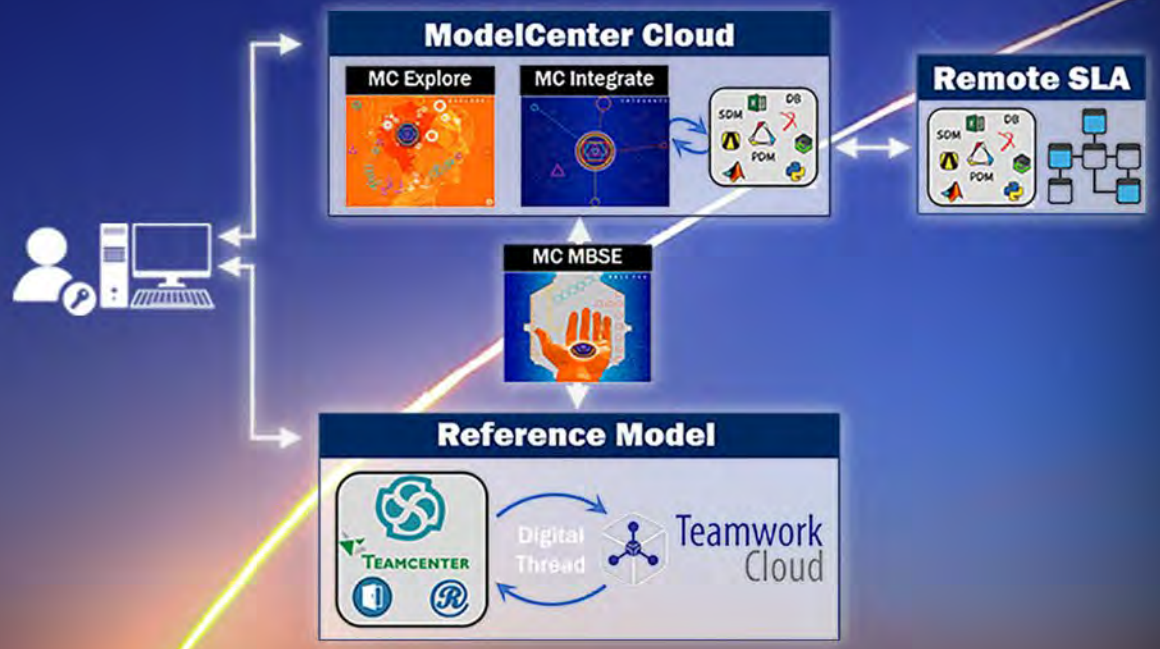
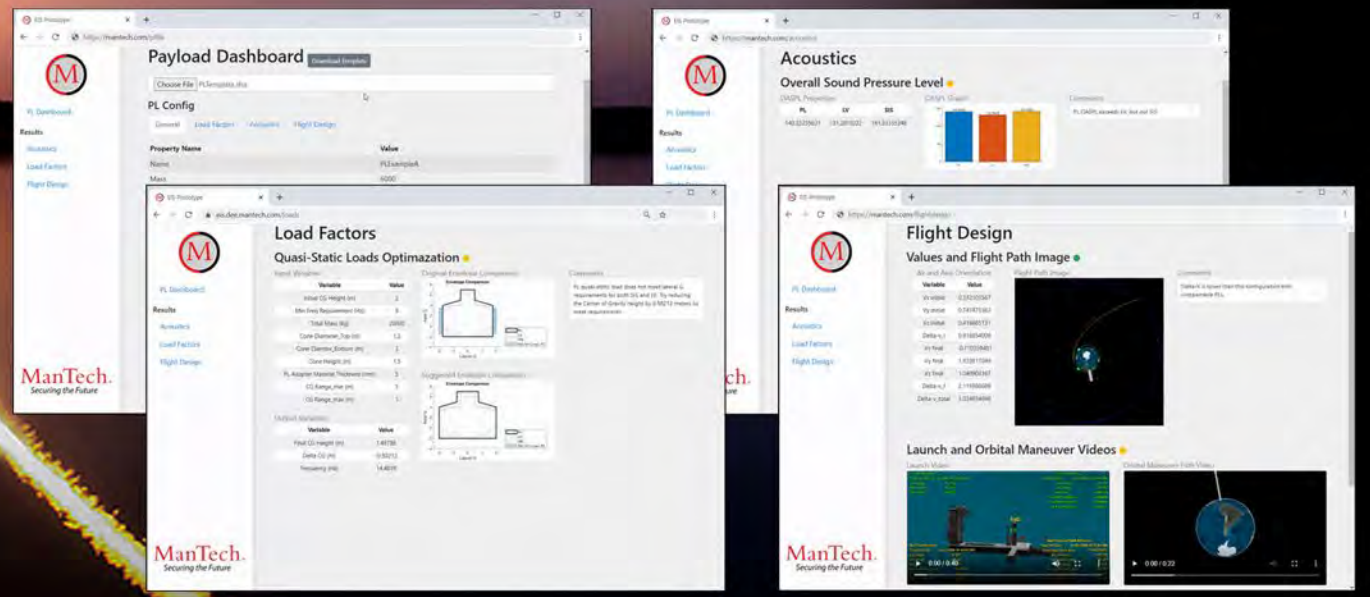


ManTech's Distributed Integration Launch Assessment Approach

Tyler Peterson, M.S., PMP
Lead Systems Architect



ManTech.
Securing the Future

BLUF: ManTech-Accelerated Digital Engineering Process Technology

ManTech's prototype capability for Launch Enterprise

- MBSE (Model Based Systems Engineering) and MDAO (Multi-Disciplinary Analysis and Optimization)
  - Maximize Talent management in a workforce limited future
- Utilizes Agile methodologies to develop at the speed of relevance
  - Build a strong foundation for iterative growth towards mission integration, launch, and beyond
- Starts with Early Integration Studies (EIS)
  - Real-time adjustments and trade study results using less resources
  - Transition time and labor-intensive manual tools to automated workflows

BLUF: ManTech-ADEPT and Early Integration Studies

Mission Statement: Reduce 12-month process to a fraction of the time & cost

- Currently takes 3 years of planning & executing to procure & launch a satellite
  - One-third of this time is required to produce, prepare, and assess a launch vehicle's ability with thousands of hours of manual analysis and engineering trade studies

- MT-ADEPT develops a Digital Engineering Ecosystem that enables Launch Enterprise to assess safety & efficacy of launch vehicle and satellite compatibility
  - Incorporates off-the-shelf tools for an integrated source (digital thread & ASoT) of regulatory requirements and providers' physical characteristics (digital twin) in a secure cloud environment

- MT-ADEPT combats anticipated future Launch staffing and budget reductions
  - Enables rapid assessment of optimal launch vehicle and satellite configurations

Agenda

Digital Engineering

- Background
- What is it?
- How can we start?

Early Integration Studies (EIS): MT-ADEPT Solution

- Overarching Architecture
- Reference Model
- ModelCenter MBSE – Instance Data Framework
- ModelCenter Cloud
  - ModelCenter Integrate and Explore
- User Profiles – LV/PL and SV/Satellite

EIS MT-ADEPT Prototype

- LV/PL User:
  - Input, workflows, results
- SV/Satellite User
  - Input, workflows, results
- Executive User
  - Executive Dashboard
  - Launch Manifest

Digital Engineering

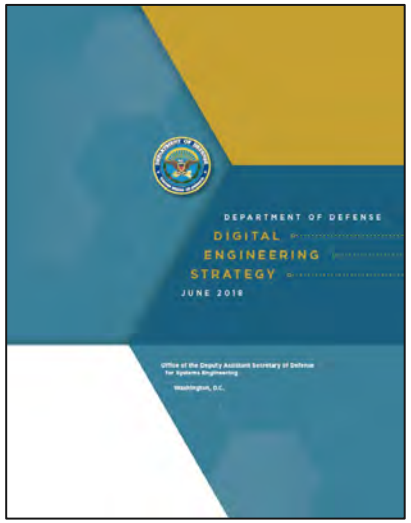
- Background
- What is it?
- How can we start?

Digital Engineering: Background

Culture shift has reached 'critical mass'

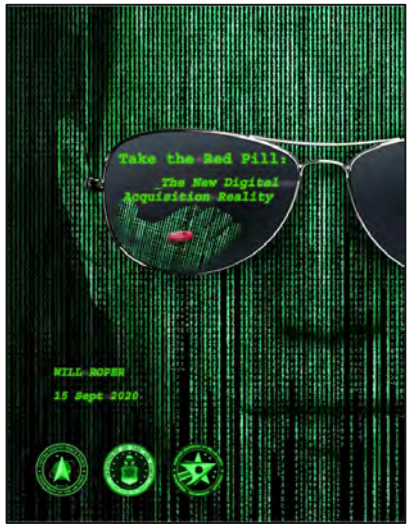
- ☑ Momentum
- ☑ Buy-in
- ☐ Path of Implementation

NDIA SE Conferences



DoD DE Strategy (2018)

DoD Data Strategy (2020)



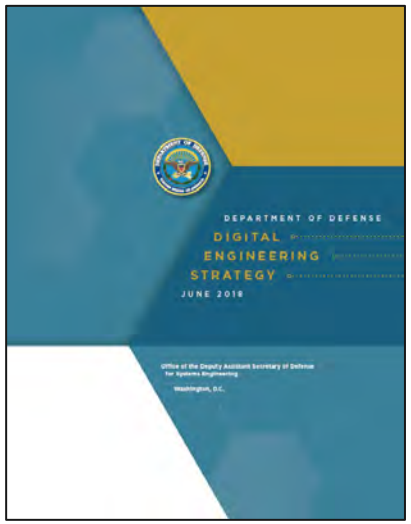
The New Digital Acquisition Reality (2020)

Cloud Based – Zero Trust Architecture

Digital Engineering: What is it?

Definition:

"**integrated** digital approach that uses **authoritative sources** of system data and models as a continuum **across disciplines** to support lifecycle activities from **concept through disposal**"



DoD DE Strategy (2018)

Goal:

modernize how DoD "**designs**, **develops**, **delivers**, **operates**, and **sustains systems**"

Optimized Approach to Mission Integration:

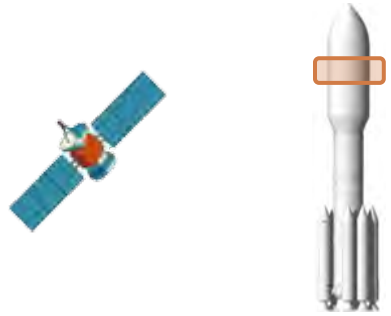
Document Supported Solution → **Model Based Systems Engineering (MBSE)**

Decentralized Information → **Network Centric Operations (Cloud)**

Digital Engineering: How can we start?

Early Integration Studies (EIS)

- complex tests → highly automated and easily repeatable workflows
- uncomplicated viewable results



Simple EIS
- Trajectory & Mission Design Analysis
- Coupled-Loads Analysis

Standard EIS
- Draft ICD
- Launch Site CONOPS

Complex EIS
- Integrated Thermal Analysis
- Acoustic Analysis
- EMI/EMC Analysis
- Contamination Analysis
- LV/PL Interface Analysis

Additional EIS Tasks
- Vibration/Shock Analysis
- Security Analysis
- GN2 Purge Analysis

Other Special Studies
- Government Reviews
- Anomaly Resolution
- Mission Assurance Activities

Digital Engineering: How can we start?

Expand EIS Capabilities:

- assess compatibility of multi-payload mission sets

Executive Dashboard

PL Echo: Secondary PL Configurations

Secondary PL	Launch Vehicle	Primary PL	Loads	Acoustics	Flight Design	Thermal	Contamination
Echo	A	Alpha	🟢	🟡	🟢	🔴	🟢
Echo	A	Bravo	🔴	🟢	🟡	🟢	🟢
Echo	B	Alpha	🔴	🟢	🟢	🟡	🟢
Echo	B	Bravo	🟡	🟢	🔴	🔴	🟢
Echo	C	Alpha	🟢	🟢	🟡	🟢	🔴

Launch Verification Matrix Testing:

- tentative mission sets with refined system, big data, and machine learning

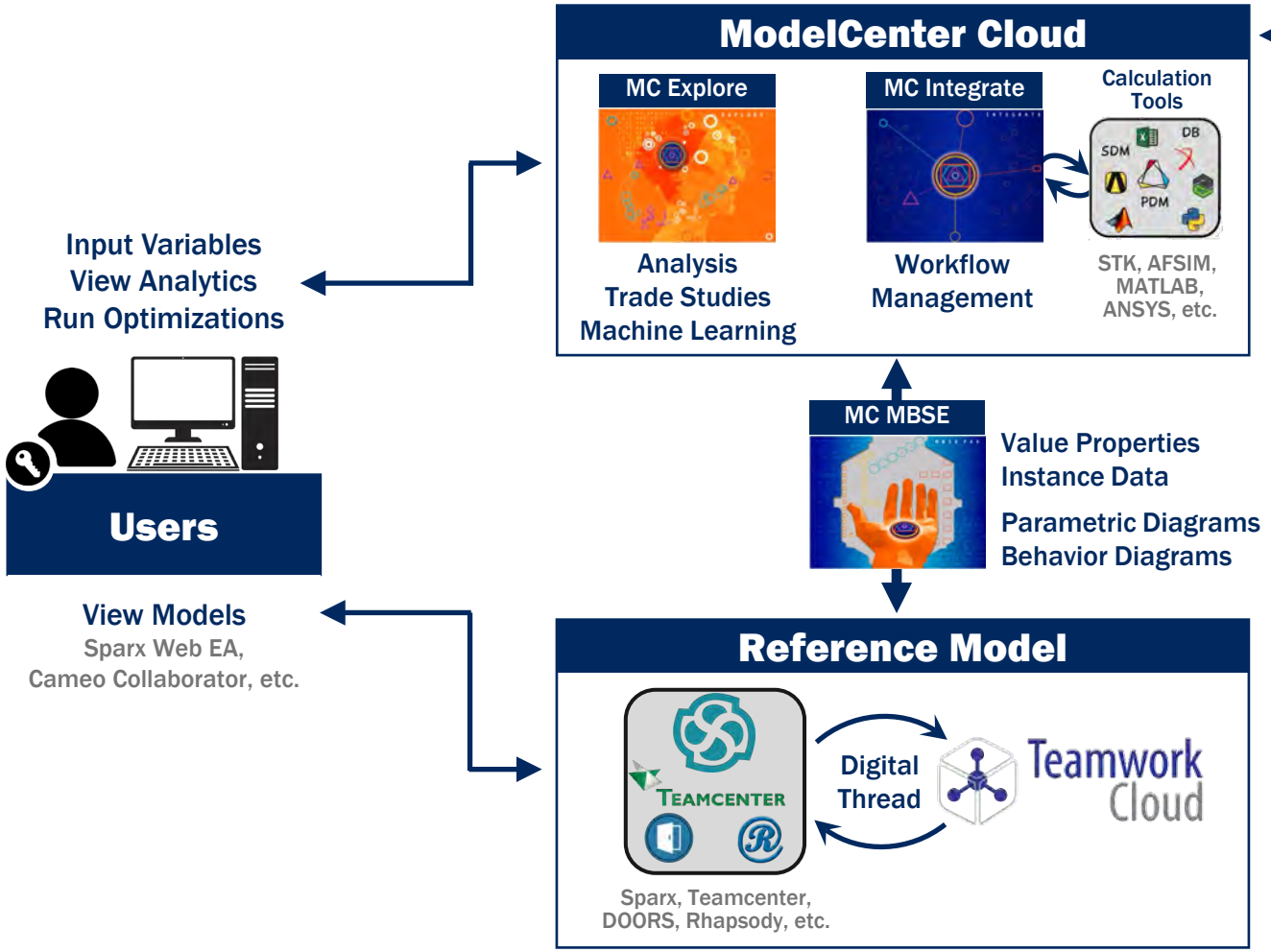
Potential Launch Manifest

Mission	Date	Launch Vehicle	Primary PL	Secondary PL	Hosted PL	Status
Mission 1	2020-11-23	C	Payload Charlie	Payload Fox	Payload Hotel	🟢
Mission 2	2021-01-02	A	Payload Zulu	Payload Sierra	Payload Bravo	🟡
Mission 3	2021-01-18	D	Payload Dedicated			🟢
Mission 4	2021-02-13	A	Payload Alpha	Payload Mike	Payload Oscar	🔴
Mission 5	2021-3-28	E	Payload Delta	Payload Lima	Payload Juliet	🟢

EIS: MT-ADEPT Solution

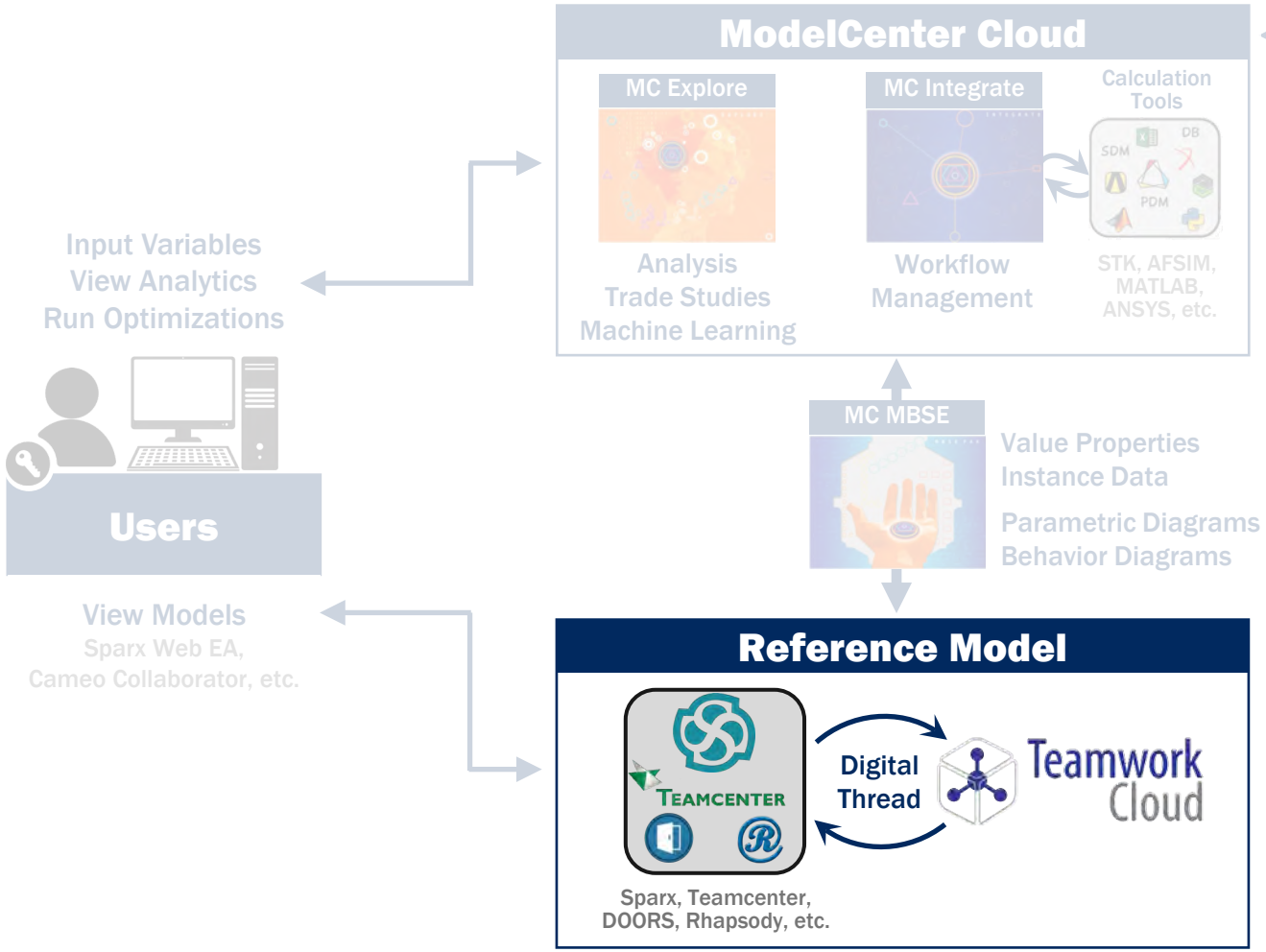
- Digital Engineering Ecosystem Architecture
- Reference Model
- ModelCenter Cloud
- User Profiles

Digital Engineering Ecosystem Architecture



- **Secure Cloud Environment**
- **Authenticated Single-Sign-On**
- **Vendor Agnostic Plug-and-Play**
- **Complete System for Full Lifecycle**
- **Fast, Useful, and Adaptable**

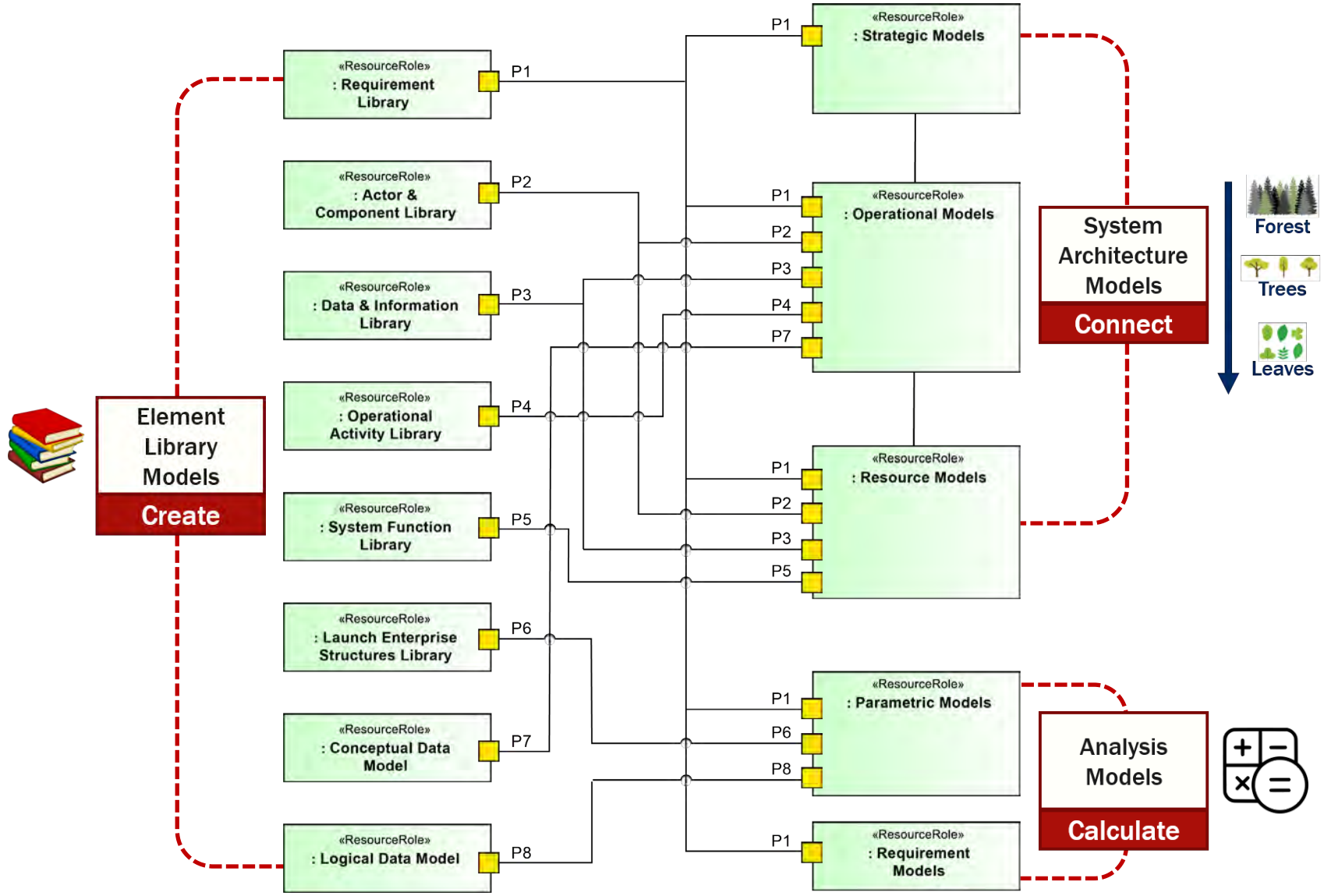
Digital Engineering Ecosystem Architecture



- Hosted in a Secure Environment
- Authenticated Single-Sign-On
- Vendor Agnostic Plug-and-Play
- Complete System for Full Lifecycle
- Fast, Useful, and Adaptable

Reference Model

Reference Model



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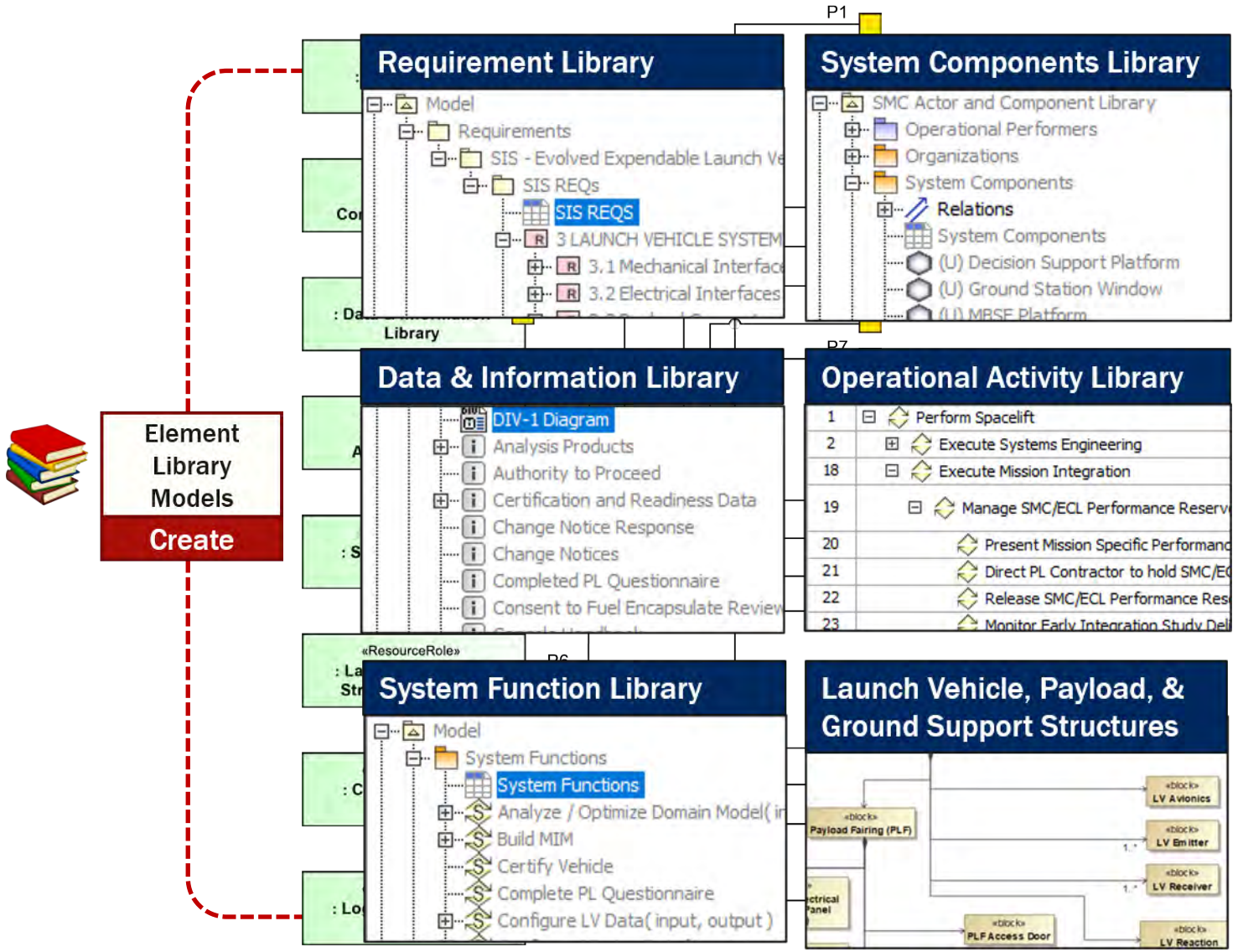

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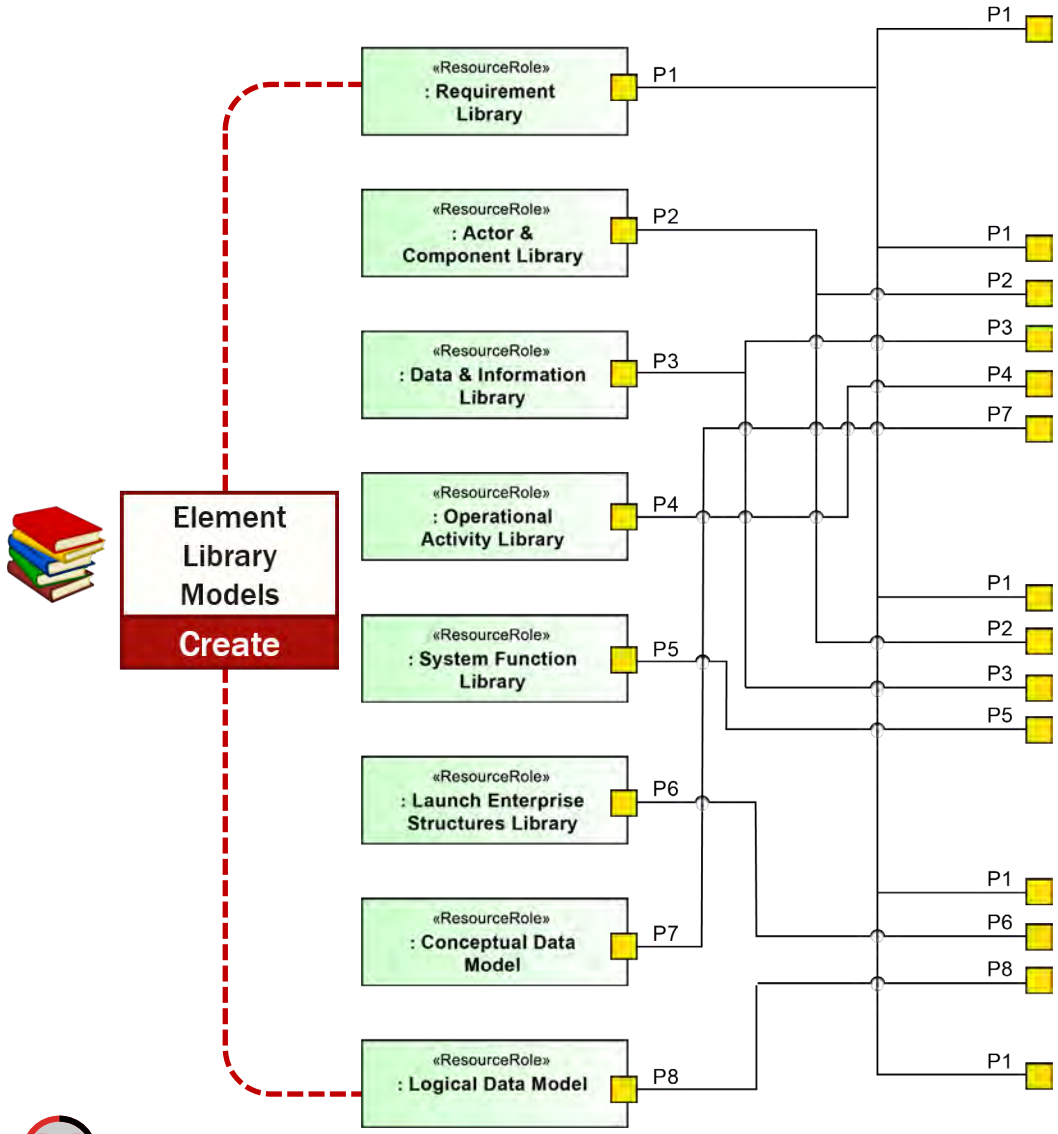

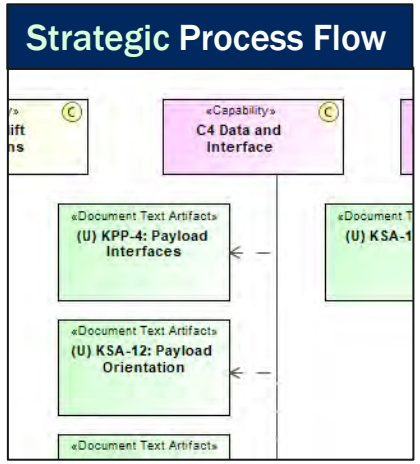

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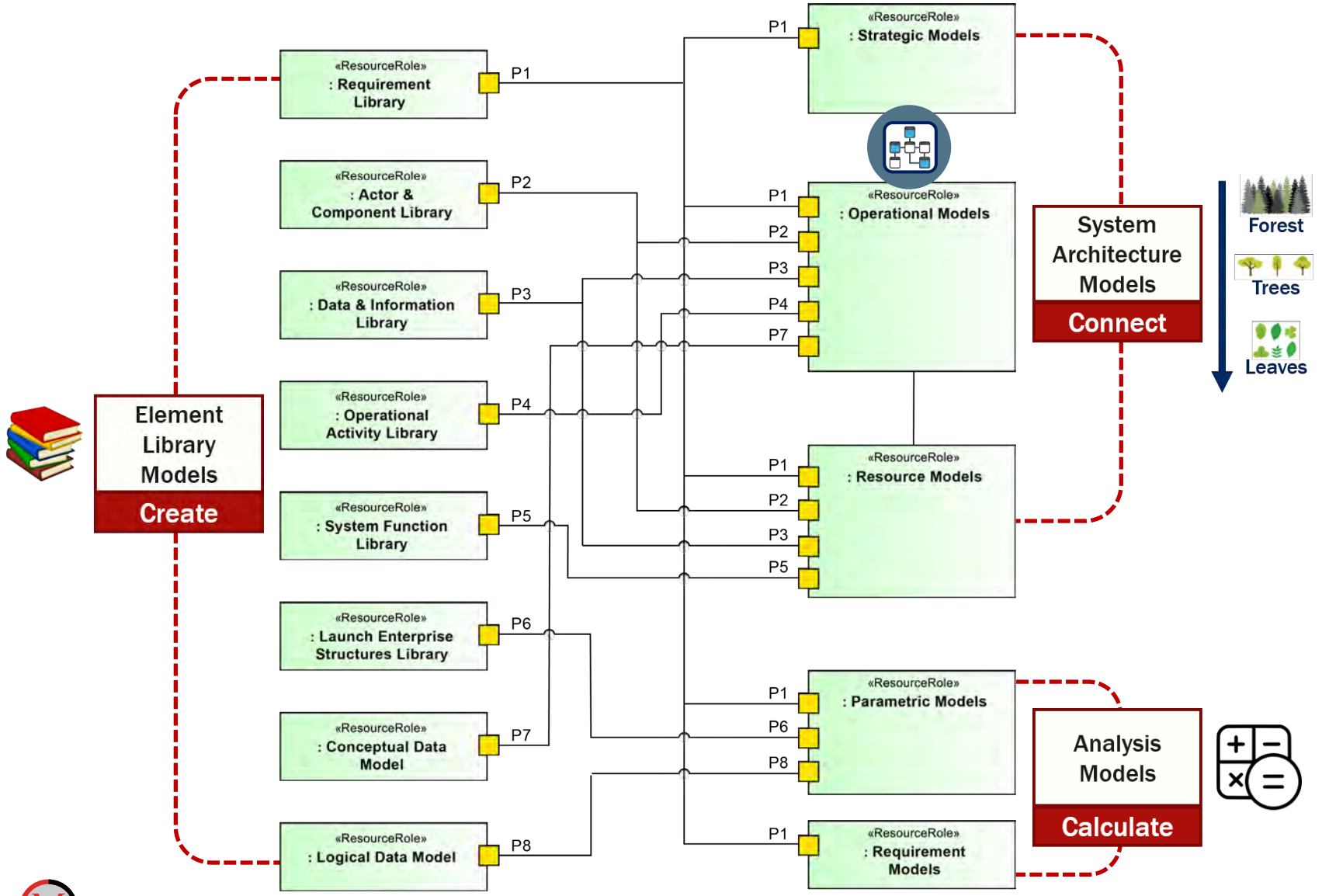

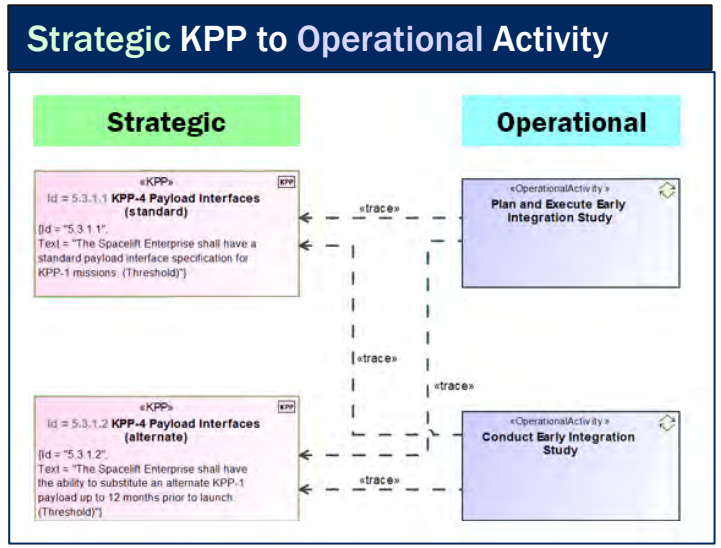

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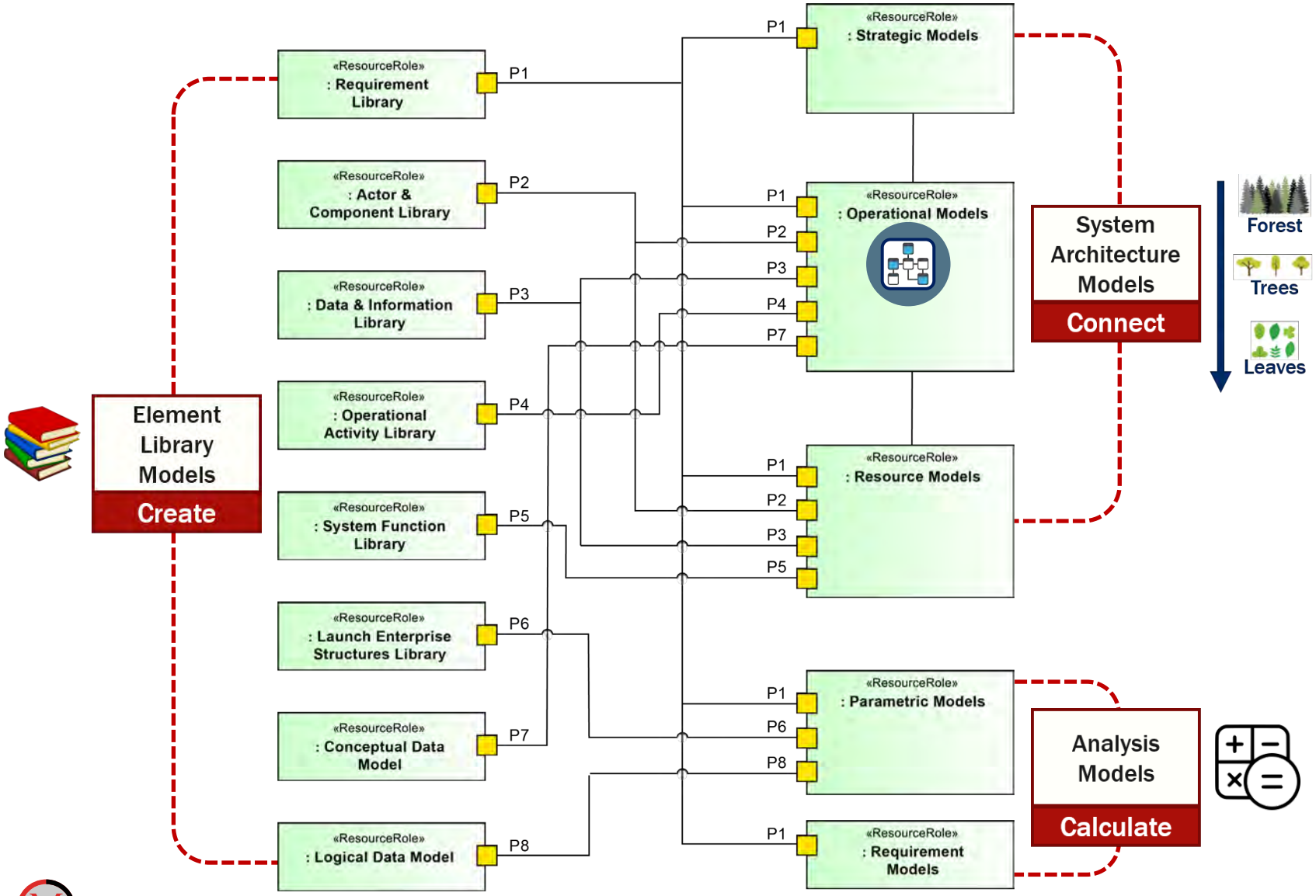

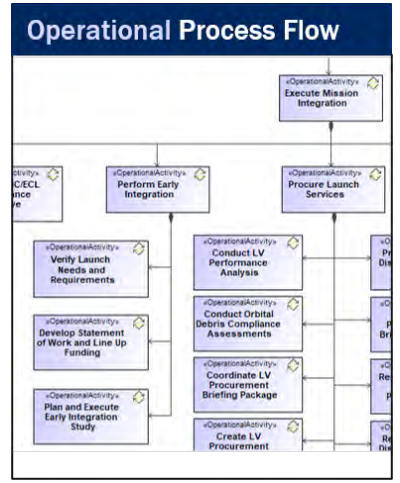

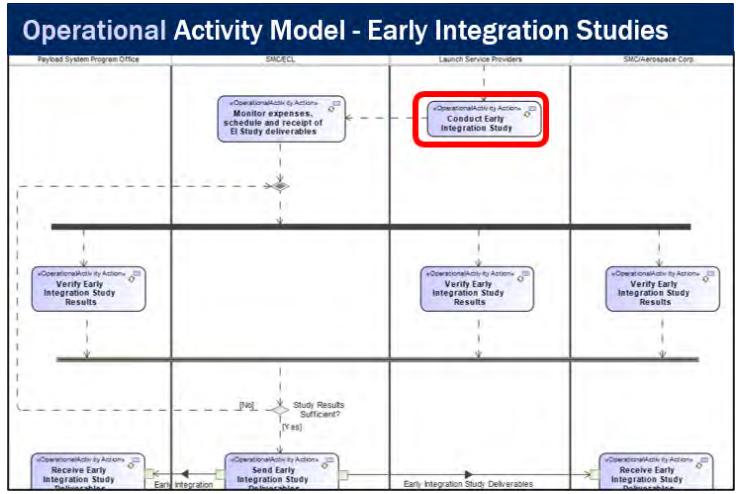

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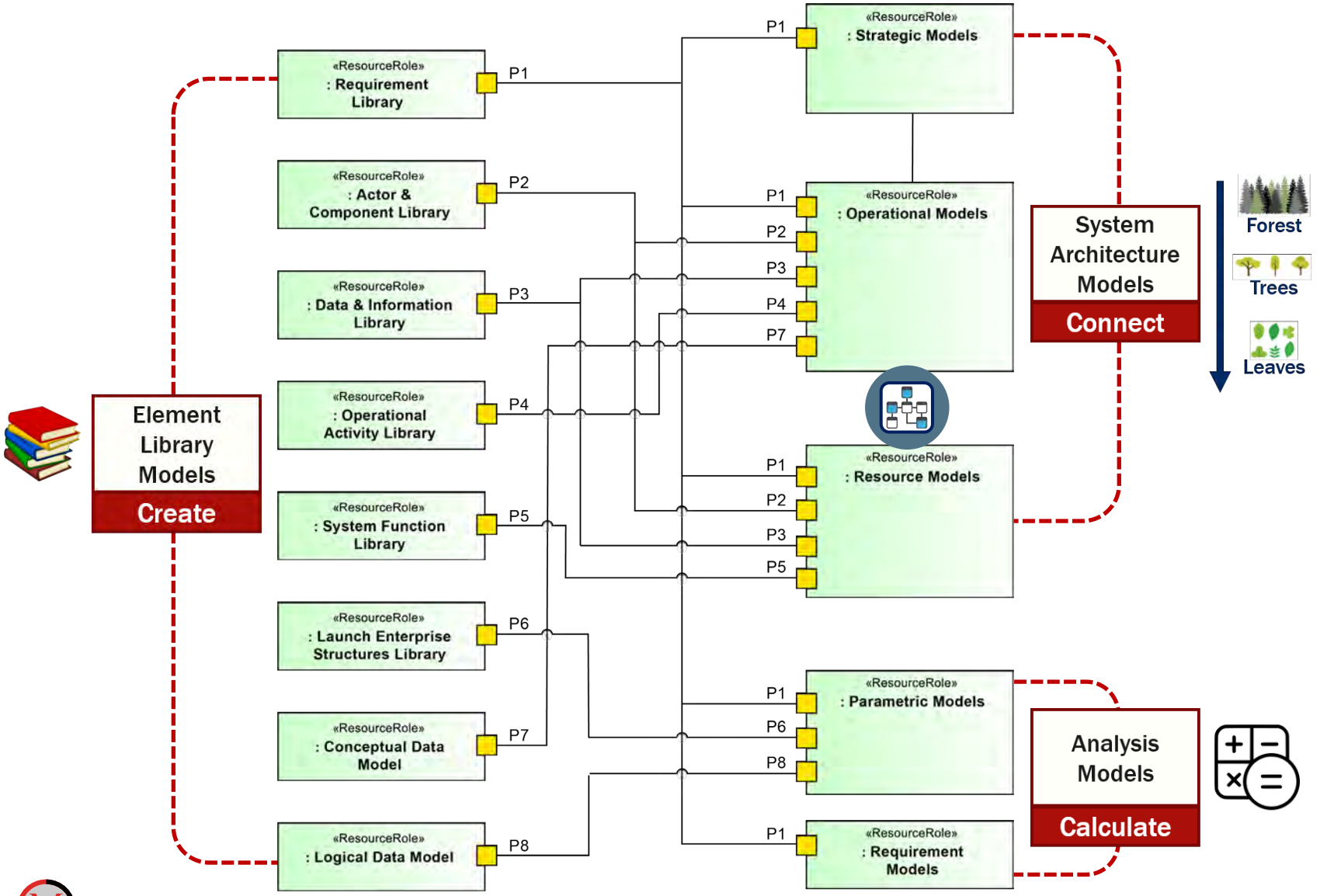

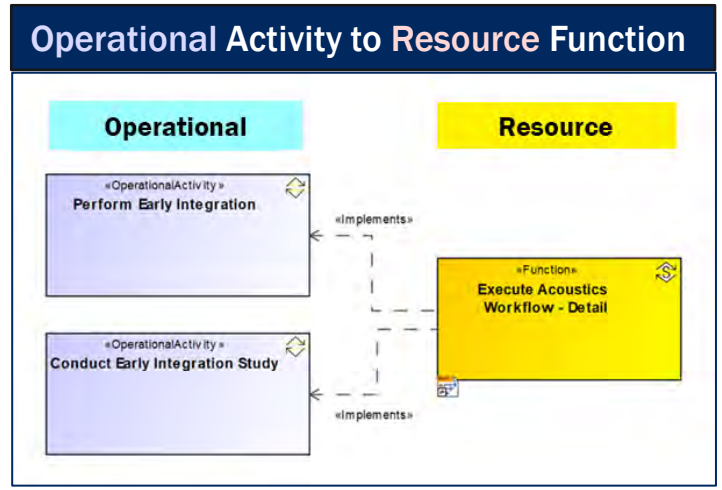

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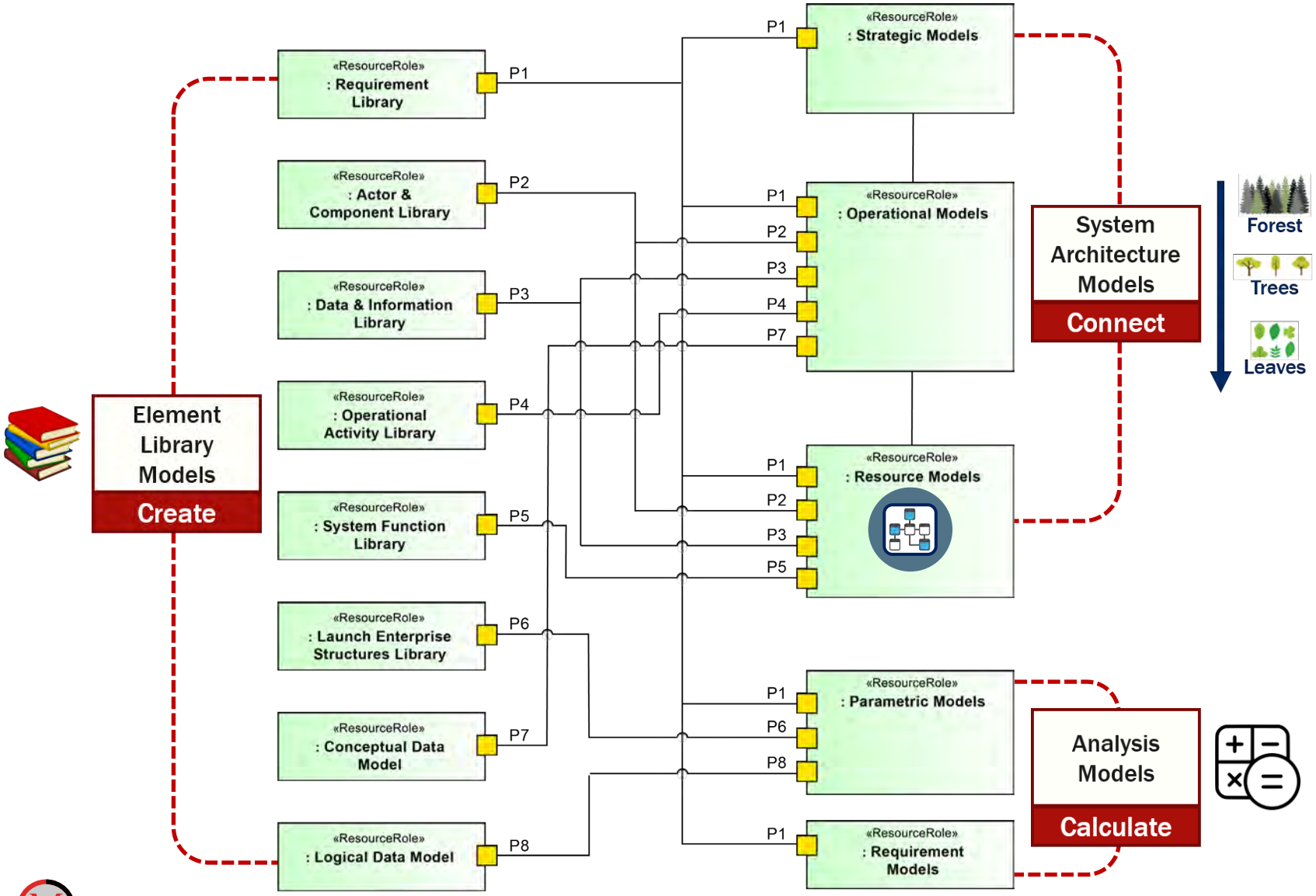

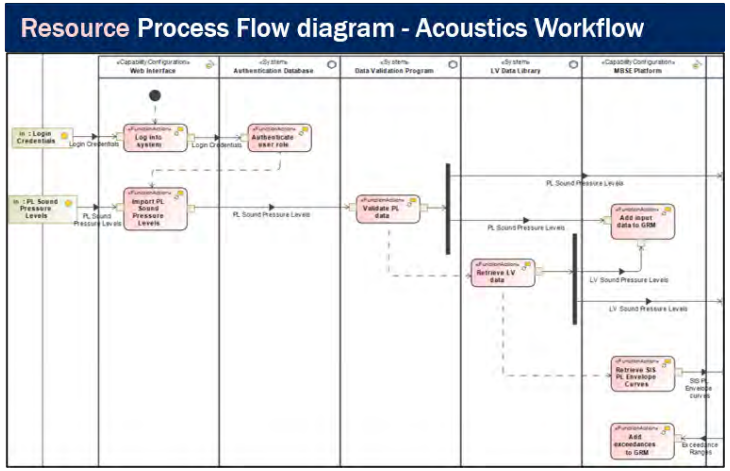

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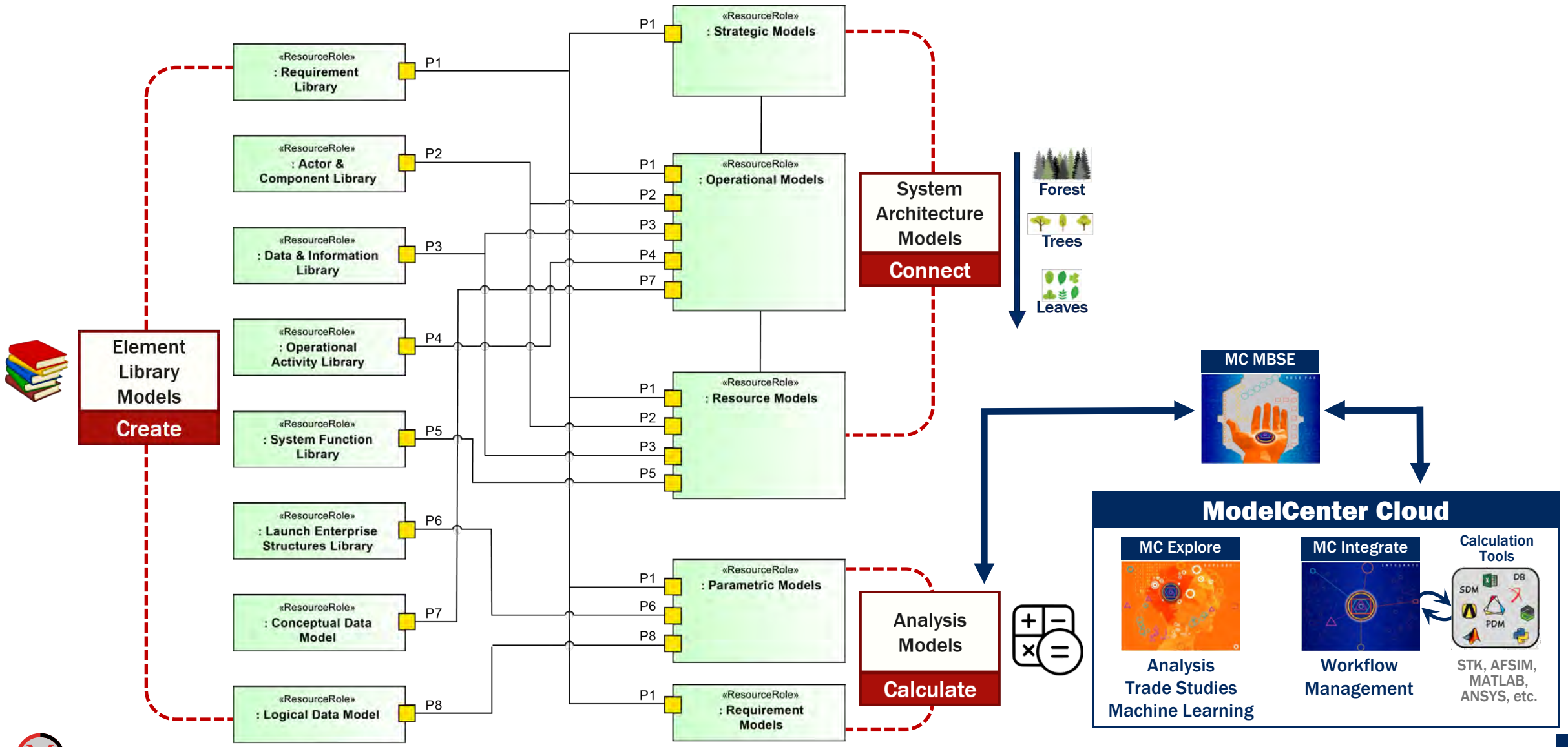

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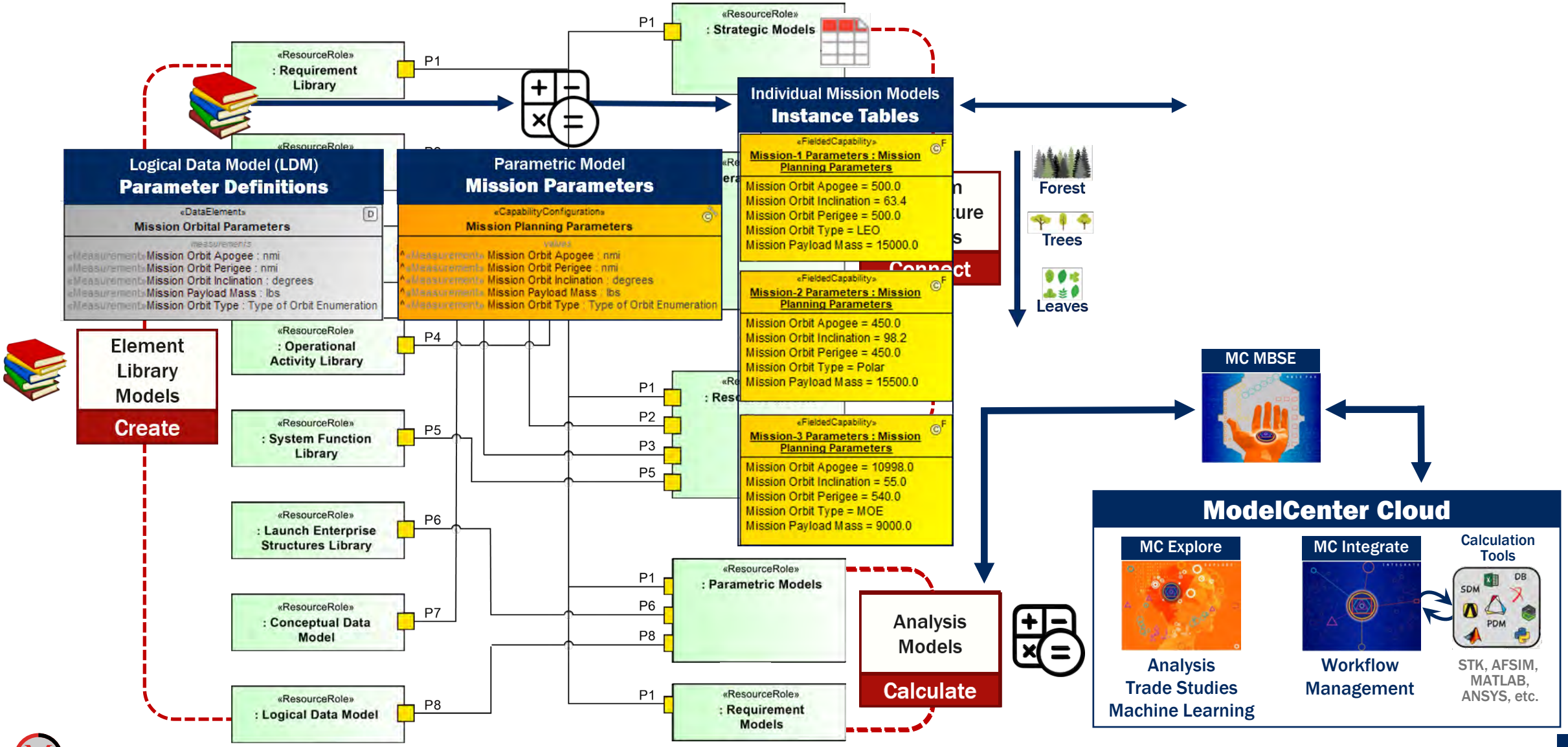
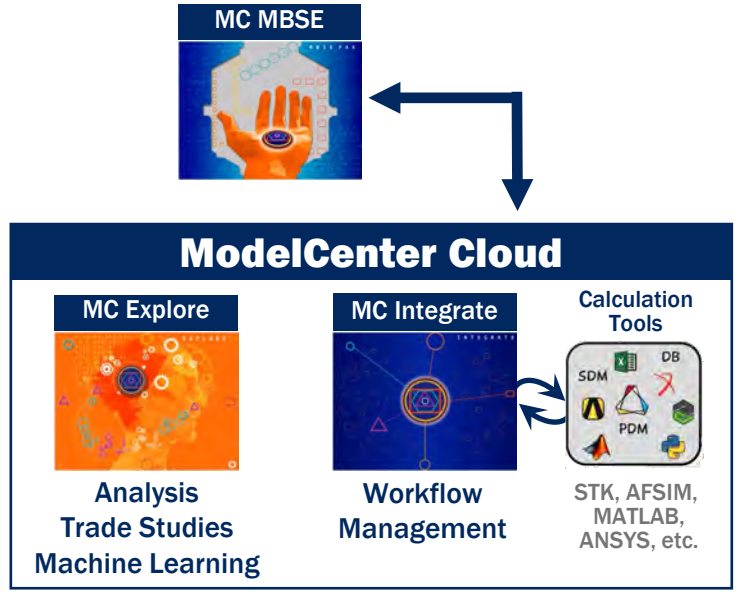
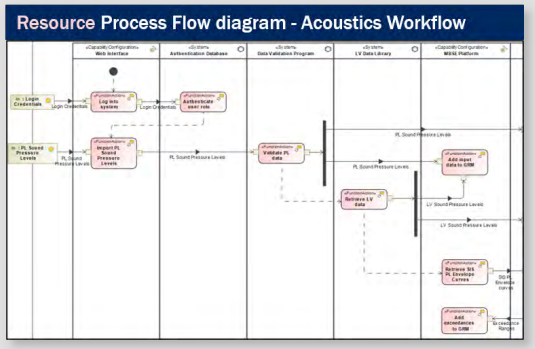
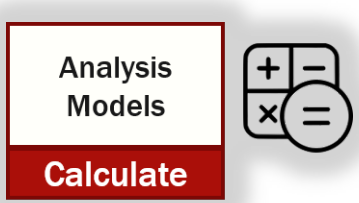


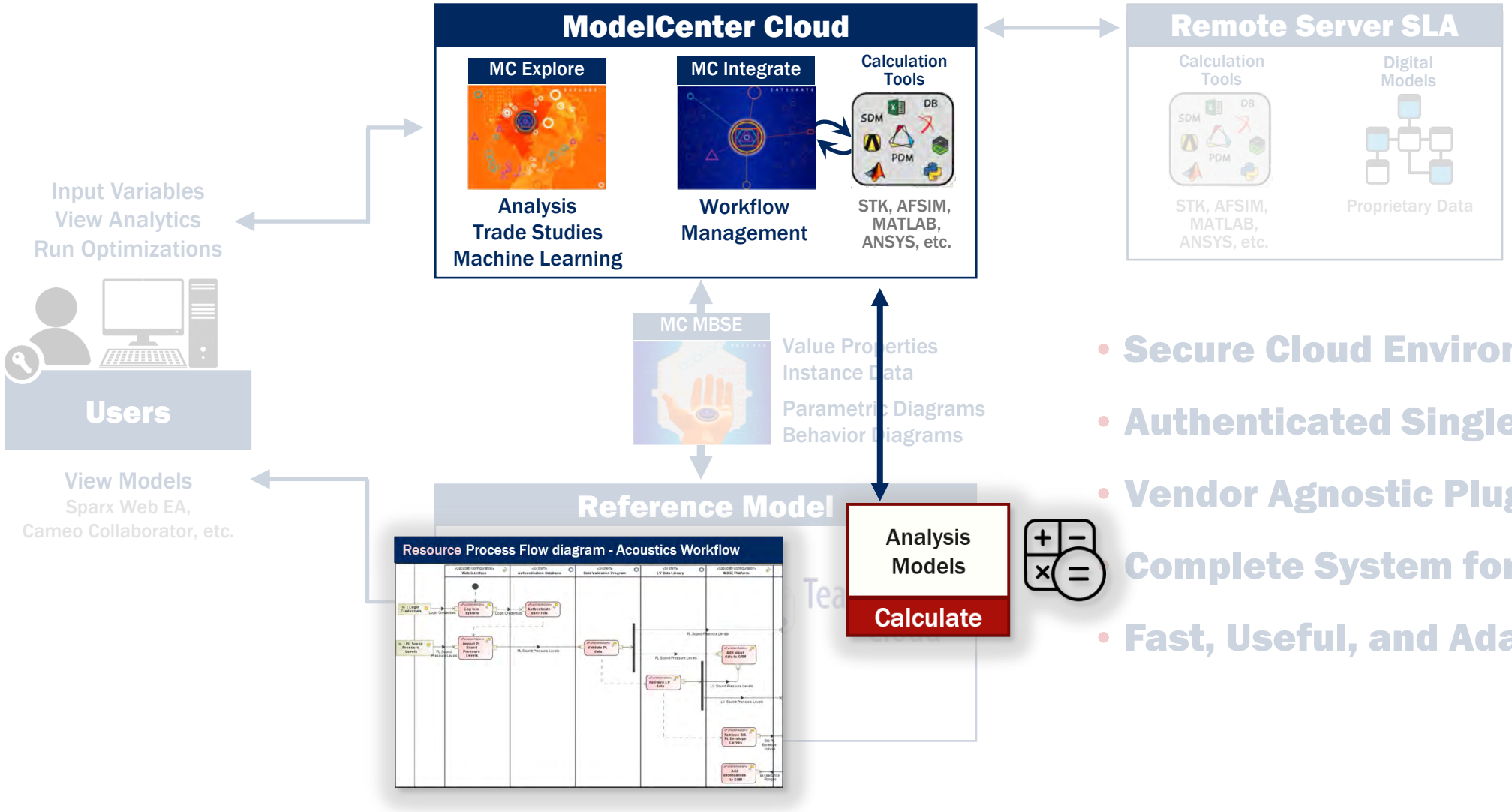
Digital Engineering Ecosystem Architecture





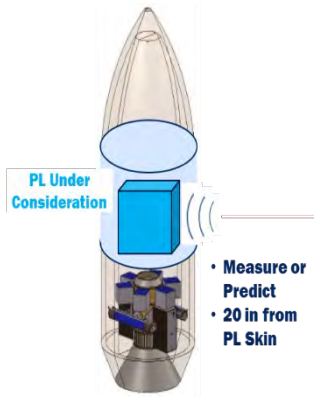


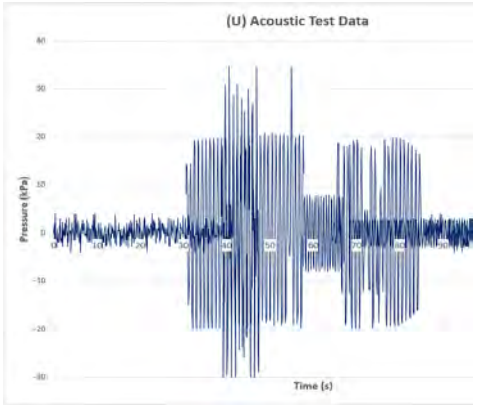
Digital Engineering Ecosystem Architecture

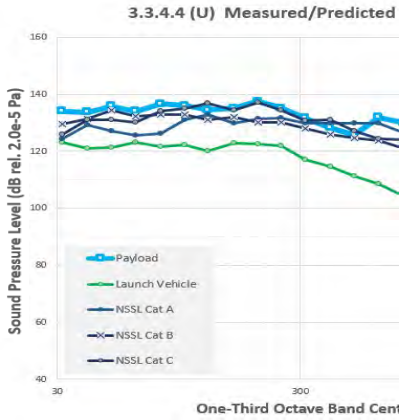


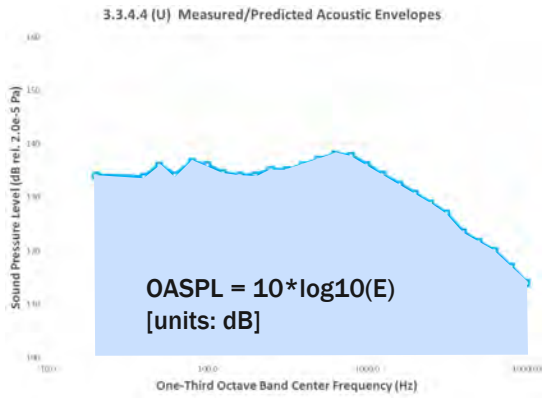
- Secure Cloud Environment
- Authenticated Single-Sign-On
- Vendor Agnostic Plug-and-Play
- Complete System for Full Lifecycle
- Fast, Useful, and Adaptable

Acoustic Analysis Context









PL or Digital Representation

Data Capture

Threshold Crossing

Sound Pressure Level at each dB (SPL)

Integrating for Area

Overall Sound Pressure Level (OASPL)

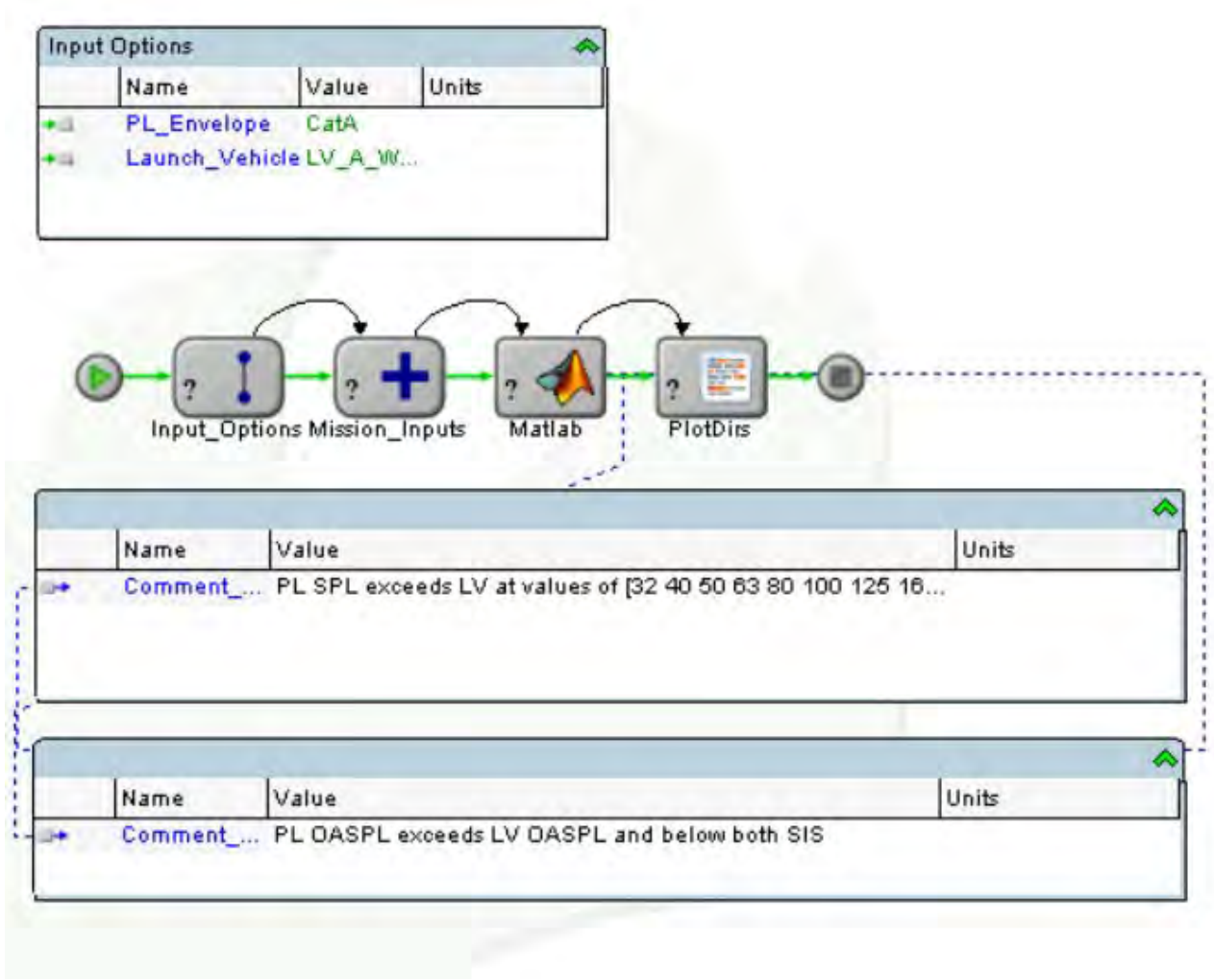
Assumptions

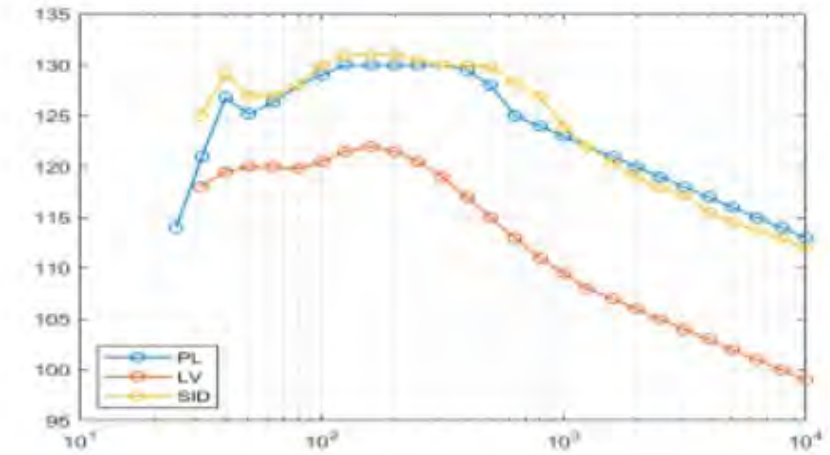
- P95/50
  (95% Probability with 50% Confidence)
- PL shall be designed to tolerate the acoustic levels generated by LV
- From liftoff through SV separation
- Reference pressure 20 μPa

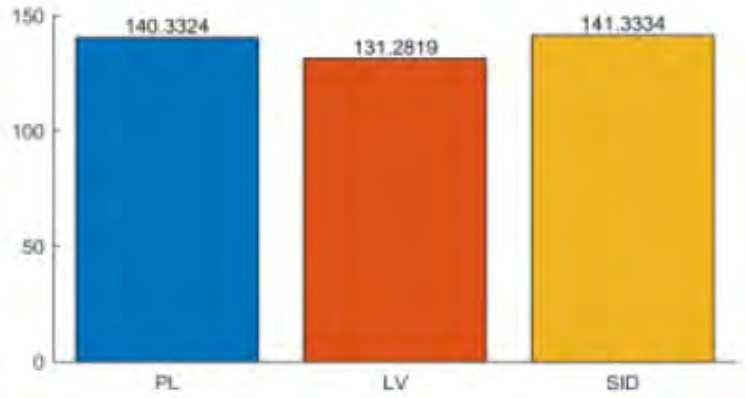
Workflow Steps

1. Obtain V(t) [voltage time trace from microphone]
2. Calc p'(t) = mic.constant * V(t), where
   p'(t) = pressure fluctuation
3. Normalize p'(t) using reference pressure 20 μPa
4. Calc S(f) using FFT, where
   S(f) = spectrum of normalized p'(t)
5. Correct S(f) for mic response and atmospheric absorption
6. Compute Sound Pressure Level (SPL) Spectrum
   $SPL(f) = 10*\log10(S(f))$ [units: dB/Hz]
7. Compute Overall Sound Pressure Level (OASPL)
   $E = \int S(f)\, df$ [total energy contained in the spectrum]
   $OASPL = 10*\log10(E)$ [units: dB]
8. Identify SPL and OASPL exceedances

ModelCenter Integrate: Acoustics Analysis

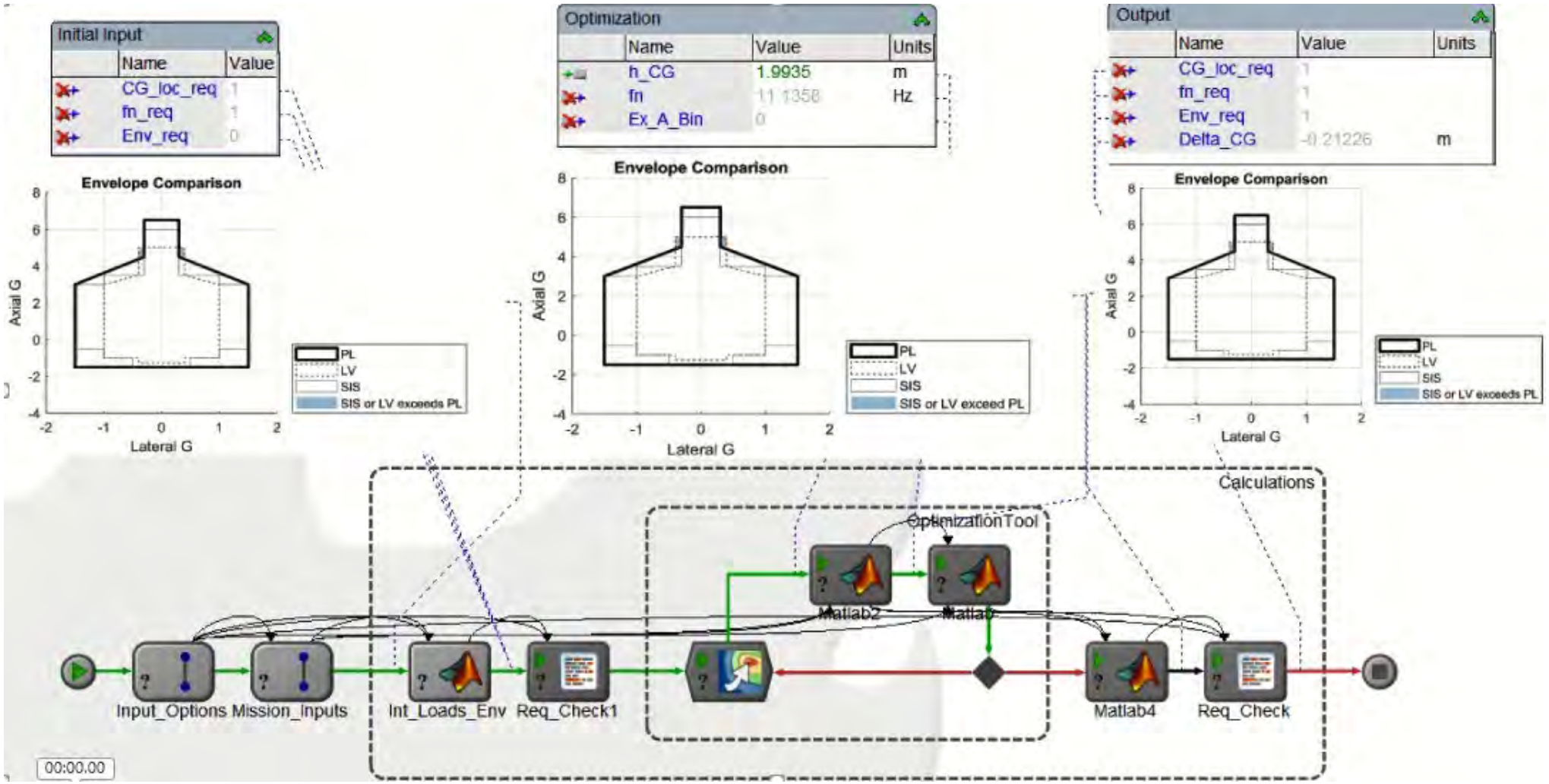






$$SPL(f) = 10 * \log10\big(S(f)\big) \qquad OASPL = 10 * \log10\big(\int S(f)\, df\big)$$

ModelCenter Explore: Load Factors Optimization

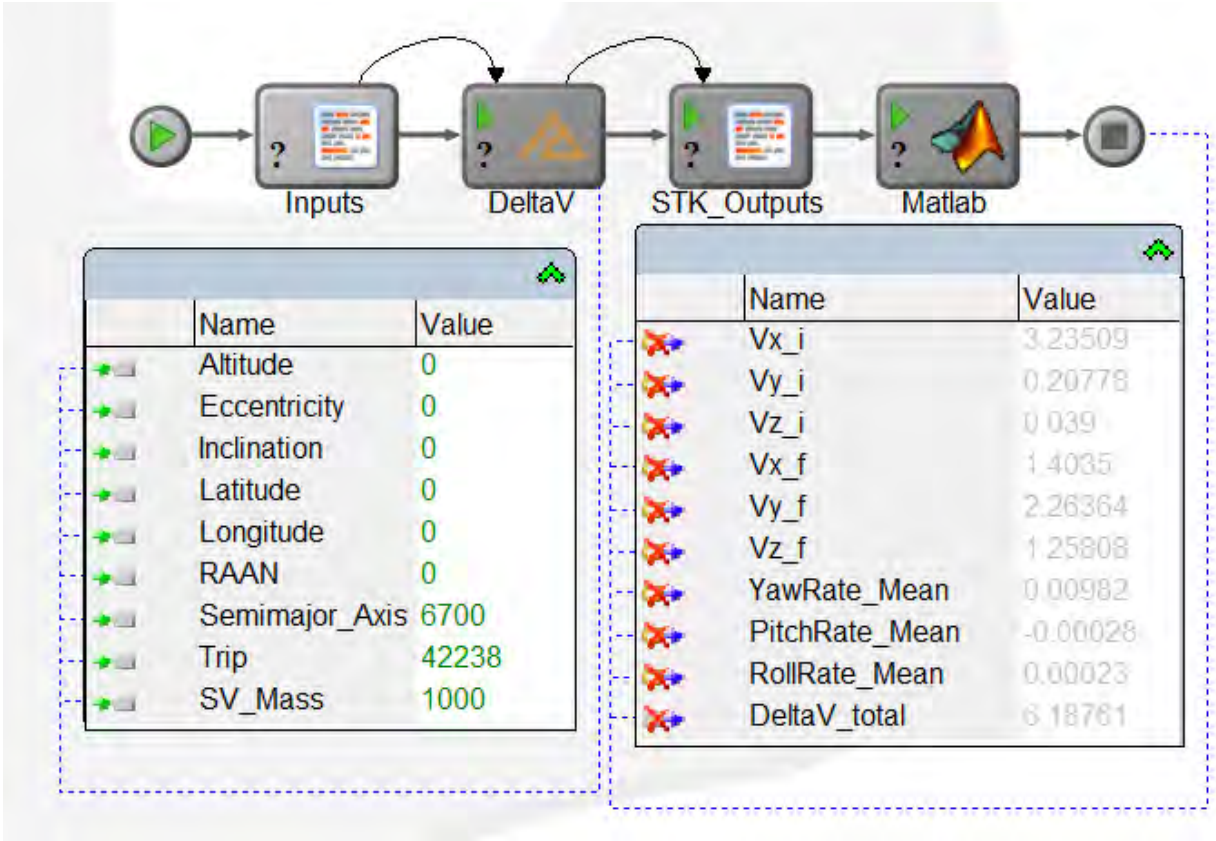


$CG_{Height} \propto Lateral\ Loads\ Envelope$

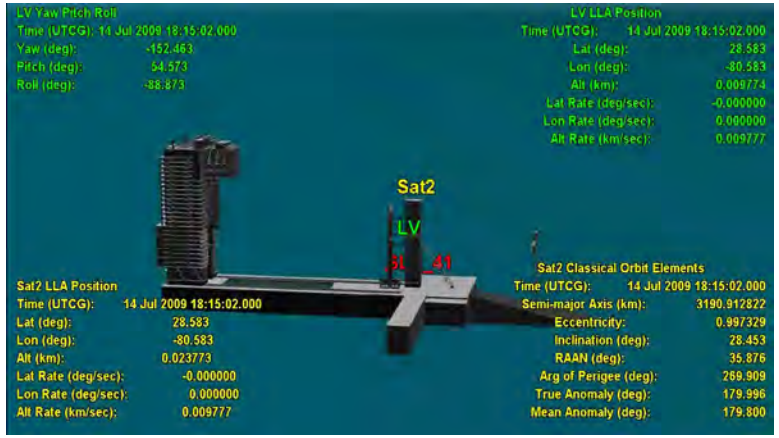
$$\Delta = \delta + h\theta$$

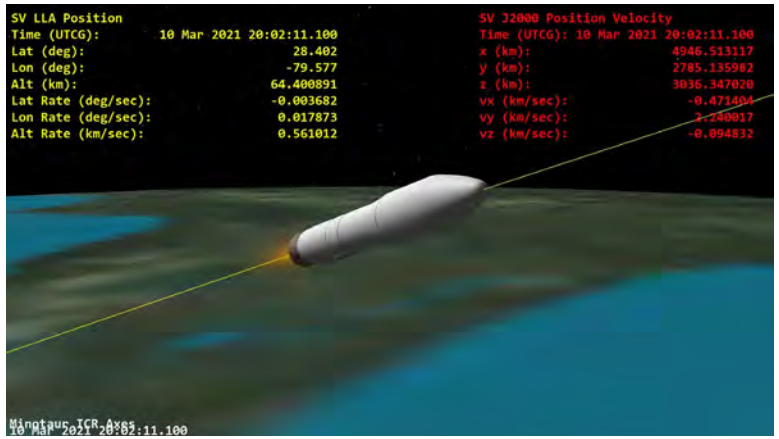
$$f_n = \frac{1}{2\pi}\sqrt{\frac{1}{\Delta}}$$

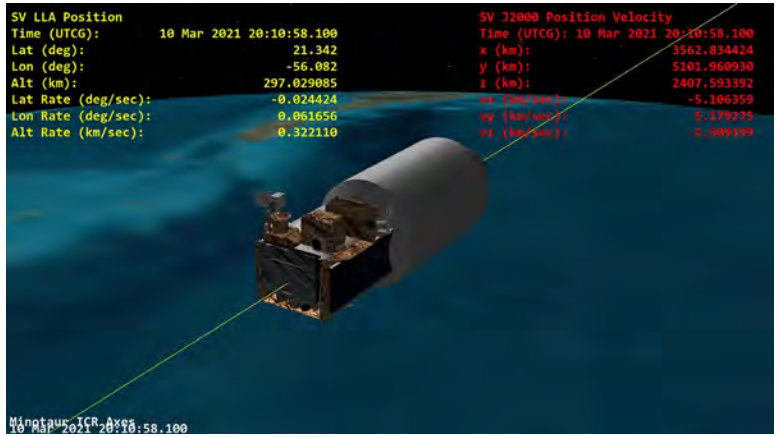
Modeling Tools: Flight Design



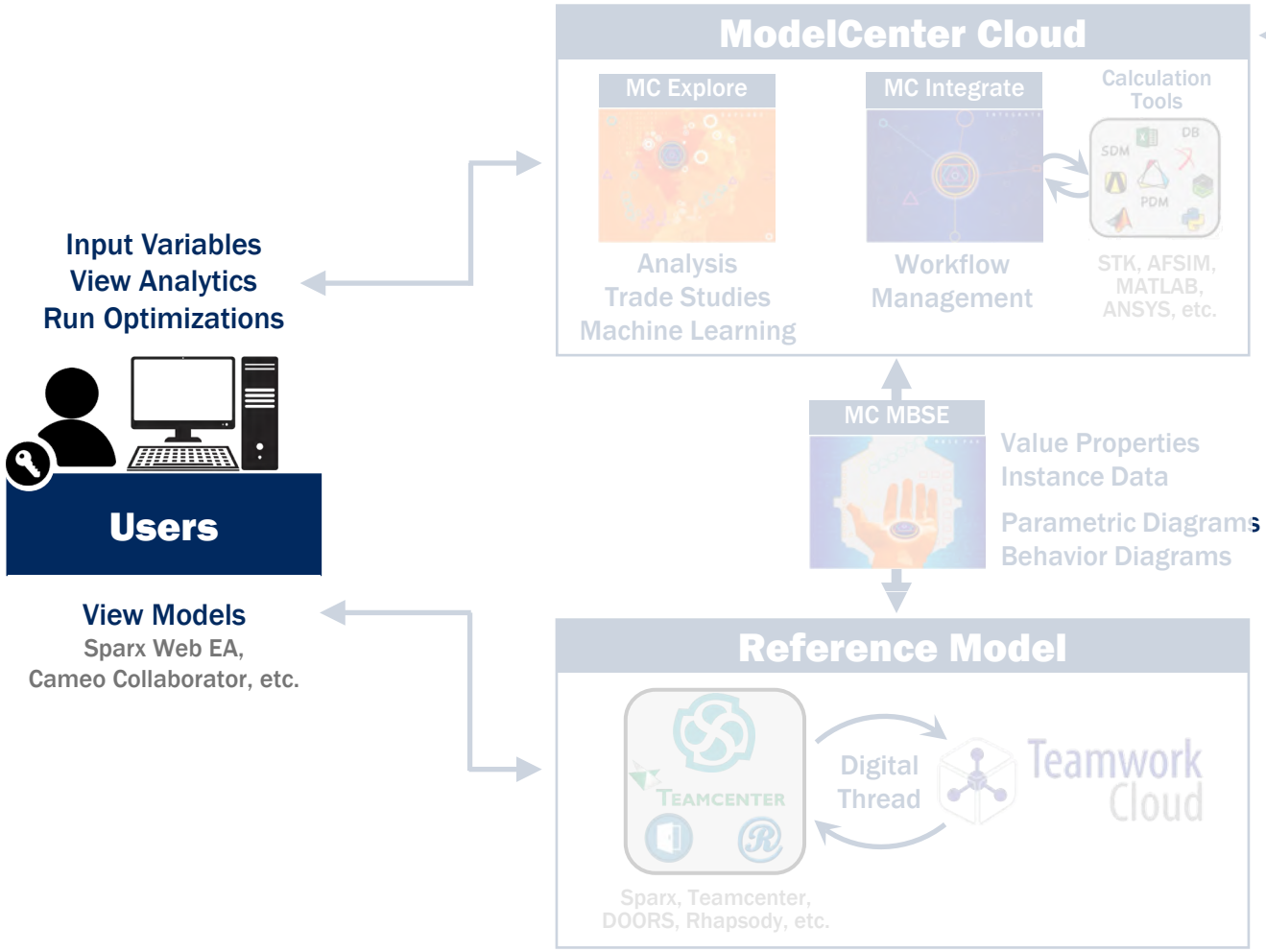
$$\Delta v = \int_{t_0}^{t_1} \frac{|T(t)|}{m(t)} dt$$





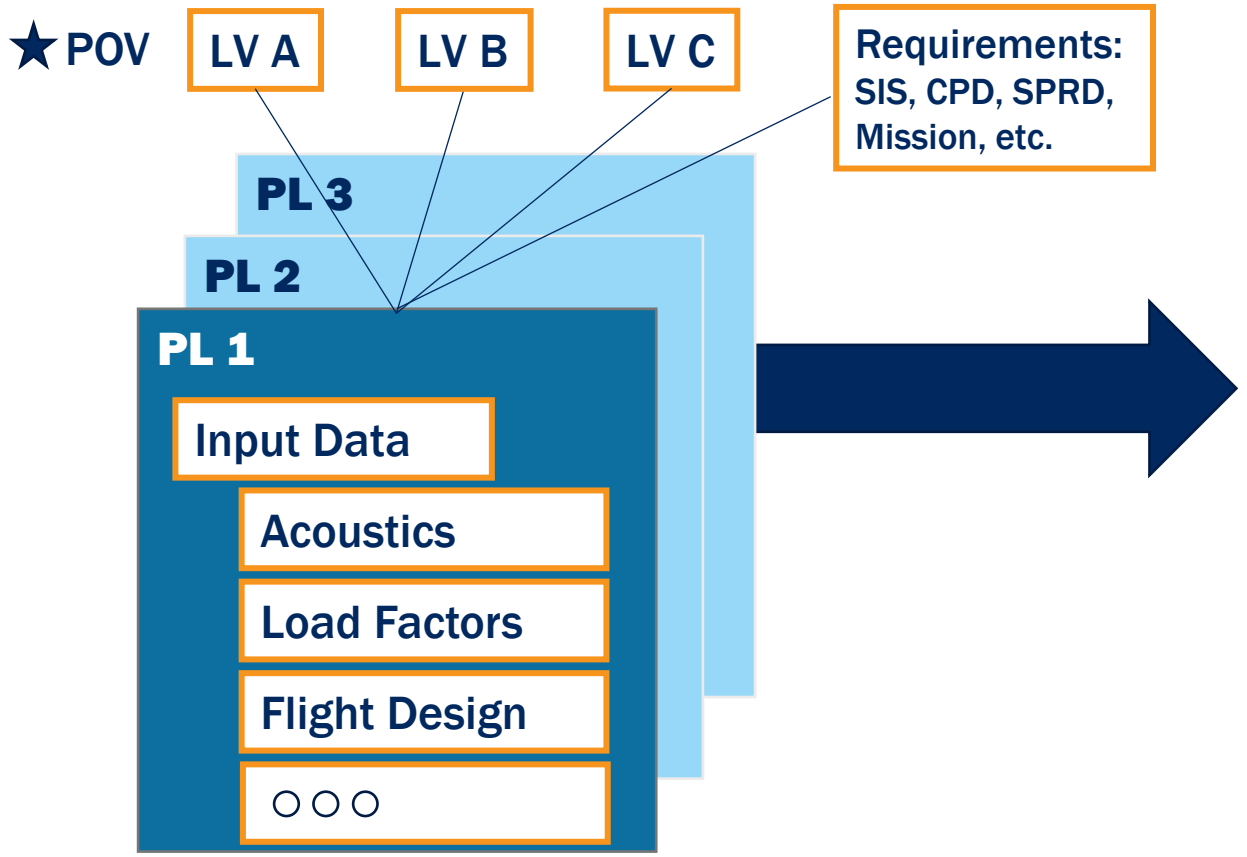


Digital Engineering Ecosystem Architecture



- Secure Cloud Environment
- Authenticated Single-Sign-On
- Vendor Agnostic Plug-and-Play
- Complete System for Full Lifecycle
- Fast, Useful, and Adaptable

User Profiles: LV and PL Perspective



Results:

- Raw Data
- Mismatches
- Suggested Changes

$\Delta_v = 3.12134$

Decrease PL CG Height by 0.5m to meet Load Factors requirements

Future Results:

- Tentative Solutions
- Multi-Mission Manifesting Solutions

Preliminary results show that PL 1 and LV B will require the fewest change orders

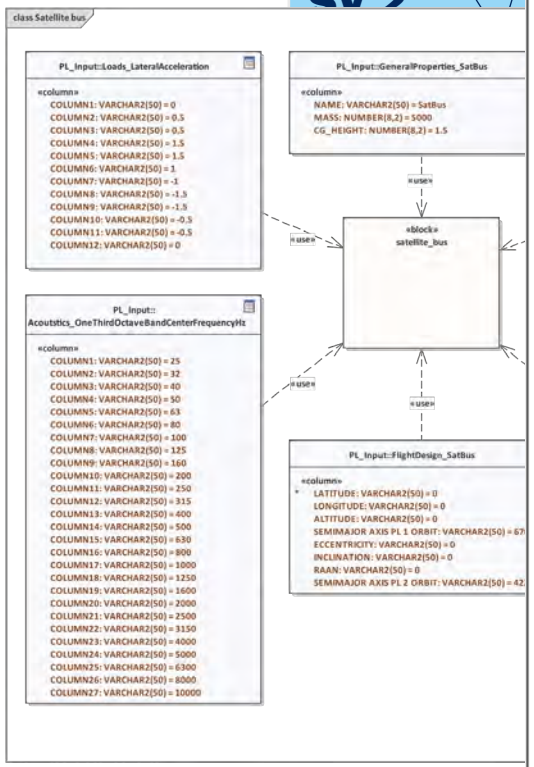
Preliminary results show that LV A can support PL 1 and PL 3 on 10/10/2021 w/minimal change orders

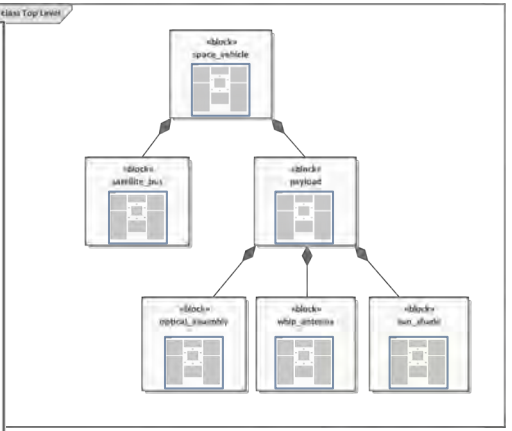
User Profi

LV A

SV 3

SV 2





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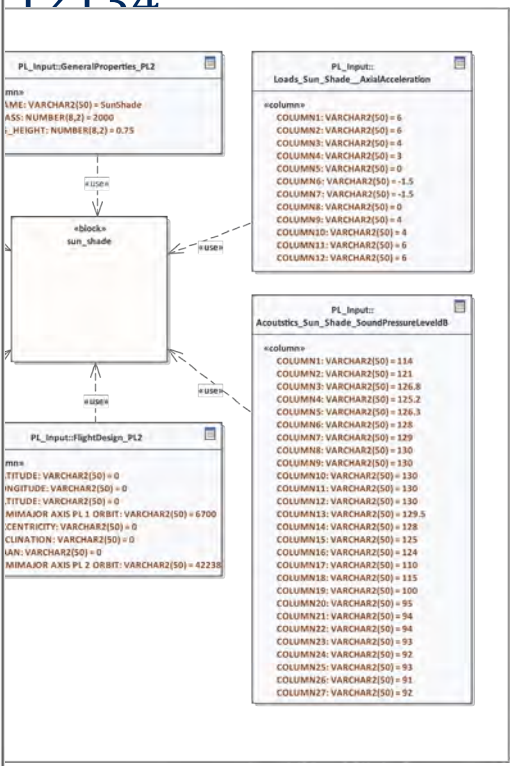


Executive Profiles: Higher Perspective

Executive Dashboard:

- No PL/SV input
- Overview of results comparing “approved” or “tentative” LV/SV/PLs

Executive Dashboard

PL Echo: Secondary PL Configurations

Secondary PL	Launch Vehicle	Primary PL	Loads	Acoustics	Flight Design	Thermal	Contamination
Echo	A	Alpha	🟢	🟡	🟢	🔴	🟢
Echo	A	Bravo	🔴	🟢	🟡	🟢	🟢
Echo	B	Alpha	🔴	🟢	🟢	🟡	🟢
Echo	B	Bravo	🟡	🟢	🔴	🔴	🟢
Echo	C	Alpha	🟢	🟢	🟡	🟢	🔴

Launch Manifest:

- Tentative configuration of LV/SV/PLs given complimentary cohesiveness and mission requirements

Potential Launch Manifest

Mission	Date	Launch Vehicle	Primary PL	Secondary PL	Hosted PL	Status
Mission 1	2020-11-23	C	Payload Charlie	Payload Fox	Payload Hotel	🟢
Mission 2	2021-01-02	A	Payload Zulu	Payload Sierra	Payload Bravo	🟡
Mission 3	2021-01-18	D	Payload Dedicated			🟢
Mission 4	2021-02-13	A	Payload Alpha	Payload Mike	Payload Oscar	🔴
Mission 5	2021-3-28	E	Payload Delta	Payload Lima	Payload Juliet	🟢

EIS: MT-ADEPT Prototype

- Cloud-Based Workflow Example

Live Demo

ManTech-ADEPT Benefits

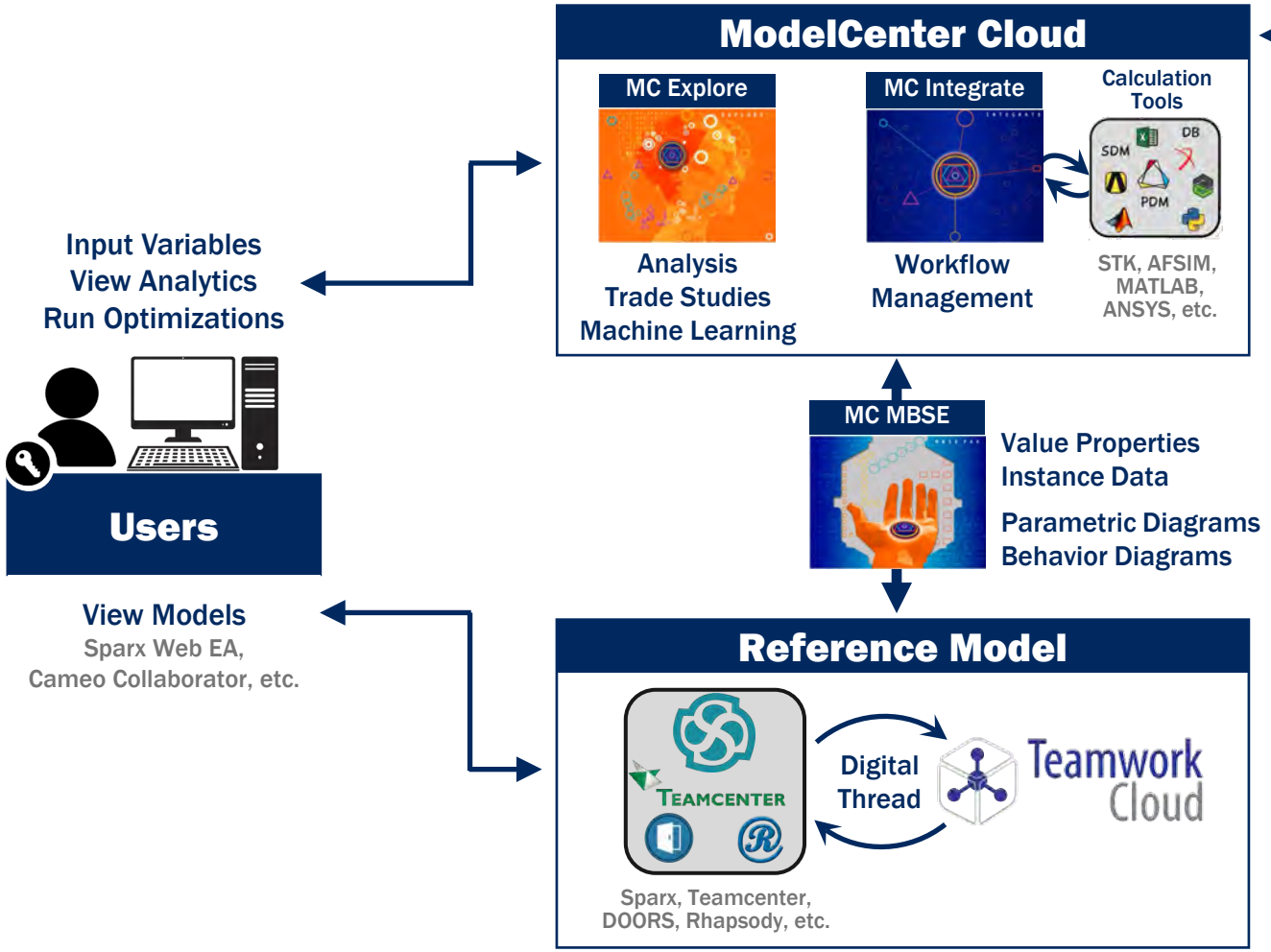
Reduces Time and Labor Cost

Maintains Decision Quality Results

- Allows for real-time adjustments and resource-unconstrained studies
- Enables automated Monte Carlo experiments and other trade studies
- Eliminates error-prone and work-intensive human data exchange
- Builds a scalable foundation for future developments

- Next Steps:
  - Refining workflows, maturing analytics, including additional EIS workflows
  - Building digital twin Reference Model and exploring a model based digital thread innovation

Digital Engineering Ecosystem Architecture



- **Secure Cloud Environment**
- **Authenticated Single-Sign-On**
- **Vendor Agnostic Plug-and-Play**
- **Complete System for Full Lifecycle**
- **Fast, Useful, and Adaptable**