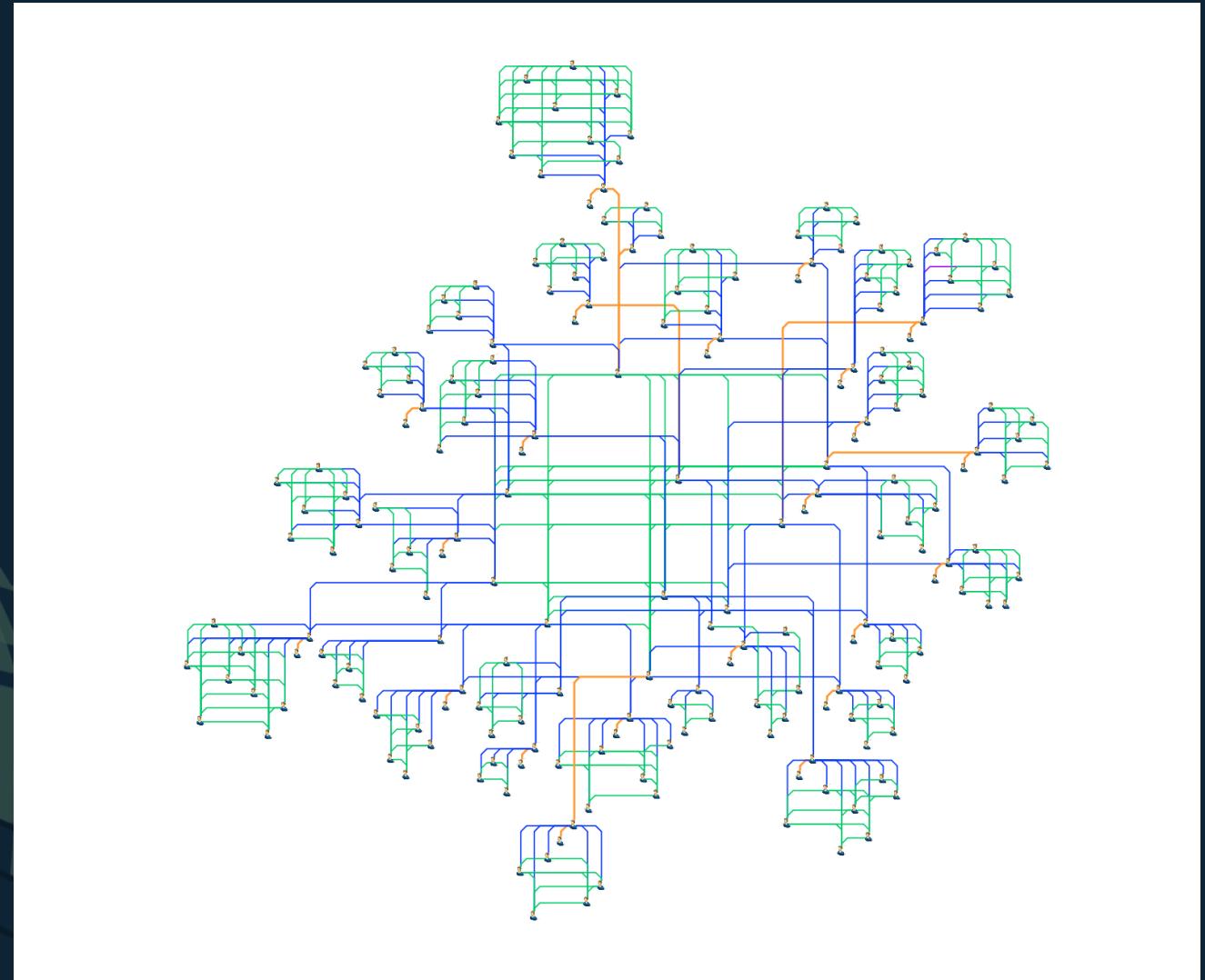
Graphs for Communication

- Communicate key results to stakeholders

Data Visualization for Systems Engineering
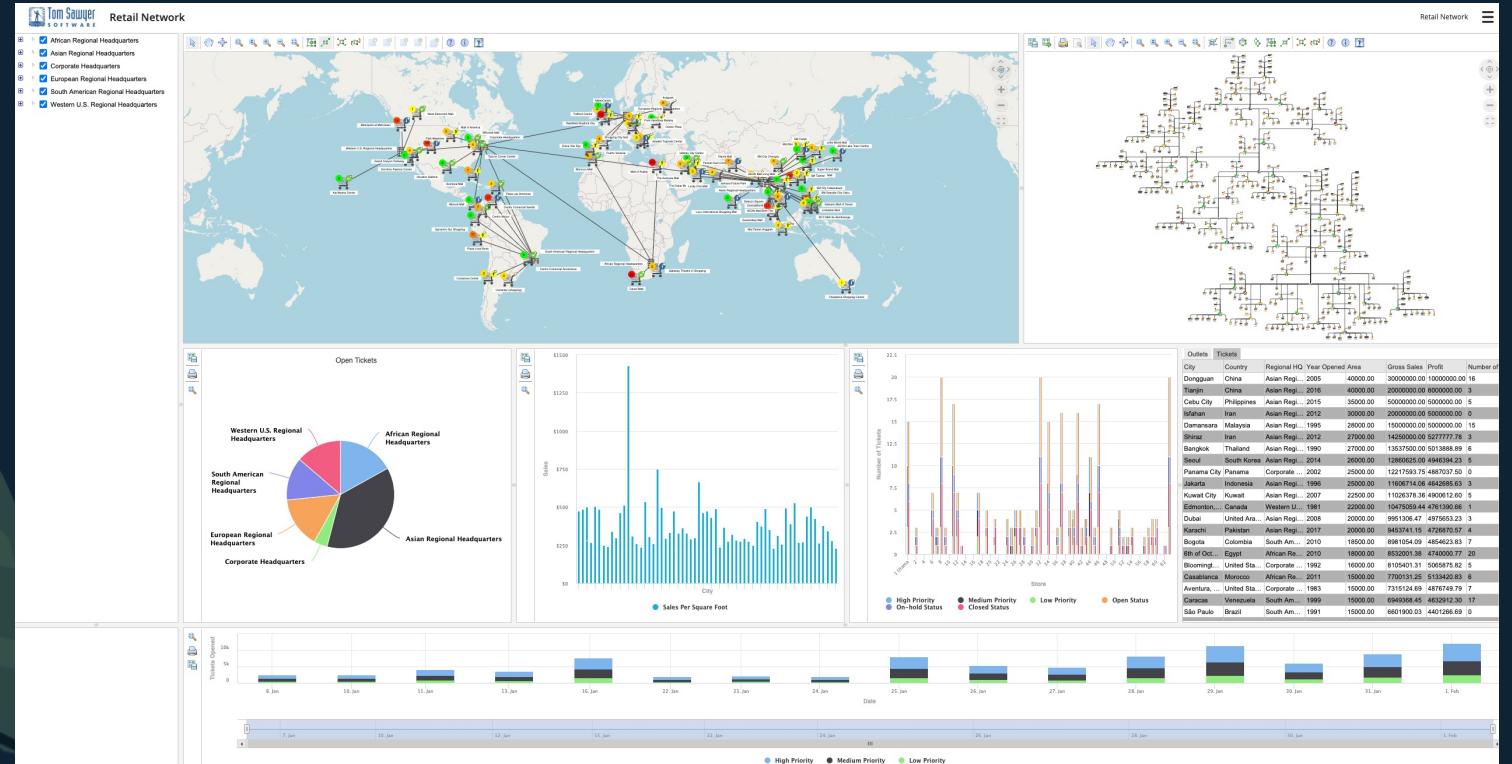
Bring human experts back into the equation

# Graphs for Modeling, Analysis, Communication

- Bring human experts back into the equation
  - "There is something interesting here, let's look further"
  - "I have seen this pattern in another situation, a similar solution may be helpful here as well"
  - "There is an almost-pattern right there!" (almost vulnerability in a communications network, almost viable alternative for supply chain component, etc.)
  - "We can optimize the system here"
  - Multiple views into the same data provide a basis for the solution

Models Changing Over Time

- Implications of dynamic change for visualization and analysis
  - Formation of new graph topology
  - Updates that need to be highlighted
  - Trends to be discovered

New Insights to be Discovered and Communicated

# Models Changing Over Time
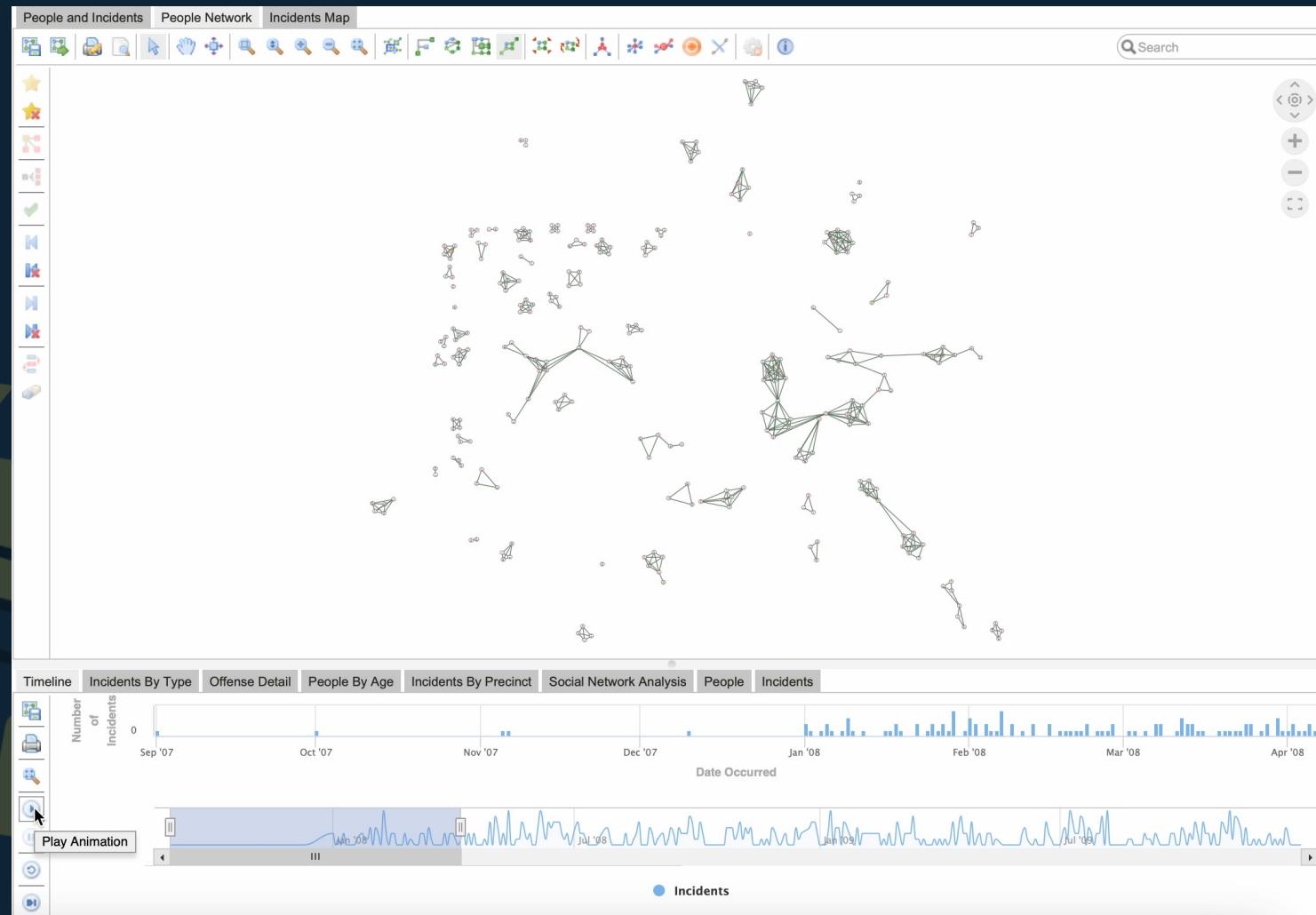
Models Changing Over Time
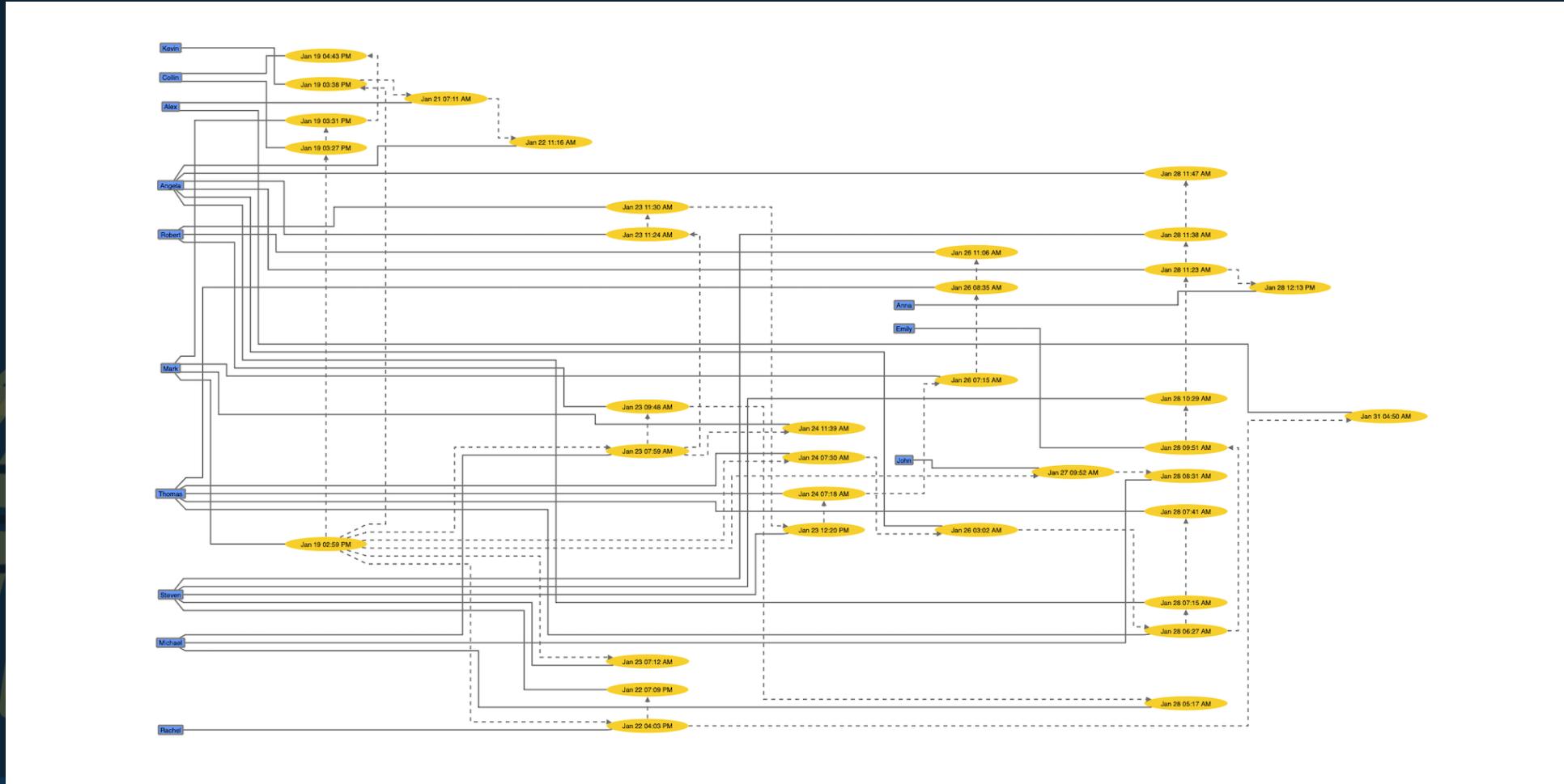
Models Changing Over Time
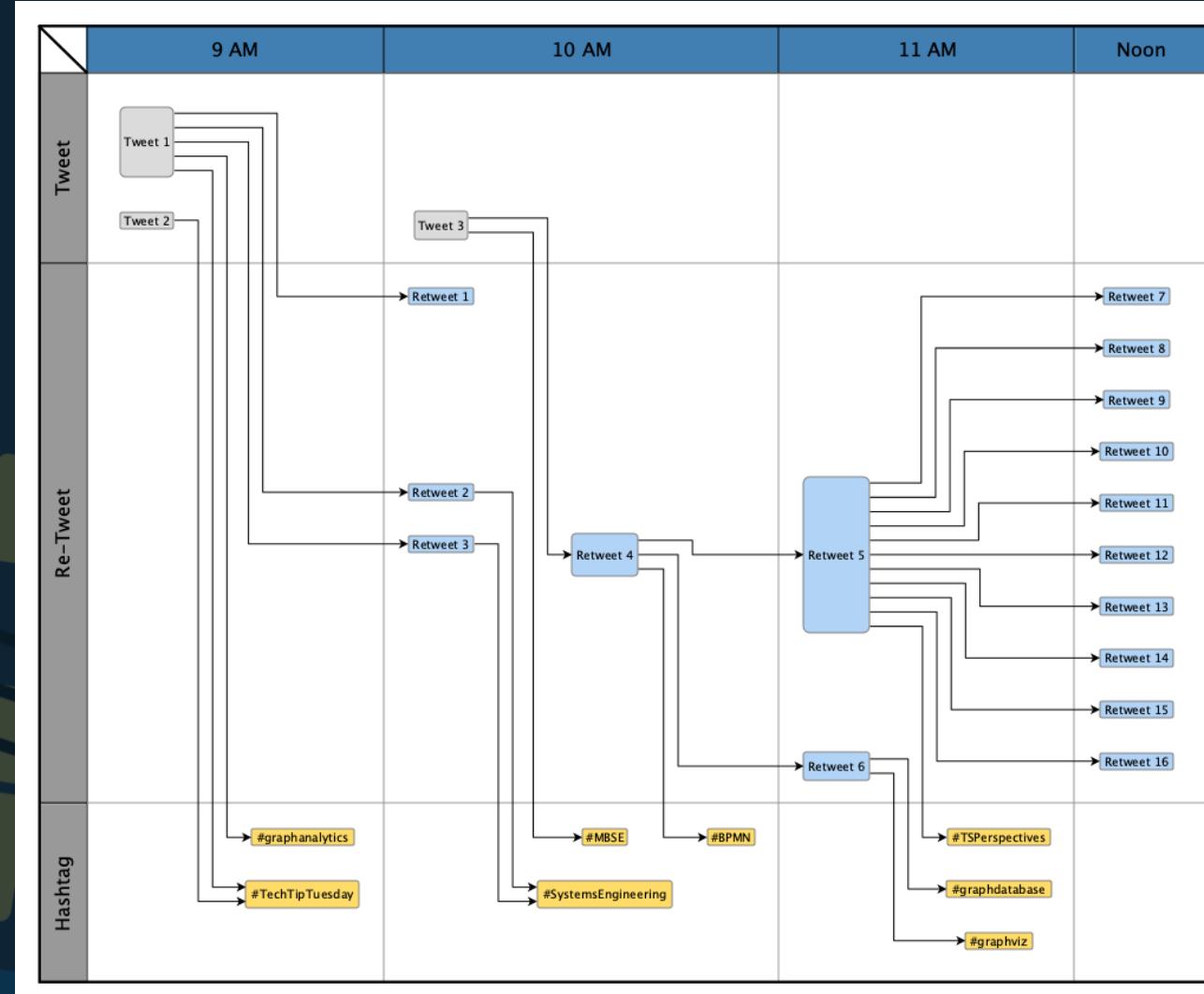
Post Situation Analysis
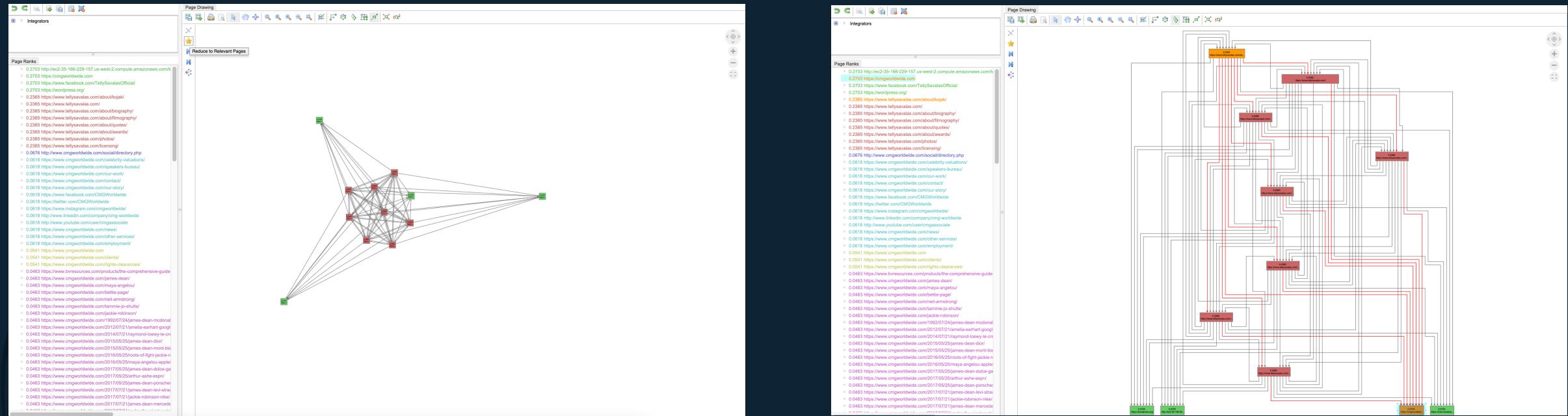
Simulate Future Scenarios
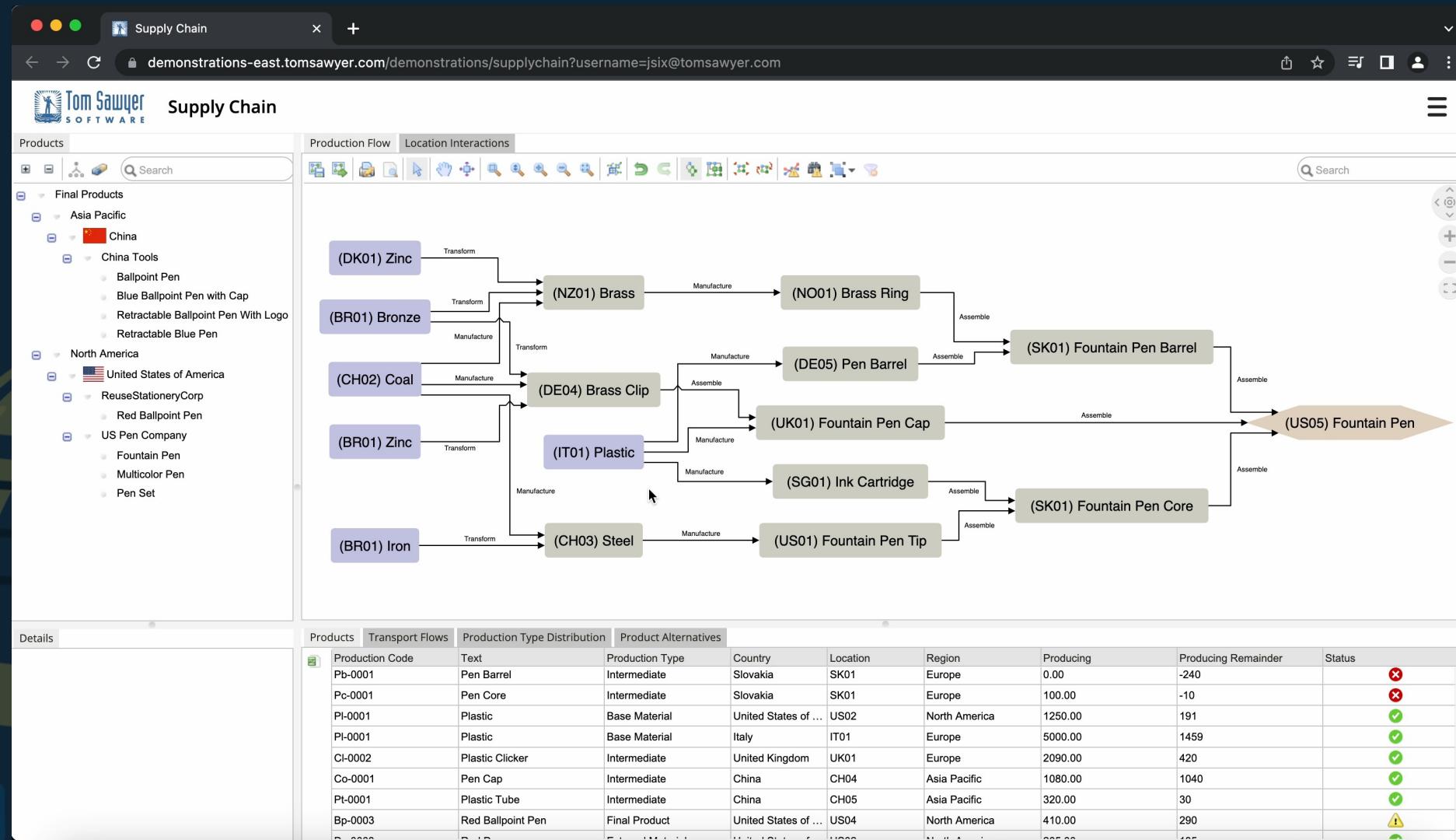
Simulate Future Scenarios
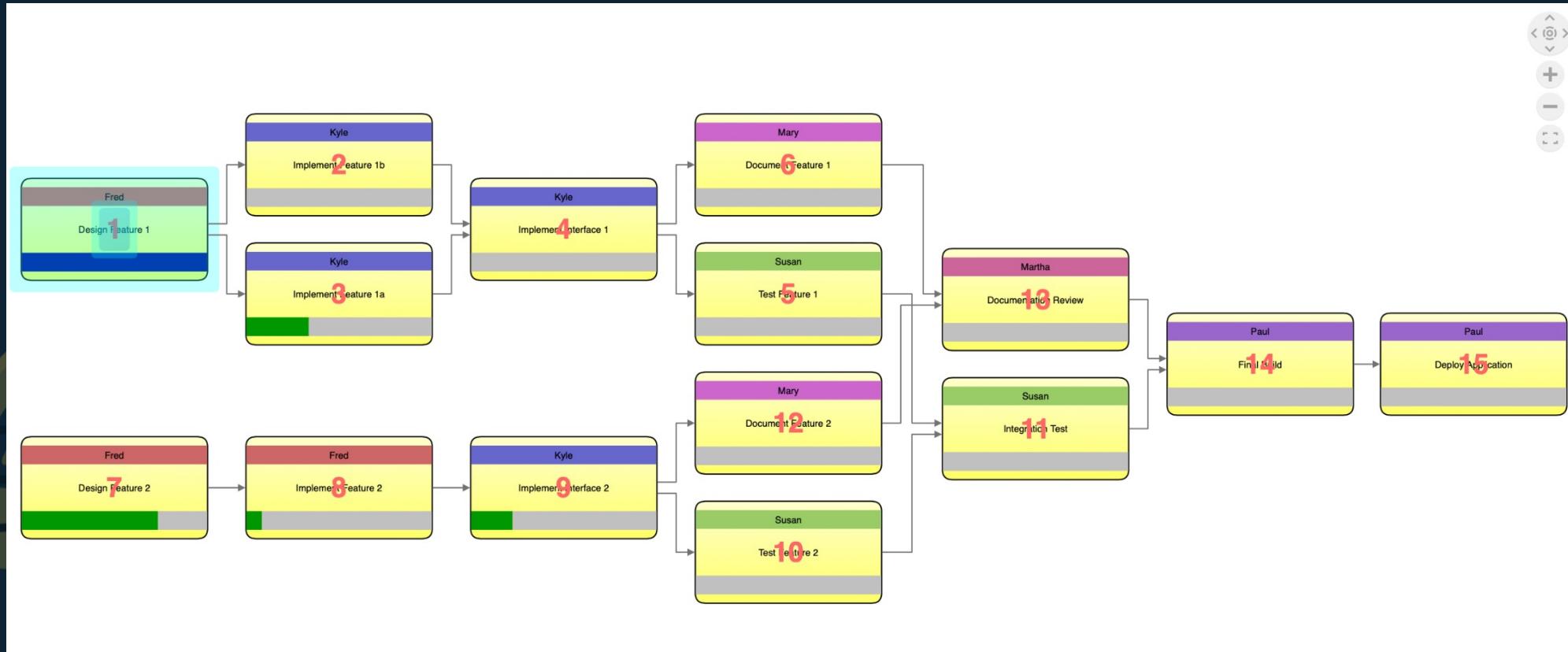
Discover Trends
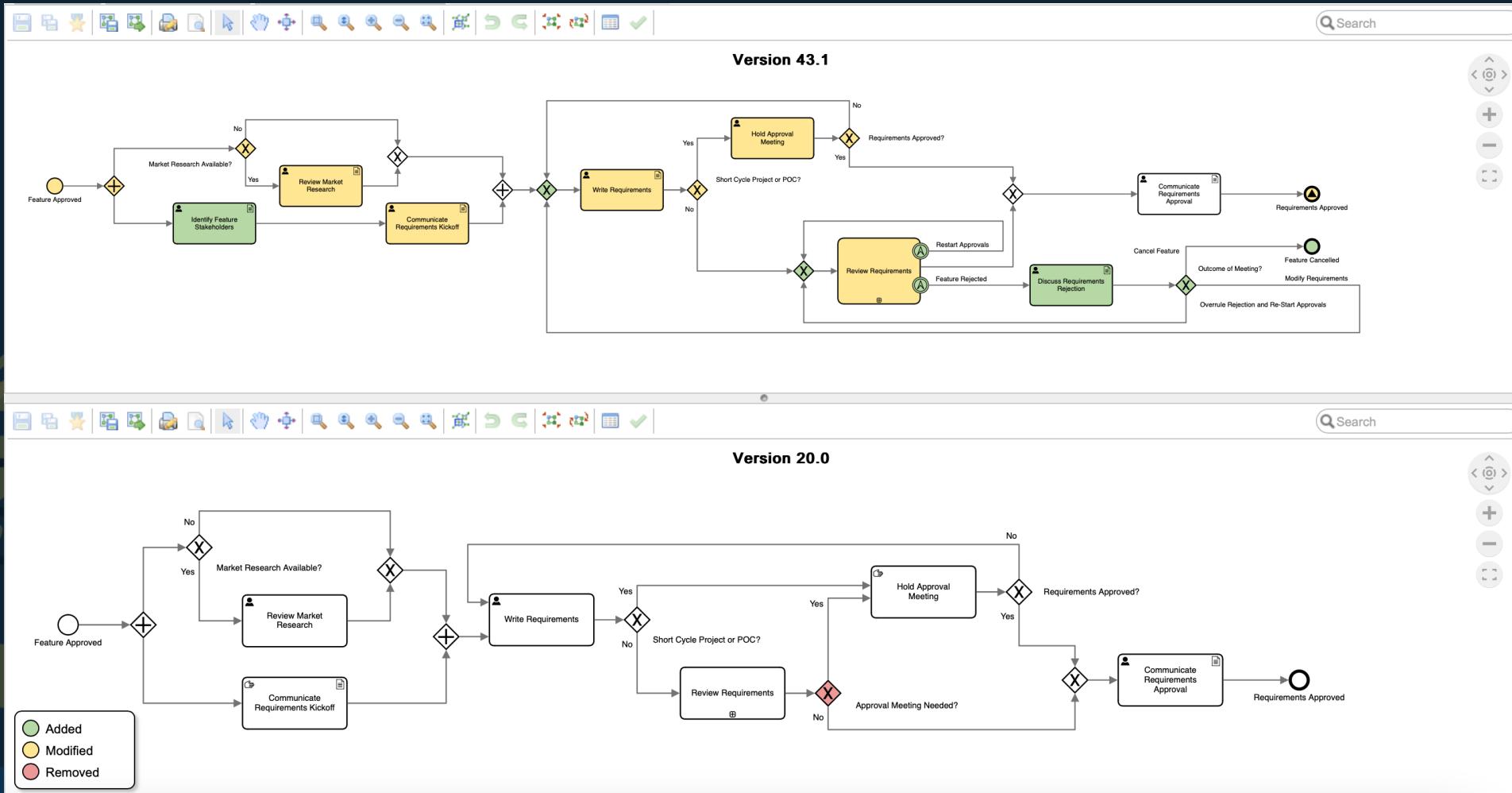
Creating the Data Model

	A	B	C	D	E	F	G	H	I
						BL Project	BL Project		
	Activity ID	Activity Name	WBS	Start	Finish	Start	Finish	Predecessors	Successors
	SDTES123010	TES: ENV Tester, Certification - Record Test Results (TD)	SDS.ABC.04.01.08-2212.11.04	-Nov-2020 A	12-Nov-2020 A	6-Nov-20	6-Nov-20	SDTES123000	SDTES123020
	SDTES123030	TES: ENV Tester, Certification - Release Tester for Operation	SDS.ABC.04.01.08-2212.11.04	-Nov-2020 A	25-Nov-2020 A	18-Nov-20	24-Nov-20	SDTES122030, SDTES122020, SDTES120150, SDTES12018(	SDTES083170
	SDTES122020	TES: ENV Tester, Software - Release Calibration Program (AP)	SDS.ABC.04.01.08-2212.11.03	-Feb-2020 A	30-Apr-2020 A	3-Feb-20	30-Apr-20	SDTES122010	SDTES123030
	SDTES122030	TES: ENV Tester, Software - Release Control Program (AM)	SDS.ABC.04.01.08-2212.11.03	-Mar-2020 A	17-Jul-2020 A	23-Mar-20	15-Jul-20	SDTES122000	SDTES123030
	SDTES123000	TES: ENV Tester, Certification - Certification Test	SDS.ABC.04.01.08-2212.11.04	1-Jul-2020 A	10-Nov-2020 A	1-Jul-20	30-Sep-20	SDTES121330, SDTES120120, SDTES120020	SDTES123010
	SDTES121330	TES: ENV Tester, Hardware, Build - #2 Assemble	SDS.ABC.04.01.08-2212.11.02.03	-Oct-2019 A	31-Oct-2019 A	1-Oct-19	31-Oct-19	SDTES121320, SDTES121110	SDTES123000
	SDTES121320	TES: ENV Tester, Hardware, Build - #2 Fabricate	SDS.ABC.04.01.08-2212.11.02.03	-Sep-2019 A	30-Sep-2019 A	3-Sep-19	30-Sep-19	SDTES121300, SDTES121310	SDTES121330
	SDTES121240	TES: ENV Tester, Hardware, Procure - Inventory	SDS.ABC.04.01.08-2212.11.02.02	-Aug-2019 A	30-Aug-2019 A	19-Aug-19	30-Aug-19	SDTES121200, SDTES121100, SDTES121210, SDTES12122(	SDTES123030
	SDTES121060	TES: ENV Tester, Hardware, Design Drawing Definition - Release Drawing	SDS.ABC.04.01.08-2212.11.02.01.01	-Feb-2020 A	20-Mar-2020 A	3-Feb-20	20-Mar-20	SDTES121050	SDTES123030
	SDTES121050	TES: ENV Tester, Hardware, Design Drawing Definition - Peer Review Dra	SDS.ABC.04.01.08-2212.11.02.01.01	-Nov-2019 A	3-Dec-2019 A	1-Nov-19	29-Nov-19	SDTES121040, SDTES121000, SDTES121010, SDTES12102(	SDTES121060
	SDTES120240	TES: ENV Tester, Requirements, Documentation, Software Requirement	SDS.ABC.04.01.08-2212.11.01.02.05	-Feb-2020 A	20-Mar-2020 A	3-Feb-20	20-Mar-20	SDTES120230	SDTES123030
	SDTES120230	TES: ENV Tester, Requirements, Documentation, Software Requirement	SDS.ABC.04.01.08-2212.11.01.02.05	-Dec-2019 A	6-Jan-2020 A	23-Dec-19	27-Dec-19	SDTES120220	SDTES120240
	SDTES120210	TES: ENV Tester, Requirements, Documentation, Software Documentati	SDS.ABC.04.01.08-2212.11.01.02.04	-Feb-2020 A	20-Mar-2020 A	3-Feb-20	20-Mar-20	SDTES120200	SDTES123030
	SDTES120200	TES: ENV Tester, Requirements, Documentation, Software Documentati	SDS.ABC.04.01.08-2212.11.01.02.04	-Dec-2019 A	6-Jan-2020 A	23-Dec-19	27-Dec-19	SDTES120190	SDTES120210
	SDTES120180	TES: ENV Tester, Requirements, Documentation, Operating Procedure (/	SDS.ABC.04.01.08-2212.11.01.02.03	-Feb-2020 A	20-Mar-2020 A	3-Feb-20	20-Mar-20	SDTES120170	SDTES123030
	SDTES120170	TES: ENV Tester, Requirements, Documentation, Operating Procedure (/	SDS.ABC.04.01.08-2212.11.01.02.03	-Dec-2019 A	13-Dec-2019 A	2-Dec-19	13-Dec-19	SDTES120160	SDTES120180
	SDTES120150	TES: ENV Tester, Requirements, Documentation, Maintenance Procedur	SDS.ABC.04.01.08-2212.11.01.02.02	-Feb-2020 A	20-Mar-2020 A	3-Feb-20	20-Mar-20	SDTES120140	SDTES123030
	SDTES120140	TES: ENV Tester, Requirements, Documentation, Maintenance Procedur	SDS.ABC.04.01.08-2212.11.01.02.02	-Nov-2019 A	11-Dec-2019 A	21-Nov-19	9-Dec-19	SDTES120130	SDTES120150
	SDTES120120	TES: ENV Tester, Requirements, Documentation, Test Plan (TK) - Release	SDS.ABC.04.01.08-2212.11.01.02.01	-May-2020 A	30-Jun-2020 A	20-May-20	29-Jun-20	SDTES120110	SDTES123000
	SDTES120110	TES: ENV Tester, Requirements, Documentation, Test Plan (TK) - Peer Re	SDS.ABC.04.01.08-2212.11.01.02.01	-May-2020 A	19-May-2020 A	1-May-20	19-May-20	SDTES120100	SDTES120120
	SDTES120020	TES: ENV Tester, Requirements, Compatibility (CD) - Release	SDS.ABC.04.01.08-2212.11.01.01	-Sep-2019 A	20-Mar-2020 A	3-Sep-19	10-Mar-20	SDTES120010	SDTES123000
	SDTES120010	TES: ENV Tester, Requirements, Compatibility (CD) - Peer Review	SDS.ABC.04.01.08-2212.11.01.01	-May-2019 A	17-May-2019 A	13-May-19	17-May-19	SDTES120000	SDTES120020
	SDTES116030	TES: ENV Tester, Certification, BTT, Record Test Results (TD)	SDS.ABC.04.01.08-2212.10.05	20-Feb-23	24-Feb-23	27-Apr-21	3-May-21	SDTES116200	SDTES116050
	SDTES116190	TES: ENV Tester, Certification, Build #2, VTT, Release Tester for Operatio	SDS.ABC.04.01.08-2212.10.05	23-Mar-23	29-Mar-23	7-Apr-22	13-Apr-22	SDTES116180	SDTES1009770, SDTES1017610
	SDTES116180	TES: ENV Tester, Certification, Build #2, VTT, Analyze Test Results	SDS.ABC.04.01.08-2212.10.05	16-Mar-23	22-Mar-23	31-Mar-22	6-Apr-22	SDTES116170	SDTES116190
	SDTES116170	TES: ENV Tester, Certification, Build #2, VTT, Record Test Results (TD)	SDS.ABC.04.01.08-2212.10.05	9-Mar-23	15-Mar-23	24-Mar-22	30-Mar-22	SDTES116160	SDTES116180

Creating the Data Model

- Nodes are activities in the schedule

- Relationships are the schedule logic (predecessors and successors)

Creating the Data Model

Creating the Data Model

Creating the Data Model

Creating the Data Model

Creating the Data Model

Case Study

Case Study

- Active project
- Schedule implemented in Oracle Primavera P6
  - 3 years old – rebaselined 3 times
  - Design Agency and Production Agency schedules
  - Over 13,000 activities in each schedule
  - Manual handoffs between schedules
  - In the middle of rebaselining again
  - Trying to plan verification and production activities
  - Trying to assess impact of changes
  - Cannot meet schedule

- This research developed a process to model schedule logic and analyze the results
  - Problem framing – questions that needed to be answered and how the answer can be understood
  - Work within limitations of existing resources
  - Modeling the schedule logic (workflow or predecessors/successors)
  - Tom Sawyer Perspectives data visualization software
  - Interactive meetings

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Process to Develop the Interactive Schedule Logic Modeling Capability

Developing the interactive schedule logic modeling capability

Process the data — Export/Import Data

Identify key factors — From dataset based on project structure and needs

Set filters /nesting — Based on key factors

Once the initial set up is complete, the capability can be used over and over with new schedule data.

Update Data — Import updates as they occur and assess changes

ORACLE PRIMAVERA P6

Tom Sawyer SOFTWARE

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Process – Identify Key Factors

Five data elements pulled from schedule
Derived additional elements from Activity text for filtering/grouping

Work Breakdown
Structure (WBS)

Relationship
(Predecessors/
Successors)

Activity ID

Element 5

Element 4

Element 3

Element 2

Element 1
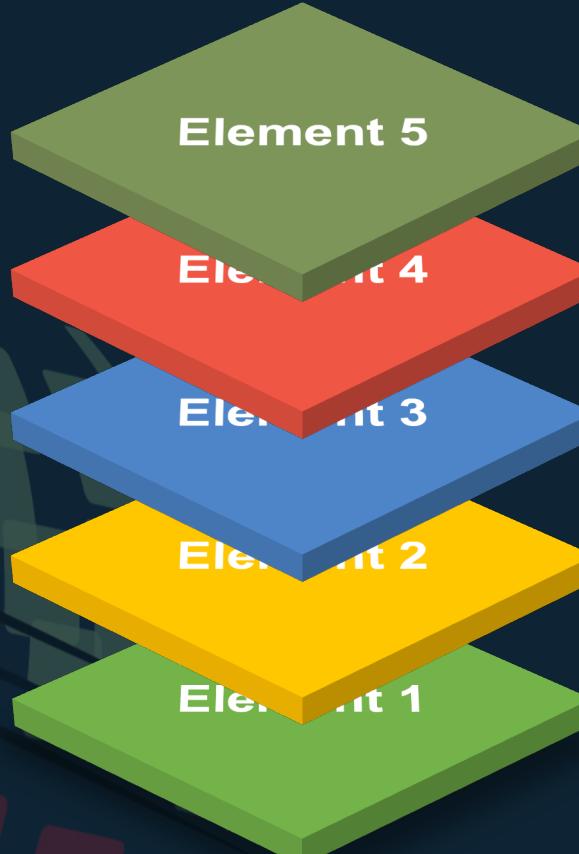
Start/Finish

Activity
Name/Description

Process – Set Filtering/Nesting

Searchable Activity Table

Activity ID
Activity Name/Description
Relationship (predecessors/successors)
Start/Finish (baseline, current)
WBS for hierarchy/structure

Filters for Diagram

Status (Complete, In work, Not started)
Project Realization Team (PRT)
Project Phase
Process Area

Timeline

Activities by date

Nesting/Grouping for Diagram

PRT
WBS
Relationship
Multiple 'depths' of schedule path

Results

Addressed specific schedule and program problems

1. Program schedule flowchart generated for basis of replanning - compared to implementation in schedule (Correctness)

2. Testers supporting environmental and functional testing. All activities are occurring at the same time and there are not enough testers to support this. Does this need to be reworked? (Identification of Risk)

3. Overlap of planned functional, environmental and acceptance testing for electronics modules. (Identification of Risk and Verification planning)

4. Acceptance testing durations for electronics modules – too long and all on top of each other (Identification of Risk)

5. Test Equipment hardware deliveries to production agency – new scope (Impact Assessment)

6. Path from Advanced Engineer Release (AER) to First Production Unit (Correctness and Identification of Risk)
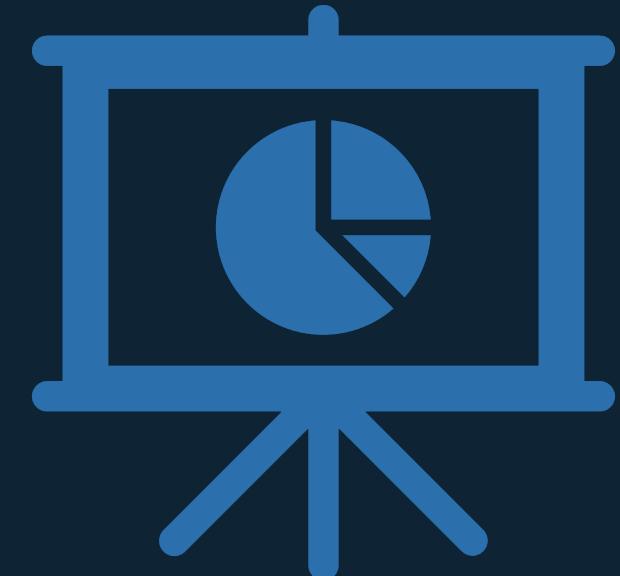
Results – Correctness of Schedule

Replan – verify correctness of schedule

- Matches planned flow of work

- Missing links in schedule

- PRT missing entire interface to another subsystem

- Incorrect coding in schedule (naming convention)

- Missing handoffs from production schedule – no ties into real body of work
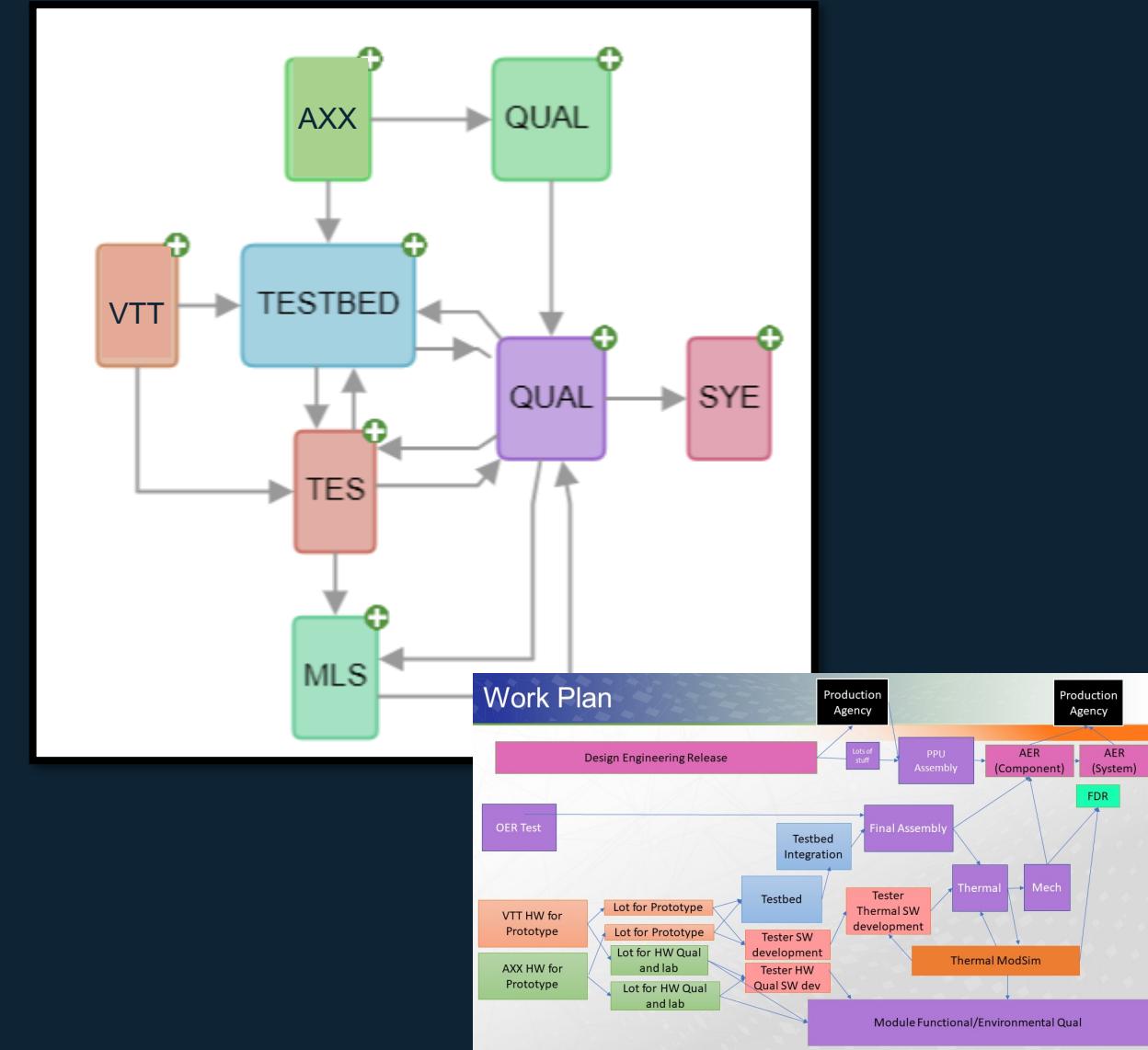
Results – Identification of Risk

Understand known areas of concern better as well as identify areas of concern not realized before

- Rolling bow wave of activities as schedule pushes (timeline)

- Multiple activities in parallel

- Downstream areas of activities at risk

- Production planning and handoffs – linking of schedules
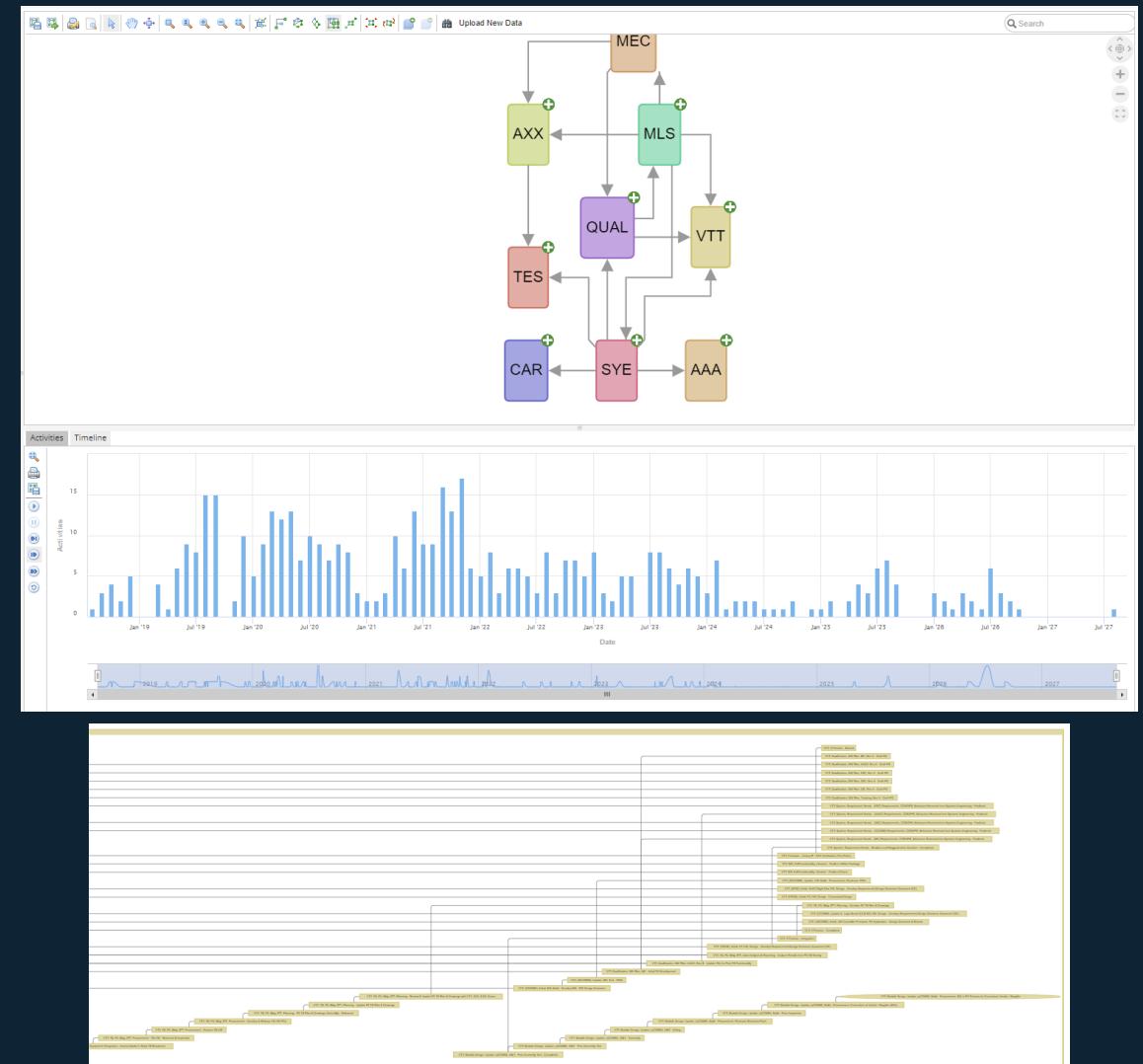
Results – Impact Assessment for Proposed Changes

- Identify each touchpoint for area of change

- See farther downstream
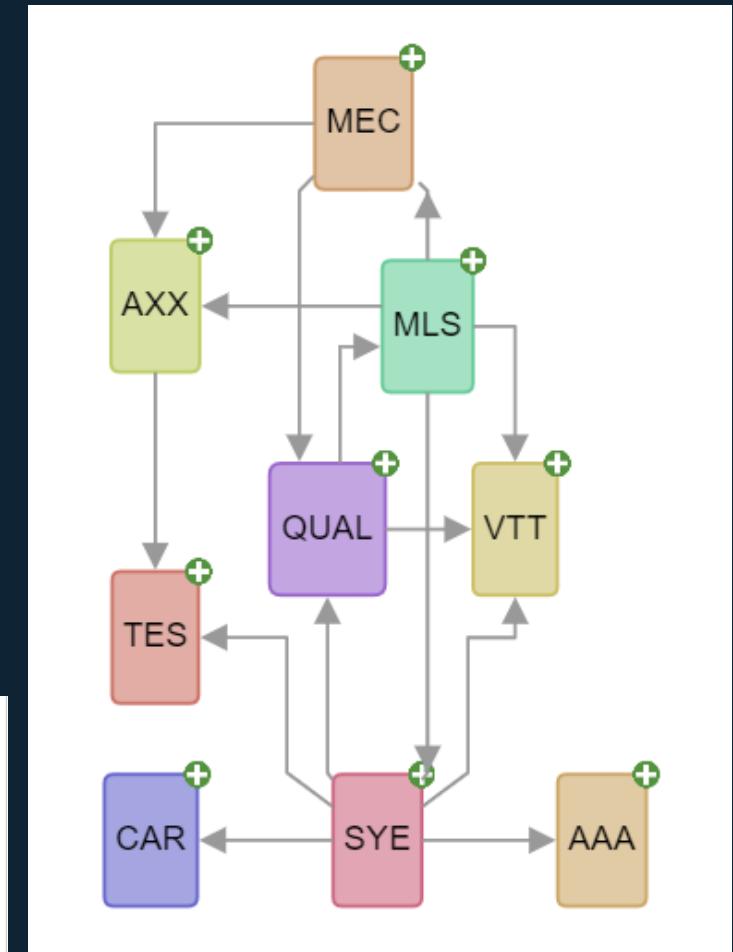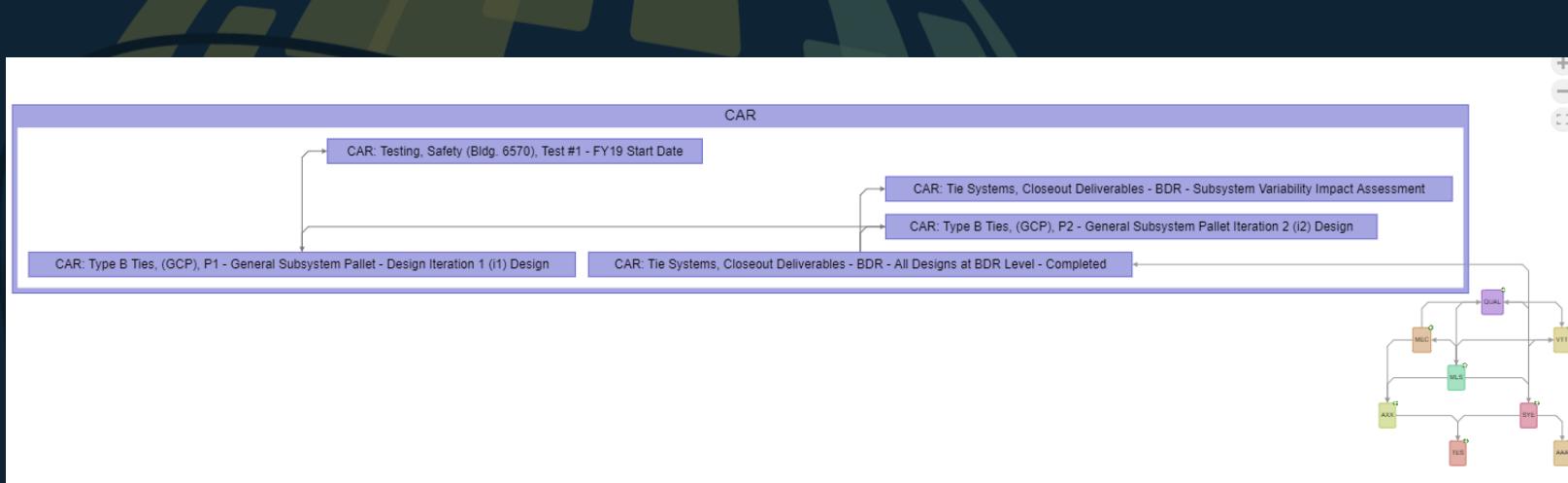
Results – Verification Planning

- Identification of activities and data feeding into a verification activity

- Identification of bottlenecks for shared facilities or resources

- Feasibility of verification approaches based on availability of data and resources
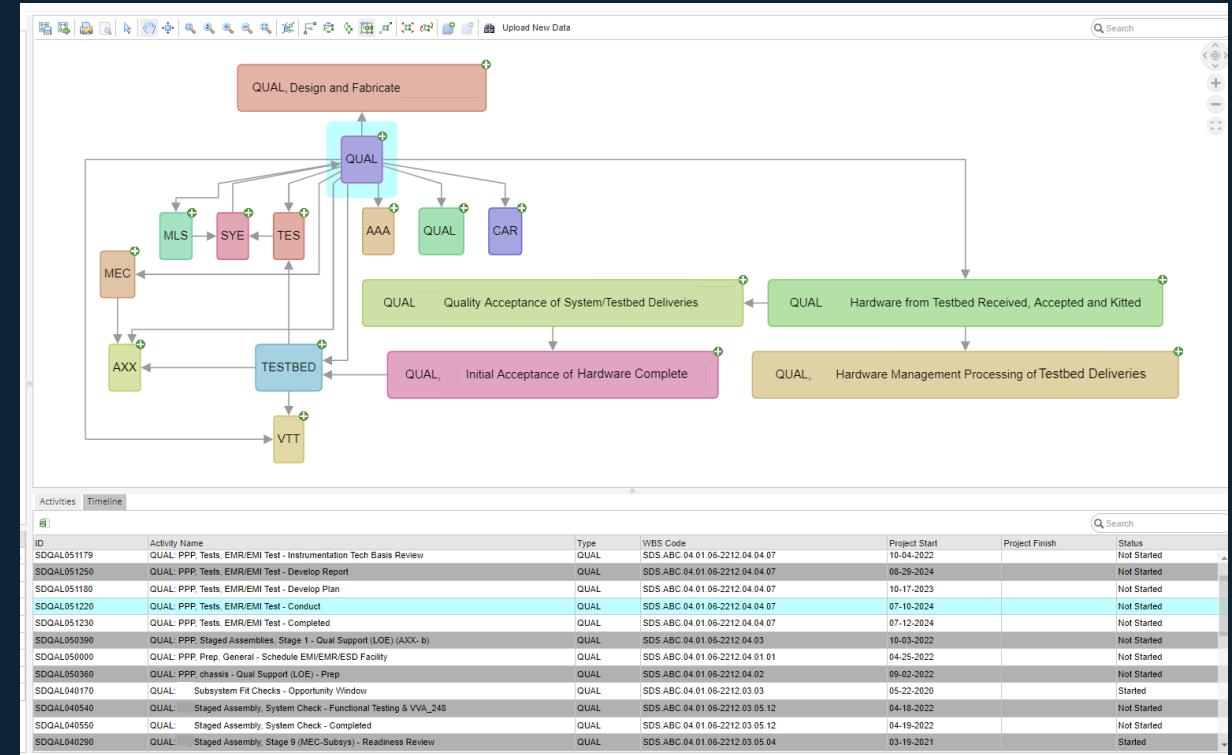
Importance of Interactivity

Results – importance of interactivity

- Comprehension

- Consensus

- Credibility

- Correct

- Comparison

- Change Verification or Impact Assessment

- (Re)Centering during investigation

- Concentration/Focus

- Communication/Awareness

Results – importance of interactivity

- Comprehension
- Consensus
- Credibility

- Correct
- Comparison
- Change Verification or Impact Assessment

- (Re)Centering during investigation
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- Communication/Awareness

Common understanding

Results – importance of interactivity

- Comprehension
- Consensus
- Credibility

- Correct
- Comparison
- Change Verification or Impact Assessment

- (Re)Centering during investigation
- Concentration/Focus
- Communication/Awareness

Common understanding

Work with Data to address issues

Results – importance of interactivity

- Comprehension
- Consensus
- Credibility

- Correct
- Comparison
- Change Verification or Impact Assessment

- (Re)Centering during investigation
- Concentration/Focus
- Communication/Awareness

Common understanding

Work with Data to address issues

Tools to facilitate work

www.ir...

Ease of Process

Results - Feasibility

Can this process be performed by a Systems Engineer with no training in the tool set?

Easy

- Export of data from schedule
- Using the interactive diagrams
- Updates with new schedule data
- Repeating process
- Inviting users to use the application

Moderate

- Identification of factors critical for viewing (several iterations)
- Setting up filters in Perspectives
- Determining what to investigate first when addressing a problem
- Setting up nesting/grouping in Perspectives (for someone with training)

Hard

- Setting up nesting/grouping in Perspectives (for someone with no training or experience)
  - Needed training
  - One time effort to establish settings

www.irr

Future Work

- Highlight changes from updates (comparison)

- Expansion of timeline capability

- Providing guidelines to activity naming structure to maximize capability

- Research performed for projects in the aerospace and defense industry, but application can be more broad

  - Applicable to any industry with large, multi-faceted projects such as education, energy, healthcare, information and technology, large infrastructure projects

  - SysML v 2.0

  - Digital Engineering Environment

  - Digital Thread

  - App Building

Additional Material

Exhibit Map

Want to see more? Ask more questions?

Come by the Tom Sawyer booth (#2)

This case study data is available for demo

Times to come by:

Monday, July 17   09:30 – 19:30
Tuesday, July 18   09:30 – 18:00
Wednesday, July 19   09:30 – 17:00

Questions? Contact Us

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Dr. Janet Six, Tom Sawyer Software

- jsix@tomsawyer.com

Joshua Salinas, Aerospace Corporation

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