Welcome to SysML, the Language of MBSE

Paul White

October 8, 2019

Brief Introduction About Myself

- Work Experience
  - 2015 – Present: KIHOMAC / BAE – Layton, Utah
  - 2011 – 2015: Astronautics Corporation of America – Milwaukee, Wisconsin
  - 2001 – 2011: L-3 Communications – Greenville, Texas
  - 2000 – 2001: Hynix – Eugene, Oregon
  - 1999 – 2000: Raytheon – Greenville, Texas
- Education
  - 2019: OMG OCSMP Model Builder—Fundamental Certification
  - 2011: Graduate Certification in Systems Engineering and Architecting – Stevens Institute of Technology
  - 1999 – 2004: M.S. Computer Science – Texas A&M University at Commerce
  - 1993 – 1998: B.S. Computer Science – Texas A&M University
- INCOSE
  - Chapters: Wasatch (2015 – Present), Chicagoland (2011 – 2015), North Texas (2007 – 2011)
  - Conferences: WSRC (2018), GLRCs (2012-2017)
  - CSEP: (2017 – Present)
  - 2019 INCOSE Outstanding Service Award
  - 2019 INCOSE Wasatch -- Most Improved Chapter Award & Gold Circle Award
- Utah Engineers Council (UEC)
  - 2019 & 2018 Engineer of the Year (INCOSE) for Utah Engineers Council (UEC)
  - Vice Chair
- Family
  - Married 14 years
  - Three daughters (1, 12, & 10)

Introduction

Our Topics

- Definitions and Expectations
- SysML Overview
- Basic Features of SysML
- Modeling Tools and Techniques
- Next Steps

What is Model-based Systems Engineering (MBSE)?

Model-based systems engineering (MBSE) is

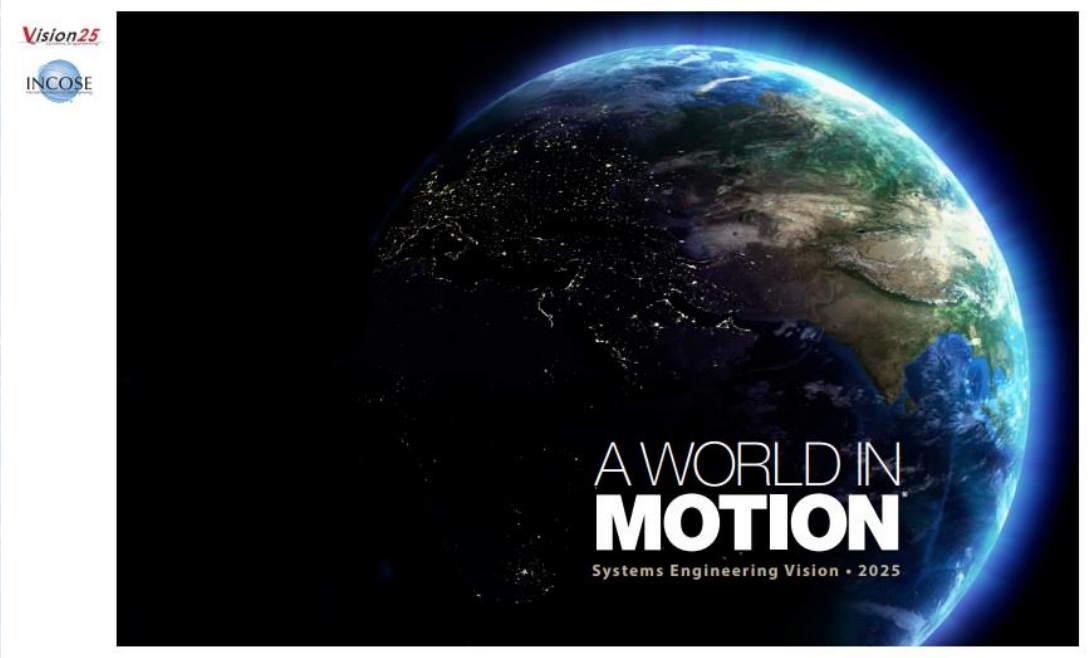
"the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."

-- INCOSE SE Vision 2020

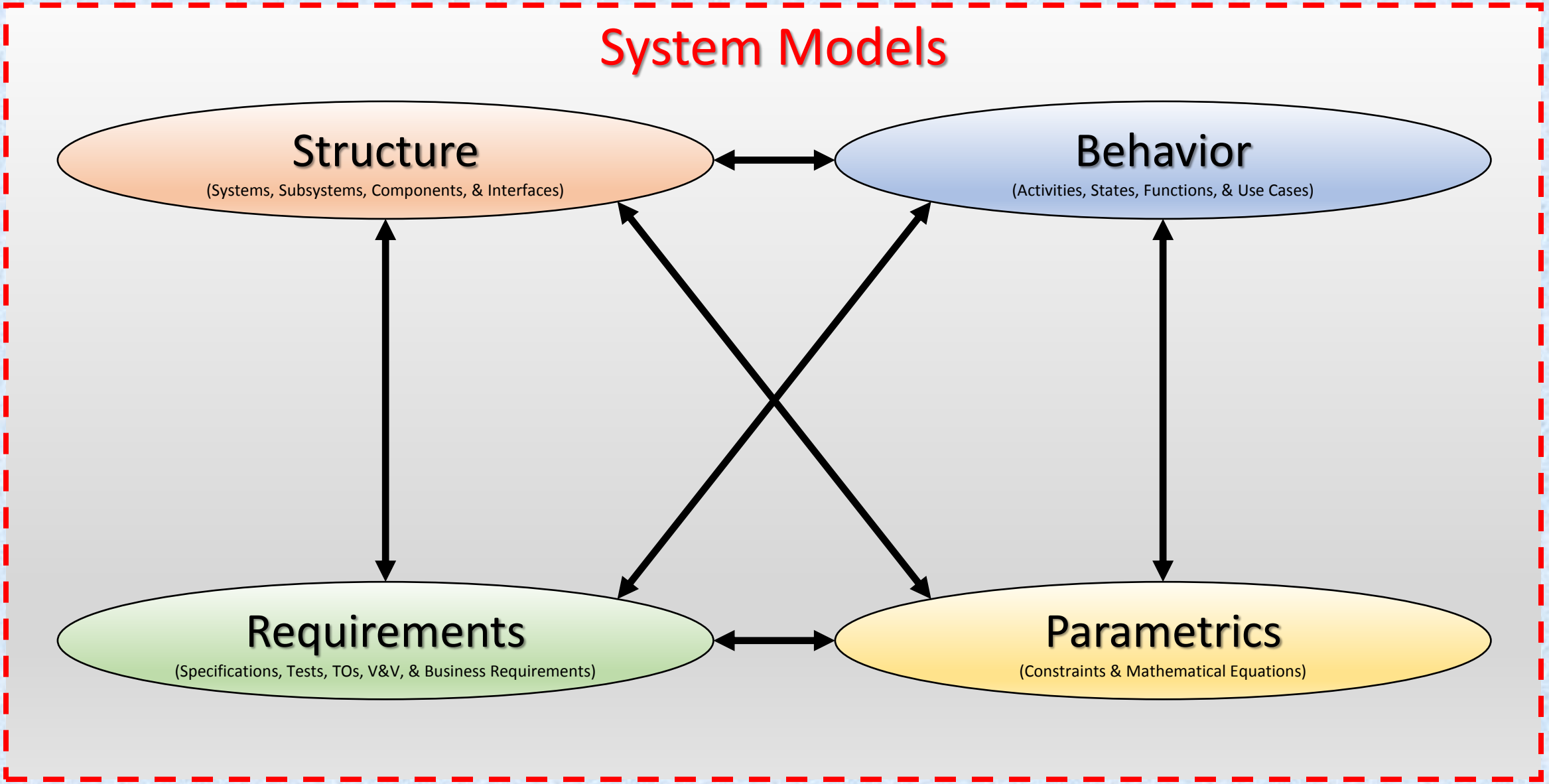
What is Model-based Systems Engineering (MBSE)?

"Formal systems modeling is standard practice for specifying, analyzing, designing, and verifying systems, and is fully integrated with other engineering models. System models are adapted to the application domain, and include a broad spectrum of models for representing all aspects of systems. The use of internet-driven knowledge representation and immersive technologies enable highly efficient and shared human understanding of systems in a virtual environment that span the full life cycle from concept through development, manufacturing, operations, and support."

-- INCOSE SE Vision 2025



MBSE & System Models



Why is this important?

2018 Department of Defense (DoD) Digital Engineering Strategy (DES)*

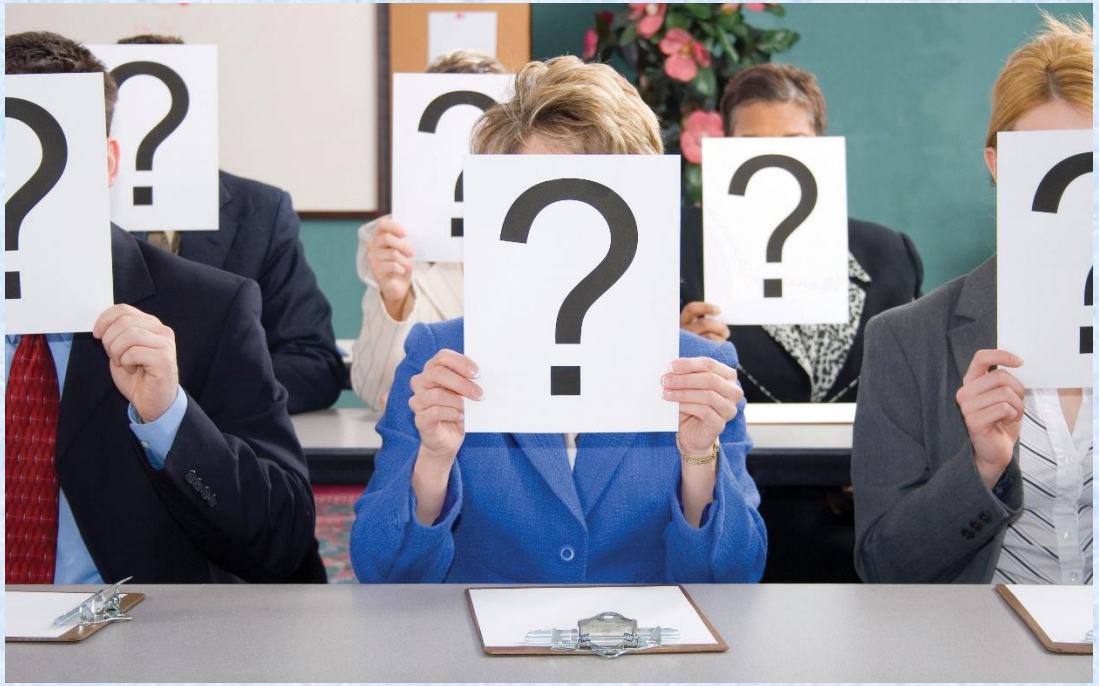
***MBSE** is necessary to effectively design and develop a modern system.

Benefits of MBSE

- Models and diagrams vs. documents
  - Enhance systems visualization
  - Foster stronger knowledge and understanding of the system
- Traceability and relationships among system elements
- Tailor presentation based on target audience
- Enforce consistency across diagrams
- Assess impact of changes to a system
- Improve communication among system stakeholders
- Strengthen a team’s collaboration

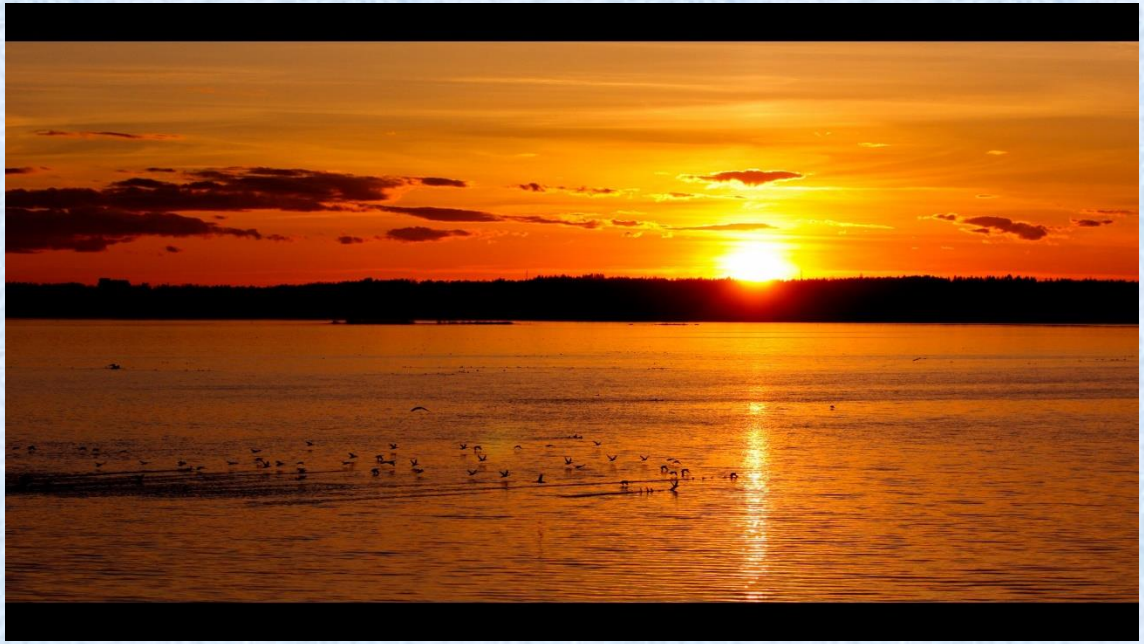
Target Audience for this Presentation

- Are you a systems engineer, or interested in systems engineering?
- Are you customers interested in MBSE or SysML?
- Have you modeled in other disciplines?
- Have you been exposed to MBSE?
- Are you interested in learning more about SysML?
- Are you currently using SysML in your daily job?



Expectations for This Presentation

- You will have enough information to start working with SysML.
- You will understand how SysML can be part of your MBSE toolkit.
- You will know where to go to learn more about SysML.

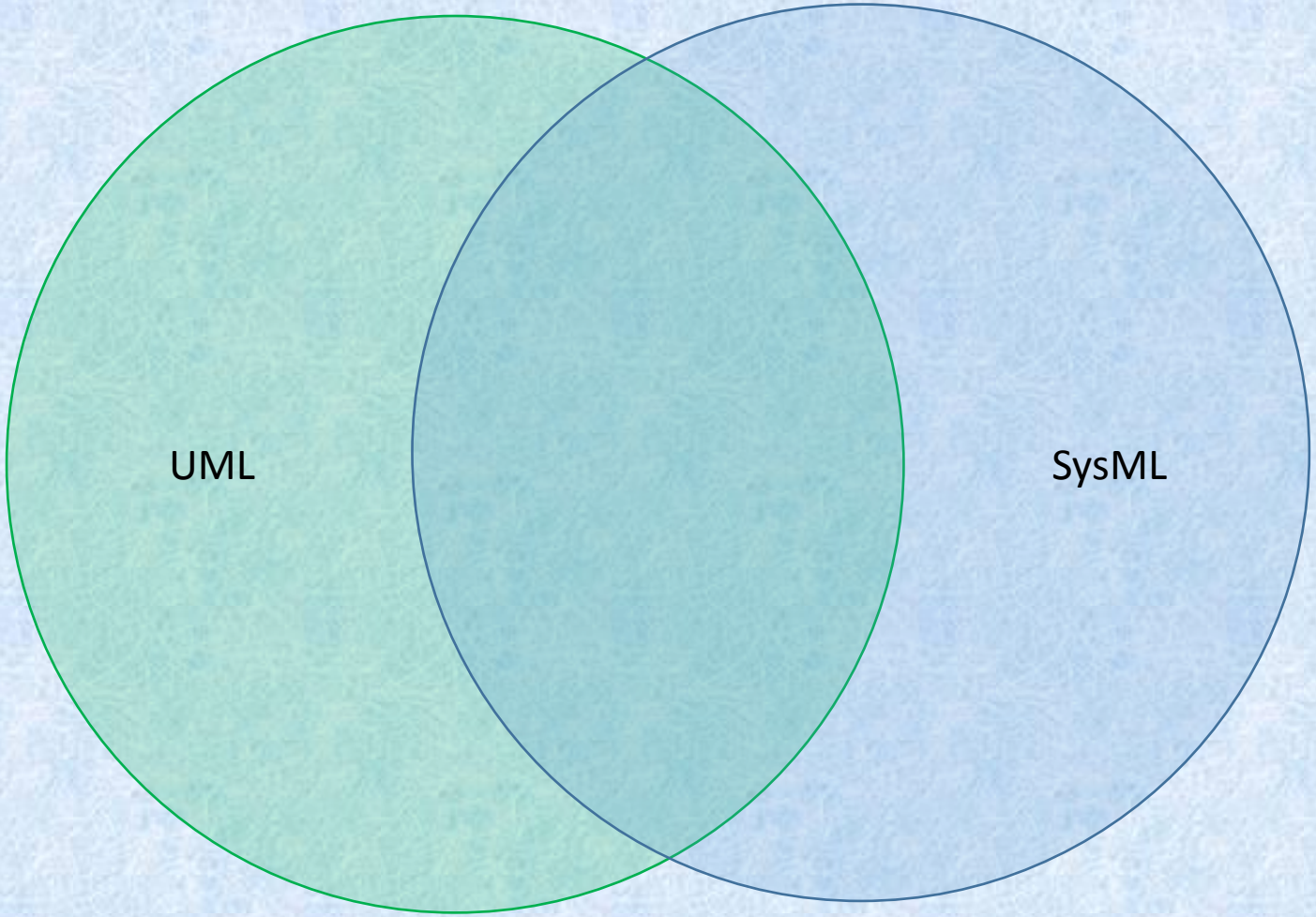


SysML Overview

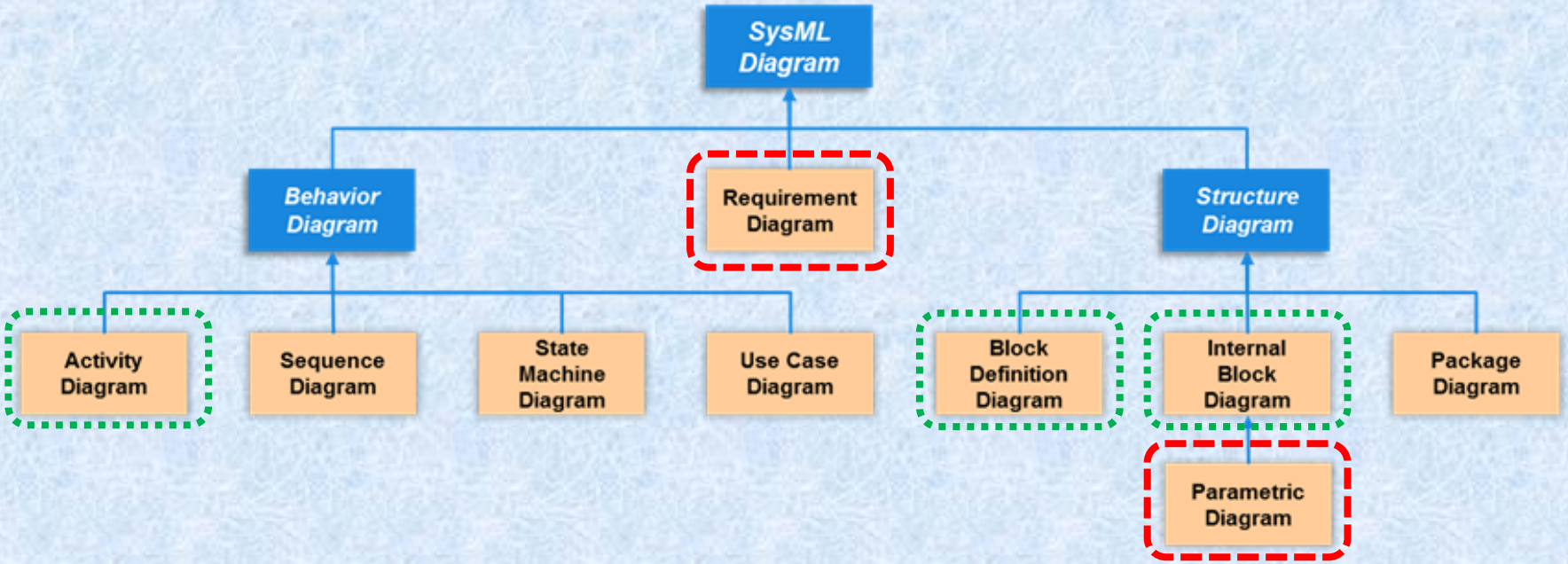
History of SysML

- Jan. 2001 – INCOSE Model Driven Systems Design working group starts customizing UML for systems engineering applications.
- July 2001 – INCOSE & Object Management Group (OMG) chartered OMG Systems Engineering Domain Special Interest Group (SE DSIG).
- 2003 – Sanford Friedenthal & Cris Kobryn organized and co-chaired SysML Partners to develop SysML.
- Sept. 2007 – OMG SysML v. 1.0 specification was released.
- May 2017 – SysML v. 1.5 issued by OMG.
- 2017 – SysML published by International Organization for Standardization (ISO) as a full International Standard (IS)
- Dec. 8, 2017 – Work began on SysML v. 2.0.

SysML & UML



SysML Diagram Types



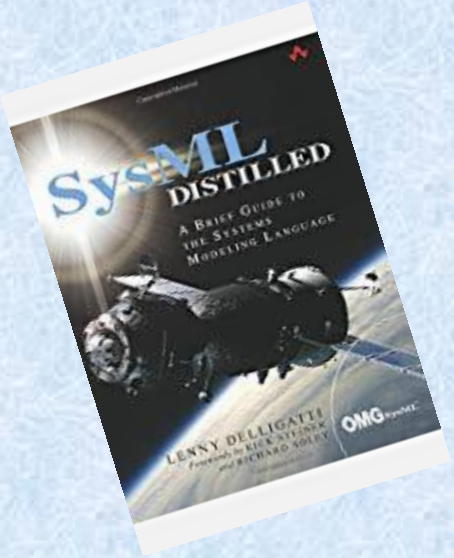
New to SysML

Modified from UML

Basic Features of SysML

Source of the Diagrams

- Lenny Delligatti – OCSMP Accelerator™ SysML Training Course
- DellSat-77 Satellite System Example

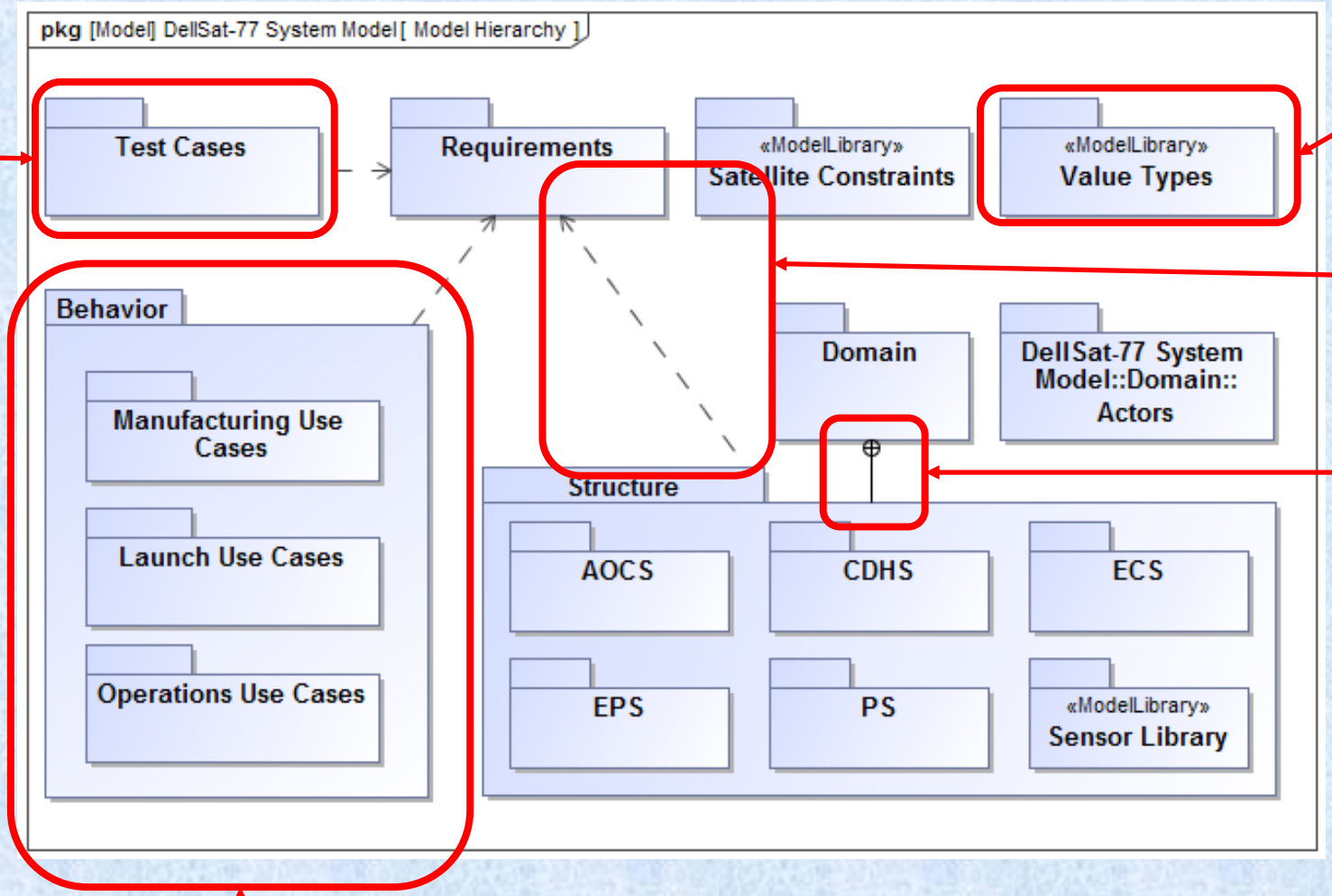


DELLIGATTI ASSOCIATES
EFFECTIVE ENGINEERING. MODEL-BASED SOLUTIONS.™

Package Diagrams

Package diagrams convey information about the structure of the model.

Package – Namespace that may contain model elements



Model Library – Model elements that are intended for reuse across multiple projects

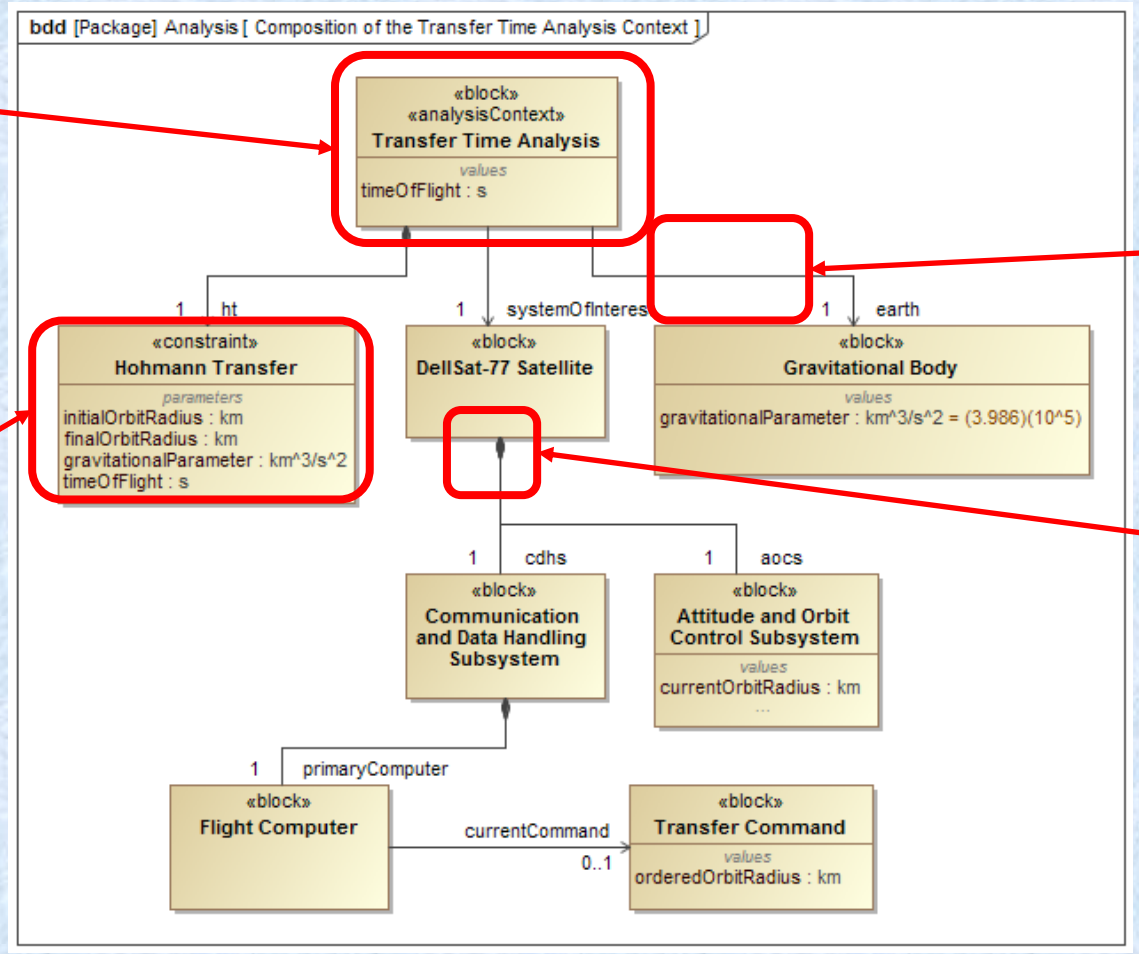
Dependency – Change to one packet may result in change to other packet.

Containment (Nested Packages)

Block Definition Diagrams

Block definition diagrams display system structure, decomposition, and type classification.

Block –
Basic unit of structure



Reference Association –
Connection can exist between blocks

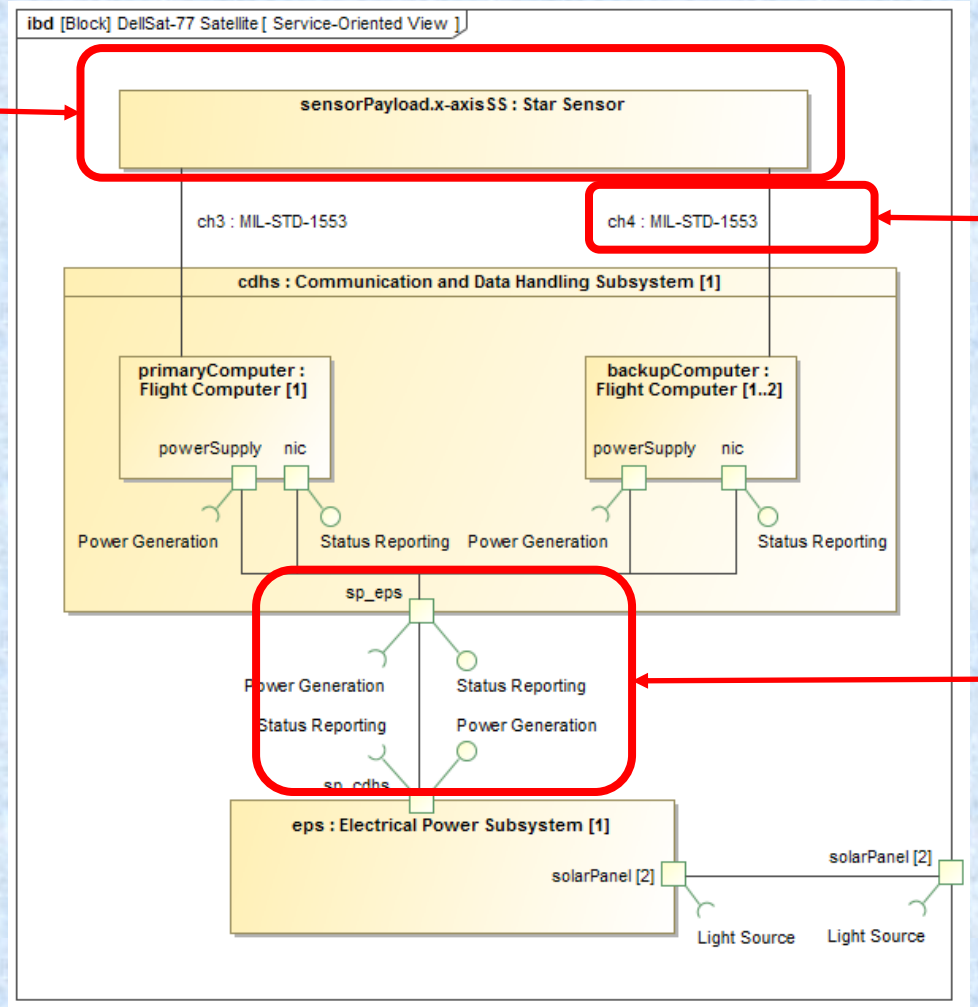
Composite Association –
Conveys structural decomposition

Constraint Block –
Defines a constraint for a system

Internal Block Diagrams

Internal block diagrams show connections; types of matter, energy, or data that flow; and services provided or required.

Usage of a block



Connector –
Conveys that two structures will have a way to access each other

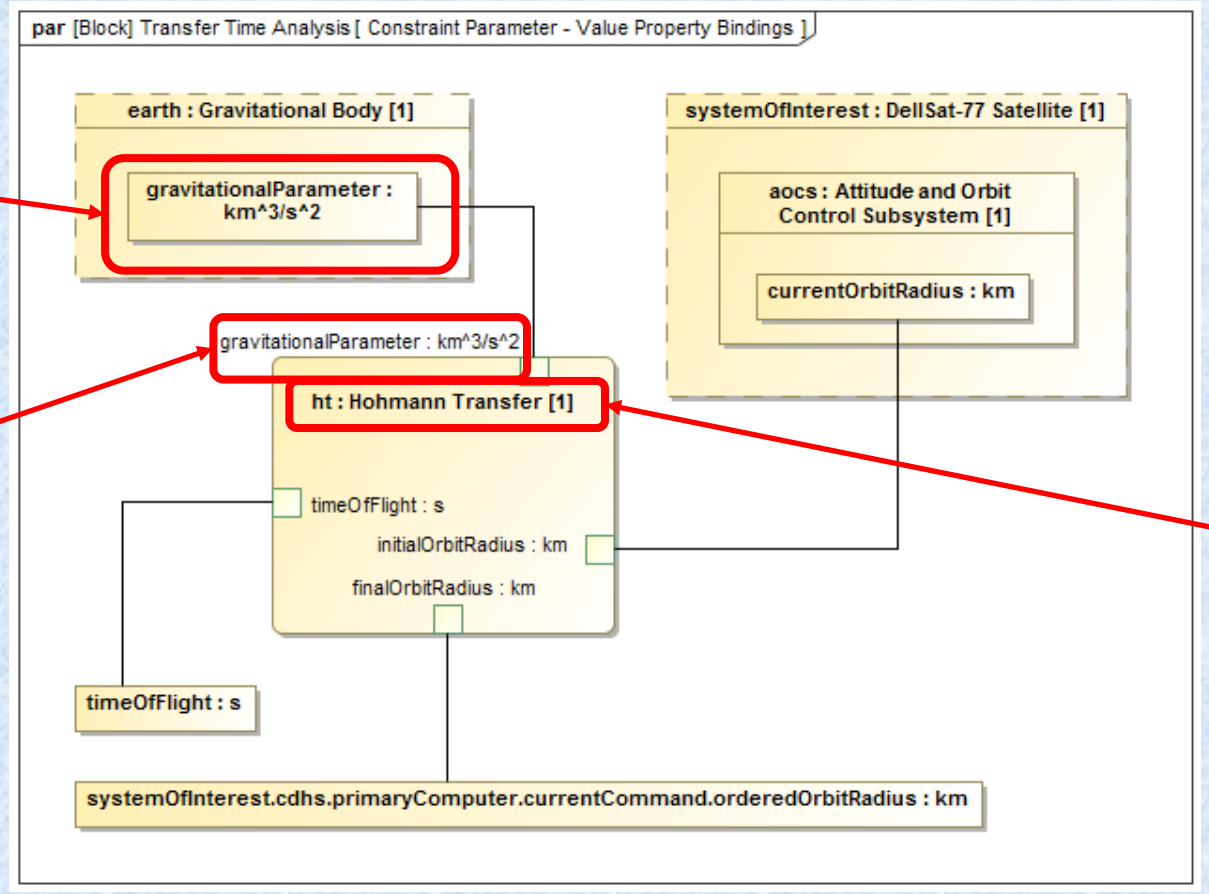
Ports –
Conveys interfaces between structures

Parametric Diagrams

Parametric diagrams expresses information about a system's constraints.

Value Property –
Value in your model

Constraint Parameter –
Variable of expression



Usage of constraint block

Requirements Diagrams

Requirements diagrams display requirements and their relationships to other model elements.

Trace Relationship – Modification may result in change

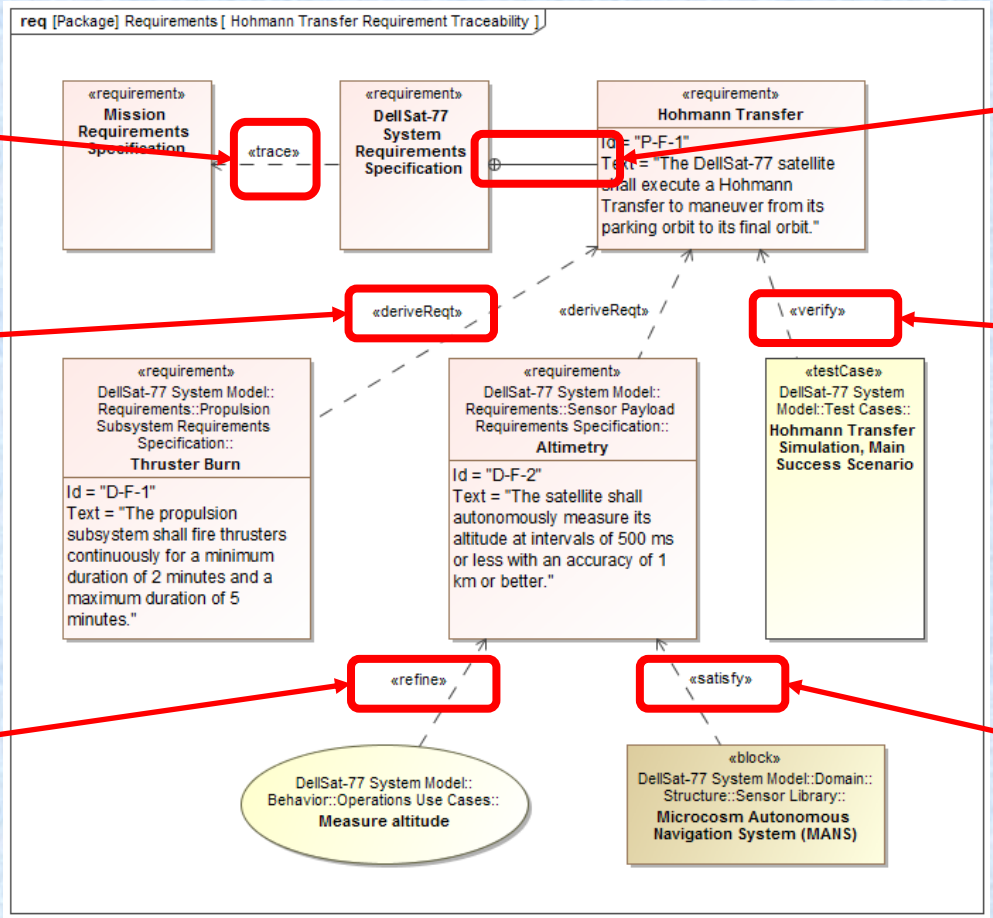
Containment – Shows hierarchy of requirements

Derive Relationship – Requirement is derived from another requirement

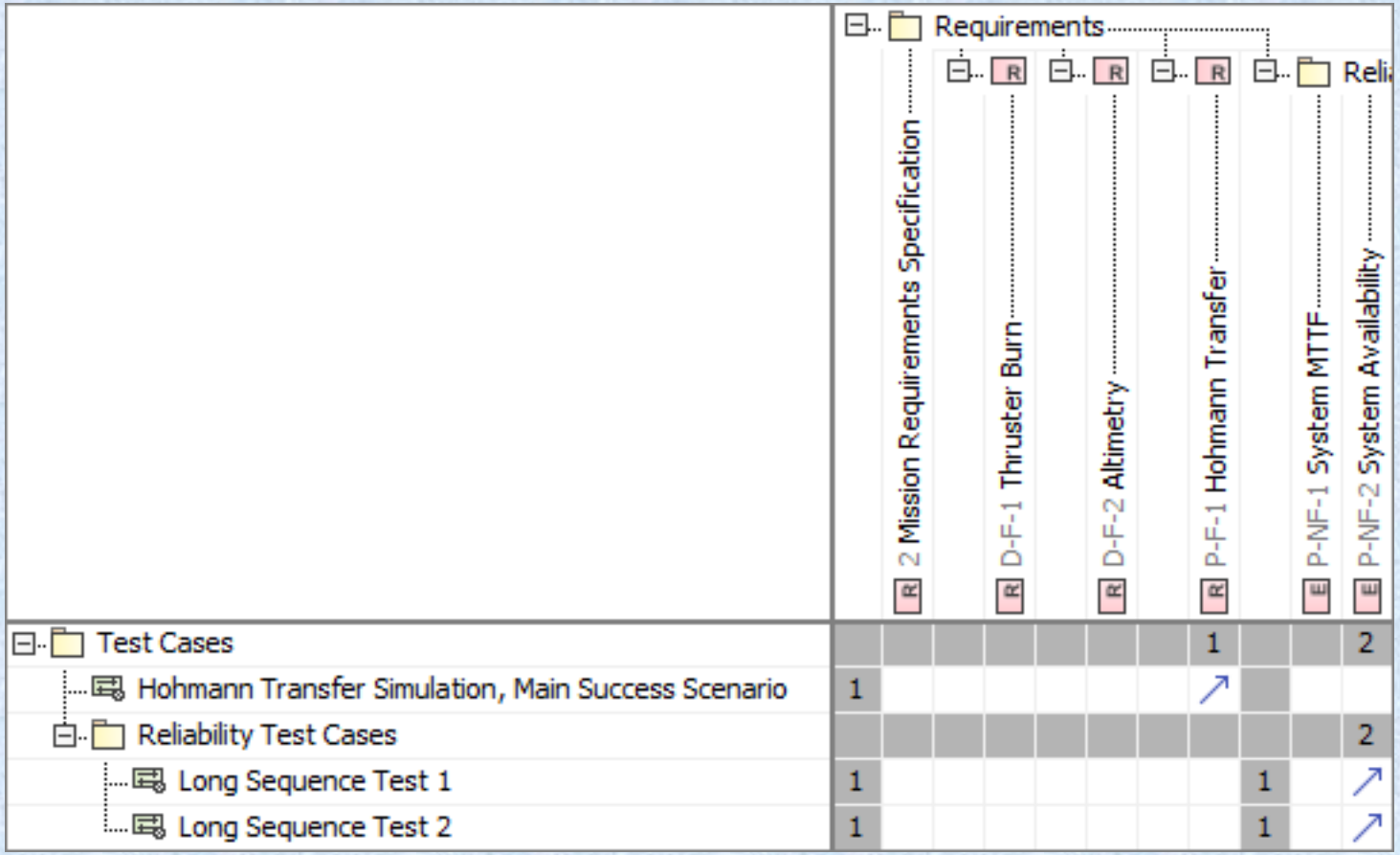
Verify Relationship – Shows that a test case verifies a requirement

Refine Relationship – Provides more detail for a requirement

Satisfy Relationship – Shows how requirements are satisfied by system structure



Requirements Matrix

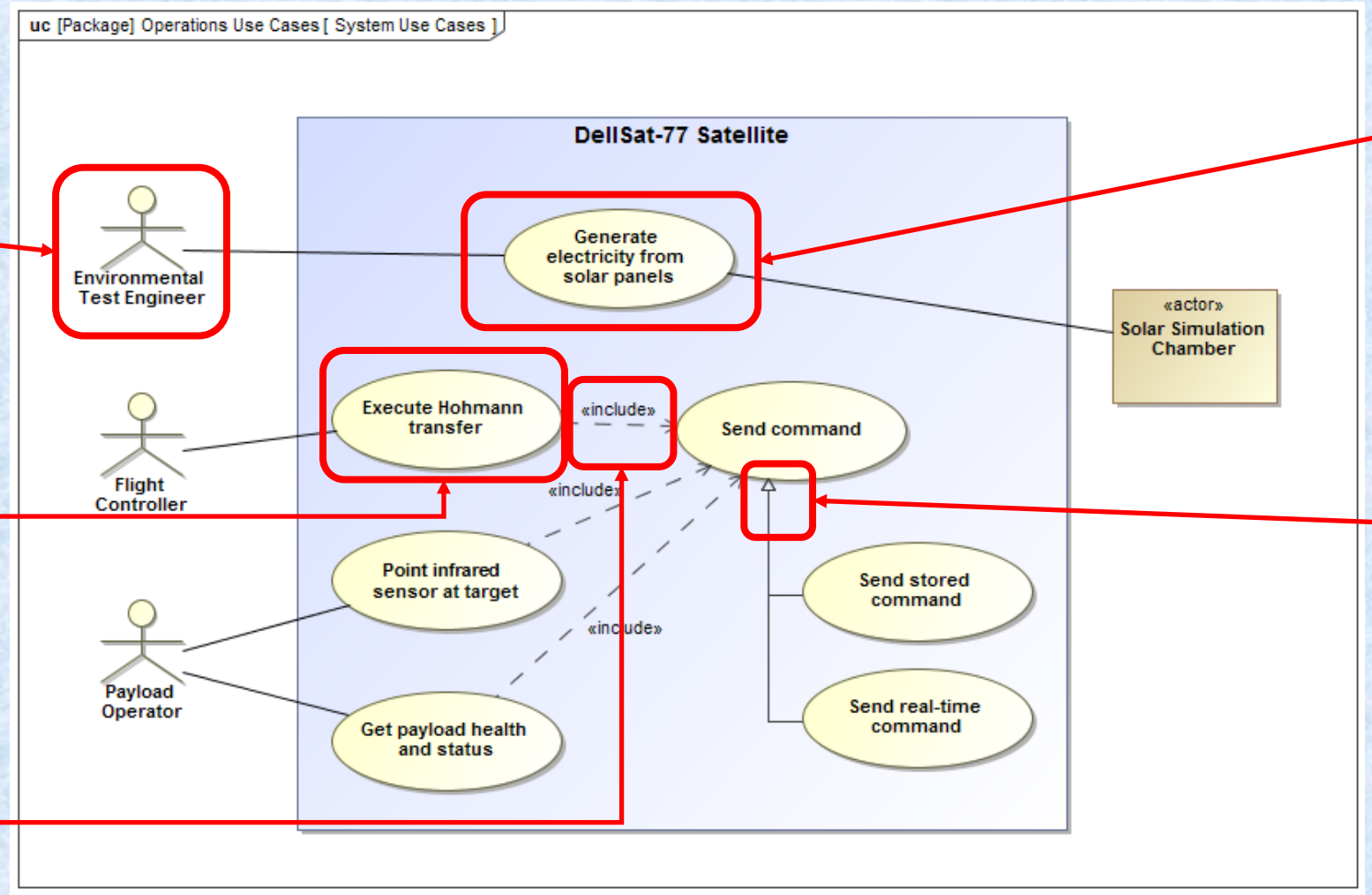


Requirement Table

#	Name	Id	Text	Satisfied By
1	Altimetry	D-F-2	The satellite shall autonomously measure its altitude at intervals of 500 ms or less with an accuracy of 1 km or better.	Microcosm Autonomous Navigation System (M…
2	DellSat-77 System Requirements Speci…	P-F-3		
3	Hohmann Transfer	P-F-1	The DellSat-77 satellite shall execute a Hohmann Transfer to maneuver from its parking orbit to its final orbit.	DellSat-77 Satellite
4	Mission Requirements Specification	2		
5	Propulsion Subsystem Requirements S…	D-F-4		
6	Sensor Payload Requirements Specific…	D-F-5		
7	System Availability	P-NF-2	The system shall have an availability greater than or equal to 0.999.	DellSat-77 Satellite
8	System MTTF	P-NF-1	The system shall have a mean-time-to-failure (MTTF) greater than or equal to 4,400 hours.	DellSat-77 Satellite
9	Thruster Burn	D-F-1	The propulsion subsystem shall fire thrusters continuously for a minimum duration of 2	Propulsion Subsystem

Use Case Diagrams

Use case diagrams show externally visible services that a system provides.



Actor – Invokes a use case

Use Case – Behavior from stakeholders' point of view

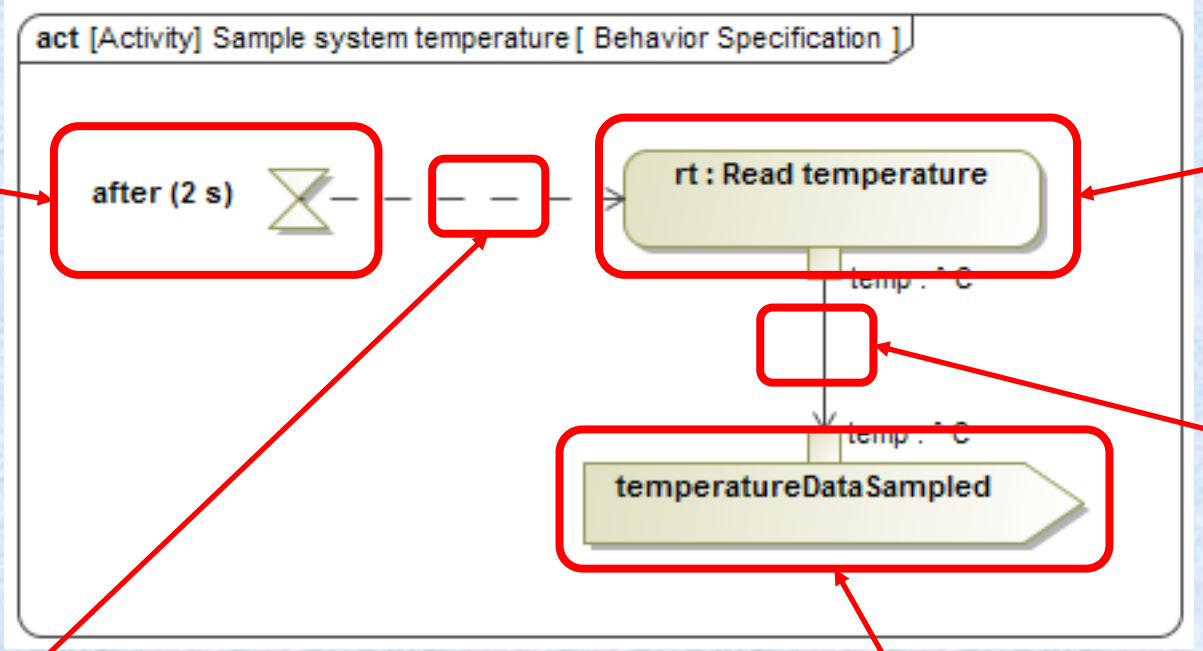
Base Use Case – Connected to a Primary actor

Generalization – Shows subtypes of use cases

Include Relationship – Included use cases are executed whenever source use case is executed

Activity Diagrams

Activity diagrams show sequence of behaviors and flow of objects.



Wait Time Action –
Actions that wait for events to occur

Action –
Basic unit of functionality

Object Flow –
Depicts transfer of matter, data, or energy between actions

Control Flow –
Depicts transfer of control between actions

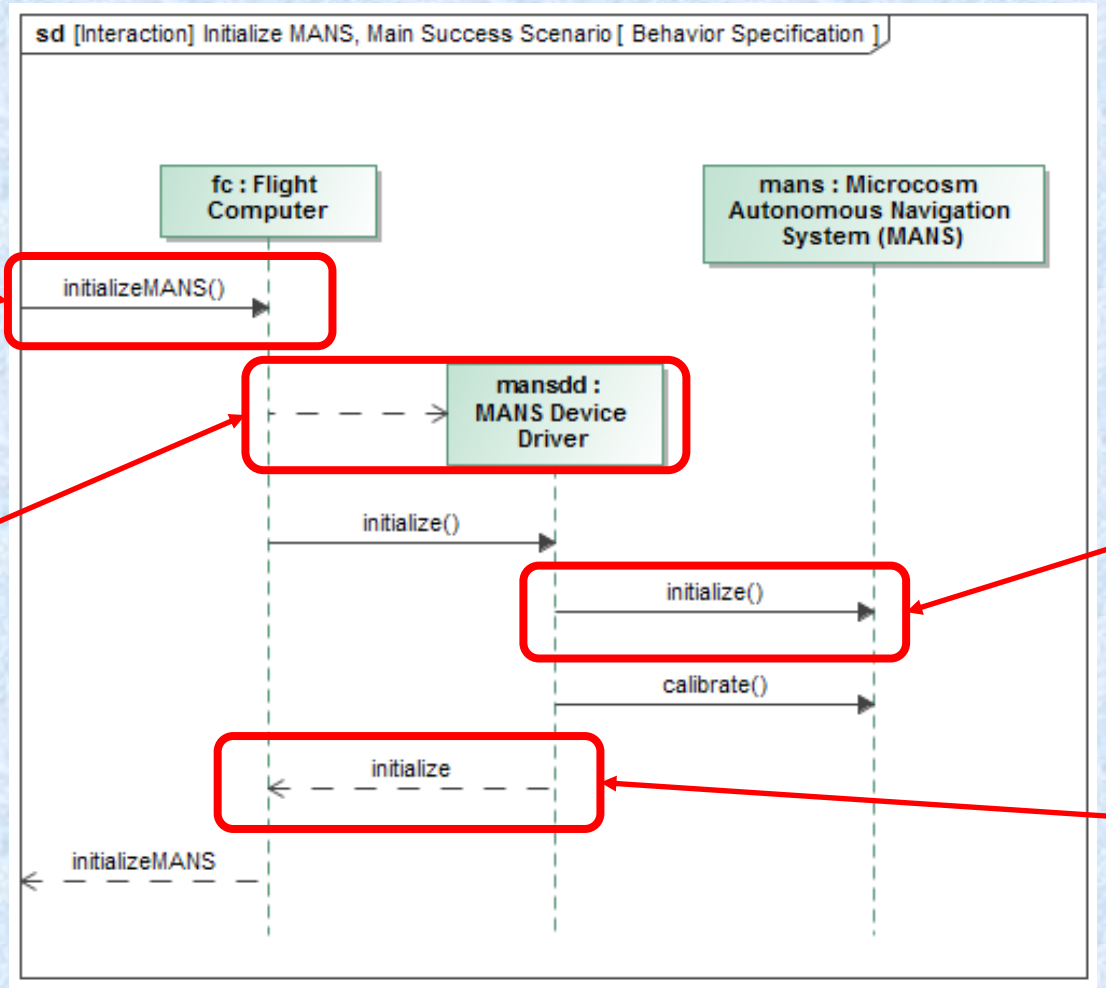
Send Signal Action –
Generates and sends a signal

Sequence Diagrams

Sequence diagrams show the order of behaviors, which structures perform behaviors, and which structures invoke behaviors.

Message – Communication between lifelines

Create Message – Communication that Creates new instances within a system



Synchronous Message – Sender sends message and waits for reply

Reply Message – Marks end of synchronous behavior (showing reply messages is optional)

State Machine Diagrams

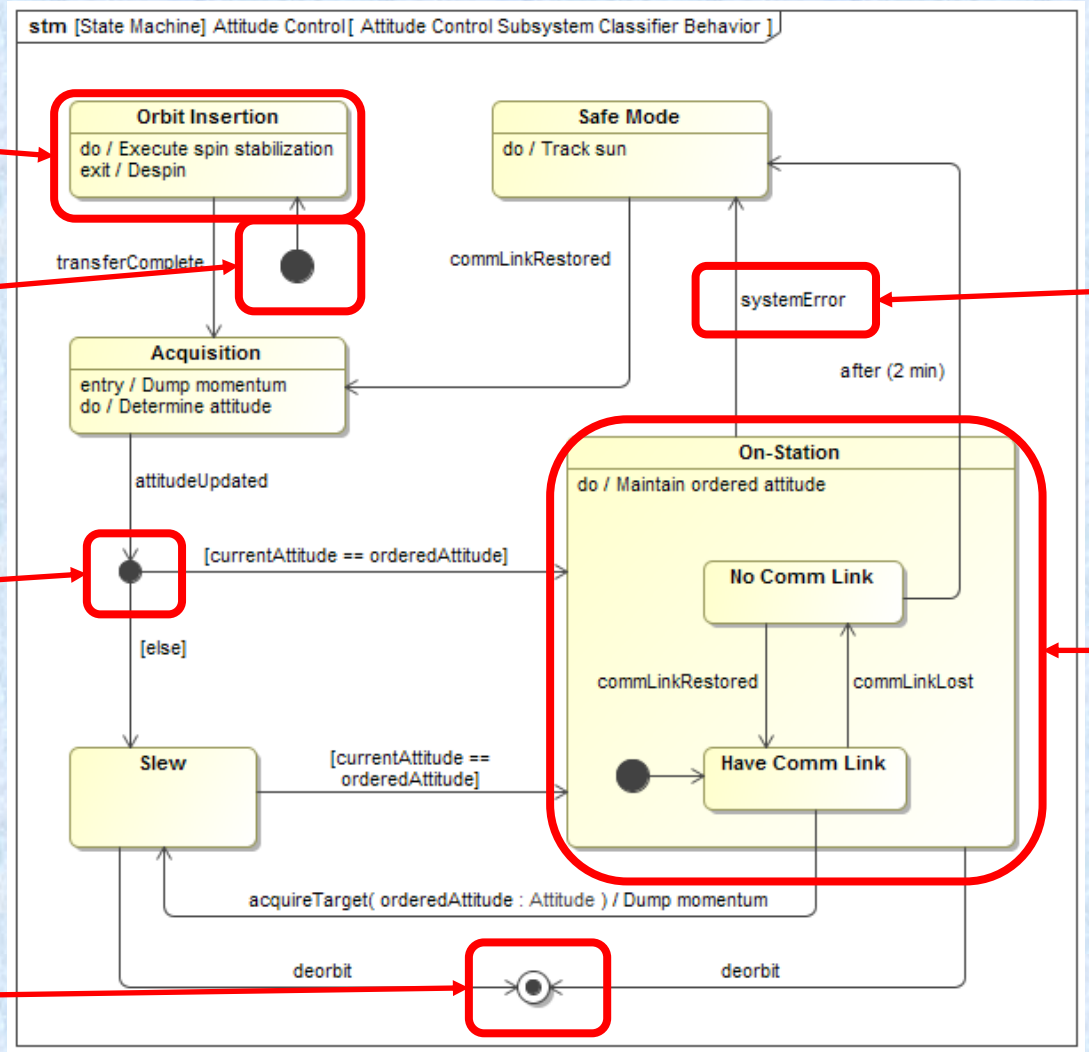
State machine diagrams focuses attention on how a structure within a system changes state in response to events.

State –
A condition that a system can exist in

Initial State –
Starting condition for a system

Pseudostate –
Intermediate states that can be used to impose control logic on state transitions

Final State –
Ending condition for a system



Transition–
Change from one state to another

Composite State –
State with nested states

Modeling Tools and Techniques

Cameo Systems Modeler

- Manufactured by NoMagic / Dassault Systemes
- Supports SysML, UML, DoDAF, MODAF, UPDM, BPMN, & others
  - Cameo supports many languages without plugins.
  - NoMagic offers suite of tools, many of which implement a single modeling languages (with plugins available to support more languages).
- MagicDraw Teamwork Cloud Server
- Trial Version – Available for download
- Architect & Enterprise Editions
- https://www.nomagic.com/products/cameo-systems-modeler#intro

DASSAULT SYSTEMES

CATIA | No Magic

Edition / What's included	Architect Edition	Enterprise Edition
MagicDraw Architect*	x	x
Cameo Simulation Toolkit		x
SysML Plugin	x	x

* Code Engineering is not included.

MBSE Benefits Realized

- Owning the technical baseline
- Knowledge Management (KM) and Knowledge Transfer (KT)
- Systems and Mission Engineering Processes

Organization Vision

- Organizations often publish long-term visions.
- Short term strategy
  - What are the near-term objectives necessary to achieve that long-term vision?
  - What are the metrics necessary to assess the organization's progress?
  - What is the right approach to a modeling project?
- Small victories can lead to large gains.

MBSE Transition

- Not instantaneous
- Structure of organization – Transition from legacy processes & people (a.k.a. culture)
- Training is important
- Start small and increase scope

Lessons Learned

- Every modeling effort must have a purpose.
- Carefully analyze stakeholder needs.
- Verify approach with tool prior to applying the approach.
- Regularly assess state of the model.
- Verify model content with subject matter experts (SMEs) and other stakeholders.
- Provide training as needed.

Modeling is a science and an art!

+

SysML Syntax & Semantics

Tool Usage

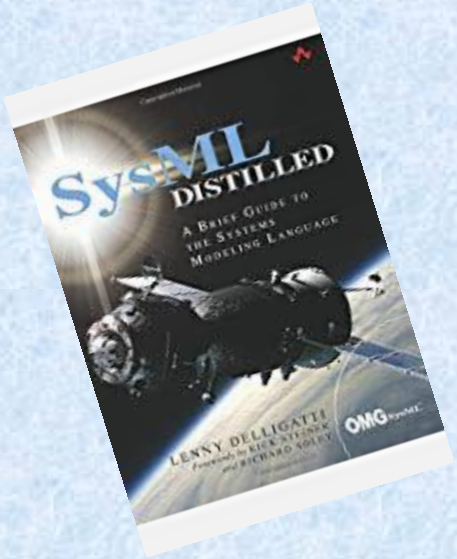
Standards & Conventions

Verification & Validation

Next Steps

Lenny Delligatti

- SysML Distilled: A Brief Guide to the Systems Modeling Language
  - Great for beginners!
  - https://www.amazon.com/gp/product/0321927869/ref=dbs_a_def_rwt_bibl_vppi_i0
- Delligatti Associates – http://delligattiassociates.com/

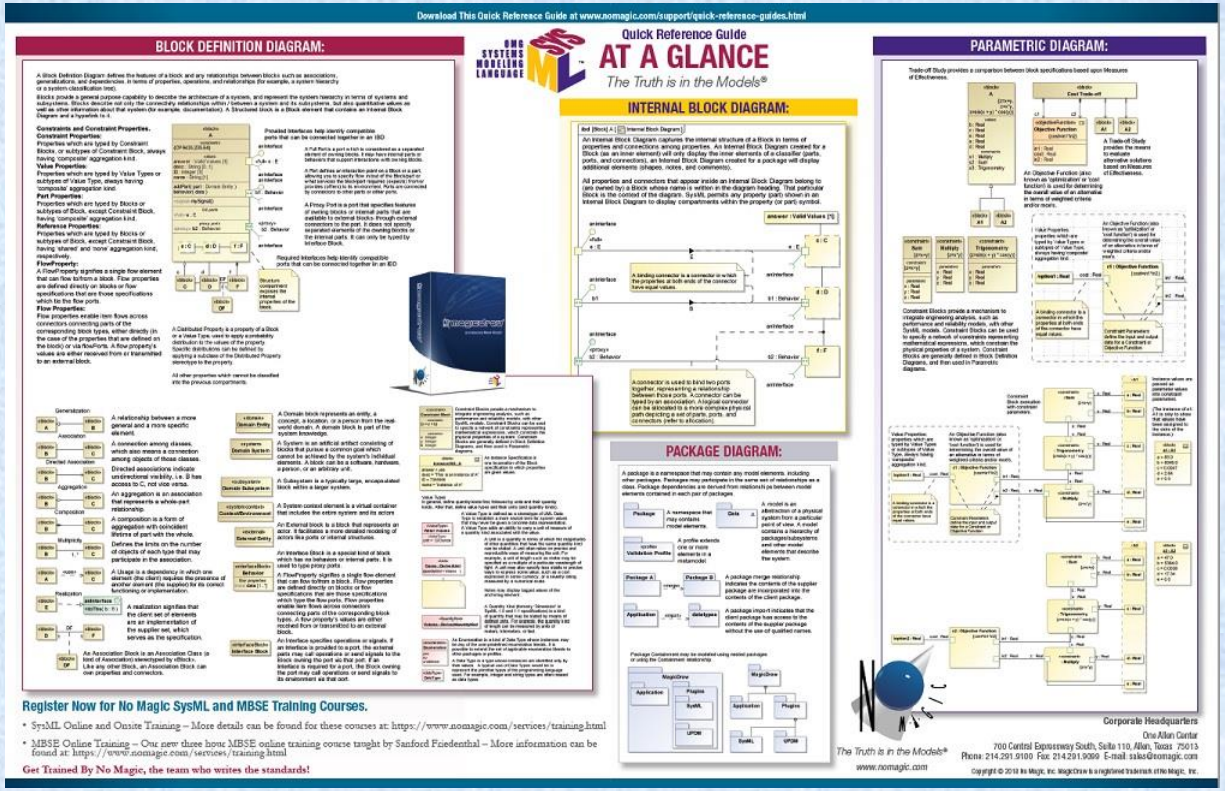


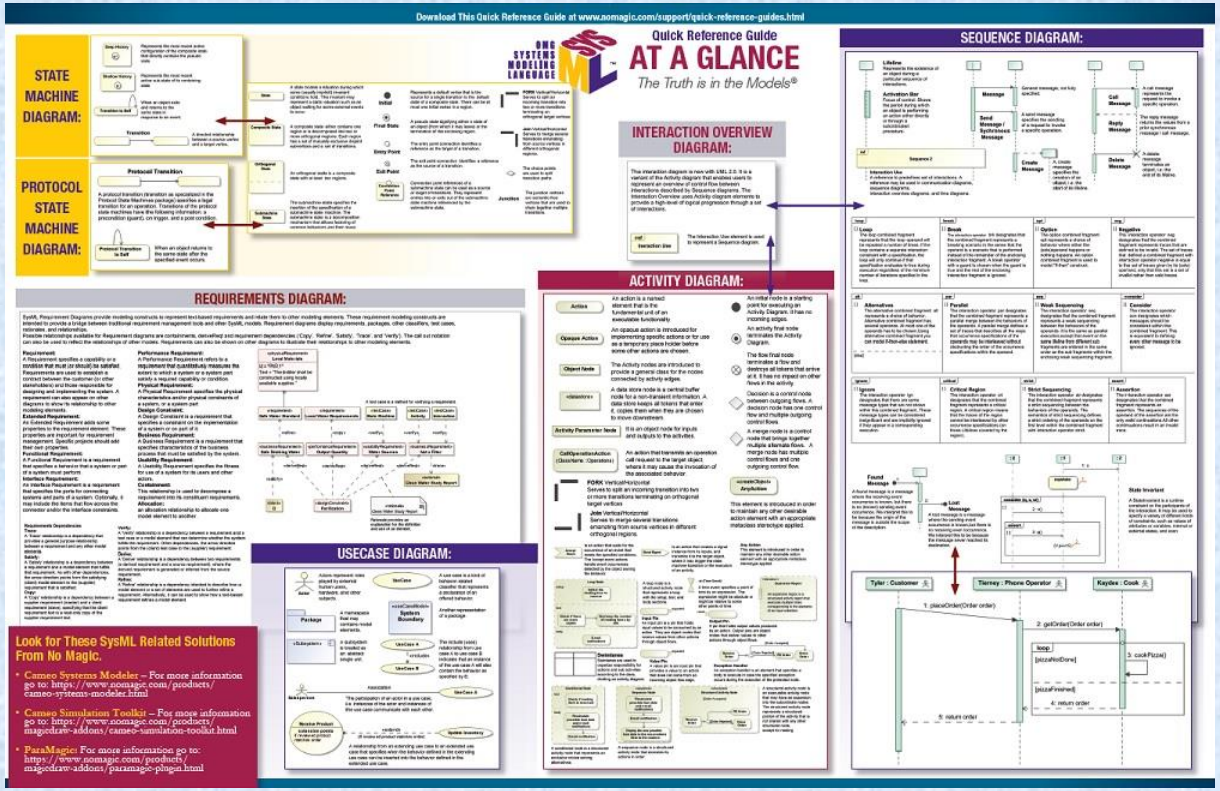
DELLIGATTI ASSOCIATES
EFFECTIVE ENGINEERING. MODEL-BASED SOLUTIONS.™

Lenny Delligatti – OCSMP Accelerator™ SysML Training Course

- 35 hours of MBSE and SysML online instruction
- 14 unlimited access, on-demand modules
- Covers all nine types of SysML diagrams
- 95 OCSMP certification exam sample questions
- Certificate of completion – Good towards Professional Development Units (PDUs)
- Course syllabus & Module 1 available for download for free
- $449.00
- https://ei194.infusionsoft.app/app/storeFront/showProductDetail?productId=6

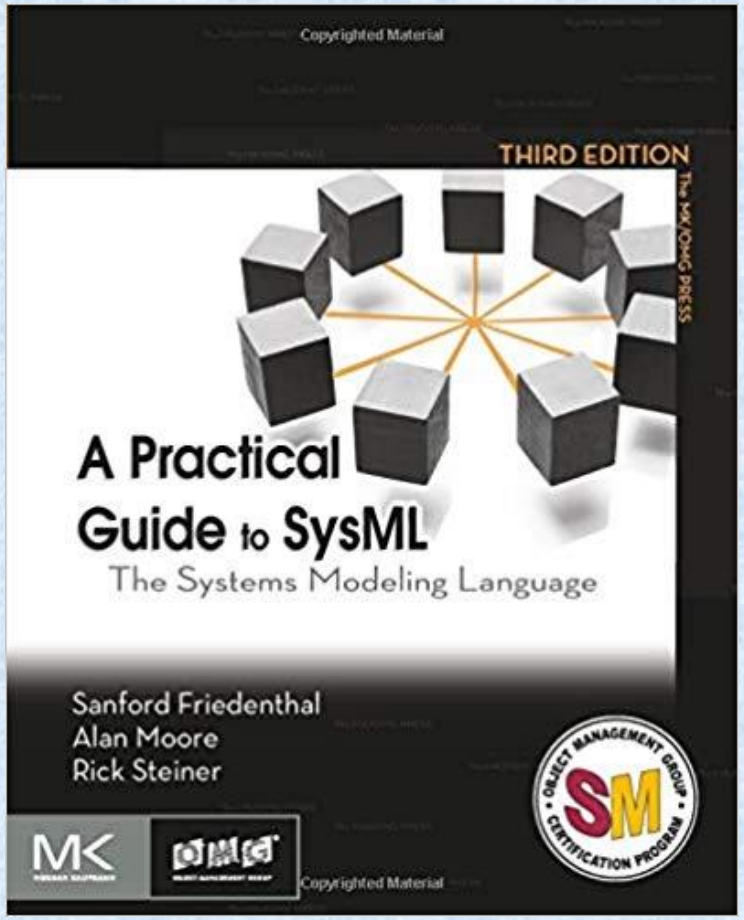
NoMagic Quick Reference Guide to SysML





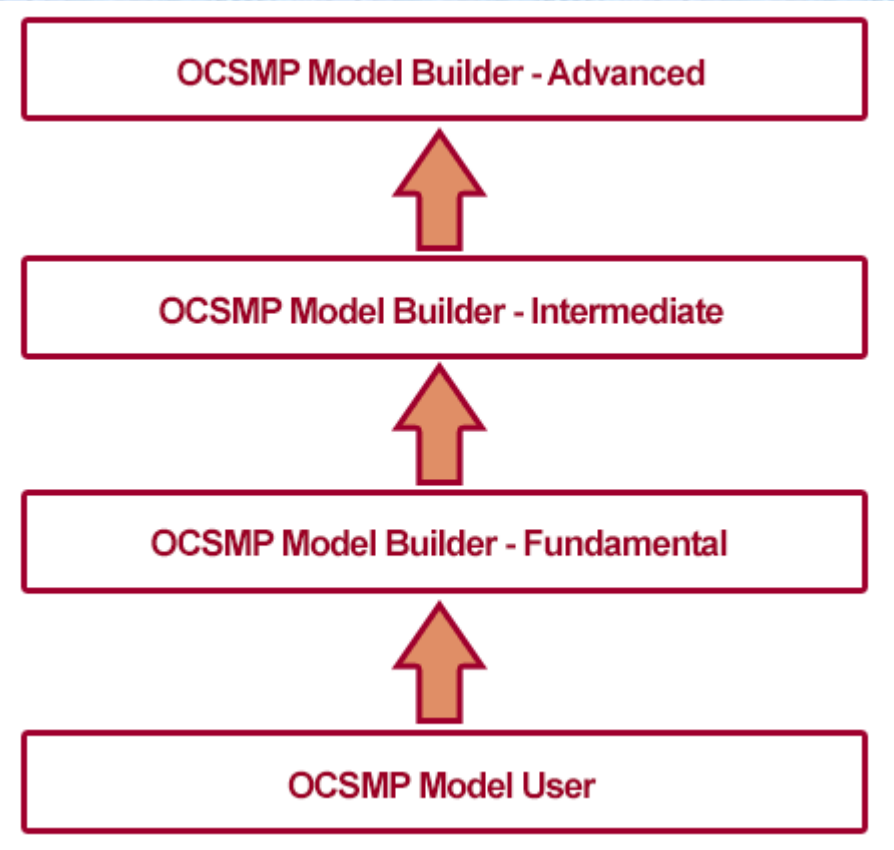
https://www.nomagic.com/component/phocadownload/category/1-quick-reference-guides?download=3:sysml-quick-reference-guide

Sanford Friedenthal – A Practical Guide to SysML

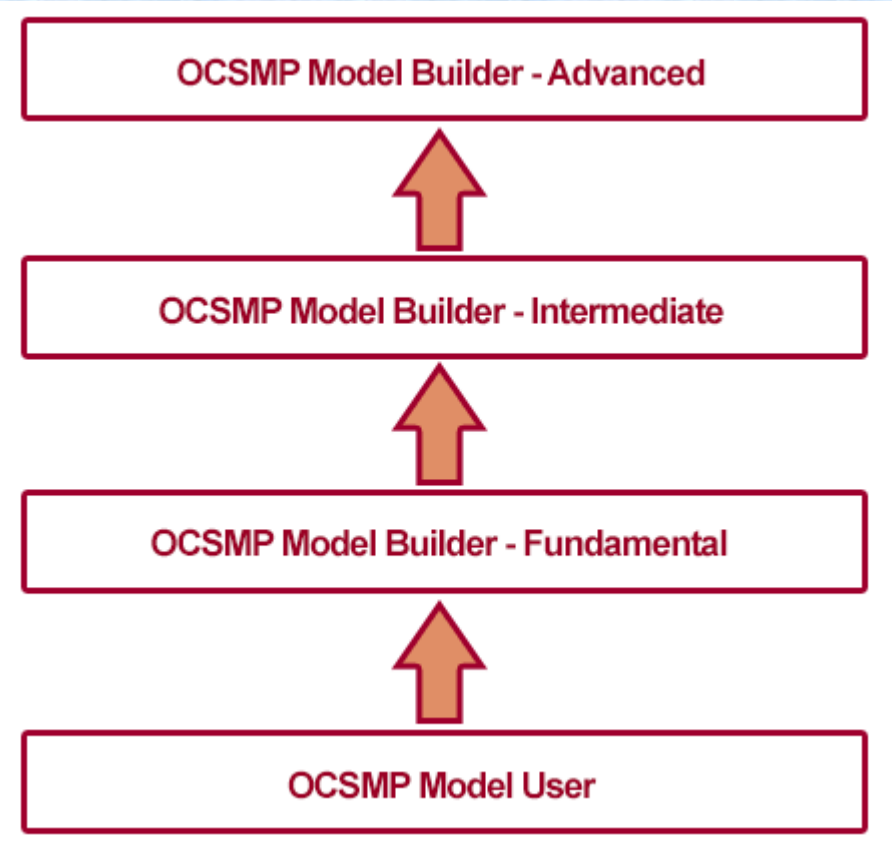


- 3rd Edition
- Sanford Friedenthal, Alan Moore, & Rick Steiner
- Part I – MBSE & SysML Overview
- Part II – SysML Language Description
- Part III – SysML Examples
- Part IV – Transitioning to MBSE
- Ideal for intermediate & advanced users of SysML
- https://www.amazon.com/Practical-Guide-SysML-Modeling-Language/dp/0128002026/ref=pd_lpo_sbs_14_t_0?_encoding=UTF8&psc=1&refRID=S81VX56RD56Z3TX2T4TS

Object Management Group (OMG) Certifications



Object Management Group (OMG) Certifications



10-15 Recommended Resources on OMG website
+
Advanced Experience (~5 years)

Sanford Friedenthal – A Practical Guide to SysML
+
Intermediate Experience (1-2 years)

Lenny Delligatti –
OCSMP Accelerator™ SysML Training Course
+
Beginning Experience (6 months)

Object Management Group (OMG) Certifications

- OMG provides certificate of completion for each level
- Complements INCOSE SEP program
- OCSMP Website: https://www.omg.org/ocsmp/
- Pearson Vue Test Centers – Many throughout DFW
- Certification does not expire
- Cost: $200 per level

Conclusion

Concluding Thoughts

- MBSE is necessary to effectively design and develop a modern system.
- MBSE will play a greater role in the future of systems engineering.
- We should learn more about SysML.
- Plenty of resources are available for learning and training.
- SysML will help develop and enhance your systems engineering career.
- You should leave with a desire to learn more and apply SysML to your systems engineering work.

Contact Information

- Paul White
  - BAE/KIHOMAC
  - E-mail: paul.white@kihomac.com
  - Phone: 385-393-2137