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Enabling MBSE with Simulation to perform System Analysis for Space-Based Solar-Power

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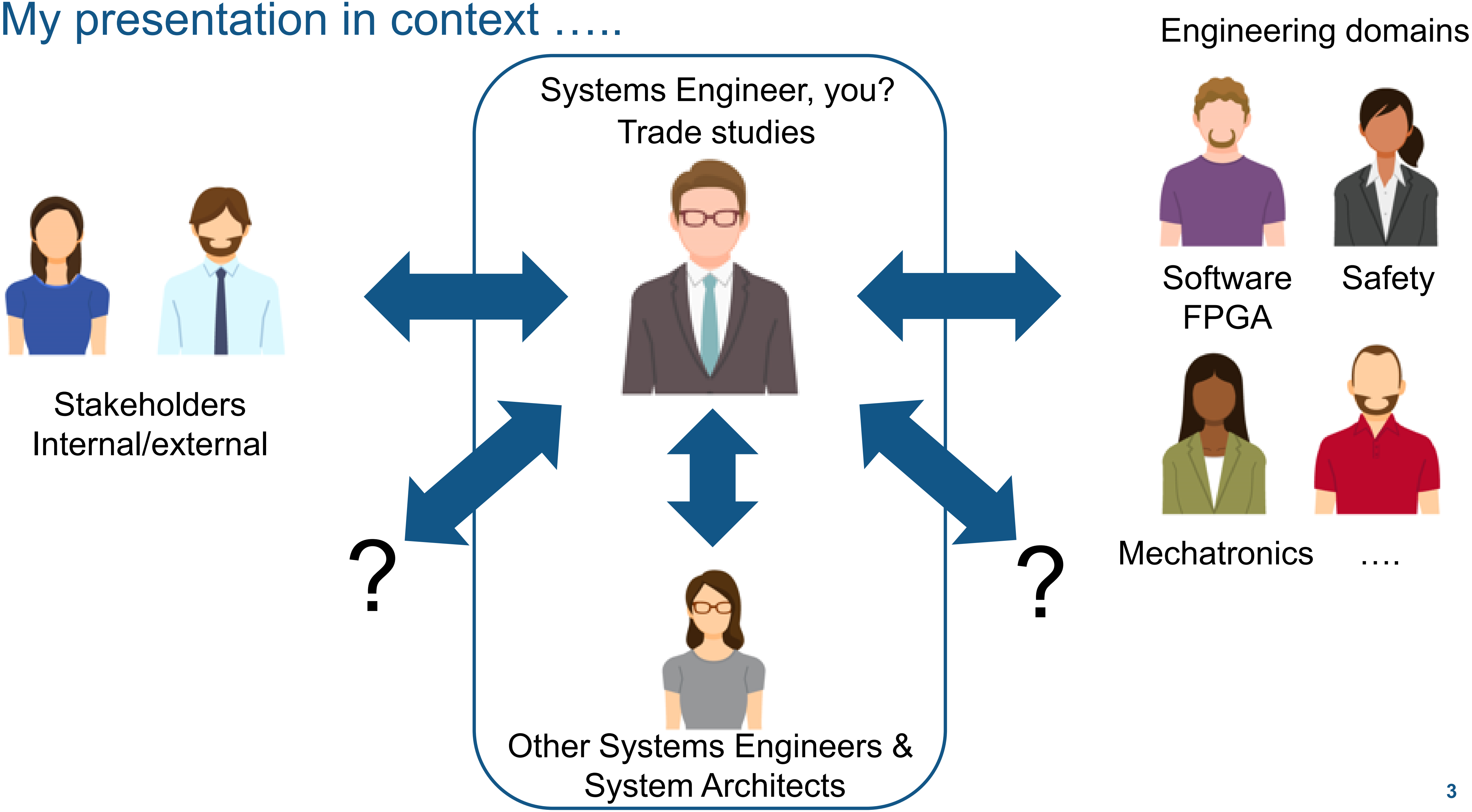
My presentation in context …..

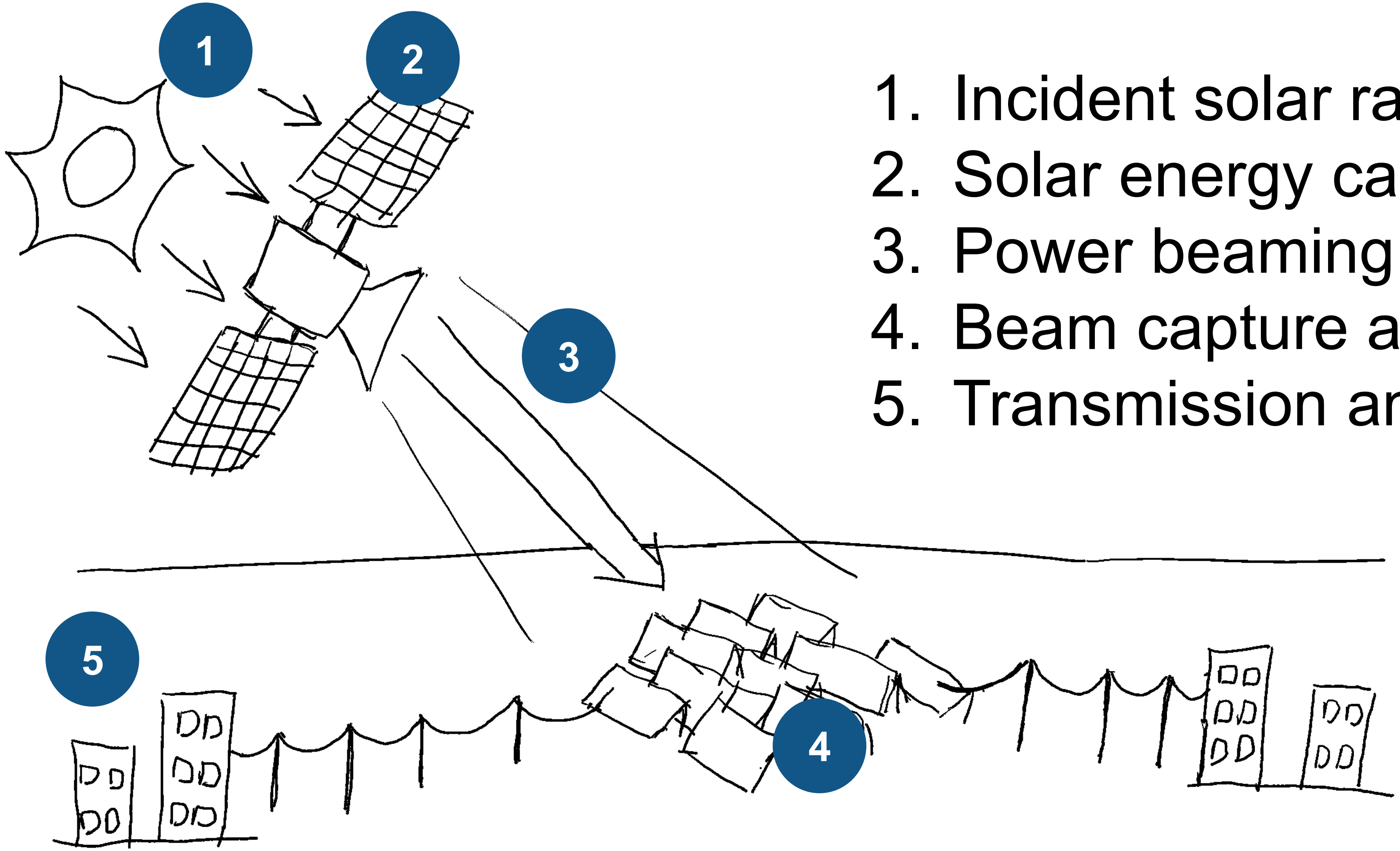


Agenda

- What is Space-Based Solar-Power?
- What are the main challenges/needs?
- Solution
  - Process/methodology
  - Bridge between Capella and System Composer
  - Analysis Workflow
- Outcomes & Concluding Remarks
- Q&A

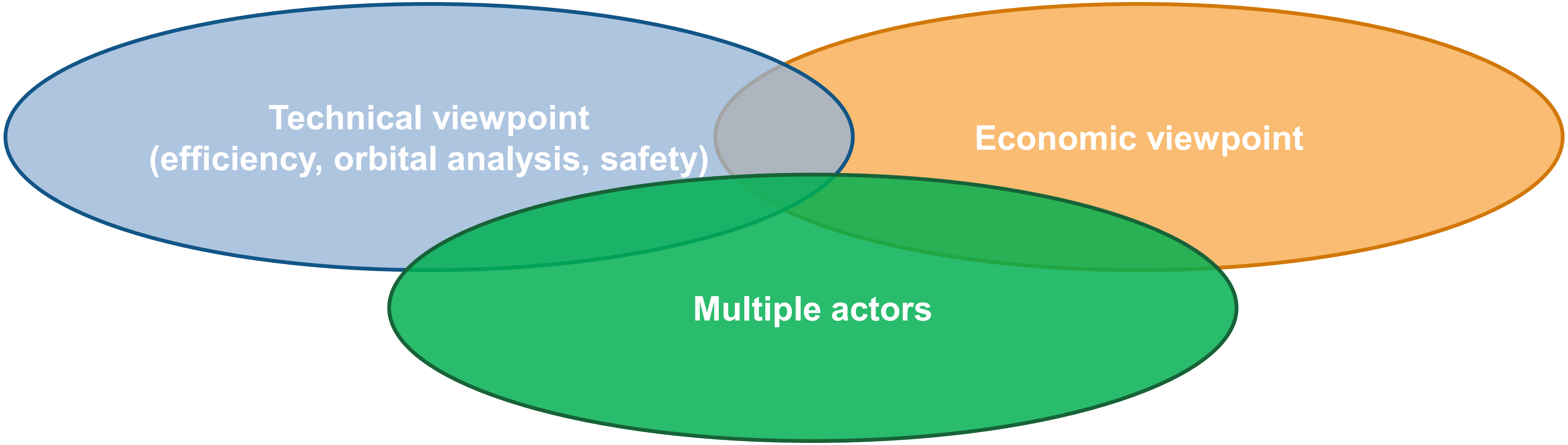
What is Space-Based Solar-Power about?

- Space-Based Solar Power involves harvesting sunlight from Earth orbit then beaming it down to the surface where it is needed.



1. Incident solar radiation
2. Solar energy capture and regulation
3. Power beaming
4. Beam capture and conversion
5. Transmission and distribution

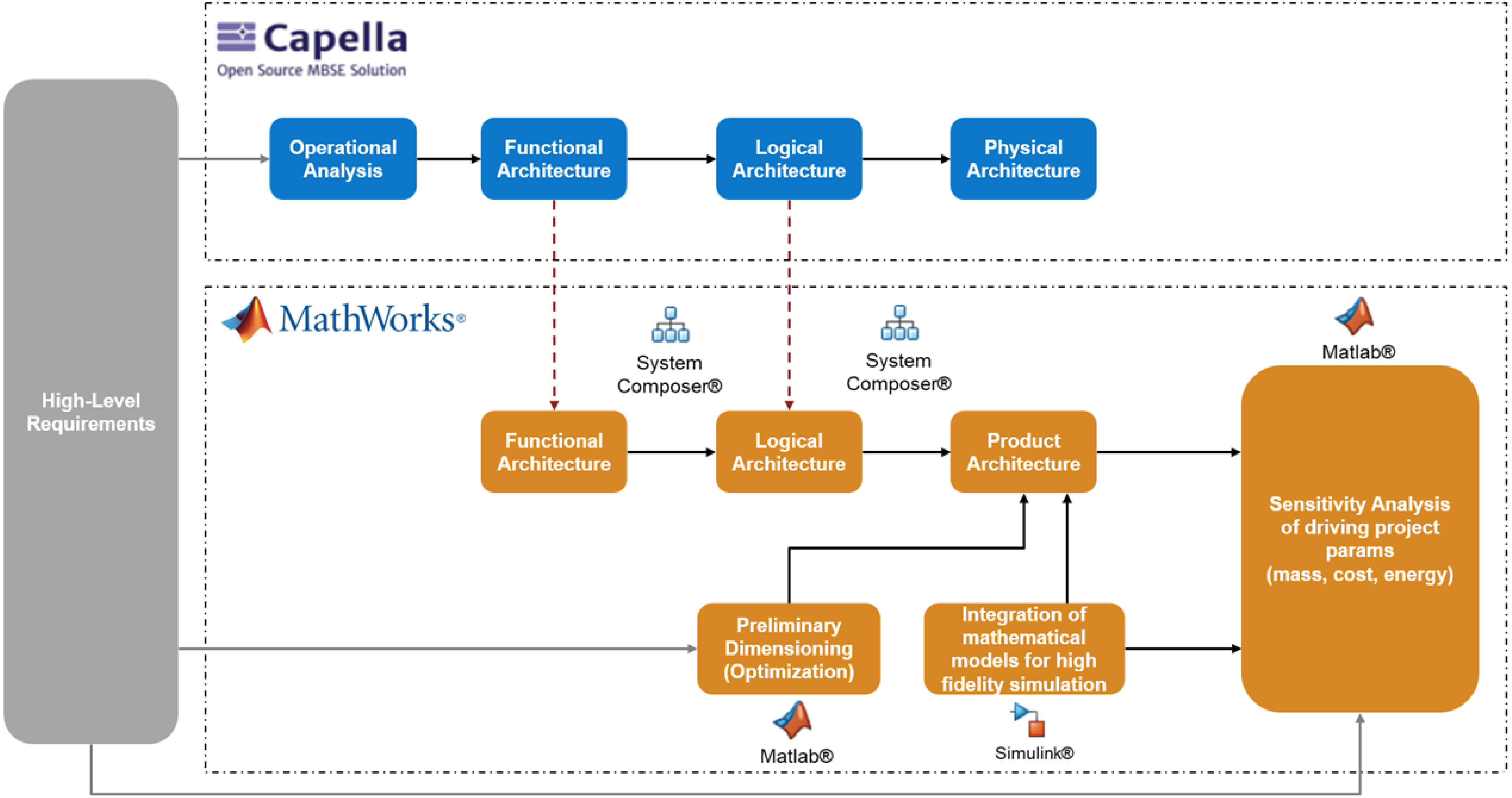
What are the main challenges/needs?



Static point of view (Capella)

Dynamic point of view (System Composer, Simulink)

Solution - Process/methodology

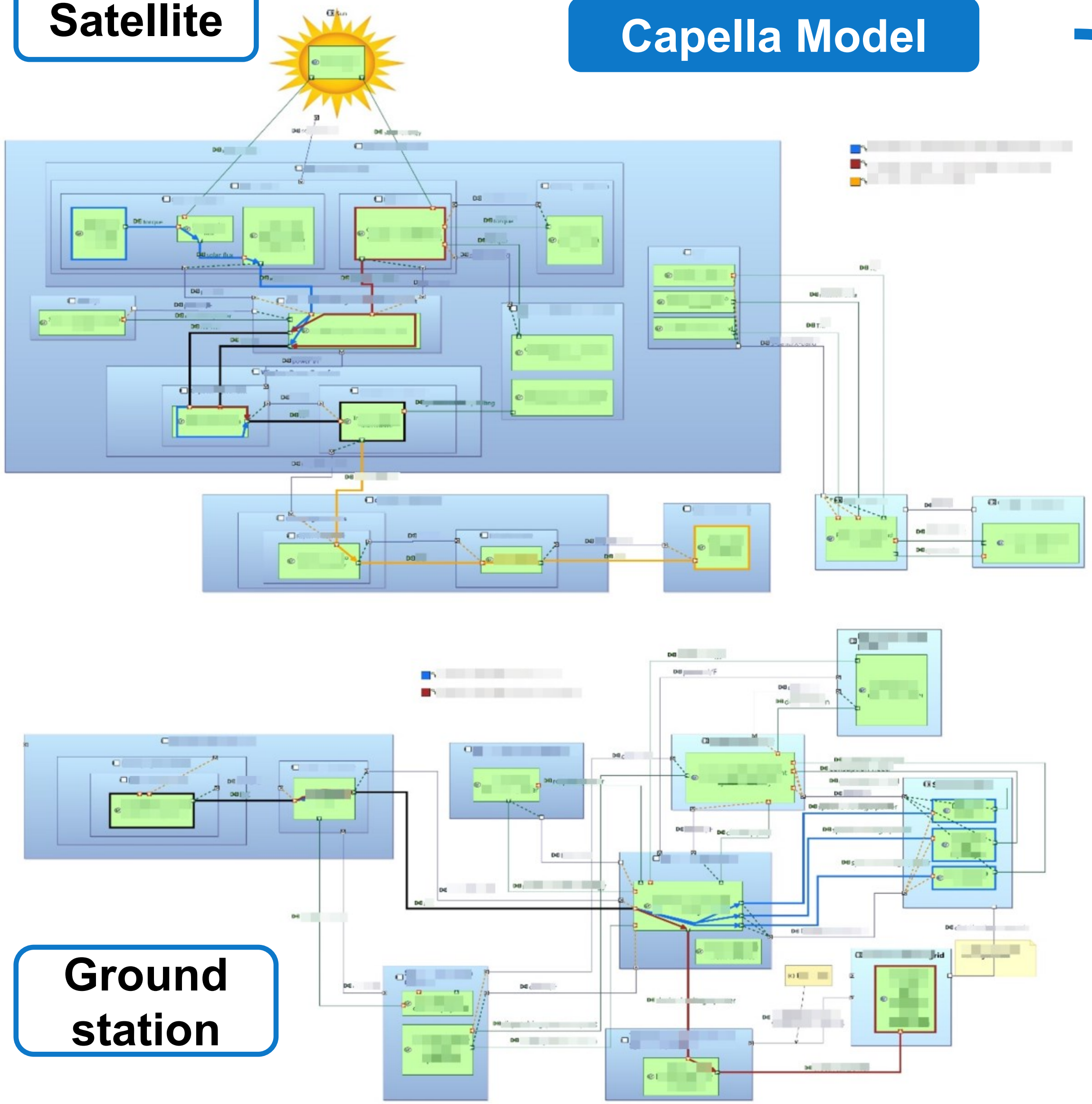


Solution - Bridge between Capella and System Composer

Capella Model

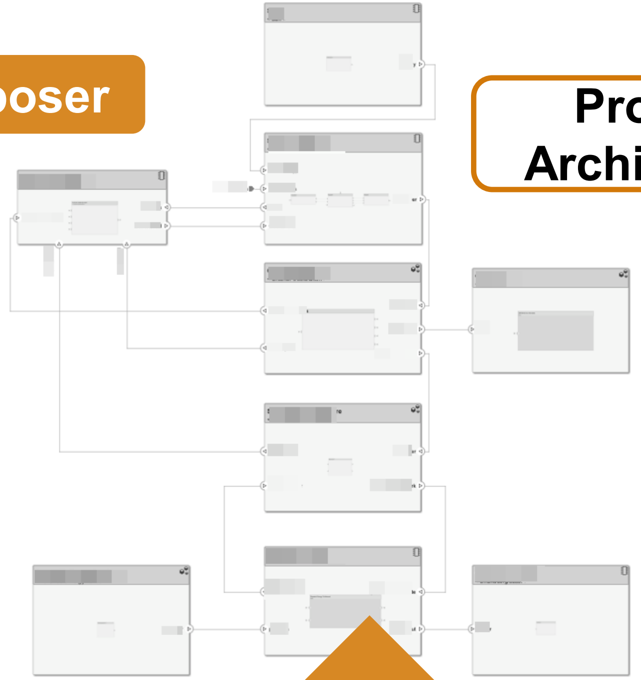
Satellite

Ground station

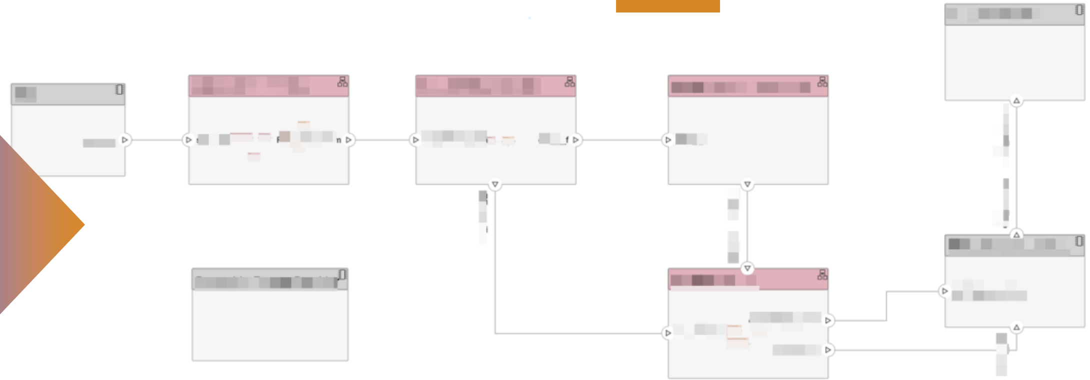


System Composer

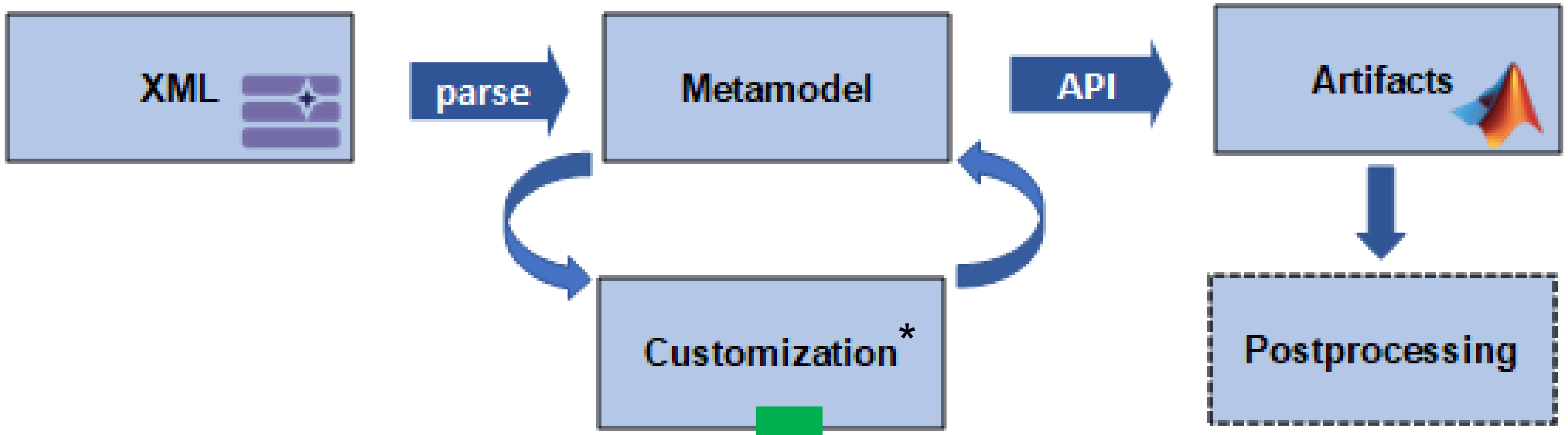
Product Architecture



Logical Architecture



Solution - Bridge between Capella and System Composer

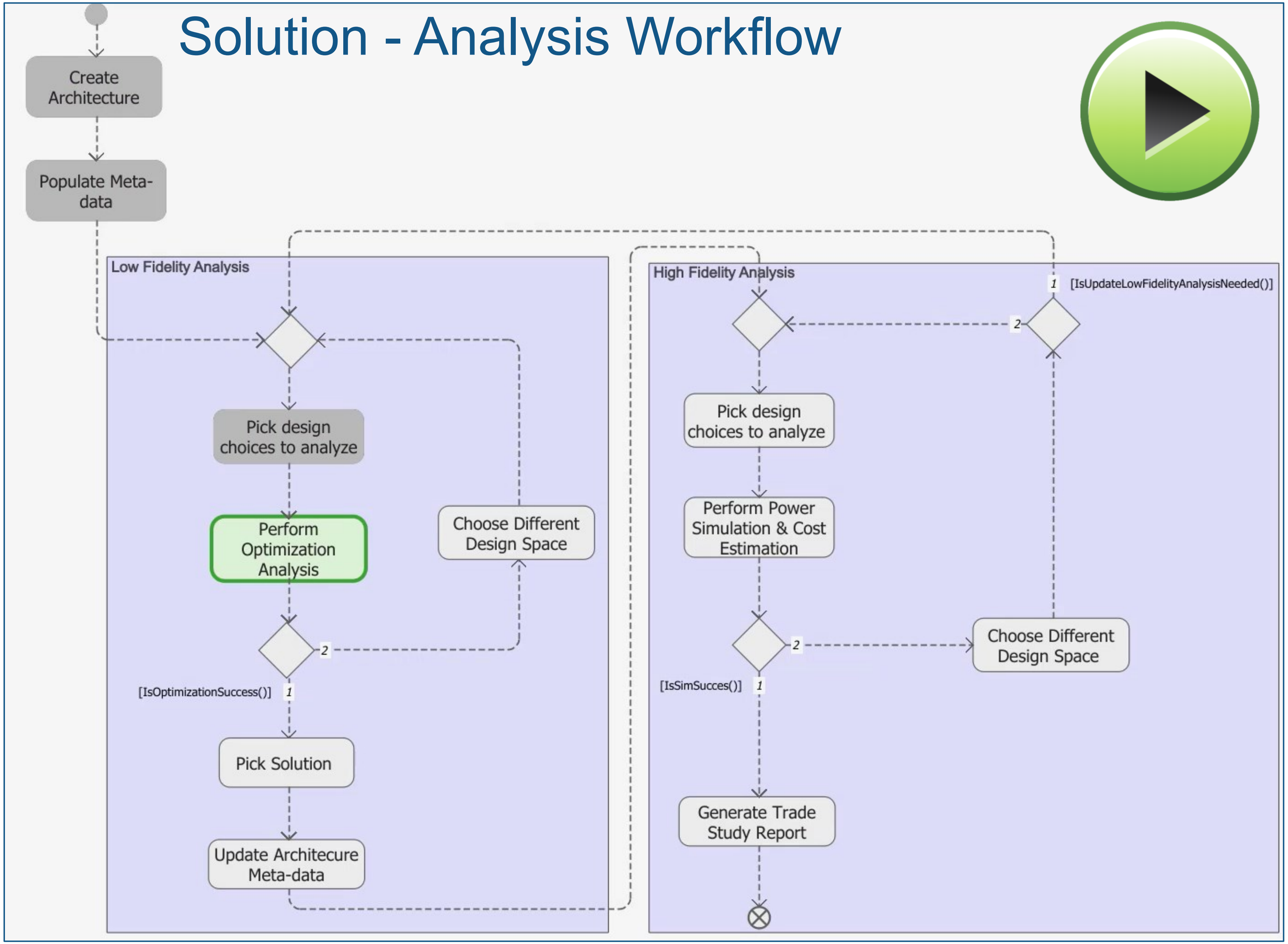


Capella →	→ System Composer
LogicalArchitecture	Architecture model
LogicalComponent	Architecture model
ComponentExchange	Root-level port with composite interface
FunctionalExchange	Connector
ExchangeItem	Interface item
Datatype	Interface item type
Class	Composite interface

[Full Article: Creating a Bridge Between Capella and System Composer]

* can be customized for other objects and mappings like requirements, profiles, etc.

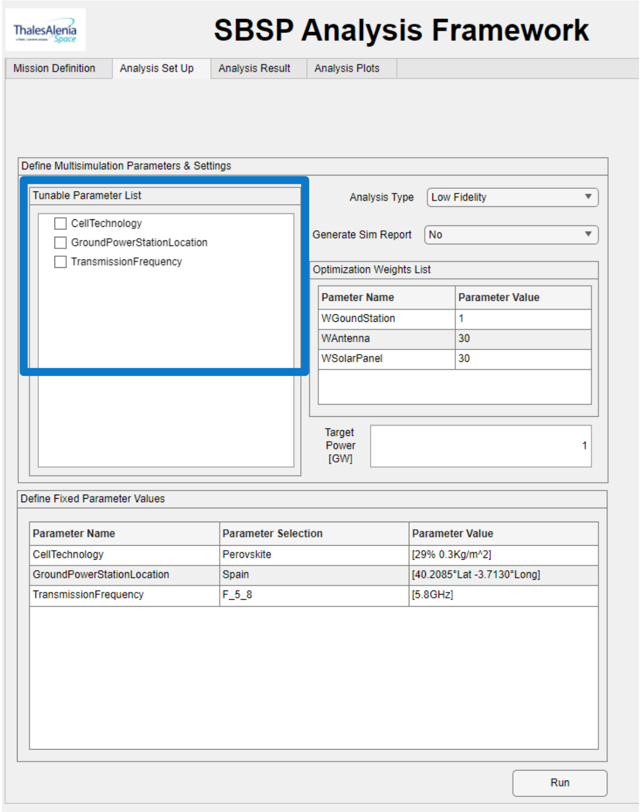
Solution - Analysis Workflow



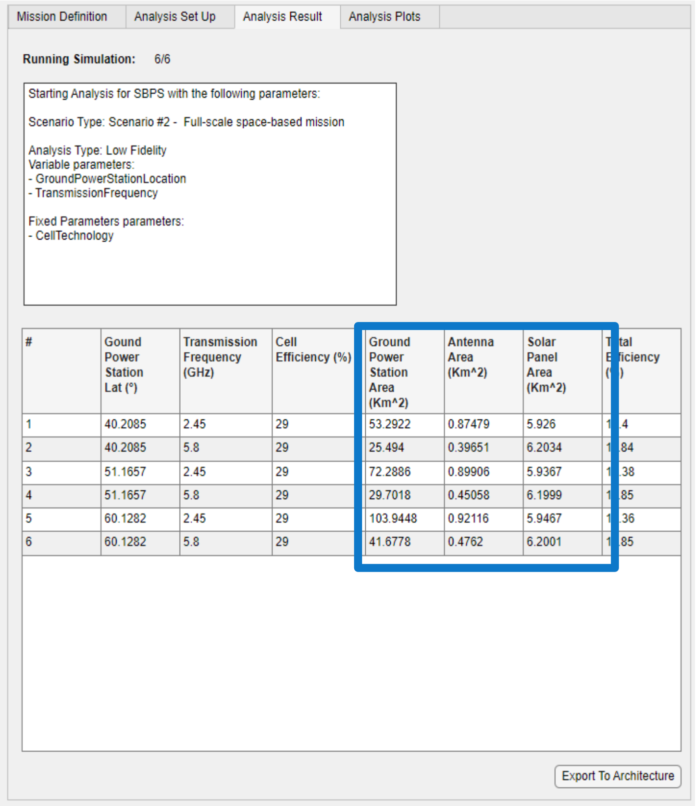
Solution - Analysis Workflow

3 x 3 x 2 = 18 unique variant combinations

Low Fidelity Analysis

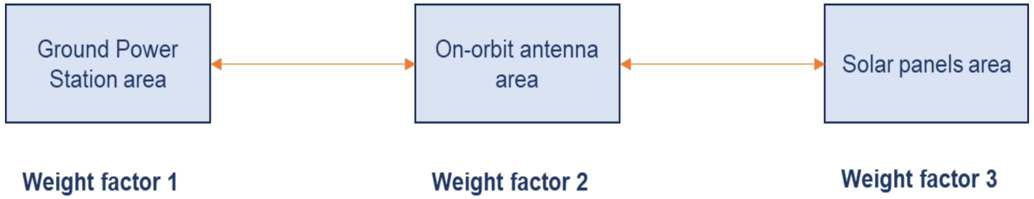


- Objective: Find optimal combination of the Photovoltaic (PV) area, antenna area, and GPS area



- Design Choices
  - (3) Cell technology
  - (3) Ground Station Location
  - (2) Transmission Frequency

objective = w1*x(1)+w2*x(2)+w3*x(3)

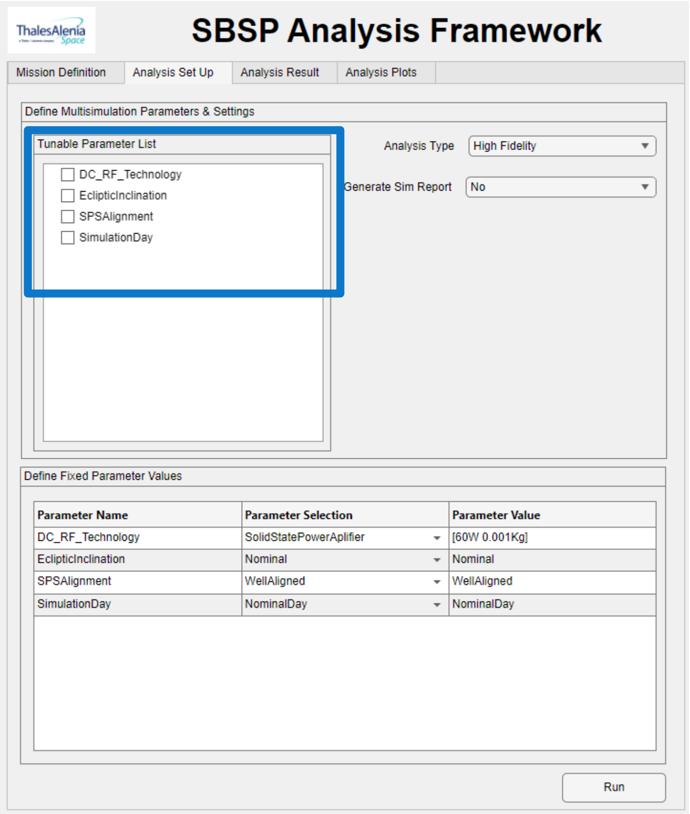


Solution - Analysis Workflow

<u>High Fidelity Analysis</u>

- Objective:
  - High-fidelity power simulations in various mission scenarios
  - Preliminary mass and cost estimation

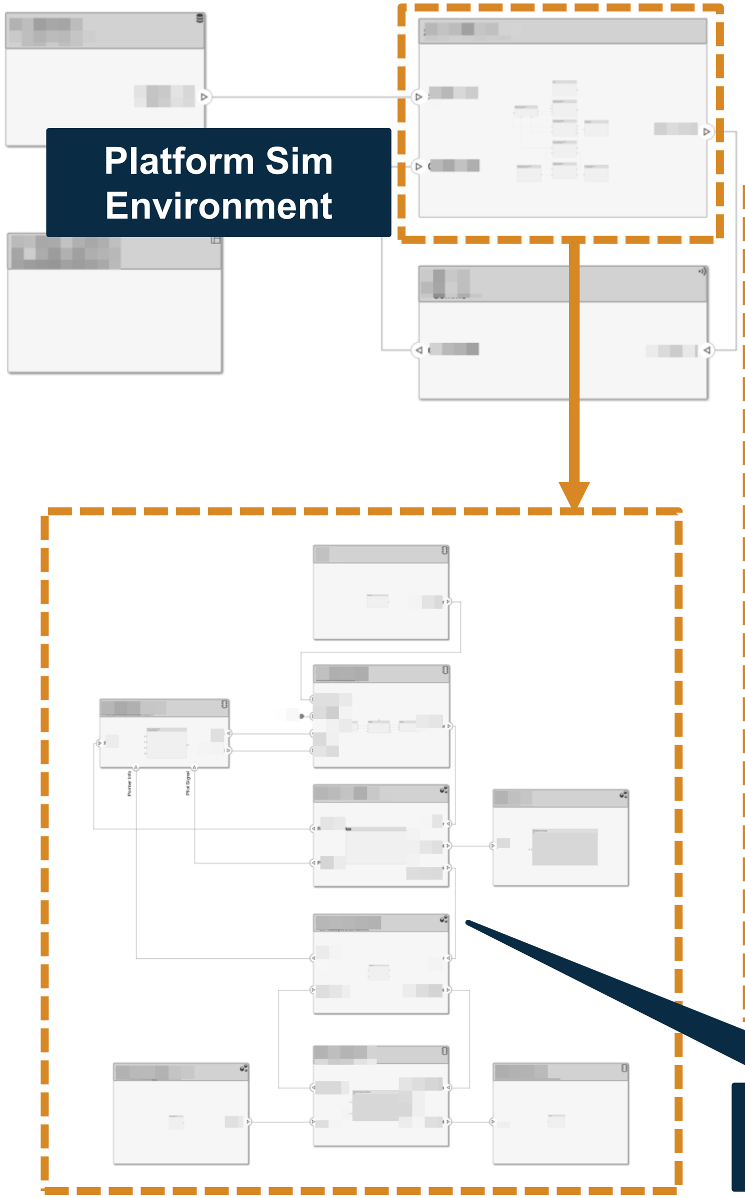
- Design Choices
  - (3) DC-RF Technology
  - (2) Simulation Day
  - (2) Ecliptic inclination
  - (2) SPS Alignment



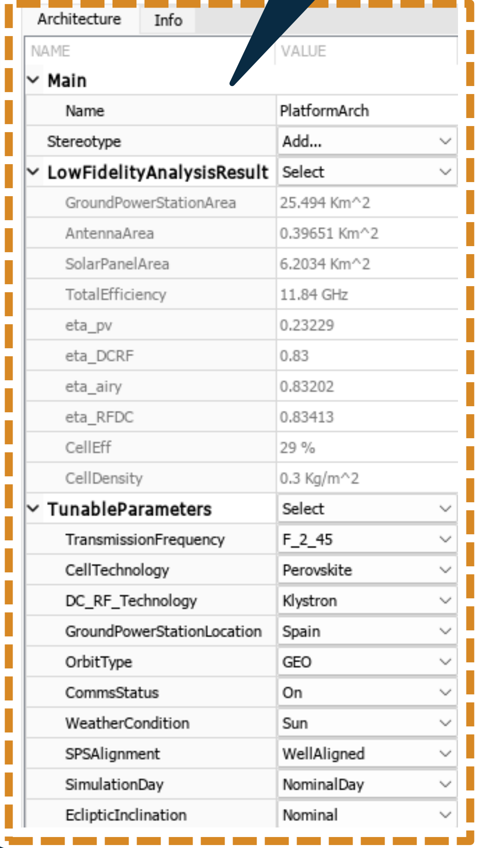
Ecliptic Inclination [-]	Average Transmission Power (MW)	Total Mass (T) & Total Launch(-)	Misson Cost (B$) & LCOE ($/MWh)	EROEI (-) & Energy Paybacktime (days)
Nominal	• @PVA=2064 • @PMainBus=1979 • @On-board Antenna=1577 • @GPS=1051 • @Grid=993	• tot_mass=6591 • tot_launch=106	• miss_cost=14 • LCOE=191	• EROEI=42 • EPBT=219
Nominal	• @PVA=1883 • @PMainBus=1805 • @On-board Antenna=1439 • @GPS=959 • @Grid=993	• tot_mass=6591 • tot_launch=106	• miss_cost=14 • LCOE=191	• EROEI=42 • EPBT=219

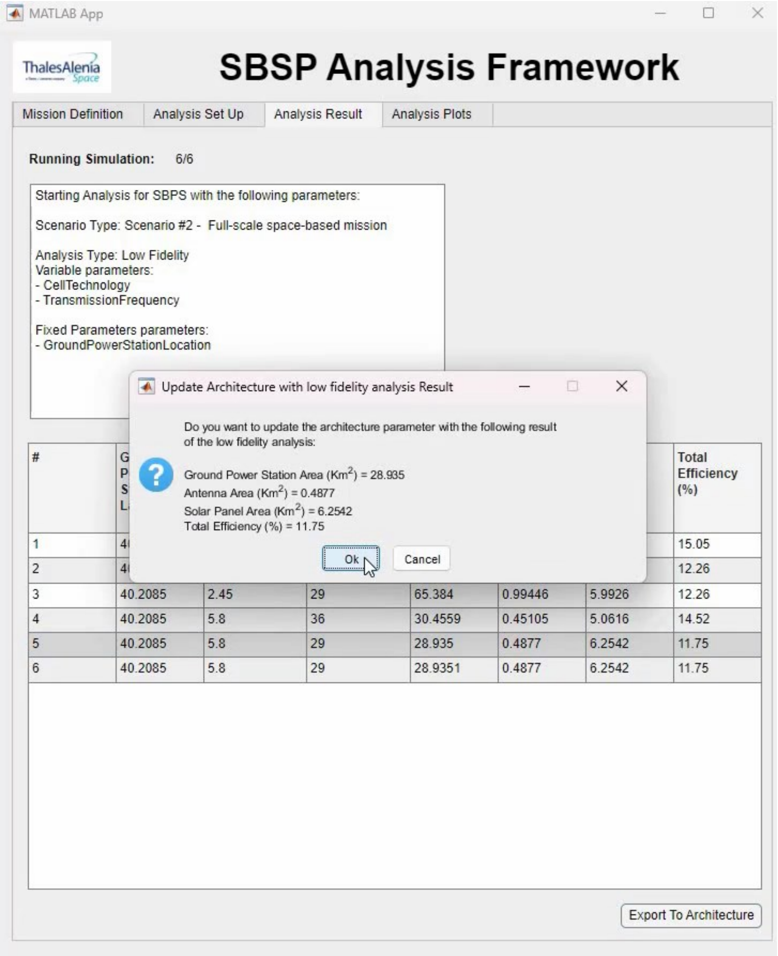
3 x 2 x 2 x 2 = 24 unique variant combinations

Solution - Analysis Workflow



Architecture Metadata

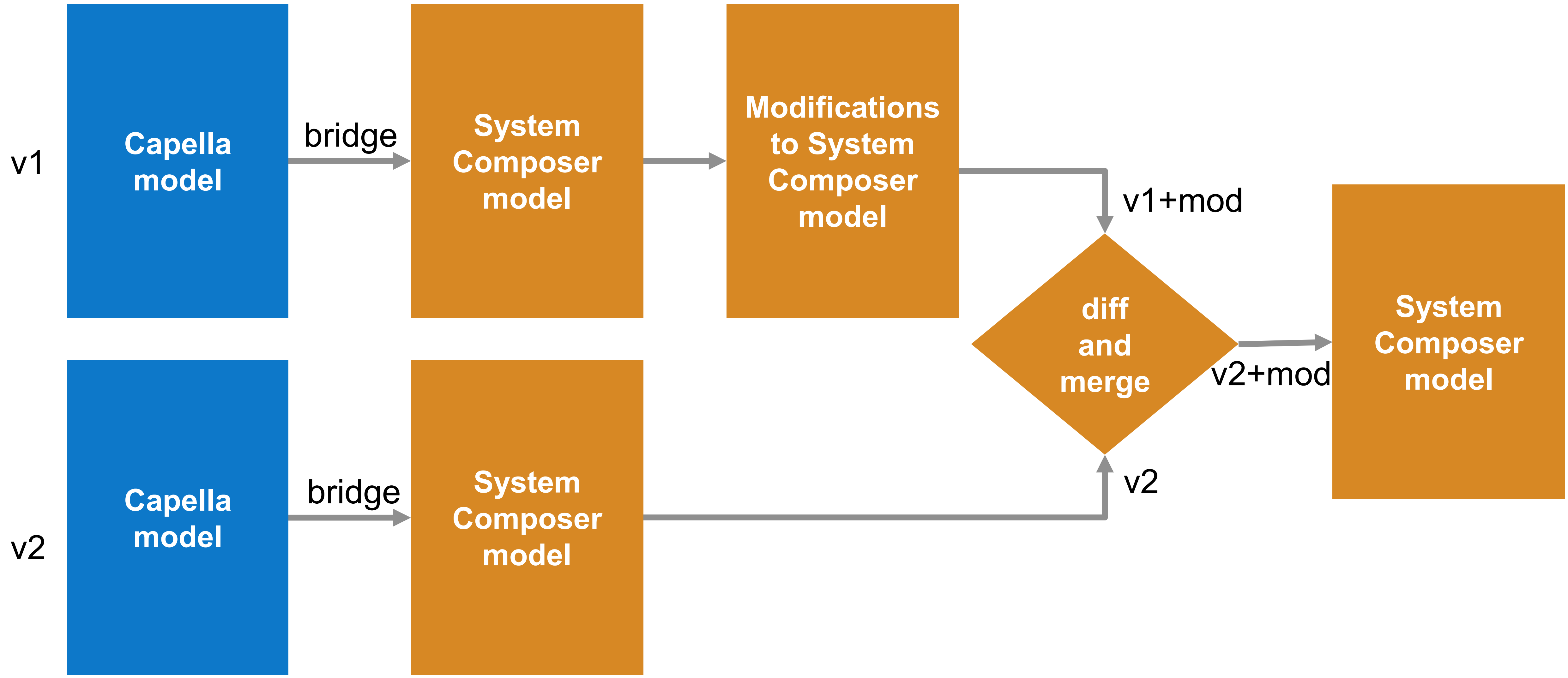




Mission Analysis

Solution - Bridge between Capella and System Composer

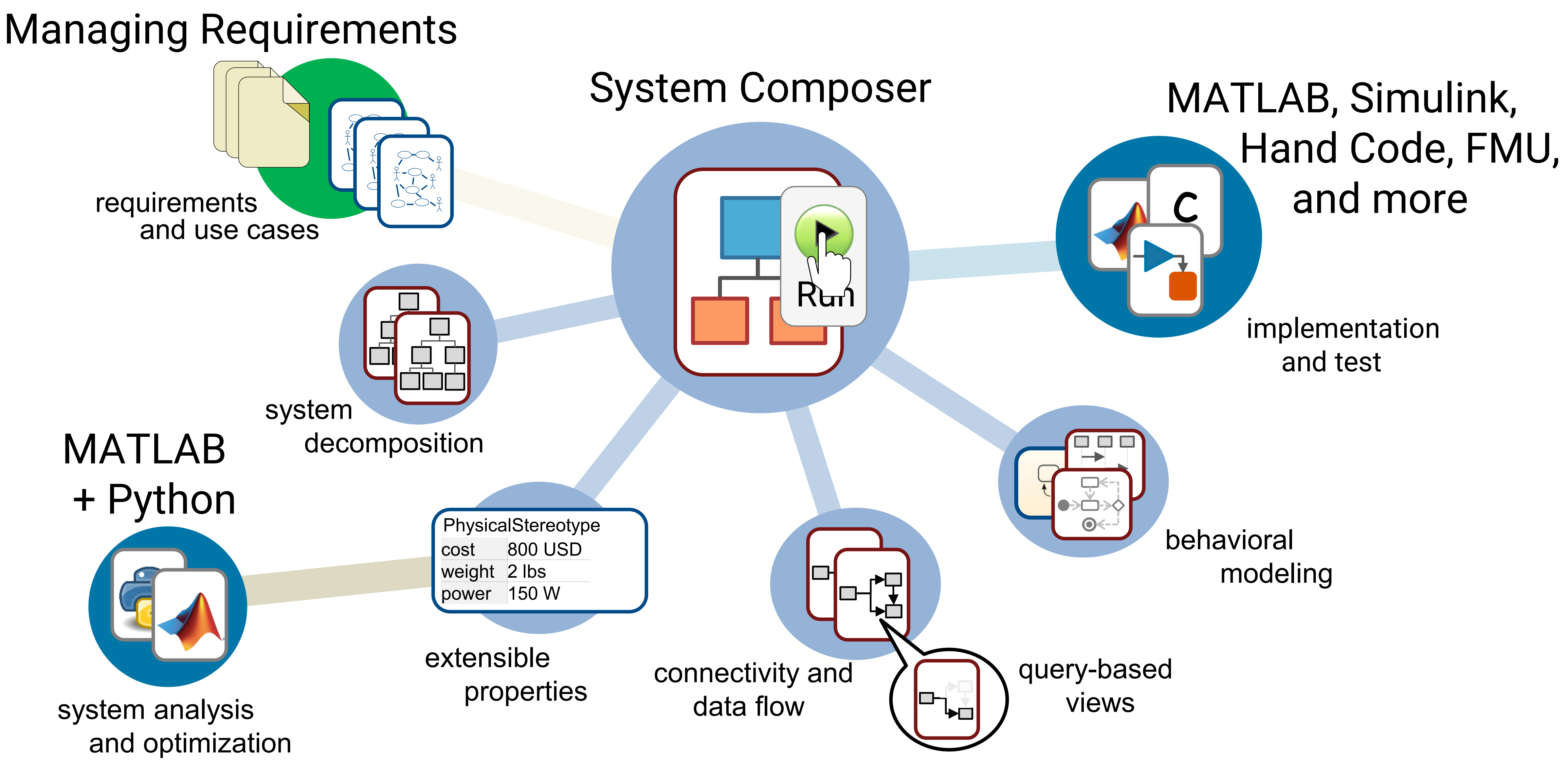
Digital continuity



Outcomes

- **Comprehensive Understanding**, systematic analysis of the mission
- **Simulation of Complex Scenarios**, different solar conditions, orbit variations, etc.
- **Data-Driven Insights** using digital models
- **Efficiency Improvements**, optimize system components
- **Risk Mitigation**, identify challenges early
- **Iterative Design**, refine and improve the mission design over time
- **Cost and Resource Savings**, reduce the need for physical prototypes
- **Communication and Collaboration**, models facilitate effective communication

Model-Based Systems Engineering at MathWorks



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Q&A

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