

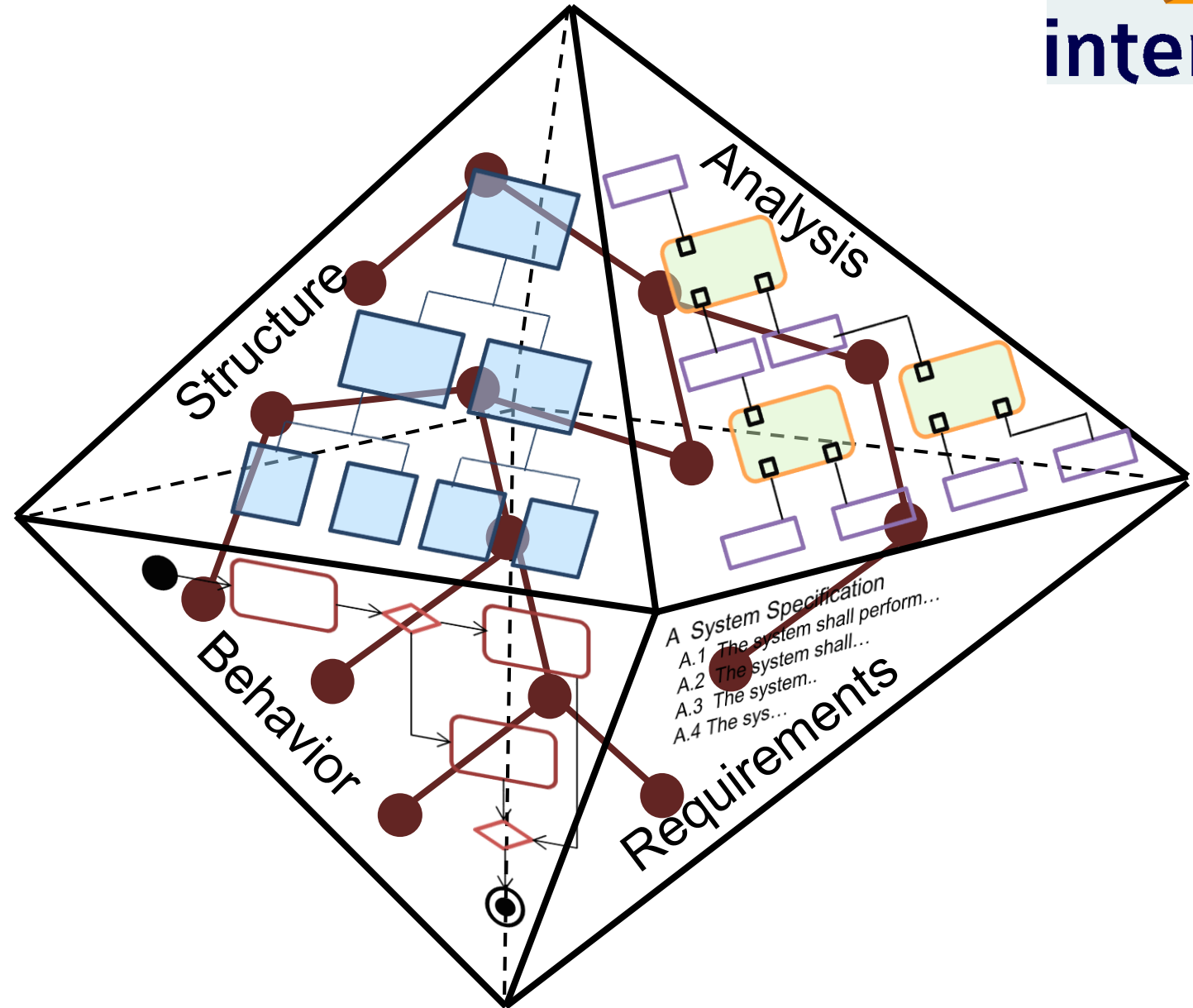
# Introduction to SysML

## Part 5.0: Analysis and Parametric Diagrams

With tutorial exercises using MagicDraw

# MBSE

- Analysis just as important as Description
- Analysis with external tools (e.g. spreadsheets) works against the goal of MBSE – a single unified model



# Approaches to MBSE Analysis

- ▶ SysML Parametrics
  - ▶ Direct incorporation of a network of equations in a SysML model
- ▶ Activity and State Machine Simulation
  - ▶ Testing behavior logic, numbers and equations may be involved
- ▶ Interfacing to Functions and Models in External Tools
  - ▶ Wrapping analysis and simulation models as SysML elements
- ▶ Model Transformation
  - ▶ Sharing analysis models between tools

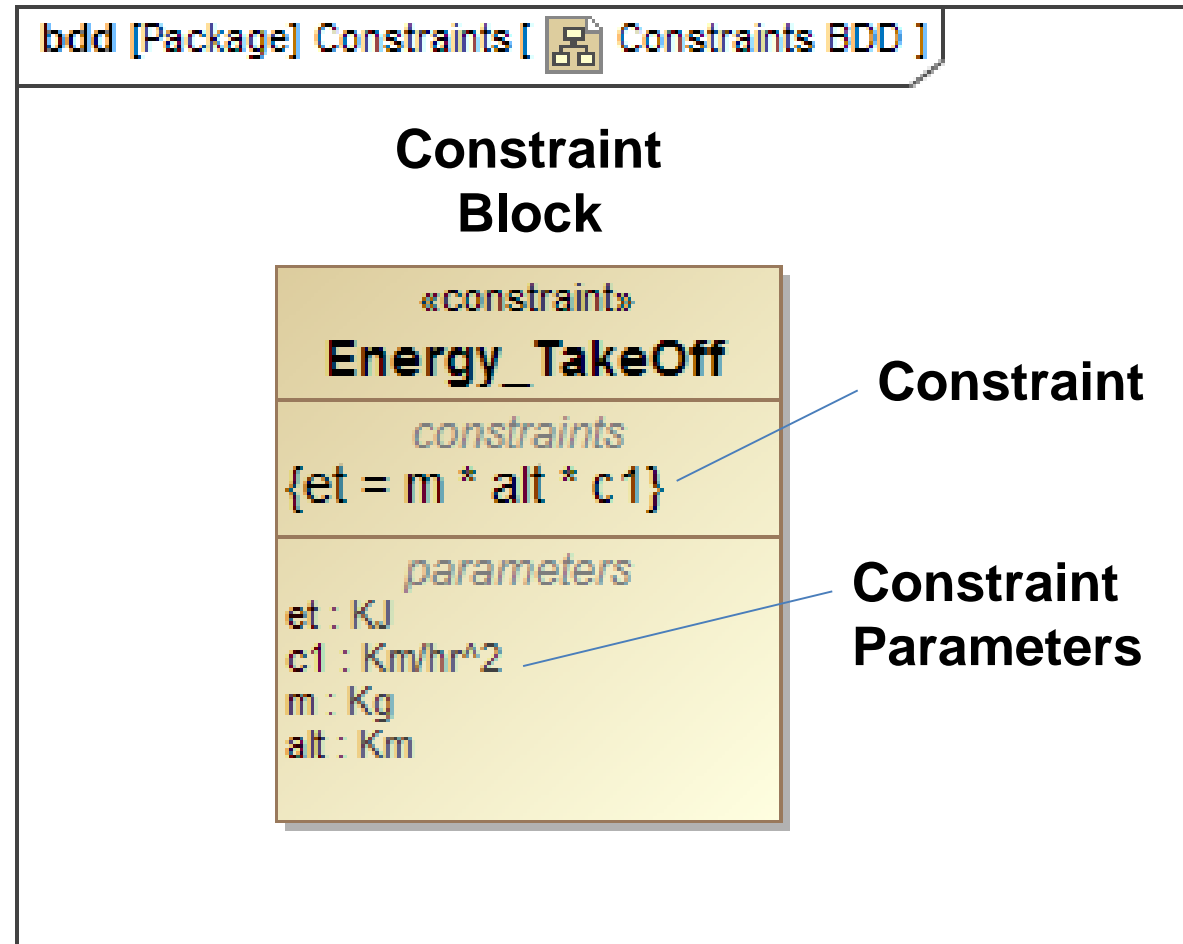
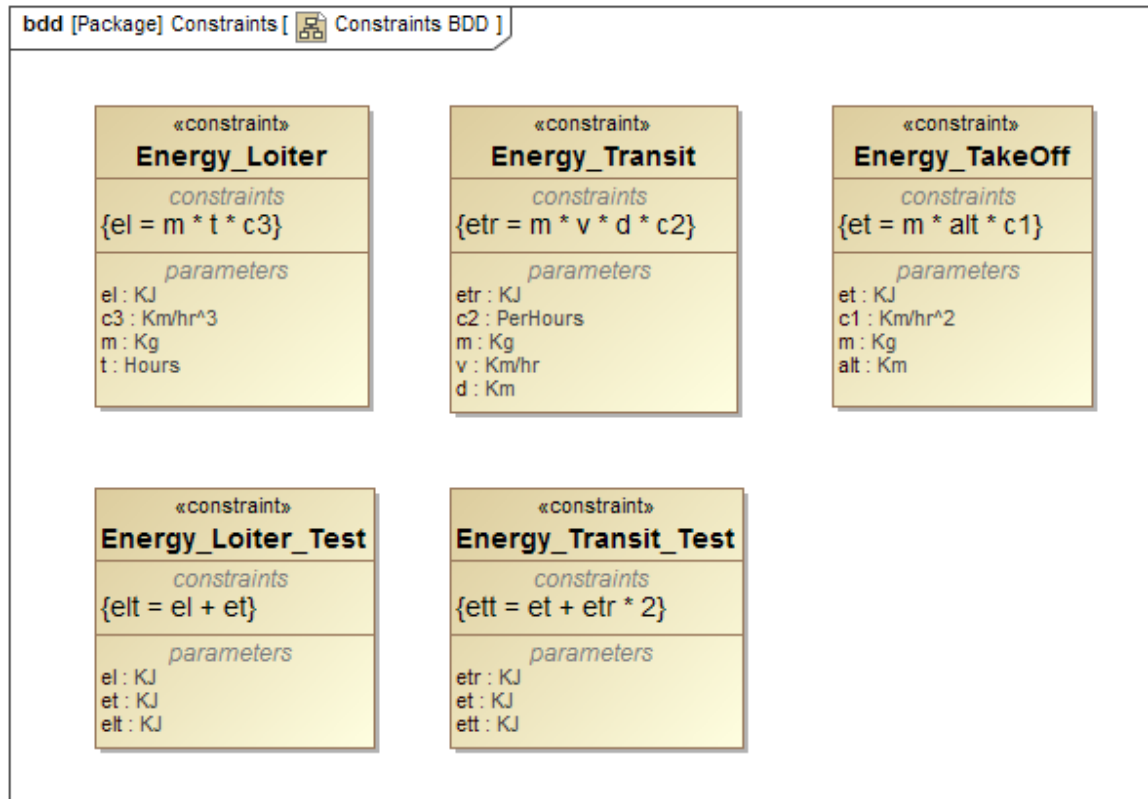
# Learning Objectives

- ▶ MBSE Analysis Objectives and Approaches
- ▶ Constraint Properties and Parametric Diagrams
- ▶ Instances of SysML Structural Models
- ▶ First Exercise, building a parametric diagram, creating an instance, and solving the model
- ▶ Complex Aggregates
- ▶ Second Exercise, mass roll-up with multiple instances
- ▶ External Analysis Blocks, Reference Properties
- ▶ Third Exercise, performance analysis

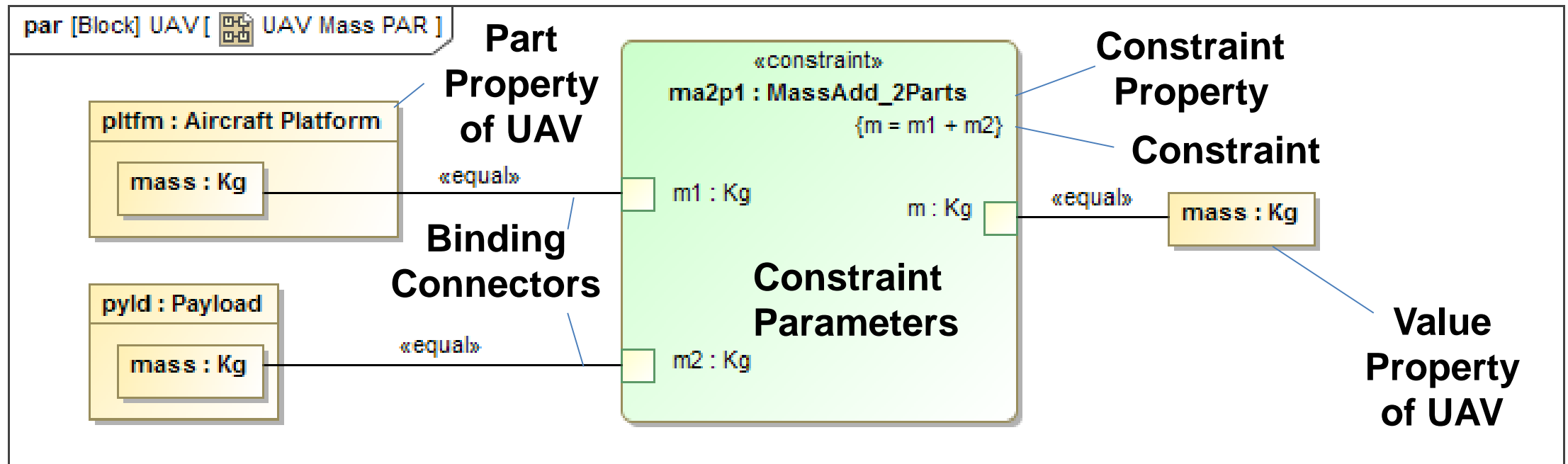
# Uses of SysML Parametrics

- Enforcement of Constraints
- Evaluation of Variants
- Verification of Requirements
- Conversion of Data Structures
- SysML parametrics work best where calculations are simple and repetitive

# Constraint Blocks



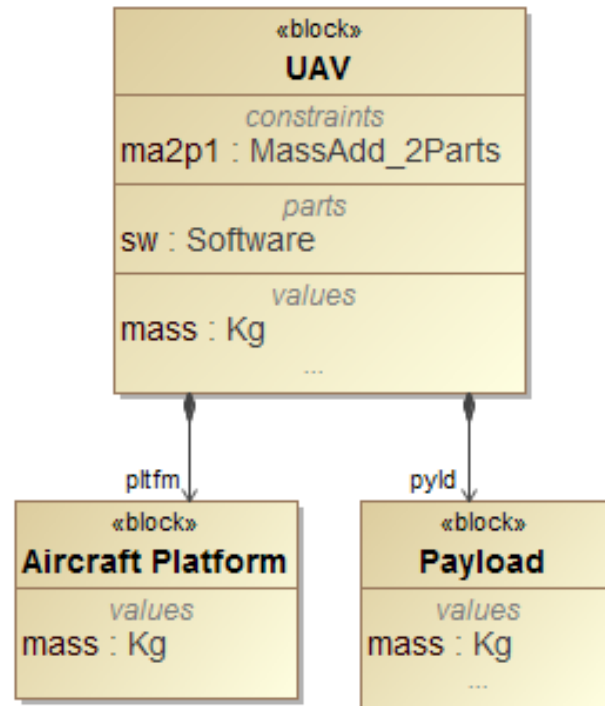
# Parametric Diagram



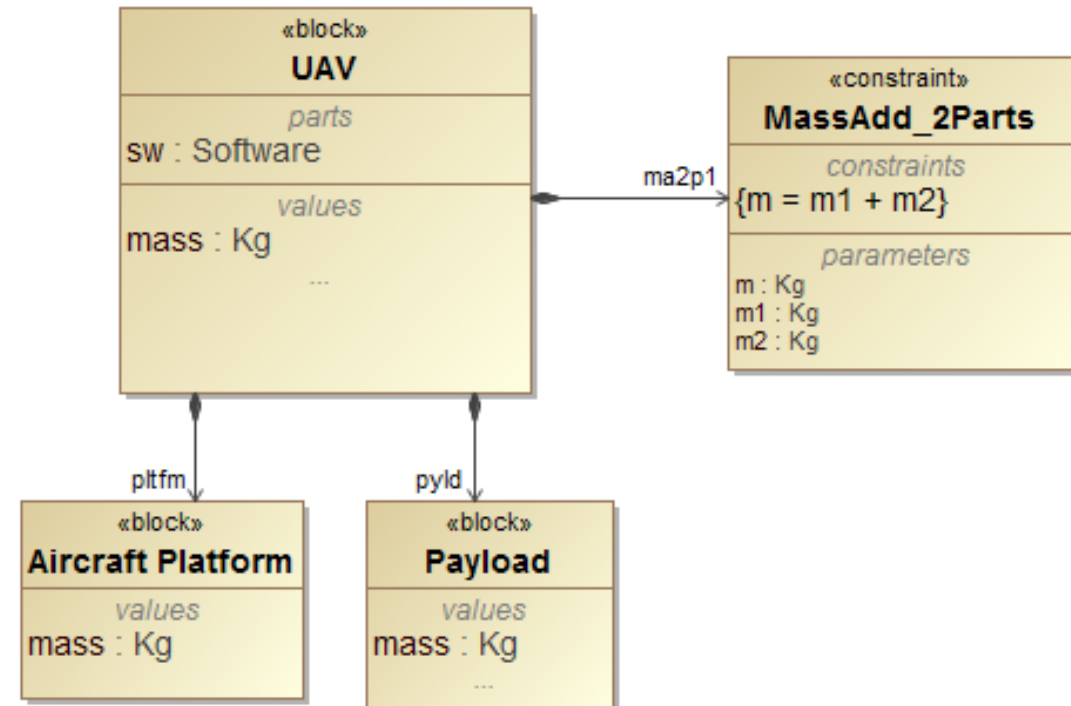
A Parametric Diagram usually belongs to a Block. It shows how the constraint properties and value properties of the block are connected.

# Parametric Diagram

bdd [Package] Part 5 Materials [ UAV TopLevel BDD ]

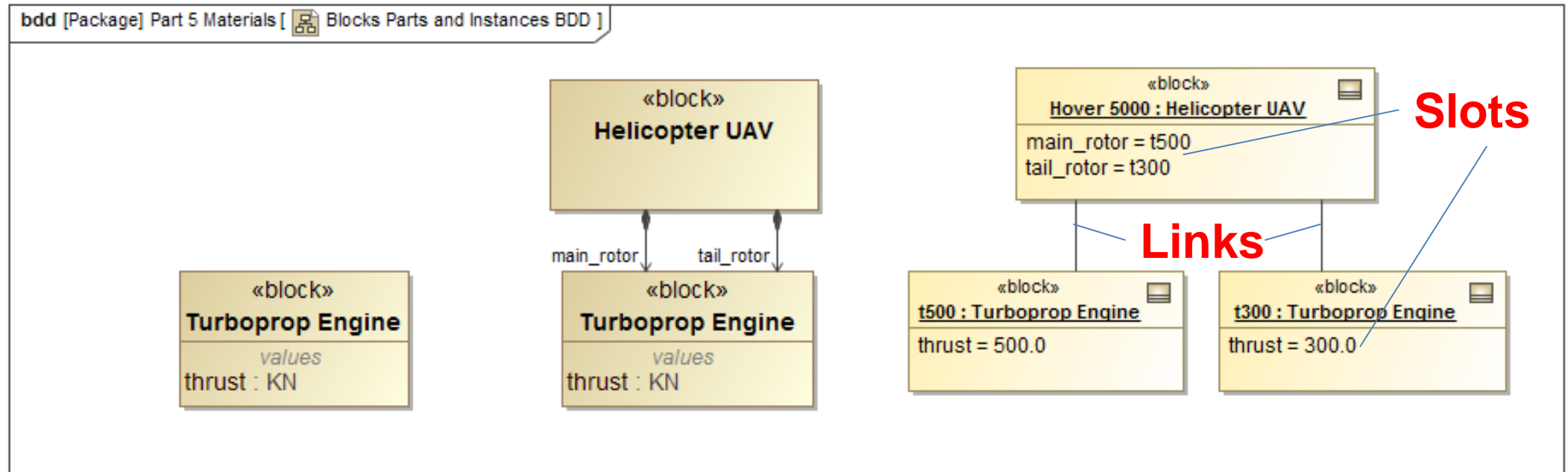


bdd [Package] Part 5 Materials [ UAV TopLevel BDD ]





# Instances

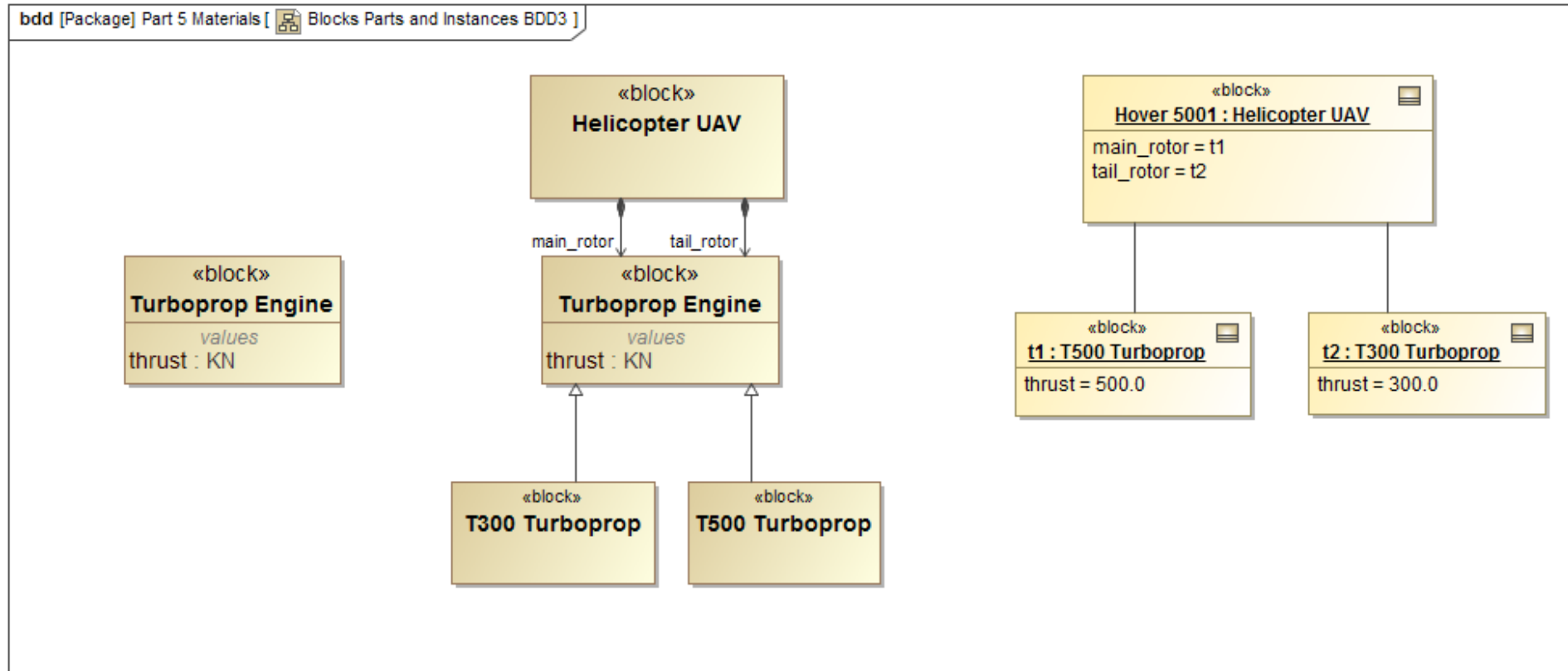


Blocks

Part Properties

Instances

# Instances – Other Approaches



Blocks

Specializations

Instances

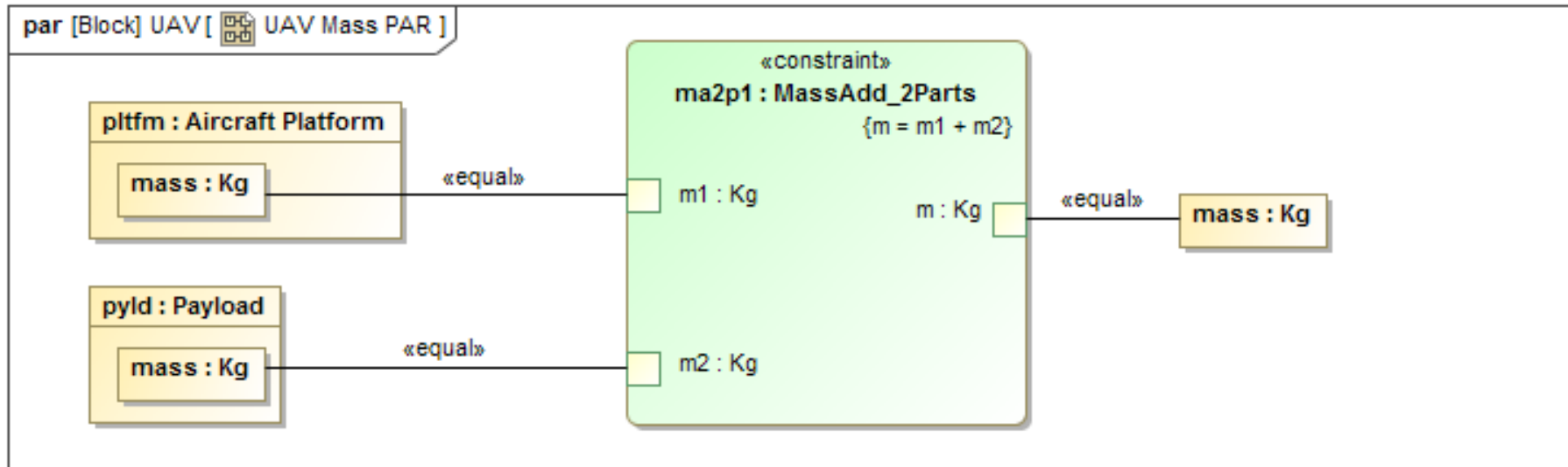
# Parametric Execution



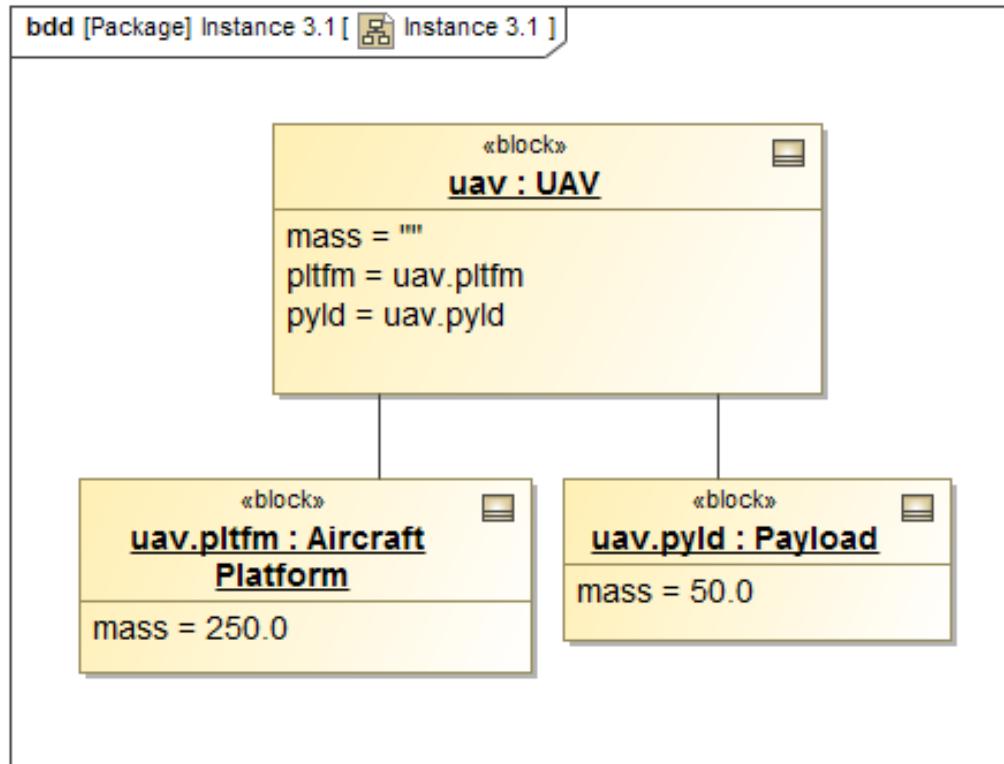
- Convert Syntax
- Add Causality
- Launch Math Engine
- Write Results to SysML Model

# First Exercise

- The objectives of this exercise are to
  - Create a Parametric Diagram for the UAV to calculate mass.
  - Use the ParaMagic tool to validate the parametric model.
  - Create an Instance of the UAV assembly
  - Use the ParaMagic tool to edit values and causality in the Instance.
  - Solve the Instance for mass roll-up



# First Exercise



ParaMagic(R) 18.0 - uav

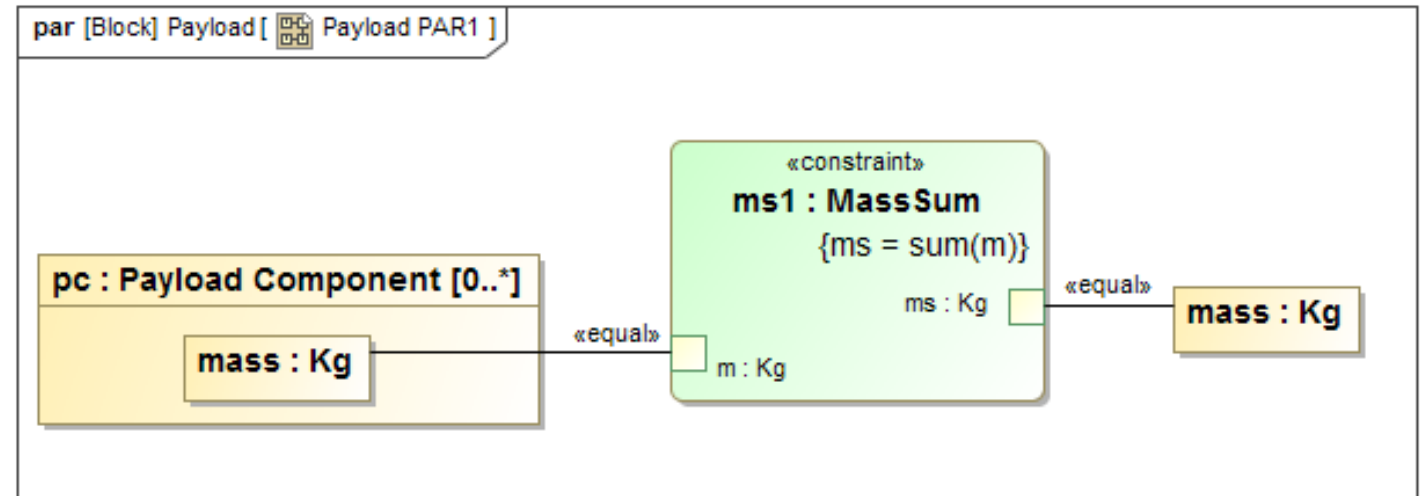
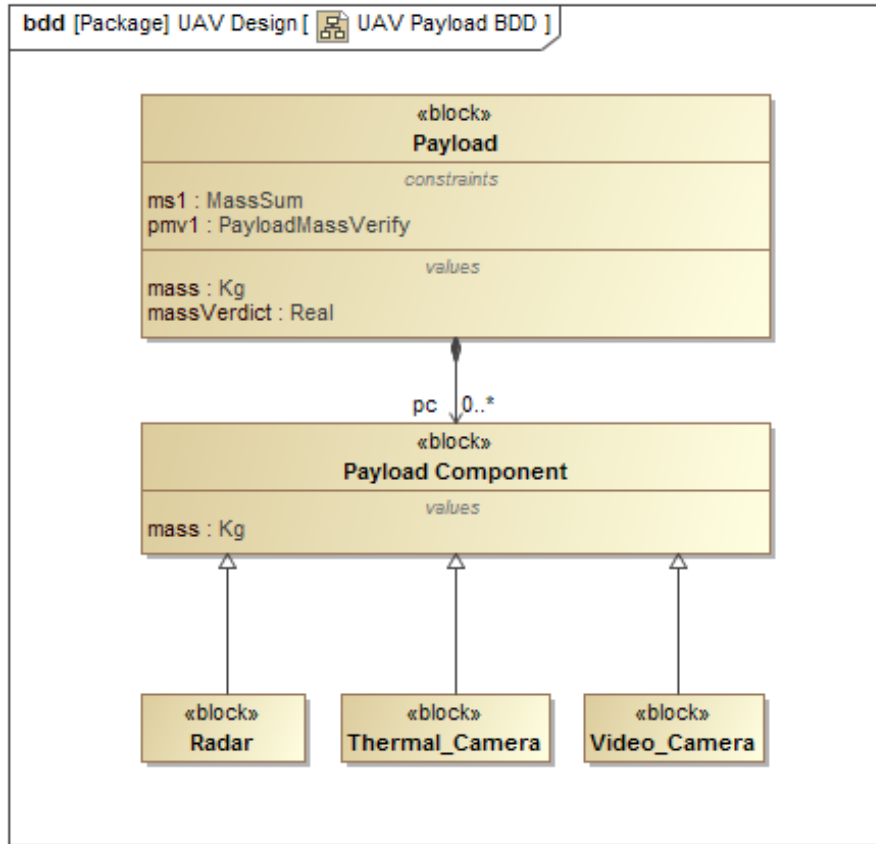
Name	Qualified Name	Type	Causality	Values
UAV	UAV Analysis::Instance 3.1::uav	UAV		
U cost		\$		0.00
U mass		Kg	target	300.00
P pltfm	UAV Analysis::Instance 3.1::uav.pltfm	Aircraft Platform		
U mass		Kg	given	250.00
P pyld	UAV Analysis::Instance 3.1::uav.pyld	Payload		
U mass		Kg	given	50.00

Expand Collapse All Solve Reset ☐ Preserve Refs Update to SysML

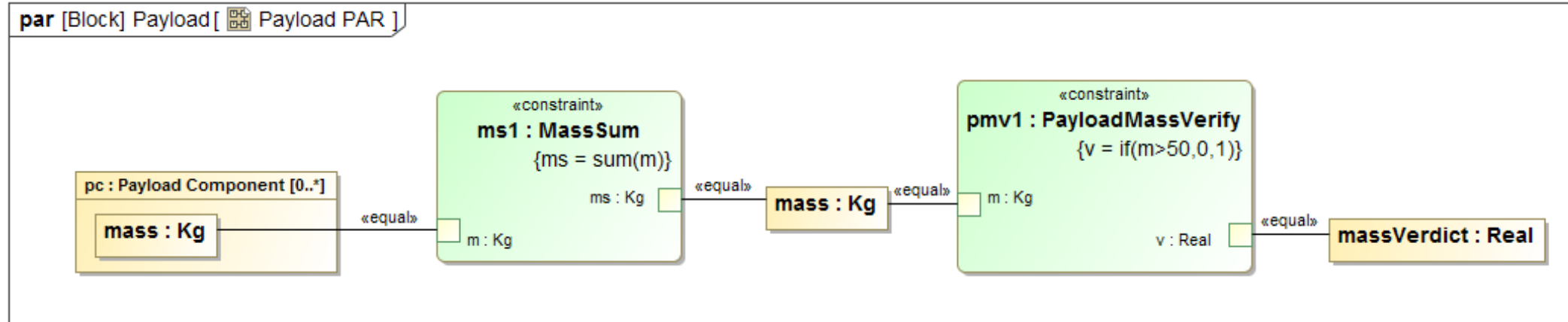
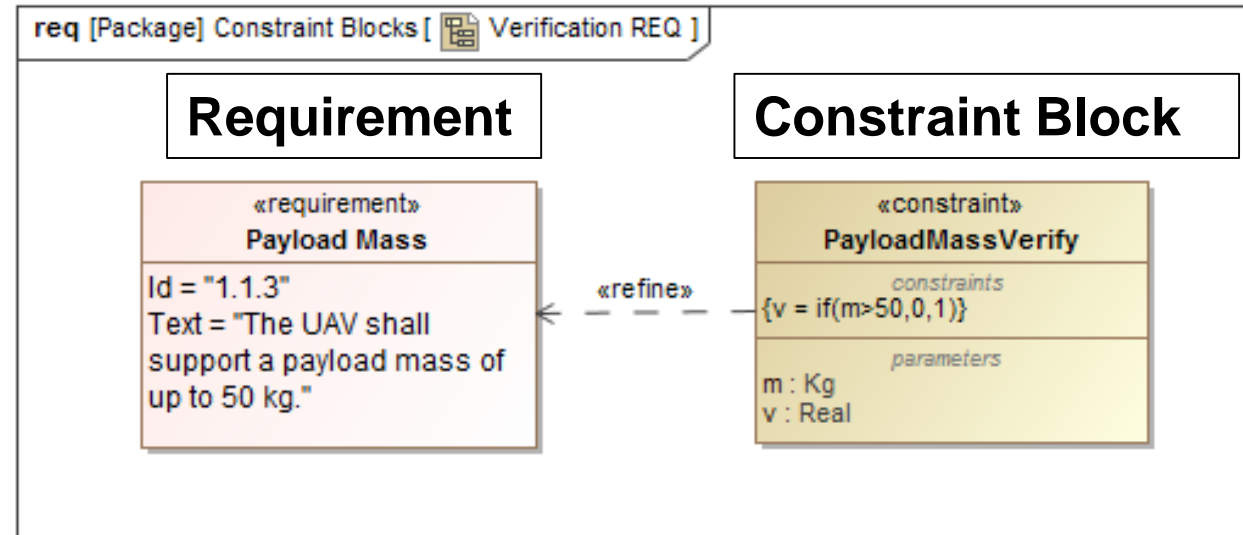
root ( UAV )

Name	Local	Red...	Relation	Active
ma2p1	Y		mass=pltfm.mass+pyld.mass	<input checked="" type="checkbox"/>

# Complex Aggregates



# Requirement Verification

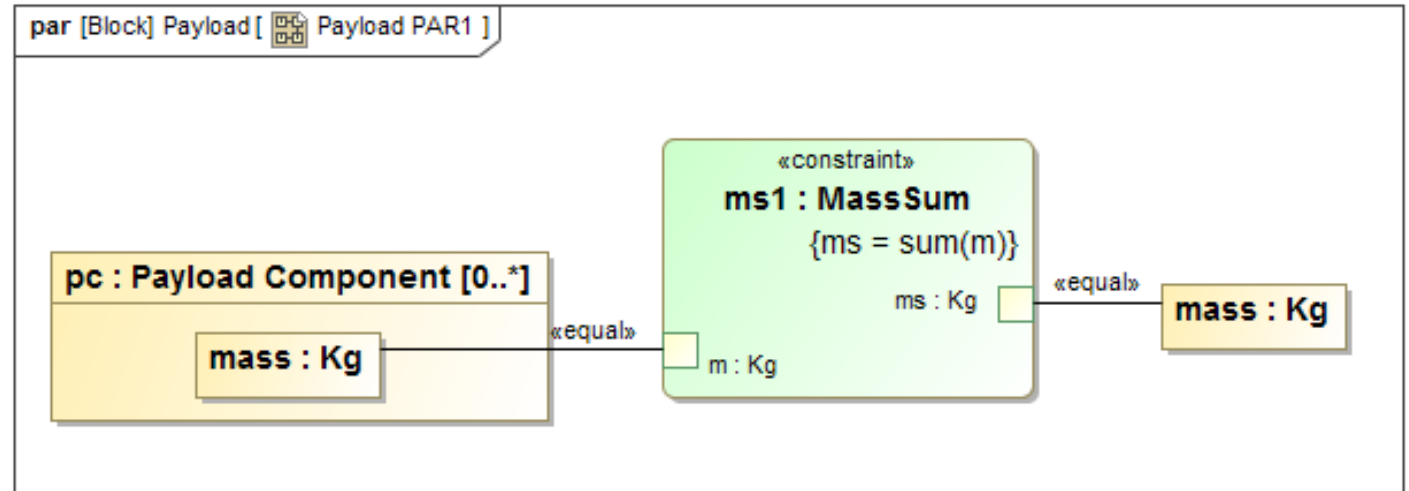
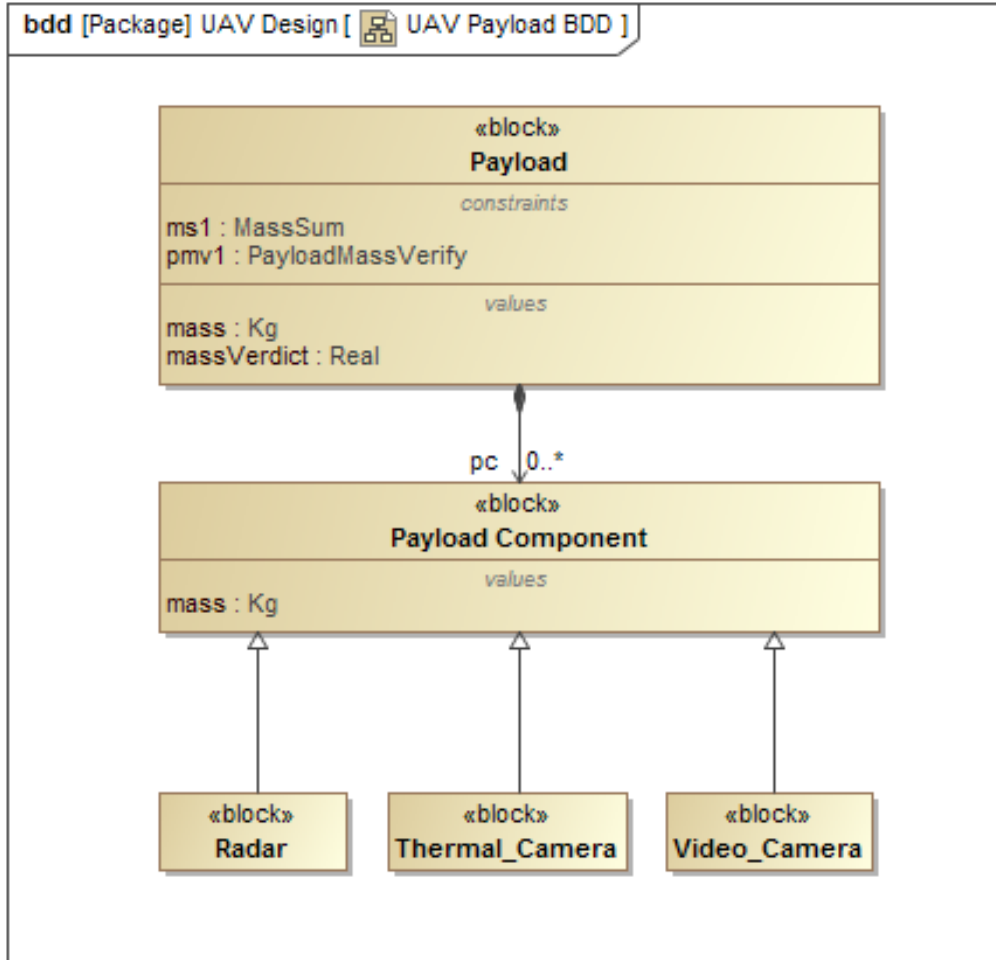


# Second Exercise

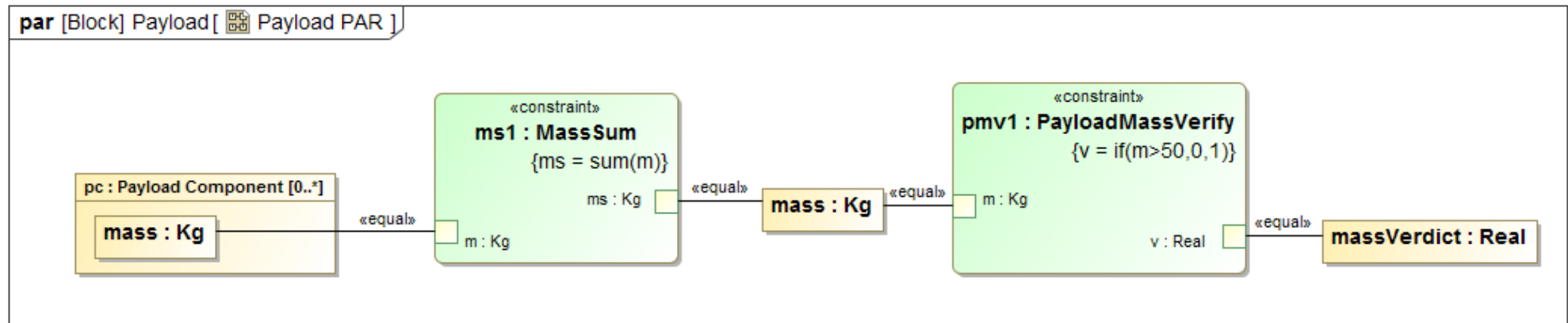
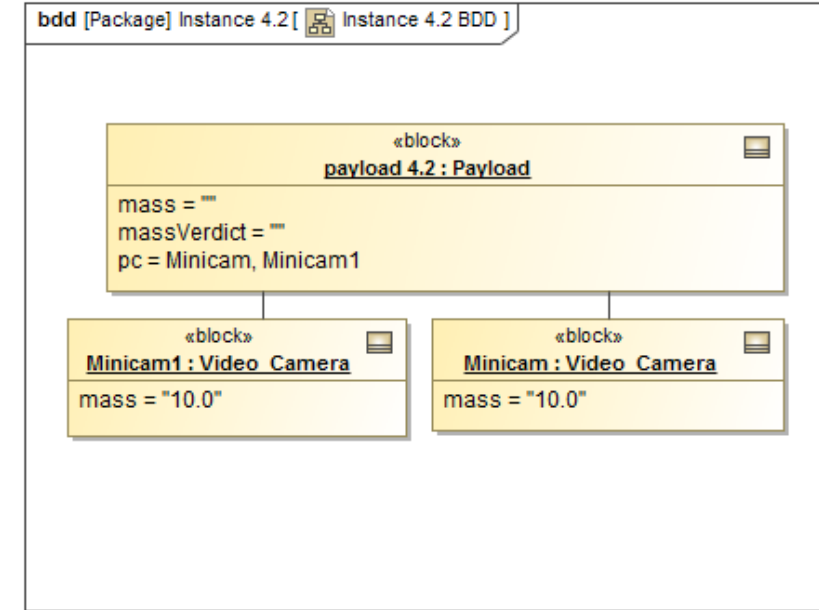
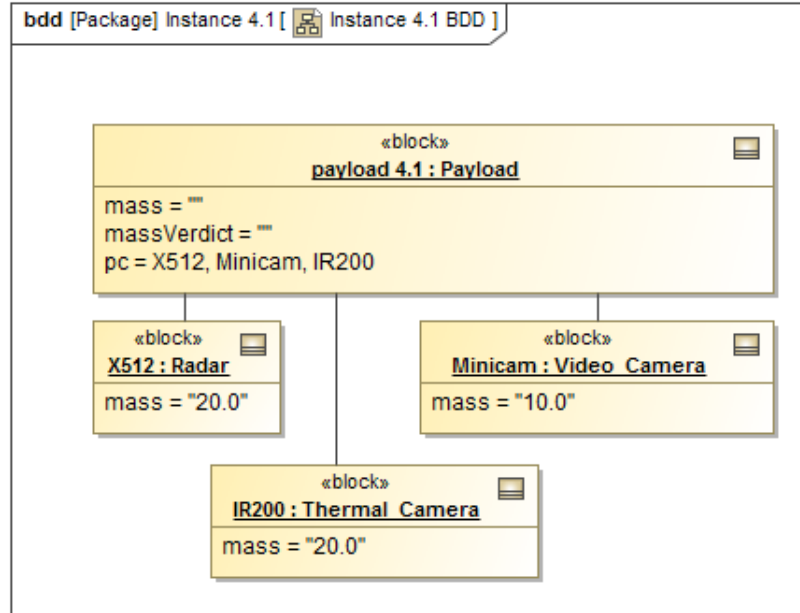
- The objectives of this exercise are to
  - Create a flexible Part Property relationship using Multiplicity and Inheritance
  - Create a Parametric Diagram using Complex Aggregates
  - Create multiple Instances of the Payload assembly
  - Solve these Instances for mass roll-up
  - Use mass roll-up calculation to verify UAV Payload Mass requirement.



# Second Exercise

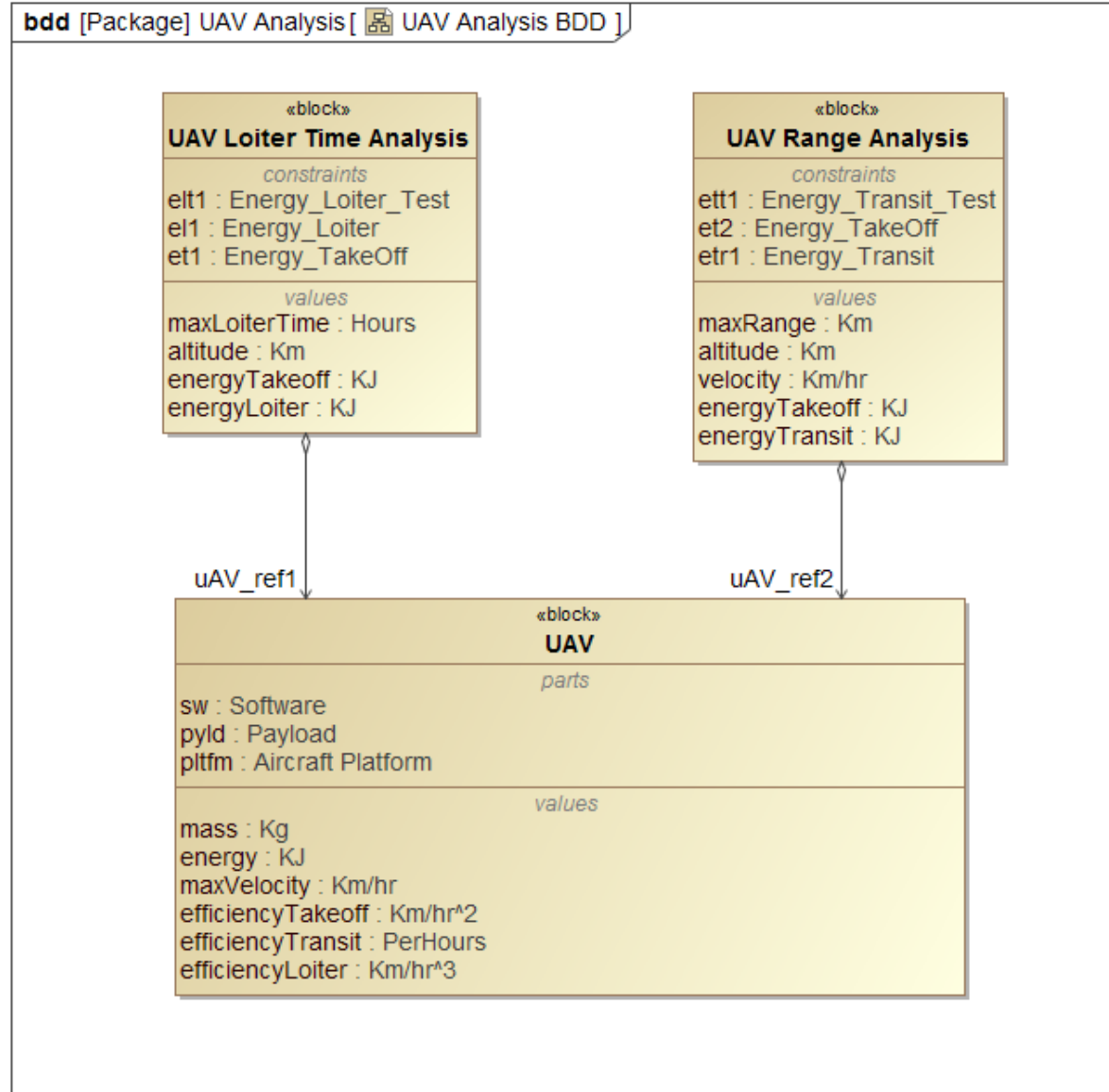


# Second Exercise



# External Analysis Blocks

## Reference Properties



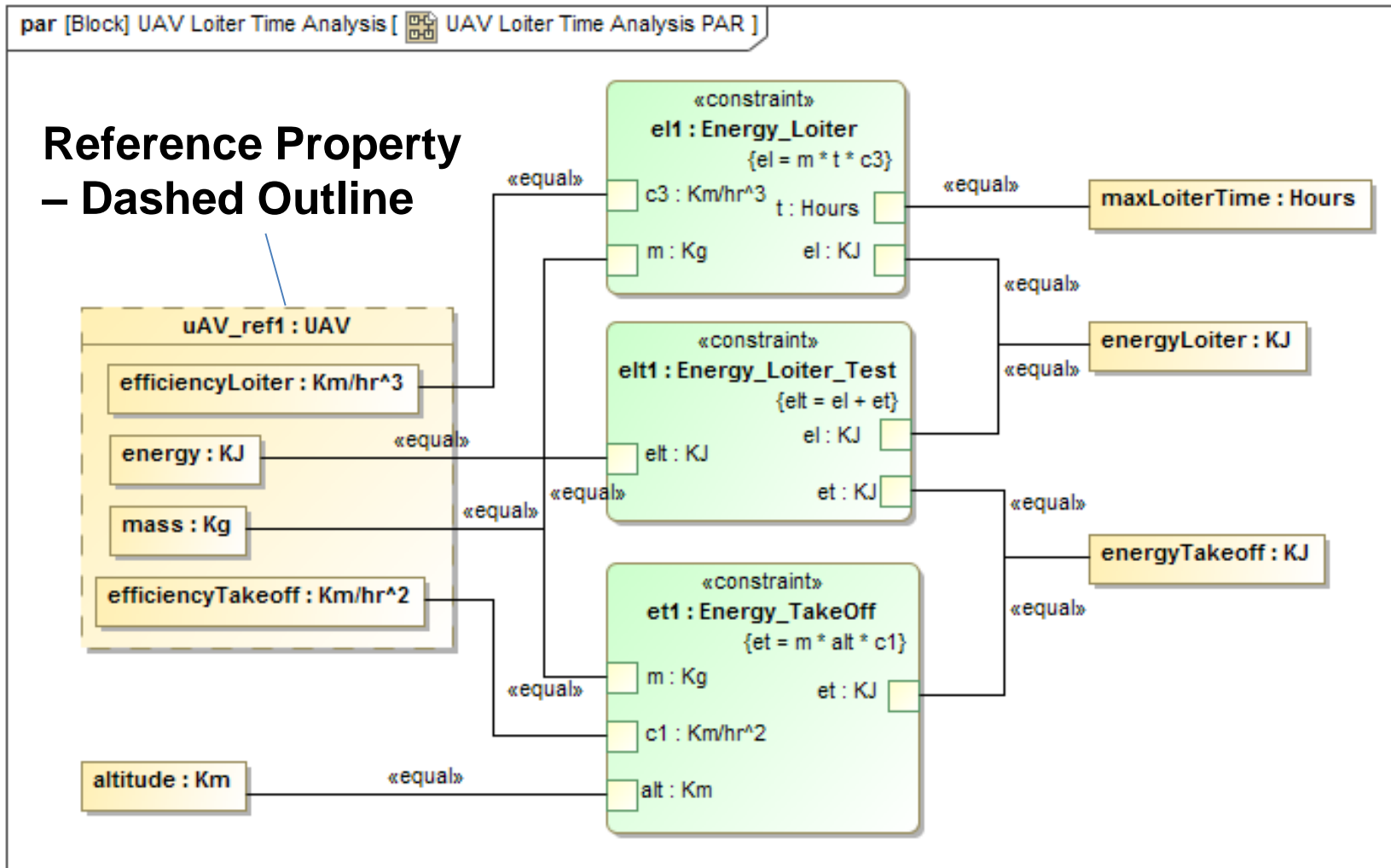
# External Analysis Blocks

- Parametric models can be embedded in the structure, or
- Captured in other blocks that reference the structure
- External analysis blocks are also a good place to put value properties that describe the experimental condition, but aren't characteristics of the structural block
- External analysis blocks allow a developer to create an analysis without changing or disturbing the structure blocks

## Reference Properties

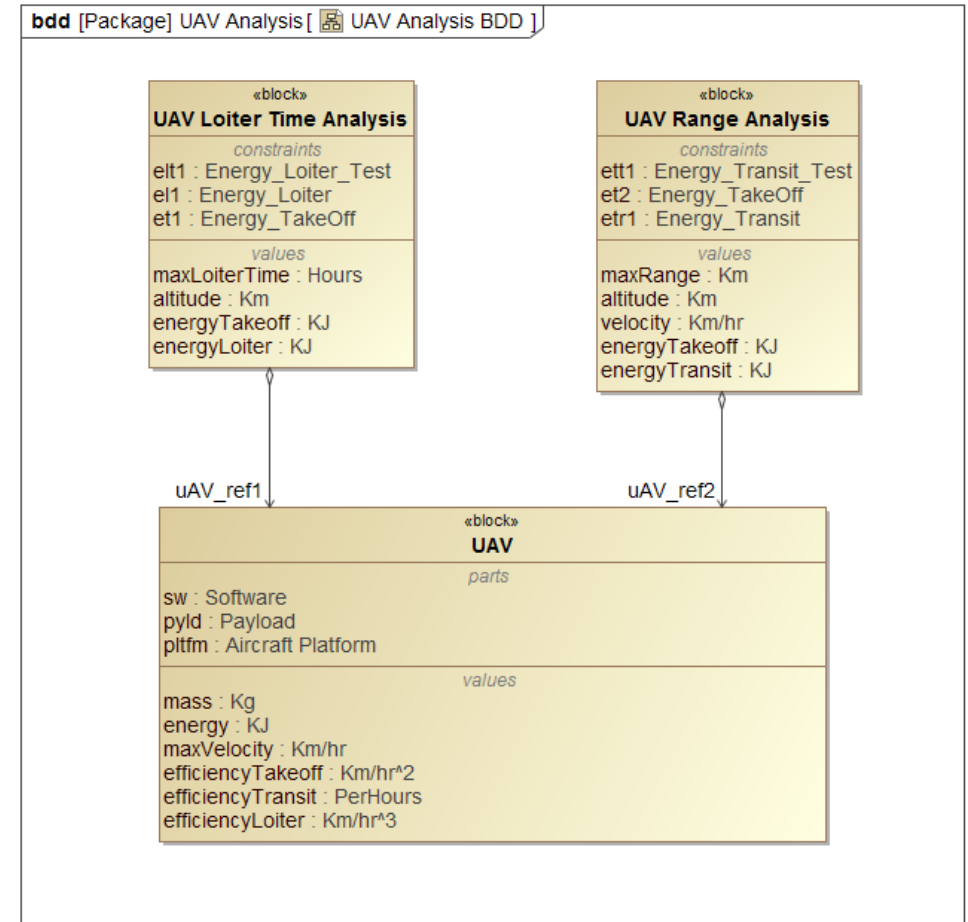
- Reference or Shared Properties allow one Block to reference the values (or other properties), without the implication of ownership
- They are shown with a white diamond arrow (or no diamond), unlike part properties with a black diamond arrow,

# Loiter Time Analysis

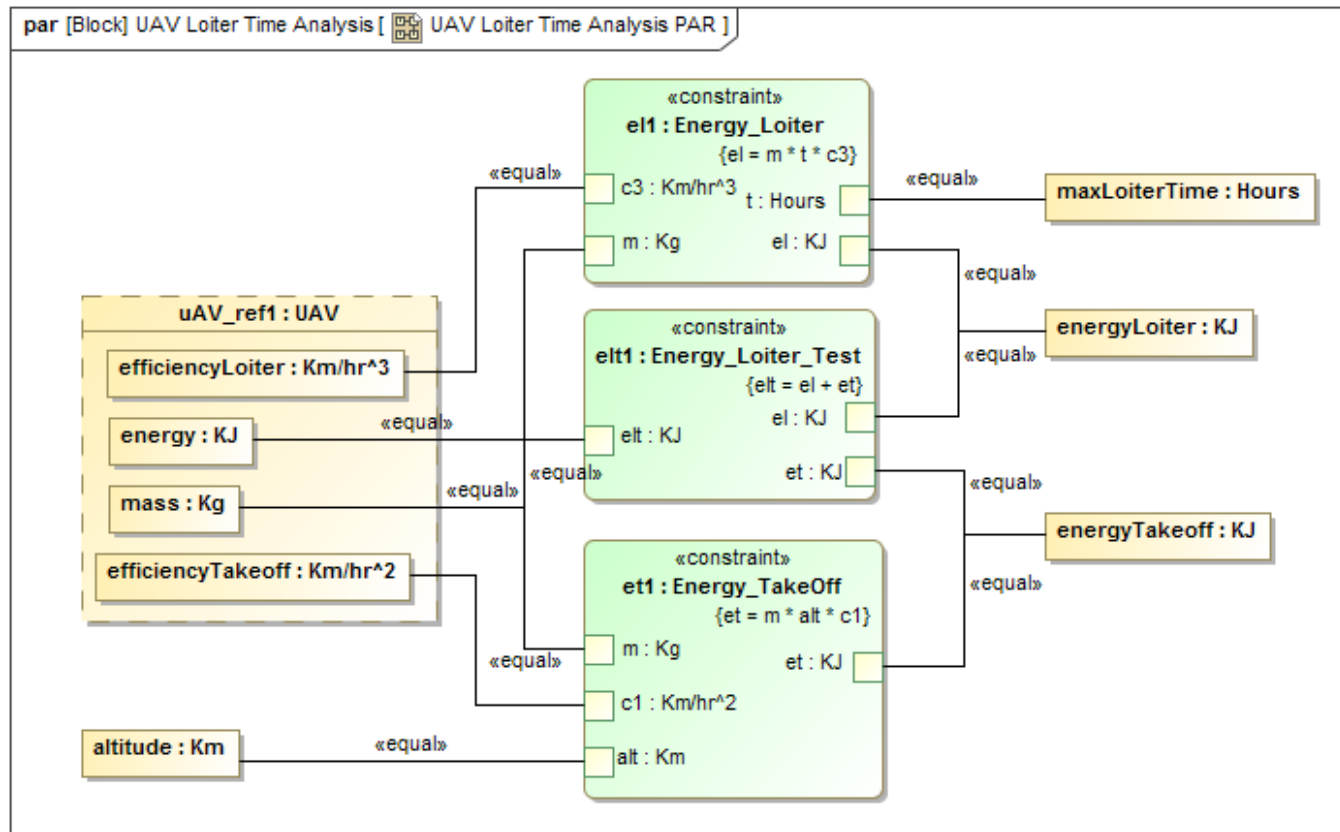


# Third Exercise

- The objectives of this exercise are to
  - Create external analysis blocks with parametric models
  - Use reference property relationships to access UAV system values
  - Create an instance involving reference properties
  - Solve this Instances for UAV range and loiter time.



# Third Exercise



ParaMagic(R) 18.0 - Ita5.1

Name	Qualified Name	Type	Causa...	Values
UAV Loiter Time Analysis	UAV Analysis::Instance 5.1::Ita5.1	UAV Loiter Tim...		
altitude	Km	given		0.50
energyLoiter	KJ	undefined		????
energyTakeoff	KJ	undefined		????
maxLoiterTime	Hours	target		????
uAV_ref1	UAV Analysis::Instance 5.1::uav	UAV		
efficiencyLoiter	Km/hr <sup>3</sup>	given		1.00
efficiencyTakeoff	Km/hr <sup>2</sup>	given		1.00
efficiencyTransit	PerHours			0.01
energy	KJ	given		1,000.00
mass	Kg	undefined		????
maxVelocity	Km/hr			25.00
pltfm	UAV Analysis::Instance 5.1::uav.... Aircraft Platform			
mass	Kg	given		250.00
ant1	UAV Analysis::Instance 5.1::uav.... Antenna			
av	UAV Analysis::Instance 5.1::uav.... Avionics			
fslg	UAV Analysis::Instance 5.1::uav.... Fuselage			
pyld	UAV Analysis::Instance 5.1::uav.... Payload			
cost	\$	target		????
dataRate	Mb/s	target		????
mass	Kg	undefined		????
massVerify	Real	target		????
powerDemand	KW	target		????
r1	Radar[0,?]			
cost	\$	given		1,000.00
dataRate	Mb/s	given		0.50
mass	Kg	given		20.00
powerDemand	KW	given		2.00
tc1	Thermal_Came...			
vc1	Video_Camera...			
pc	Payload Compo...			
sv	UAV Analysis::Instance 5.1::uav.... Software			

Expand Collapse All Solve Reset Preserve Refs Update to SysML

root ( UAV Loiter Time Analysis )				
Name	Local	Redefined	Relation	Active
el1	Y		energyLoiter=uAV_ref1.mass*maxLoiterTime*uAV_ref1.efficiencyLoiter	<input checked="" type="checkbox"/>
elt1	Y		uAV_ref1.energy=energyLoiter+energyTakeoff	<input checked="" type="checkbox"/>
et1	Y		energyTakeoff=uAV_ref1.mass*altitude*uAV_ref1.efficiencyTakeoff	<input checked="" type="checkbox"/>

# Recap

- ▶ At the end of the hands-on exercises, you should be able to
  - ▶ Describe the objectives and approaches to analysis in MBSE
  - ▶ Explain the following terms: instance, constraint block, constraint property, binding connector, reference property
  - ▶ Create a model instance and display it in a block definition diagram
  - ▶ Create a parametric diagram
  - ▶ Validate and execute a parametric model



# Questions?

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