International Council on Systems Engineering
A better world through a systems approach

Data Visualization of MBSE Models for Systems Engineering Baseline Assessments

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Introductions

Kasey Marlowe
Deloitte GPS Mission Solutions

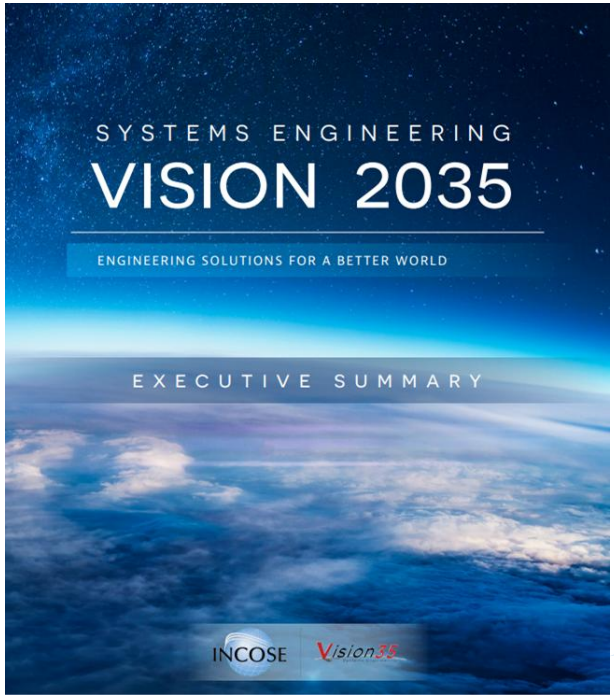
Kasey is a Systems Engineer at Deloitte with over 10 years of experience in the defense industry. She has supported systems engineering and test programs for a variety of systems including Radars, Drones, Ground Vehicles, and IoT. With specialties in Model Based Systems Engineering and Test and Evaluation, she enjoys optimizing tools and processes to make Systems Engineering and Testing more accurate and efficient.

Sean McGuinness
Deloitte GPS Mission Solutions

Sean is a Systems Engineer at Deloitte with 5 years of civil government and defense industry experience. His background in Model Based Systems Engineering and Data Analysis fuel his current work designing connected systems, automating data analysis processes, and visualizing complex datasets. Sean believes there's more our data has to say and enjoys telling new stories with it.

Deloitte.

Why it Matters

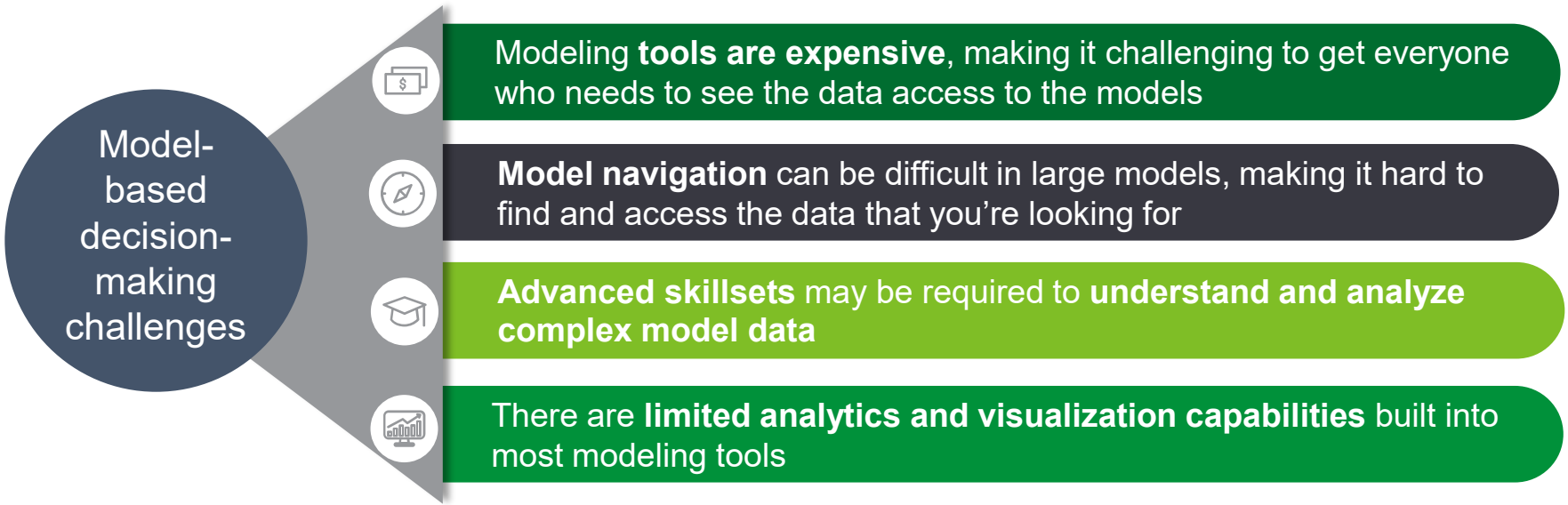


***Visualization tools** will **enable interactive analysis** from many different **stakeholder-specific viewpoints**, allowing decision makers to gain new insights, perform what-if analyses, and communicate the impact of their decisions.*

For MBSE to be transformative, it must **change** both our **decision-making processes** and the **overall experience**.

The Challenge: Common Pain Points

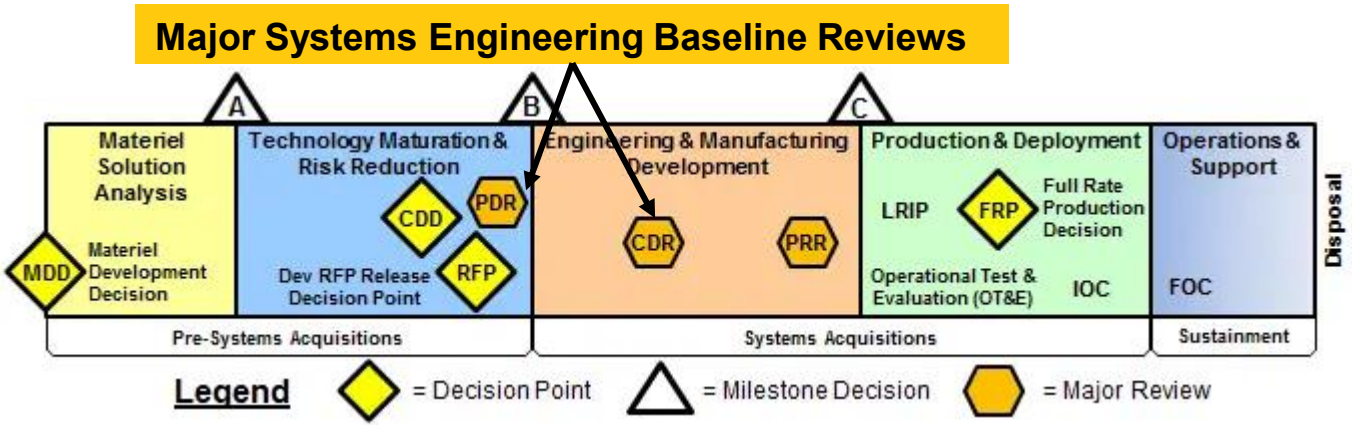
While many organizations are now using SysML models to define their system baseline, making informed decisions based on those models presents multiple challenges:



There is a **need to explore dashboarding and data visualization approaches** to help stakeholders understand their models, identify risks, and make **data-driven decisions**

Project Background

- The Deloitte team was supporting Digital Engineering efforts for a **DoD Major Acquisition Program** delivering a new ground vehicle
- As part of the DoD 5000 acquisition process, the program was progressing through their **Preliminary Design Review (PDR)** and **Critical Design Review (CDR)**
  - The government team needed to **review defined entrance and exit criteria** for each technical review
  - Many criteria involved **reviewing the Systems Engineering Baseline** that was captured in **vendor MBSE models**
  - These reviews included **assessing the completeness of the design** and **identifying risks** before deciding if the program should move forward in the acquisition process



Project Challenges

Detailed SME Model Analysis Generated Extremely Large Tables of Analysis Data

- The model contained tables for SMEs to fill out that asked questions about individual model elements
  - Example Questions: Is the higher level requirement traced to the correct lower level requirements? Is the requirement satisfied by the correct functions?
- Tables were very detailed and difficult for leadership to interpret

Challenges with Prior Model Data Visualization Efforts

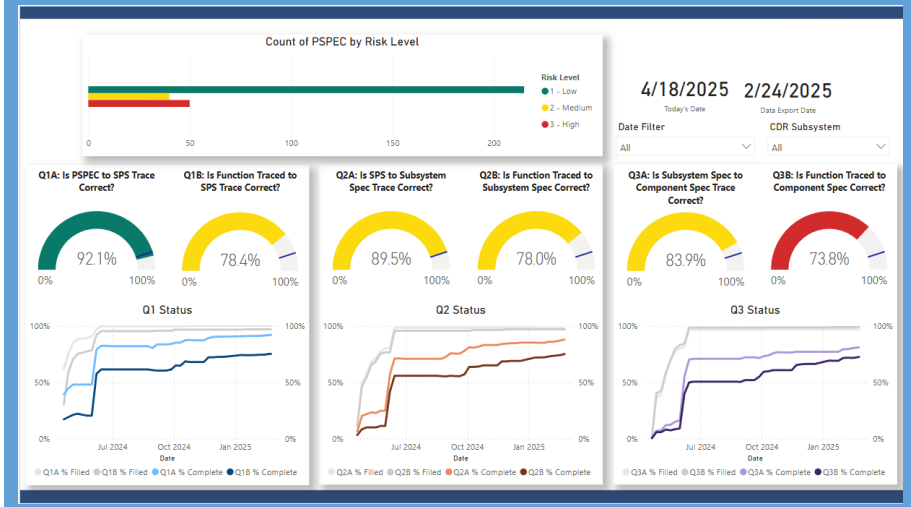
- Manual chart/table generation in Excel provided basic graphics, but updates were time consuming and prone to human error
- PLM tool dashboards were configured to show data imported from Cameo, but graphics options were limited and difficult to change

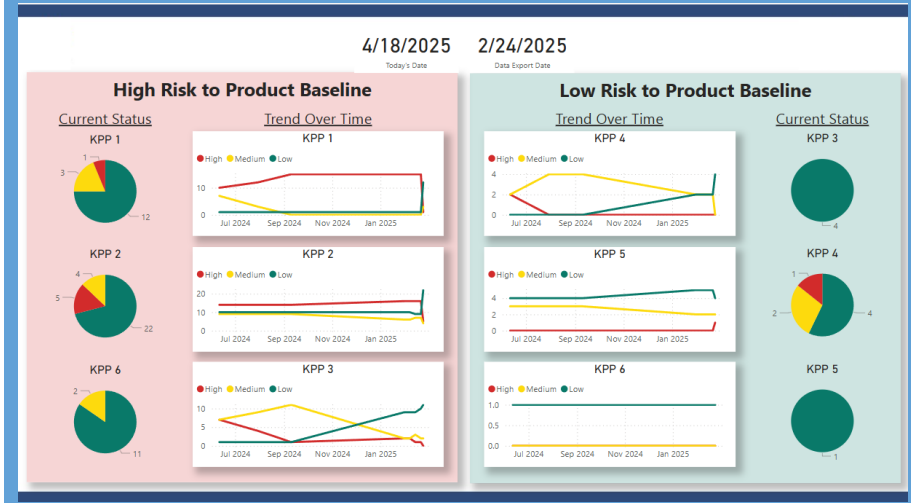
The program needed a better way to visualize model data in preparation for PDR/CDR

Data Visualization Pilot

- The Deloitte team piloted an effort to build **dashboards of the SME model assessment data** in preparation for PDR / CDR
  - **Power BI** was chosen for the pilot because the program already had licenses and access to the tool
- **Dashboard Goals:**
  - Summarize current model review status and results
  - Identify risks
  - Track historical progress

Sample Dashboards





Cameo -> Power BI Approach Overview

Configure Cameo Tables for Power BI Usage

- Adapt existing tables to make data easier to use in Power BI

Export data from Cameo to Excel Spreadsheets

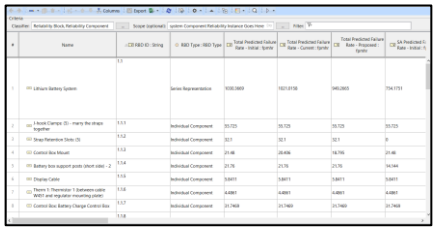
- Automate export process using Cameo Report Wizard

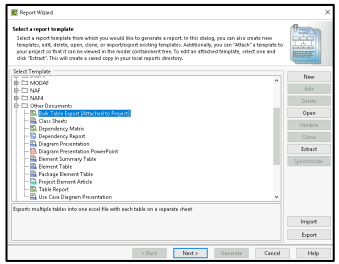
Manipulate and Enrich Data for Visualization

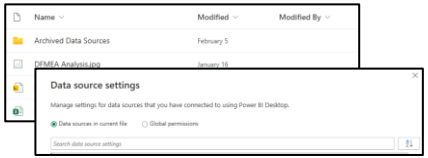
- Update Power BI data source to new export file
- Design views tailored for each user need

Socialize Dashboards

- Refresh and update dashboards as new data is available
- Build additional reports to address new questions



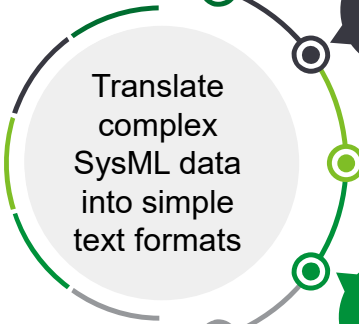




Agile, accessible, and consistent reporting with fast turnarounds

Configuring Cameo Tables

Building Cameo Tables for Power BI: Best Practices



Power BI Use Only: Existing tables in the model may be used as a starting point, but you will likely need to modify them to produce a clean dataset for Power BI usage.

Simplify and Consolidate Tables: Limit tables to a single element type and contain all values and relationships of interest for that element type. Avoid using multiple tables for the same sets of elements. Avoid including excess columns.

2-Way Relationship Tracing: If you have a relationship between 2 types of elements, include the related element in a column on both tables so that you can trace the relationship both directions in Power BI

Filter Columns to Element Types of Interest: If a table cell lists elements, Power BI does not have any information on the type of element – it only sees a text representation of that element. You may need to filter custom columns to show only certain model elements types of interest.

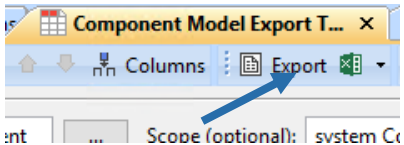
Be Careful of Excel Limitations - Excel has a limitation of 32,767 characters per cell and 31 characters for sheet names. Excel errors can occur if a Cameo table violates these rules, and the data could be truncated.

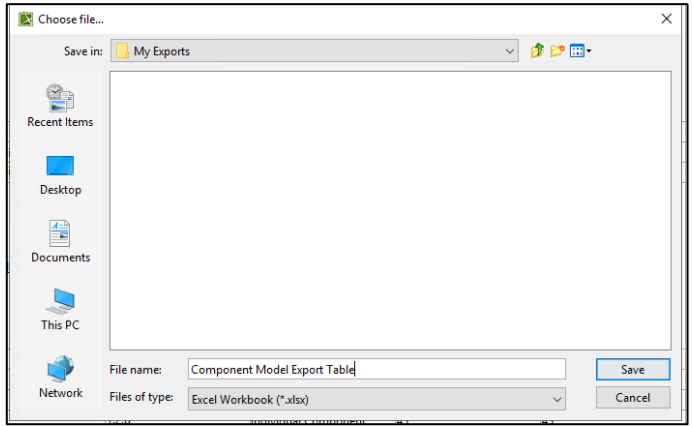
Simplify Cameo tables to create a clean dataset for Power BI

Exporting from Cameo

Cameo Table Export: Initial Manual Approach

- Initially, we opened and saved the Cameo tables 1 by 1 as Excel files
- This manual process was very time consuming for exporting multiple large tables
  - Export took up to 1-2 hours when exporting multiple tables with several thousand rows each
  - Opening our largest table (15k rows) risked crashing the Cameo application due to high resource requirements
  - Tedious process to open table, wait, kick off export, wait, and then repeat the process for additional tables

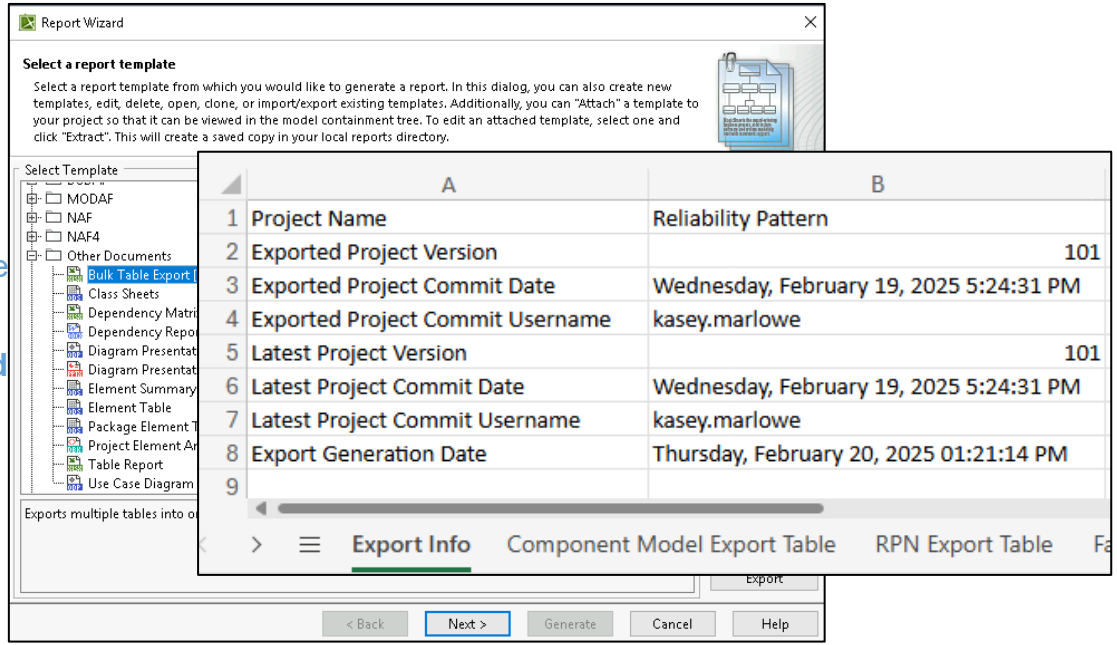




Manual table export process was not efficient for large tables

Cameo Table Export: Automation with Report Wizard

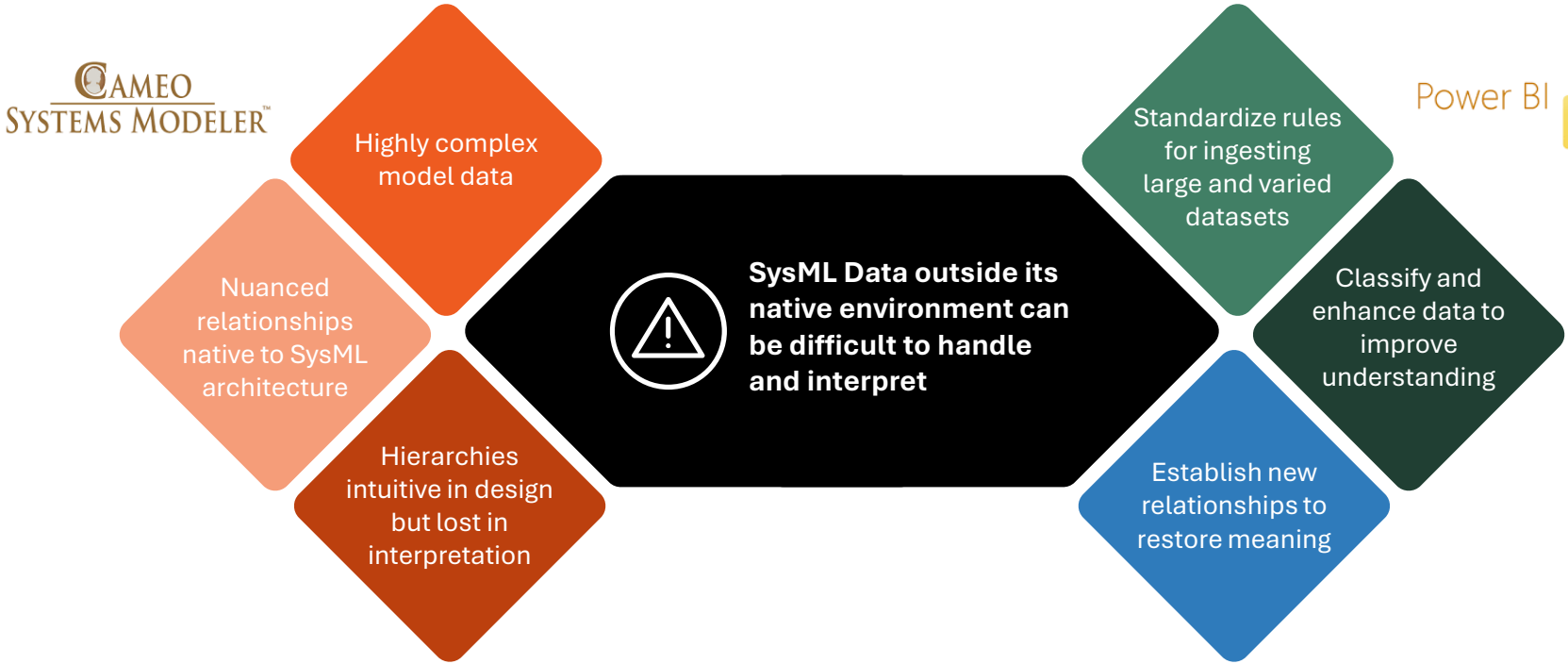
- Developed generic **Bulk Table Export template** that pulls all rows and columns for each table in the report scope, with 1 table per Excel sheet
- Exporting to a **single Excel file** is not required, but it is simpler to import a single file into Power BI vs multiple files
- Export includes **sheet with Teamwork Cloud information** that can then be used in the dashboard reports to show when the model was updated
- The export process can take still several minutes to complete for multiple large tables, but the user can kick it off and do other activities while it completes



Cameo's Report Wizard export automation was a significant timesaver

Enriching Model Data for Visualization

Making Best Use of Systems Engineering Data



Standardize Data Intake with Power Query

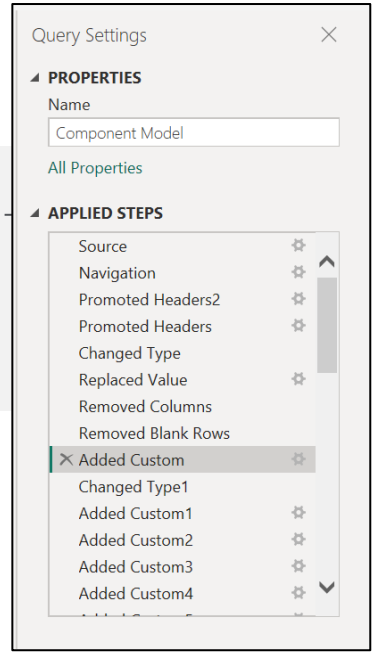
Complexity of SysML data complicates export post-processing

Intuitive, intended format can be restored with automated processes

- Relationship Cardinality and Directionality
- Graphic implications lost in text-only representation
- Many related objects appearing in the same cell
- Data format and appearance

Power Query

- Standardized & Expected Data Types
- Formatted Data Ready for Charts
- Calculations and Transformations



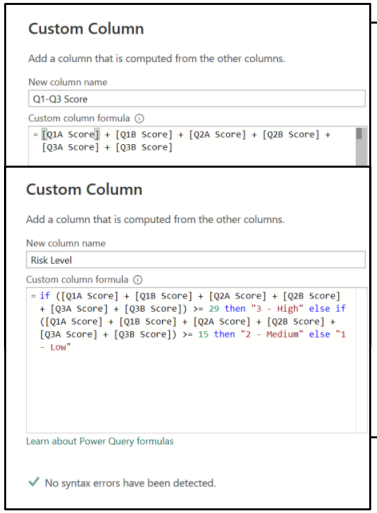
Standardized and consistent data handling practices save time and avoid errors

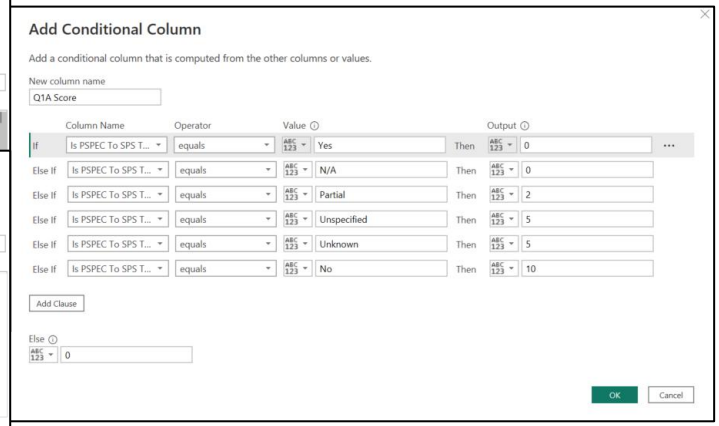
Power Query standardizes and automates data processing for report consistency

Enhance Data with Custom Columns and Metrics

Desired visuals may require more data than can be exported from the engineering tool

- It is possible to add custom metrics and calculations natively in Cameo, but it can be difficult to implement and requires advanced modeling tool knowledge
- Custom columns and measures are a more accessible way to implement metrics
  - Easily and automatically convert units of measure and align units across the datasets
  - Perform calculations to quantify insights that emerge from mixing data from different sources
  - Create buckets to indicate risk, confidence, and other characteristics





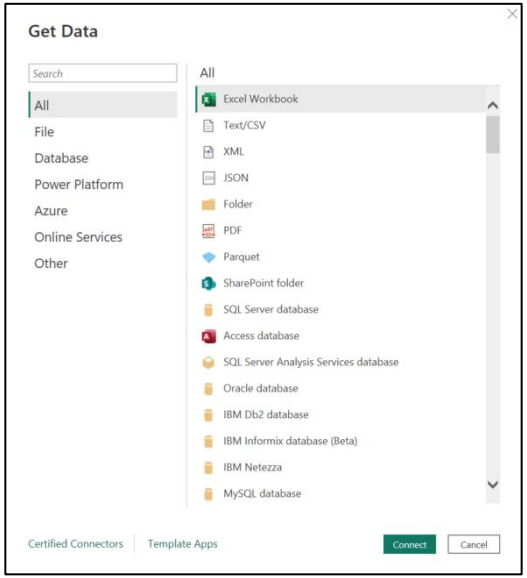
Custom calculations facilitate more impactful visuals by expanding upon existing data

Custom columns are used to enrich the raw model data for greater utility

Combine SysML Model Data with Other Data Sources

SysML Data can be difficult to integrate with data from other sources

- Investigating data from many sources is critical for major milestone reviews
  - CAD Assessments, Reliability Analyses, Software Benchmarks, Schedule, etc.
- Visualization tools consolidate and centralize data from a variety of sources
  - Export data into commonly supported formats like Excel workbooks and PDFs
  - Leverage dataflows and connect to cloud-based data storage options dynamically
  - Supplement with python scripts and manual tables when appropriate
- Leveraging Unique IDs like Specification IDs and Part Numbers is critical for establishing a connection between the different datasets
  - The consistency of these values across the program will determine the success of these connections



Combining data facilitates centralized reviews and brings visuals to life with additional detail

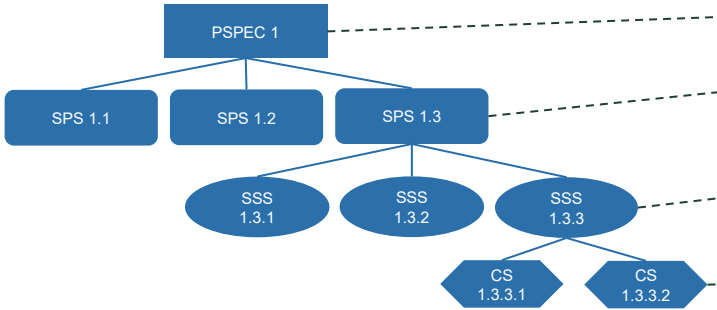
Combining SysML model data with outside data sources facilitates more informed decision-making based on all available data sources

Establish Relationships in Power BI

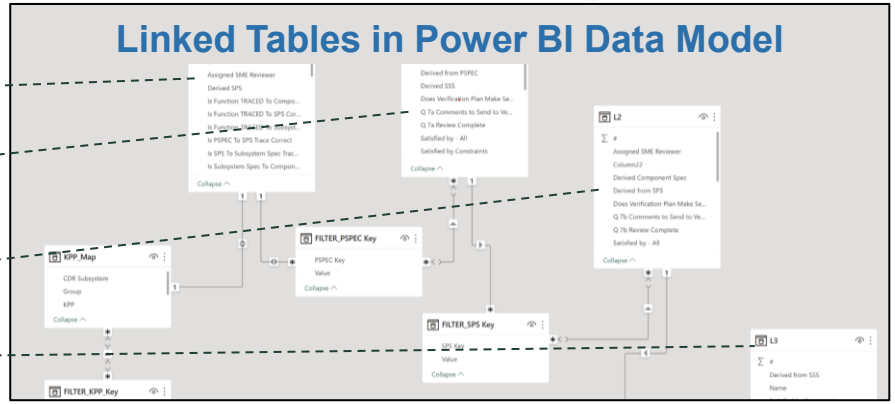
Intuitive structured relationships can be lost when the data is exported

- Exporting Cameo data to excel can give the false impression that model data is “flat” in a tabular form
  - The complexity of containment relationships and other SysML context can be restored in Power BI using relationships

Requirement Decomposition in SysML



Linked Tables in Power BI Data Model



Power BI relationships reconnect data to properly show SysML intent

SysML relationships can be mirrored in the Power BI Data Model to enable users to explore key model relationships

Explore Model Relationships with Drill-Through

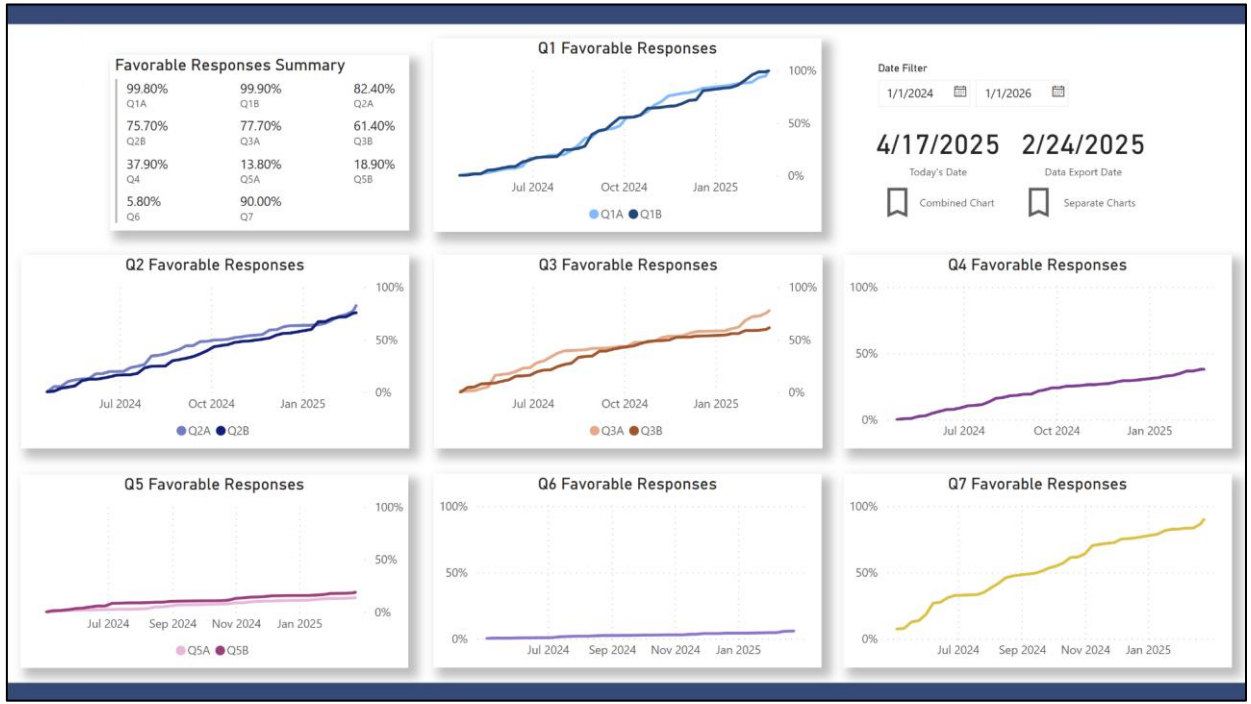
- Re-establishing data hierarchies enables data users to explore relationships between model elements outside of the SE tool
  - Trace performance specifications from the system level to the component level
  - Reveal additional information as it is needed to customize experience
  - Combine data at each level of specificity with connected data from other data tables and sources to address specific questions and needs

Assigned SME Reviewer	PSPEC	PSPEC Text	Count of SPS	Count of SSS	PSPEC Key
reviewer 9	PSPEC 1	Description of Performance Specification (PSPEC) 1	2	8	PSPEC 1
	PSPEC 10	Description of Performance Specification (PSPEC) 10	2	8	PSPEC 10
reviewer 7	PSPEC 100	Description of Performance Specification (PSPEC) 100	3	13	PSPEC 100
reviewer 1	PSPEC 101	Description of Performance Specification (PSPEC) 101	2	8	PSPEC 101
reviewer 2	PSPEC 102	Description of Performance Specification (PSPEC) 102	2	8	PSPEC 102
reviewer 1	PSPEC 103	Description of Performance Specification (PSPEC) 103	2	9	PSPEC 103
reviewer 6	PSPEC 104	Description of Performance Specification (PSPEC) 104	2	8	PSPEC 104
reviewer 9	PSPEC 105	Description of Performance Specification (PSPEC) 105	3	11	PSPEC 105
reviewer 8	PSPEC 106	Description of Performance Specification (PSPEC) 106	2	8	PSPEC 106
	PSPEC 107	Description of Performance Specification (PSPEC) 107	3	15	PSPEC 107
reviewer 6	PSPEC 108	Description of Performance Specification (PSPEC) 108	2	8	PSPEC 108
	PSPEC 109	Description of Performance Specification (PSPEC) 109	2	8	PSPEC 109
reviewer 4	PSPEC 11	Description of Performance Specification (PSPEC) 11	3	11	PSPEC 11
reviewer 6	PSPEC 110	Description of Performance Specification (PSPEC) 110	2	8	PSPEC 110

Power BI's drill-through capability allows users to intuitively explore model data without requiring MBSE tool training and licenses

Report Historical Data Trends

- Visualization tools are well-suited to show trends over time
  - This can be challenging in Cameo and other SE tools
- Creating a clear picture of progress toward a baseline is critical for major milestone reviews
  - Tracing Functions to Specifications
  - Improving confidence and reducing risk

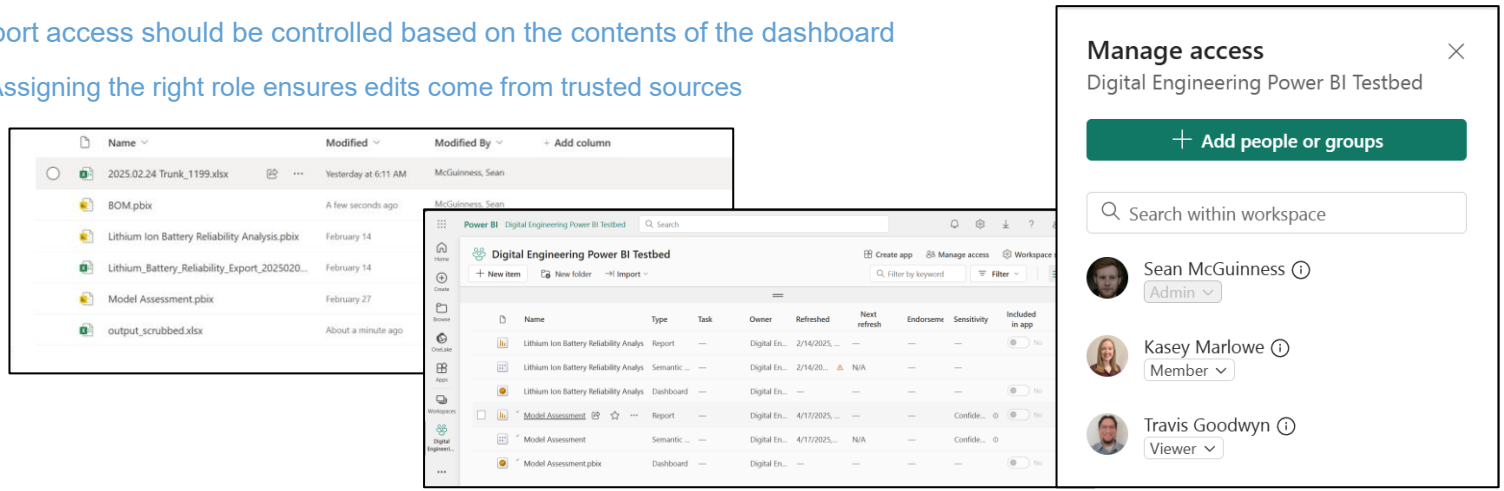


Historical reports help the team monitor progress and risk burndown over time

Socializing Dashboards

Socialize and Control Reports

- Dashboards are shared with users across the organization from a central location
  - SharePoint offers a single source of truth with strong version control
- Data consumers can access reports via the Power BI app (Teams or Web) without a Power BI developer license
- Report access should be controlled based on the contents of the dashboard
  - Assigning the right role ensures edits come from trusted sources



Power BI Reports are easy to share in the Microsoft 365 ecosystem

Benefits of Visualizing Systems Engineering Data

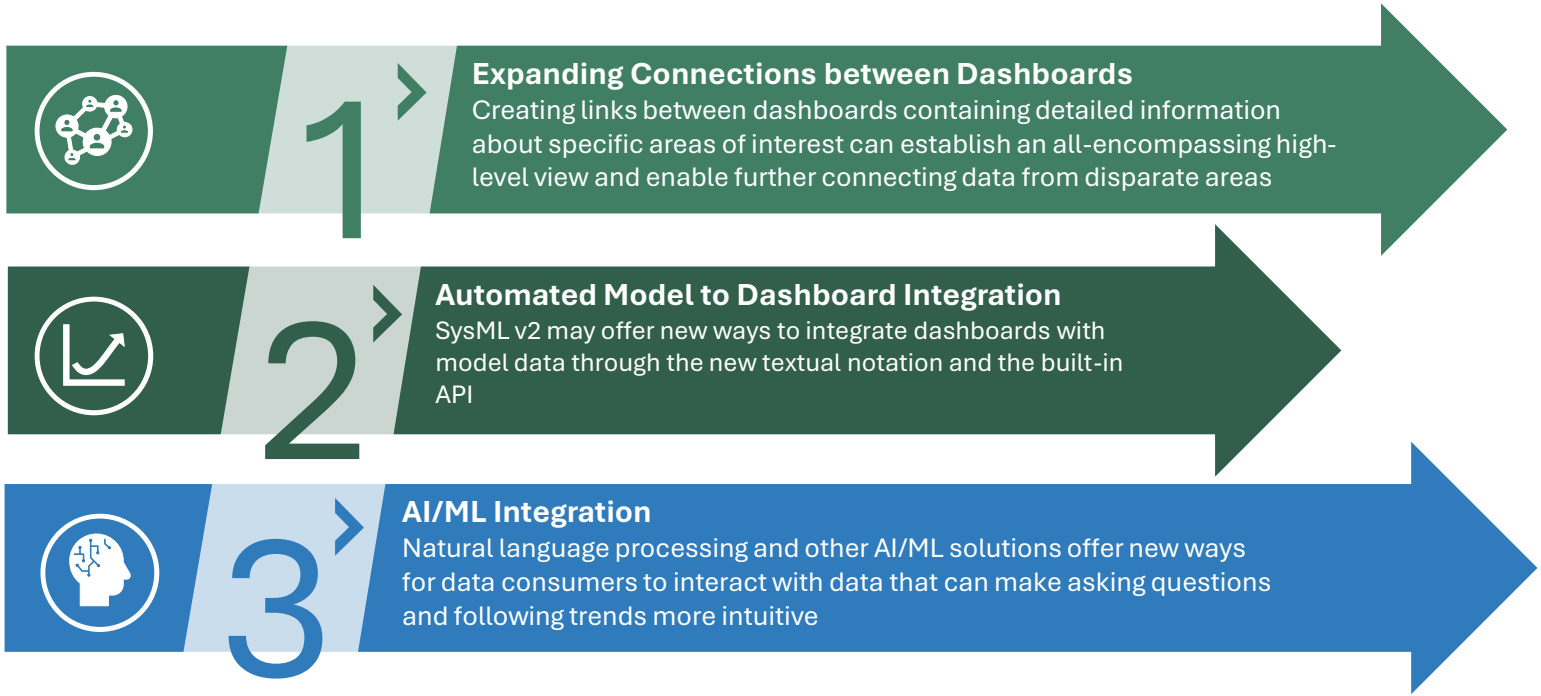
Model Insight and Accessibility
Visualizations pull valuable insights out of complex model data, removing barriers to accessing and understanding SysML models

Engineer – Decision Maker Alignment
The availability of interpreted technical data outside of the engineering environment creates common ground between engineers and decision makers at all levels

Flexible and Scalable Development
Dashboards can be quickly adapted as new questions of interest arise for the program or as new data is available

Consistent and Timely Communication
Dashboards can be updated on a recurring basis to facilitate a clear and consistent reporting cadence for leadership and address data needs as they arise

Future Improvements



Thank You

Deloitte.

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Backup