

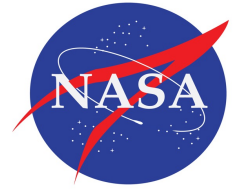
# **Integration of Model-Based Systems Engineering and Programmatic Analysis Tools**

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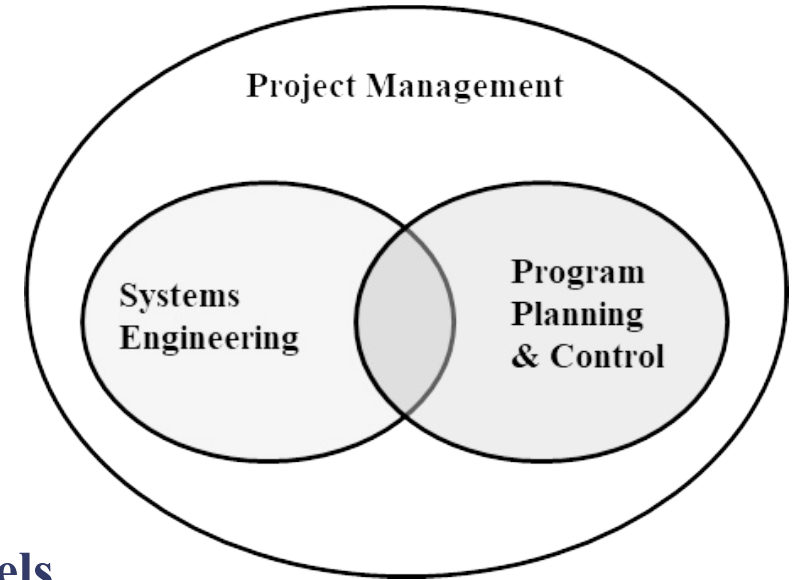
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# Introduction



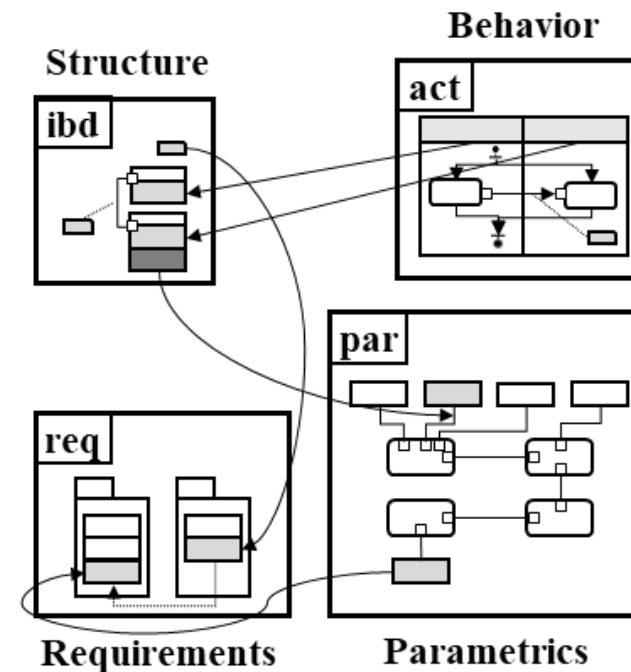
- **NASA's Systems Engineering Handbook identifies three objectives or project management**
  - **Managing people**
  - **Managing technical elements**
  - **Managing cost and Schedule**
- **Programmatic analysts depend on technical documentation**
  - **Technical data drives programmatic cost and schedule models**
- **Use of Model-based System Engineering (MBSE) tools is a growing trend**
  - **Access data through computer model rather than paper document**
- **Purpose is to demonstrate the integration of MBSE and programmatic analysis tools**





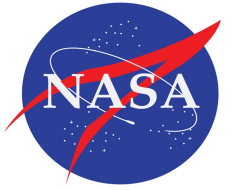
# What is MBSE?

- Use of computer models to capture system architecture and requirements
- A shared system so that all can share one authoritative source of truth
- Not one model, but a set of models representing different aspects
  - Requirements
  - Structure
  - Behavior
  - Parametrics
- Several vendors provide MBSE toolkits
  - Dassault Systems Cameo
  - IBM Rhapsody
  - Sparx Systems Enterprise Architect
  - Vitech GENESYS



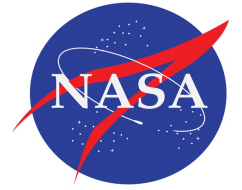


# MBSE at NASA

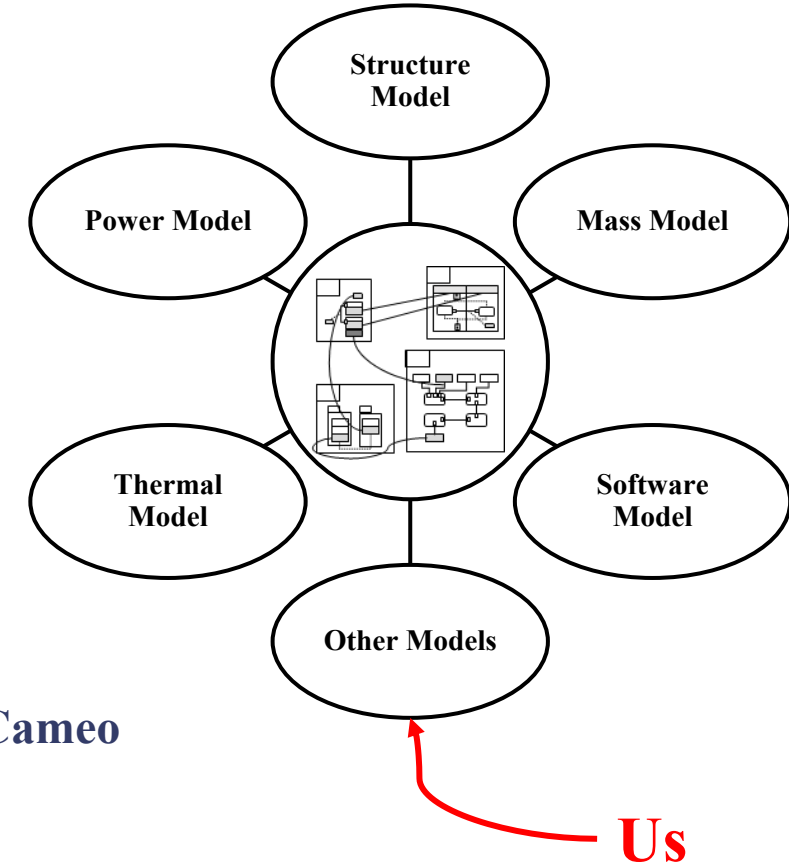




# MBSE Integration with Other Models

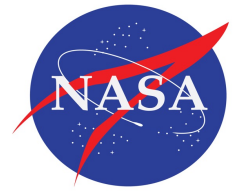


- **The vision is for MBSE to connect with other discipline models**
- **Allows for trade studies and optimization**
- **Programmatic tools seem to be overlooked**
  - **“The concept of cost estimation has still not fully arrived in the MBSE world”**
- **Some progress**
  - **2012 – Bayer et al. at JPL embedded NICM parametrics in Cameo**
  - **SEER and PRICE have interfaces with some MBSE tools**
  - **Most MBSE tools interface with MS Excel**
  - **A few tools have interfaces with MS Project and Primavera**

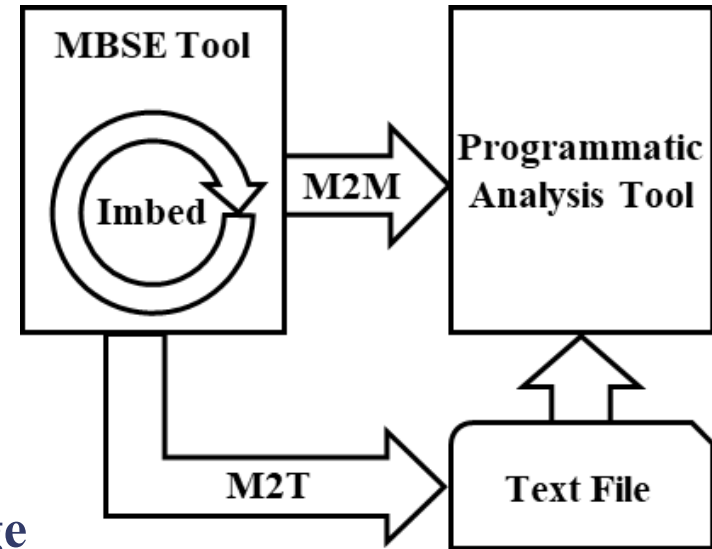




# Three Methods for Integration

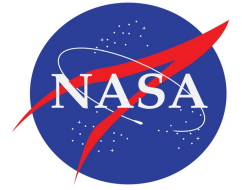


- **Imbed programmatic capability in MBSE tool**
  - Enter parametric equations into MBSE tool
  - Use MBSE simulation capability to perform analysis
- **Pass data from MBSE tool to programmatic tool**
  - Model to Text (M2T) approach
  - Model to Model (M2M) approach
- **M2M and M2T facilitated by standard modeling language**
  - Universal Modeling Language (UML) or extension Systems Modeling Language (SysML)
- **Demonstrate these three approaches**
  - Vitech's GENESYS interface with NICM and JACS
  - These examples are very simple

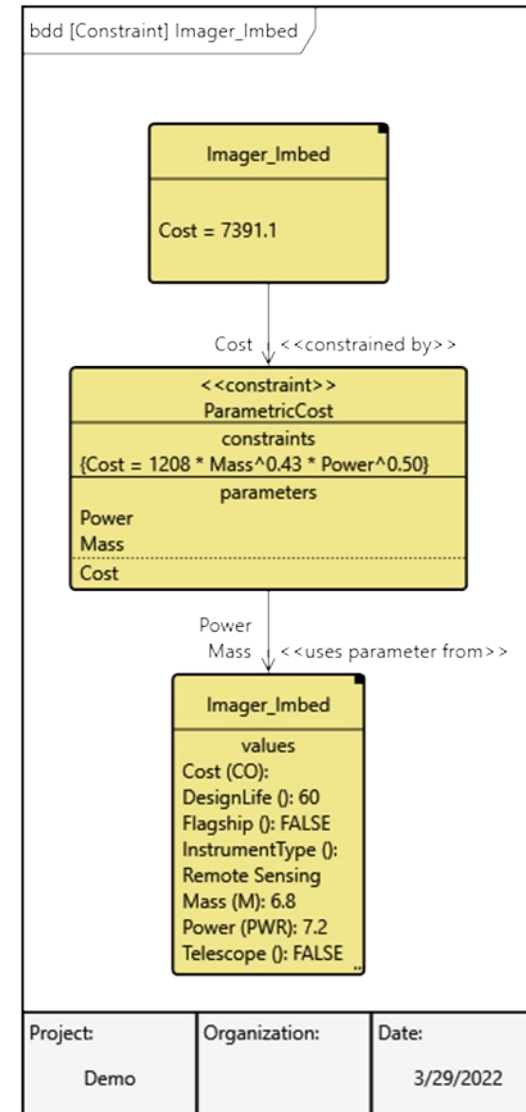




# Embedding Programmatics in MBSE

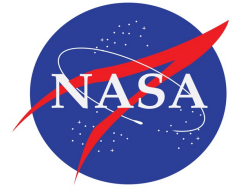


- **Technical parameters are already captured in MBSE models**
  - **Mass**
  - **Power**
- **Embed parametric equation from NICM**
  - **Entered as a “constraint” in GENESYS**
  - **Can also embed schedule estimating relationship**
- **Could allow you to fix cost and optimize mass and power**





# M2T Interface between MBSE and NICM



*MS Excel is the "text" interface*

## 1. Technical parameters exported from GENESYS

bdd Imager\_M2T

Imager_M2T values		
Cost (CO):		
DesignLife (I):	60	
Environment (I):	Planetary	
Flagship (I):	FALSE	
InstrumentType (I):	Remote Sensing	
Mass (M):	6.8	
MissionClass (I):	B	
Power (PWR):	7.2	
Telescope (I):	FALSE	
Type (I):	Optical	

Project:	Organization:	Date:
Demo		3/29/2022

Parameters.xlsx - GENESYS

	A	B	C	D	E	F	G	H	I	J	K
1		InstrumentType Objective	Environment Objective	MissionClass Objective	Flagship Objective	Type Objective	Telescope Objective	mass Objective	power Objective	DesignLife Objective	cost Objective
2		Remote Sensing	Planetary	B	FALSE	Optical	FALSE	6.8	7.2	60	\$7,724.97
3											

## 4. Cost published to GENESYS

bdd Imager\_M2T

Imager_M2T values		
Cost (CO):	12837.67	
DesignLife (I):	60	
Environment (I):	Planetary	
Flagship (I):	FALSE	
InstrumentType (I):	Remote Sensing	
Mass (M):	6.8	
MissionClass (I):	B	
Power (PWR):	7.2	
Telescope (I):	FALSE	
Type (I):	Optical	

Project:	Organization:	Date:
Demo		3/29/2022

## 2. Parameters links in NICM

## 3. Cost link in worksheet

**Inputs**

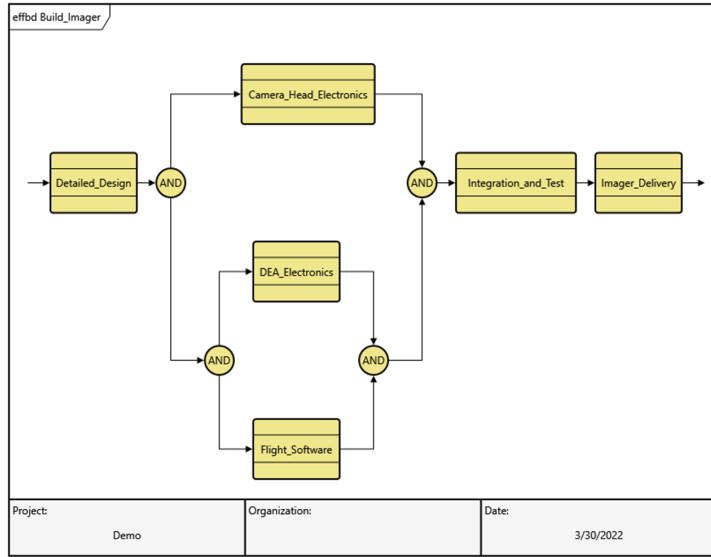
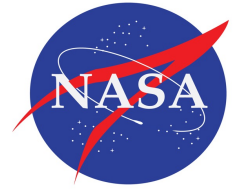
Instrument Name	Imager	Costs in \$K FY	2020
Instrument Type	Remote Sensing	Remote Sensing Type	Optical
Environment	Planetary	Instrument Includes Telescope?	FALSE
Mission Class	B		
Flagship Mission?	FALSE		

	Minimum	Most Likely	Maximum
Total Mass (kg)		6.8	
Max Power (W)		7.2	
Design Life (months)		60	
Number of Instruments			

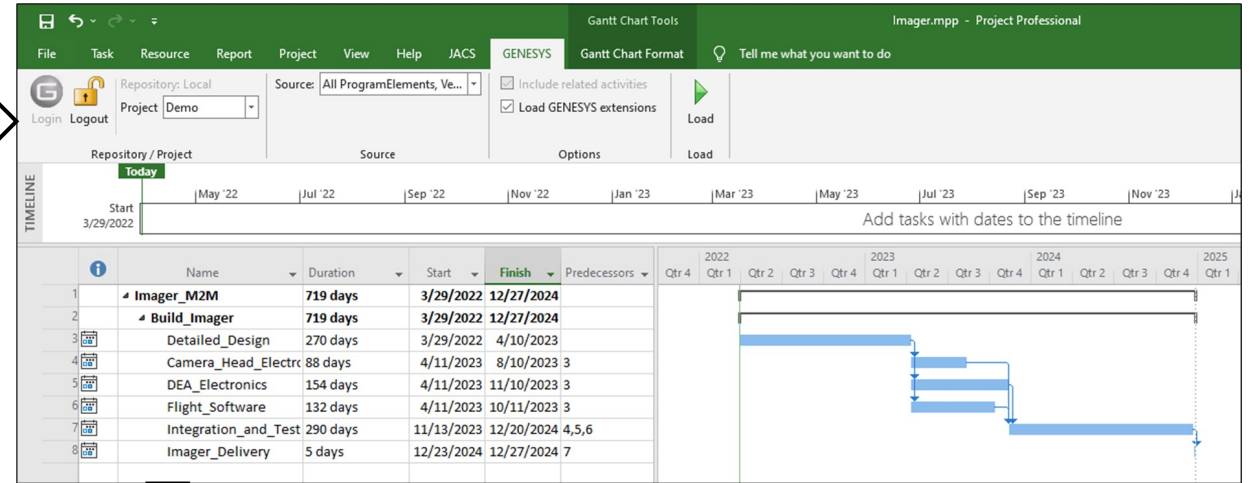




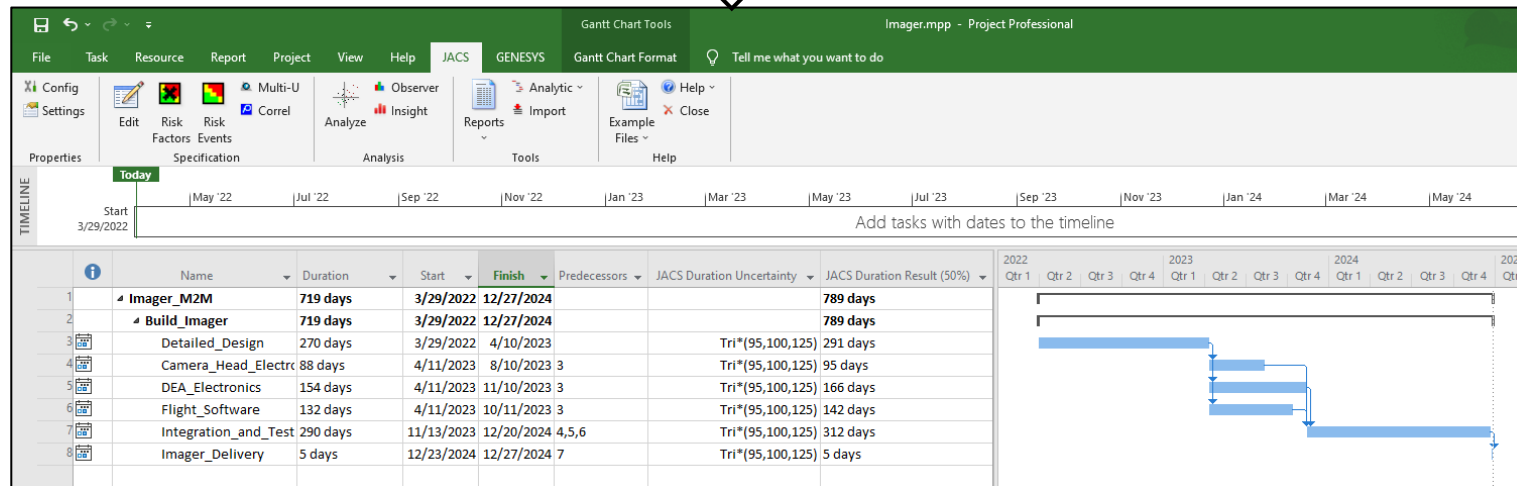
# M2M Interface between MBSE and JACS



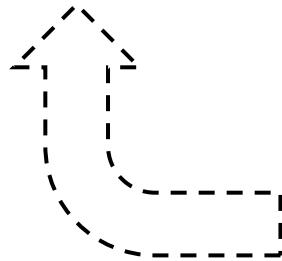
**1. Schedule data exported from GENESYS into MS Project**



**2. JACS model information added**

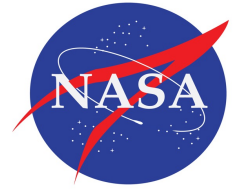


**3. MS Project to GENESYS capability is not available**





# MBSE is the Future



- Not sure where NASA is on the technology adoption curve
- NASA has an active MBSE community
  - Active at all Centers and JPL
- Broader adoption of MBSE is inevitable
- MBSE integration with programmatic analysis tools will be more sophisticated
  - We need to be prepared

