Systems Modeling Language (SysML) Overview

SysML Merge Team (SMT)

March 16, 2006

Draft

These slides are in process of development by the SMT team and are subject to change as the SysML specification is finalized. Please check for current SysML status at syseng.omg.org.

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Caveat

- This material is based on Draft V0.99 of the SysML specification and is still subject to change prior to adoption

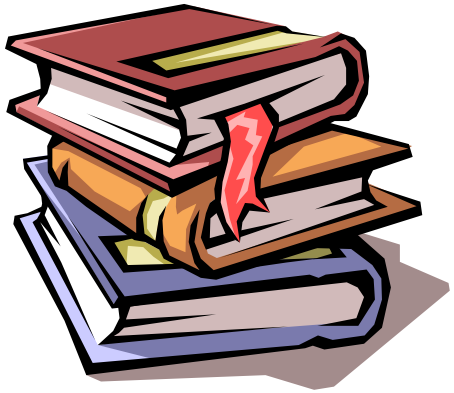
Topics

- Motivation & Background
- Diagram Overview
- SysML Modeling as Part of an SE Process
- SysML in a Standards Framework
- Transitioning to SysML
- Summary

Motivation & Background

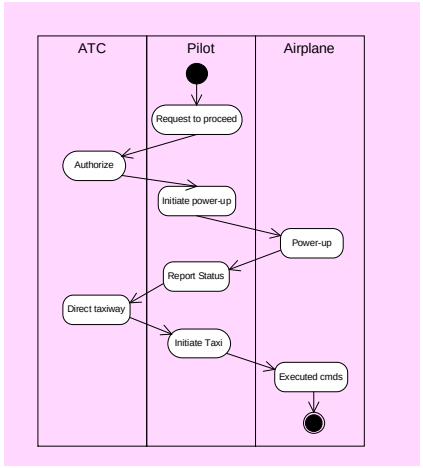
SE Practices for Describing Systems

Past



- Specifications
- Interface requirements
- System design
- Analysis & Trade-off
- Test plans

Future

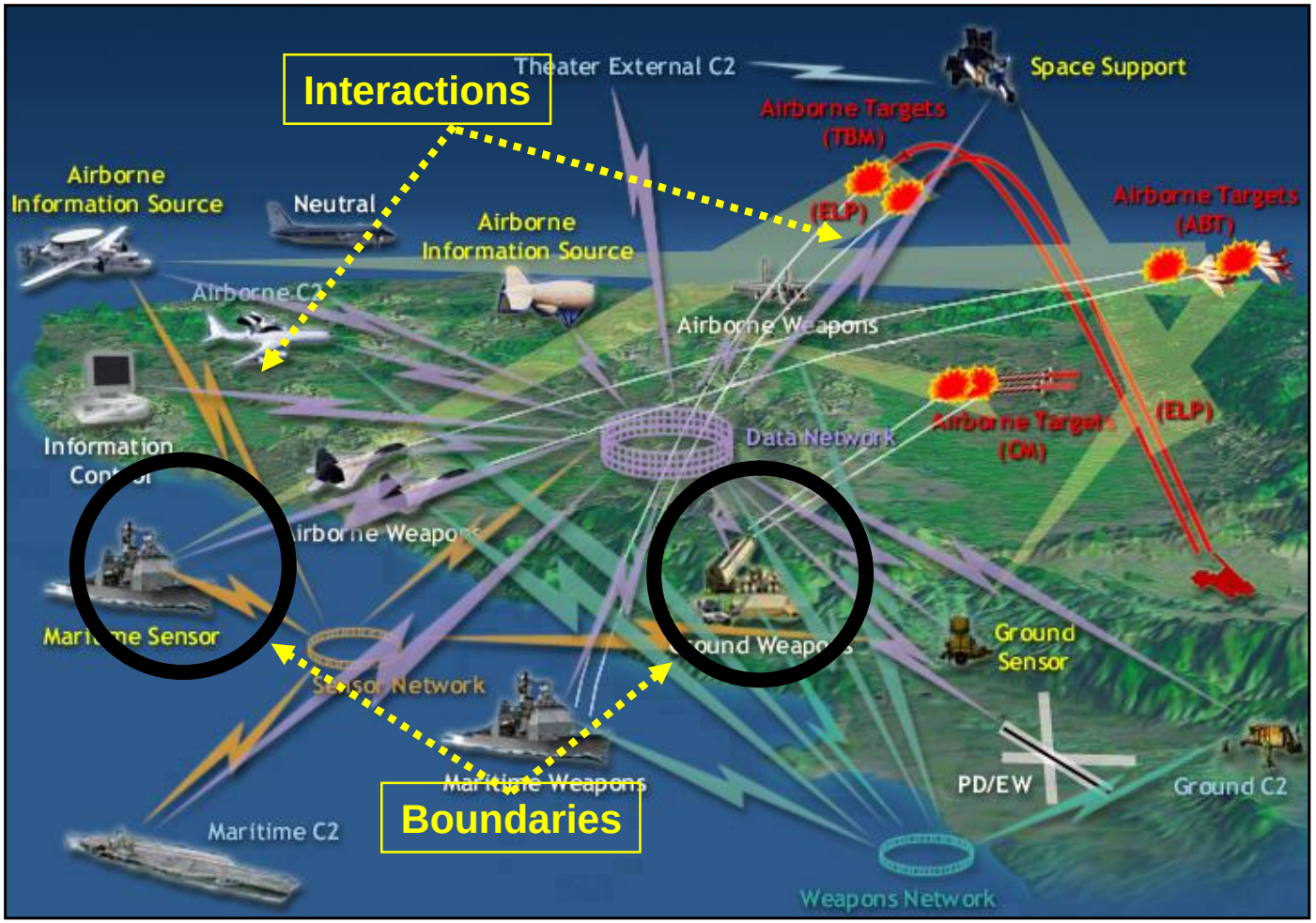


Moving from Document centric to Model centric

Model Based Engineering Benefits

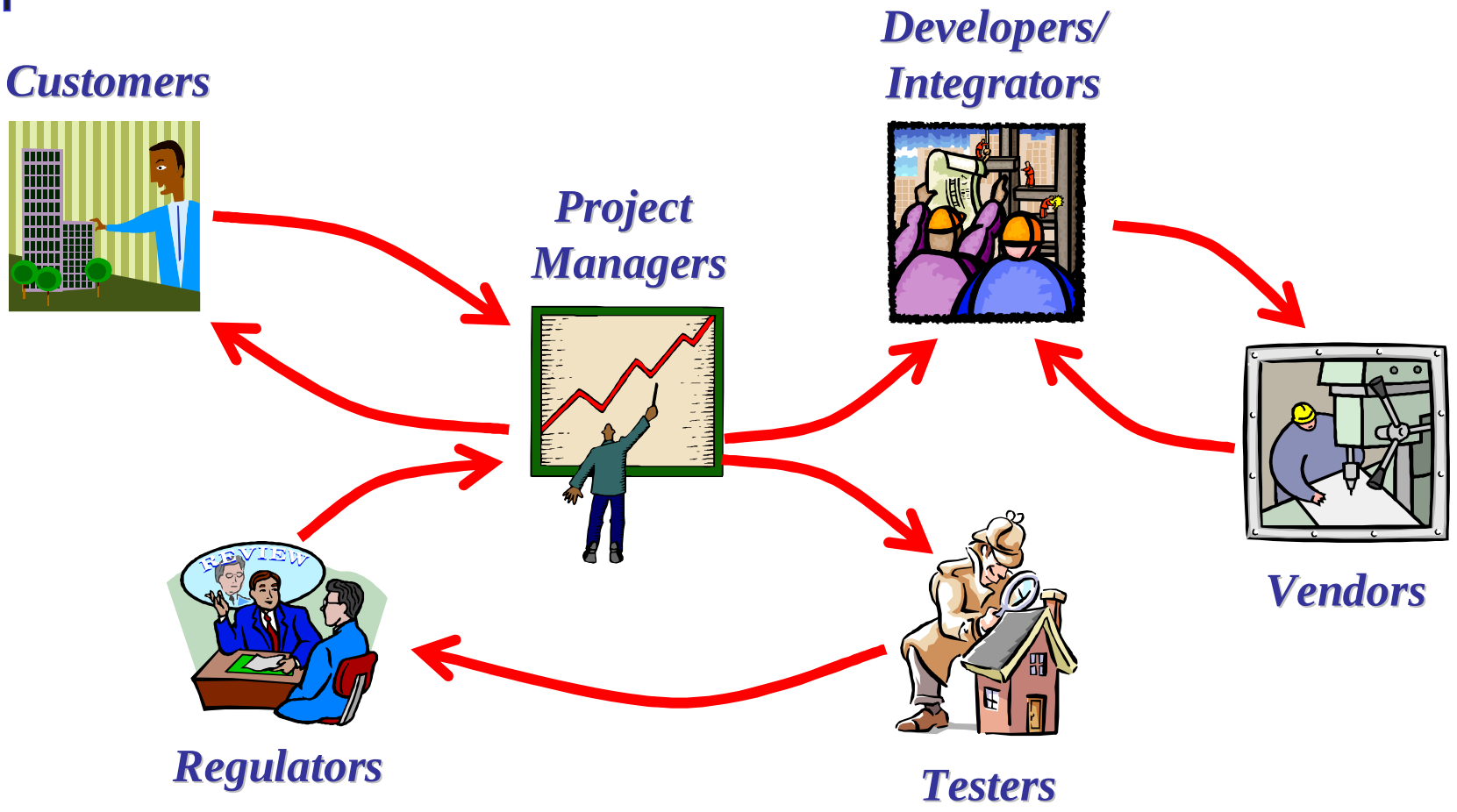
- Improved communications
- Improved design quality
  - Reduced errors and ambiguity
  - More complete representation
- Reduced maintenance costs
- Enhanced knowledge capture

System-of-Systems



Modeling Needed to Manage System Complexity

Stakeholders Involved in System Acquisition



Modeling Needed to Improve Communications

What is SysML?

- A graphical modeling language in response to the UML for Systems Engineering RFP developed by the OMG, INCOSE, and AP233
  - a UML Profile that represents a subset of UML 2 with extensions
- Supports the specification, analysis, design, verification and validation of systems that include hardware, software, data, personnel, procedures, and facilities
- Supports model and data interchange via XMI and the evolving AP233 standard (in-process)

SysML is Critical Enabler for Model Driven SE

UML/SysML Status

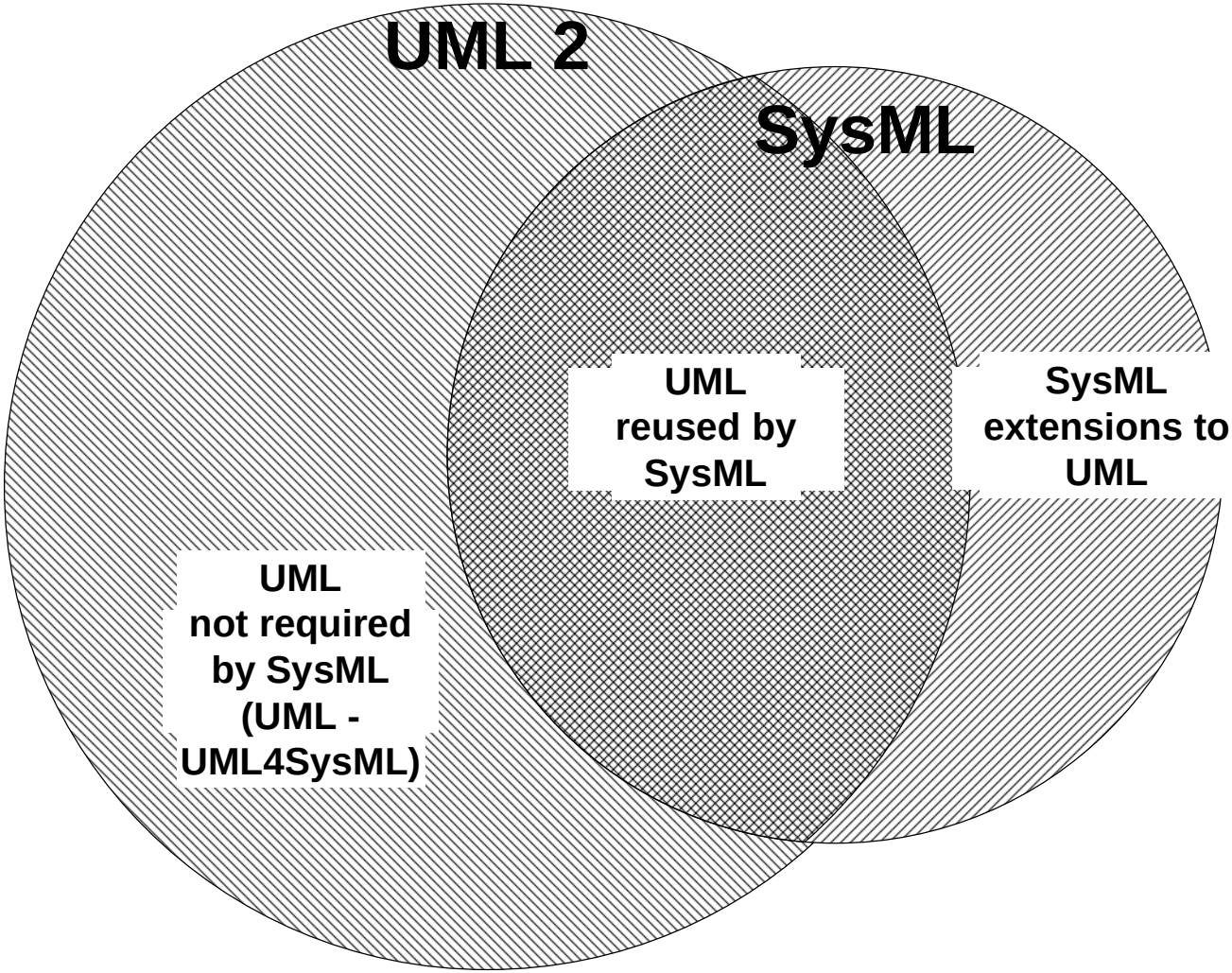
- UML V2.0
  - Updated version of UML that offers significant capability for systems engineering over previous versions
  - Finalized in 2005 (formal/05-07-04)
- UML for Systems Engineering (SE) RFP
  - Established the requirements for a system modeling language
  - Issued by the OMG in March 2003
- SysML
  - Industry Response to the UML for SE RFP
  - Addresses most of the requirements in the RFP
  - Current version 0.99 and expected to begin adoption in April 06
  - Being implemented by 5 vendors

SysML Merge Team (SMT)

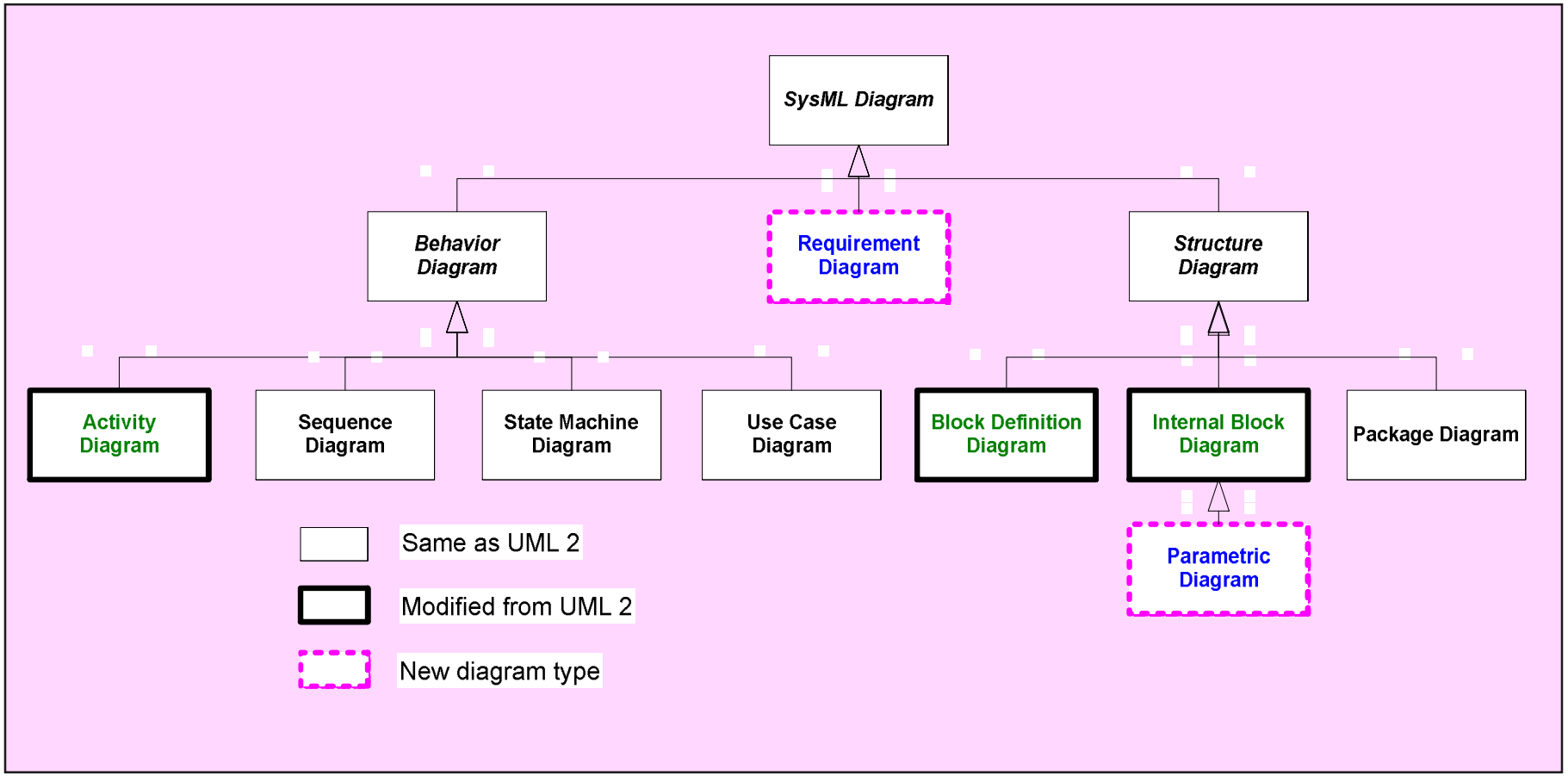
- Industry & Government
  - American Systems, BAE SYSTEMS, Boeing, Deere & Company, EADS-Astrium, Eurostep, Lockheed Martin, Motorola, NIST, Northrop Grumman, oose.de, Raytheon, THALES
- Vendors
  - Artisan, EmbeddedPlus, Gentleware, IBM, I-Logix, Mentor Graphics, PivotPoint Technology, Sparx Systems, Telelogic, Vitech Corp
- Academia
  - Georgia Institute of Technology
- Liaison Organizations
  - INCOSE, AP233 WG

Diagram Overview

Relationship Between SysML and UML

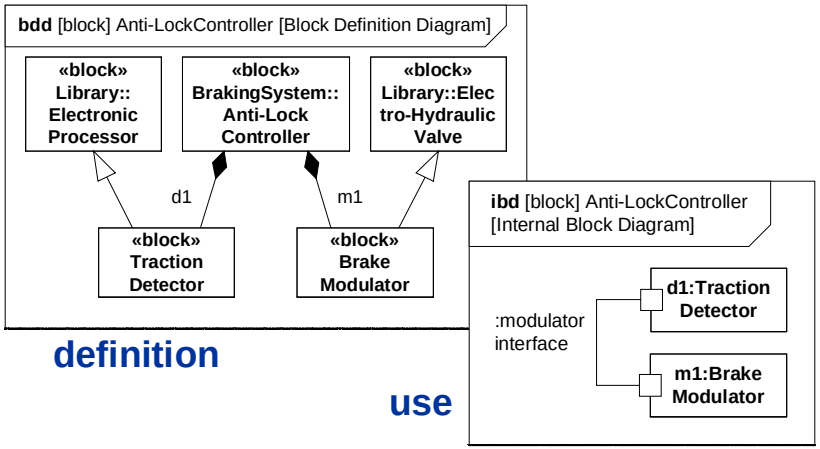


SysML Diagram Taxonomy



4 Pillars of SysML –ABS Example

Structure



definition

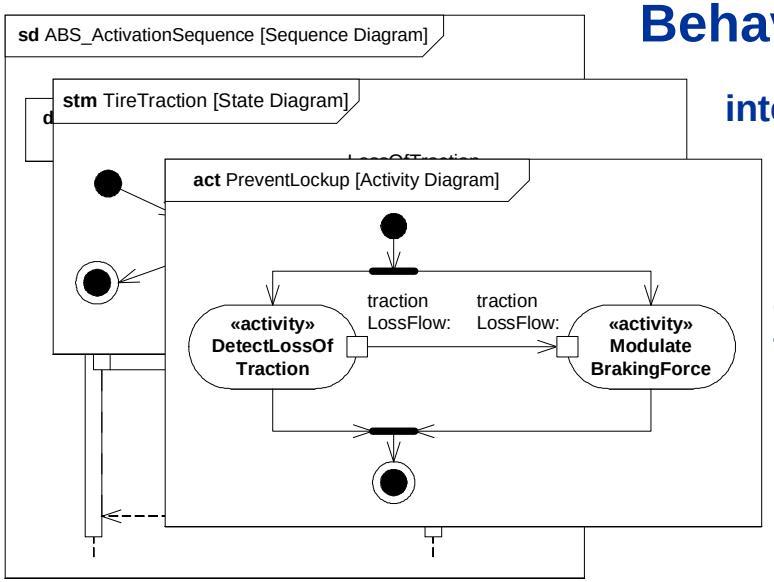
use

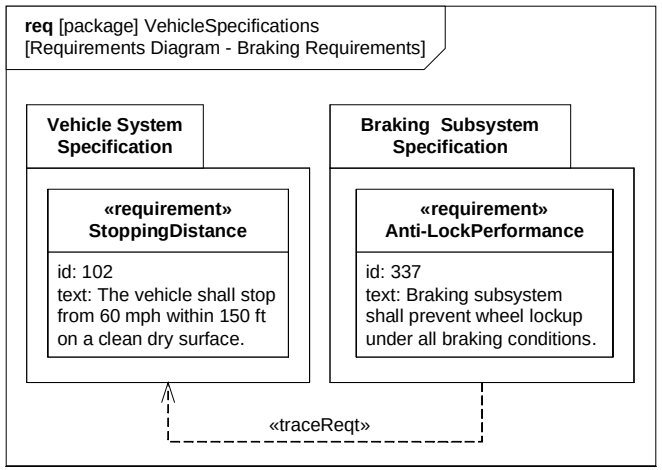
Behavior

interaction

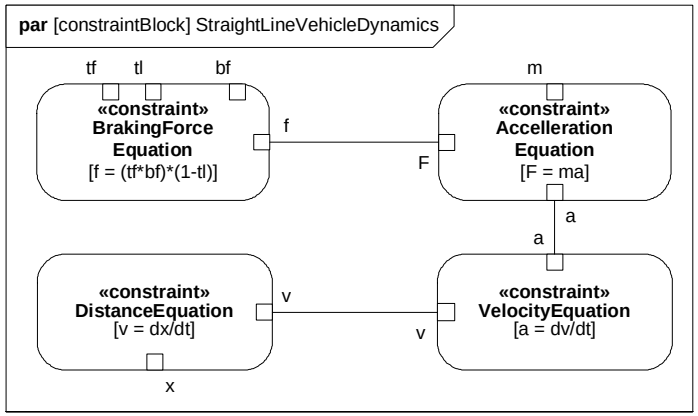
state machine

activity/ function



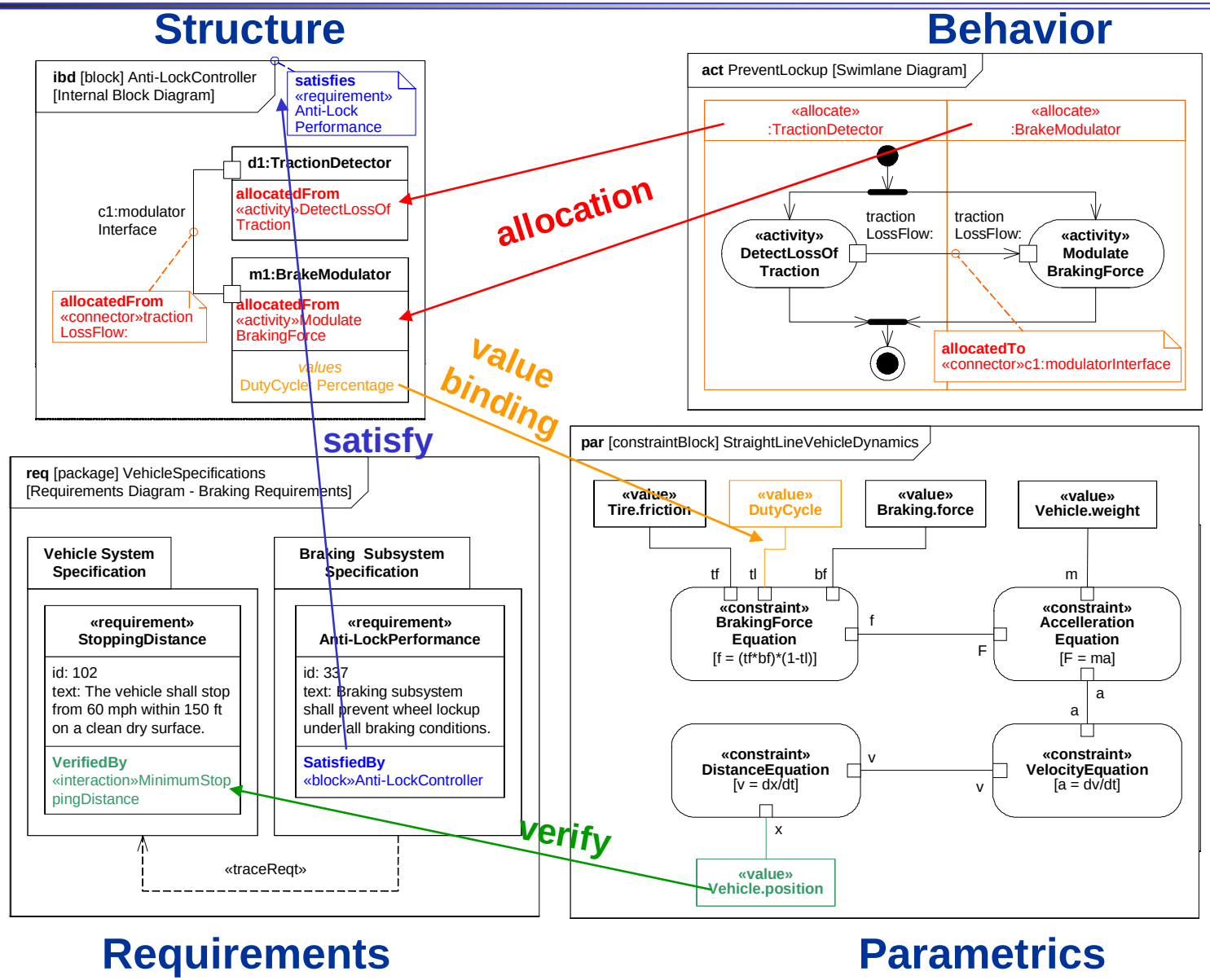


Requirements

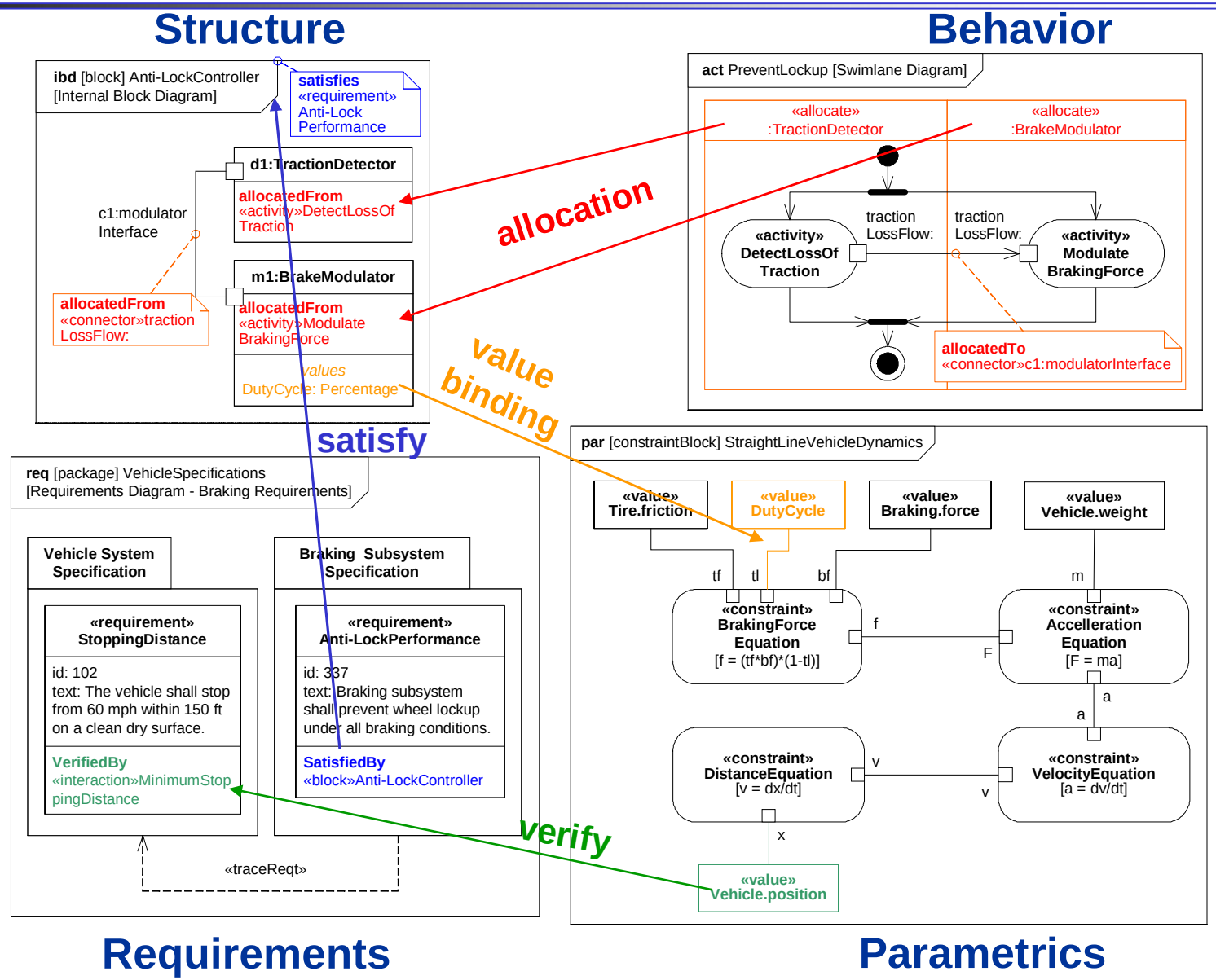


Parametrics

Cross Connecting Model Elements

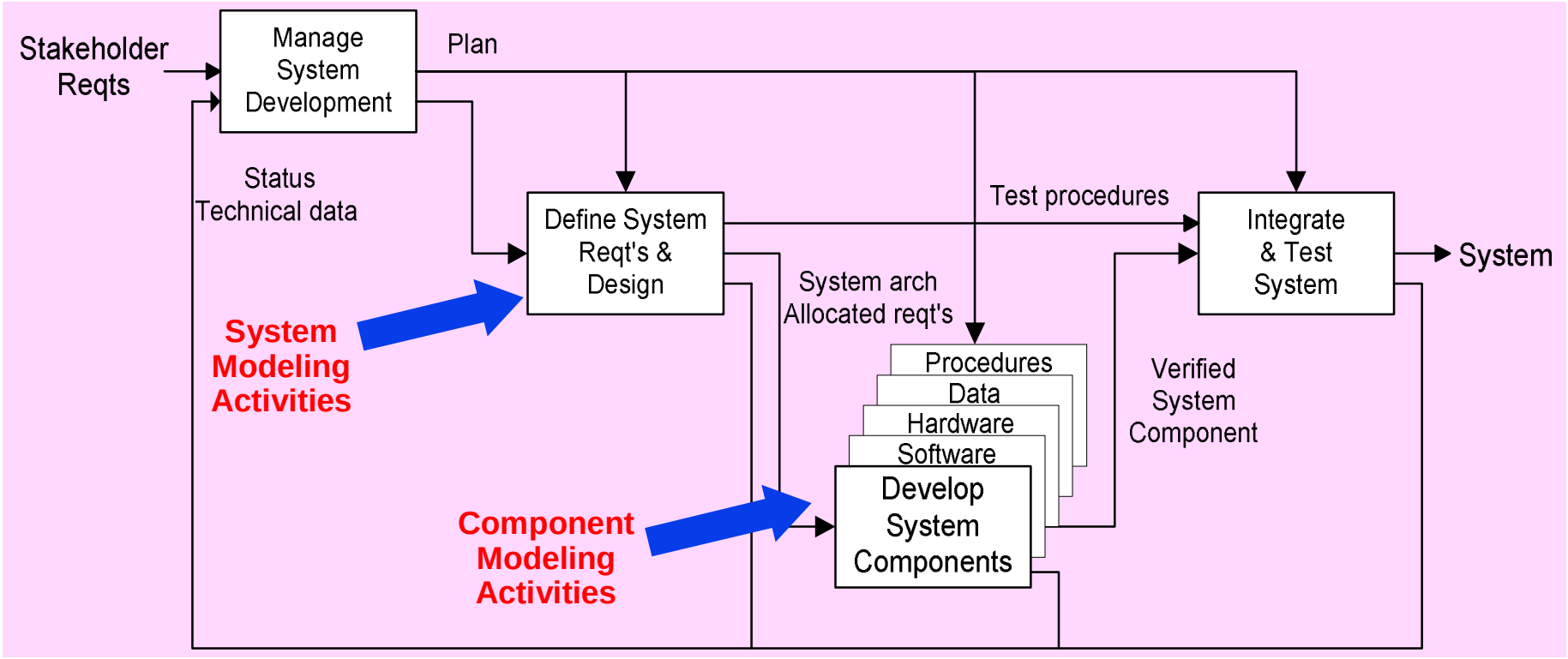


Cross Connecting Model Elements



SysML Modeling as Part of the SE Process

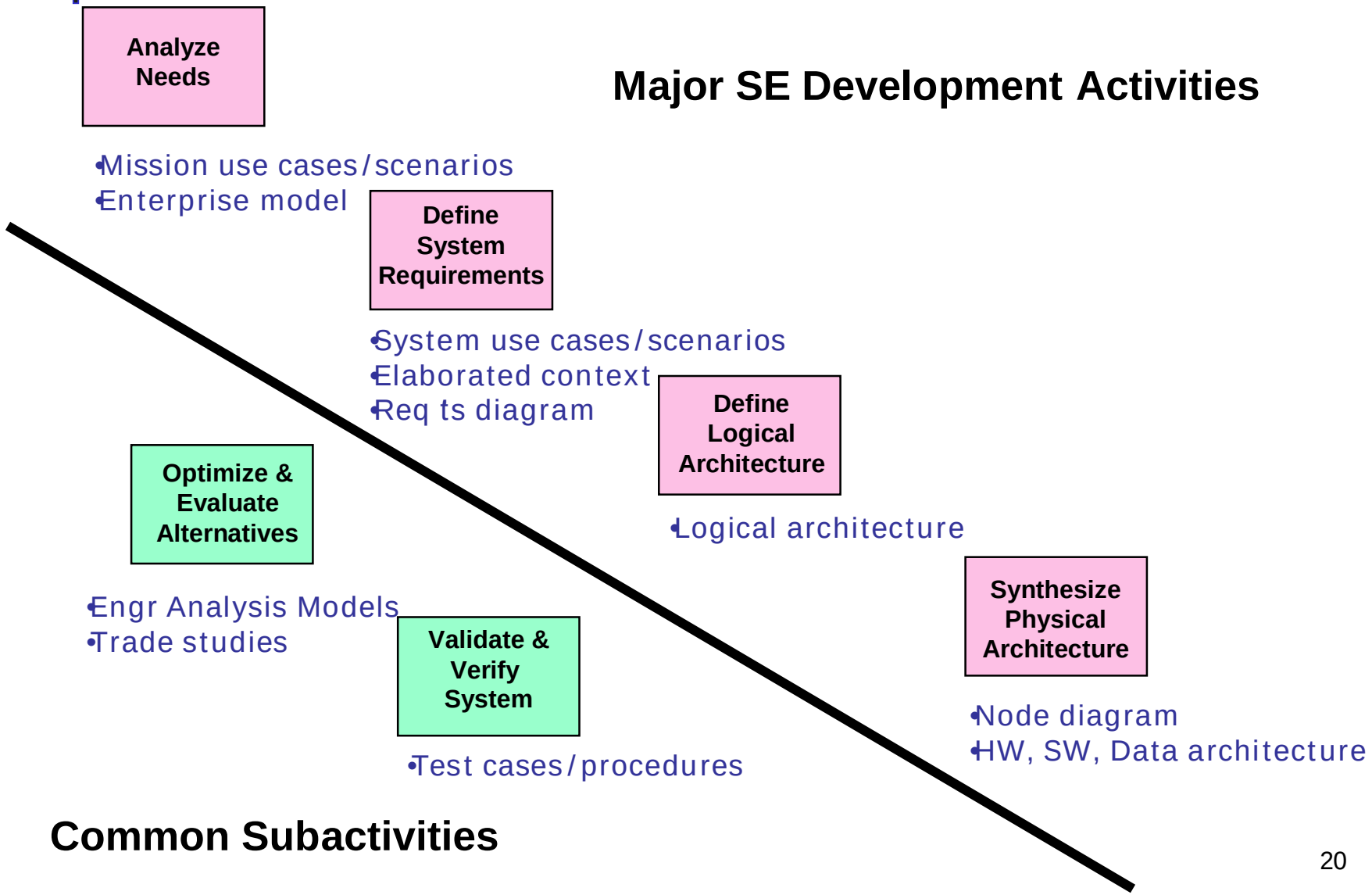
System Development Process



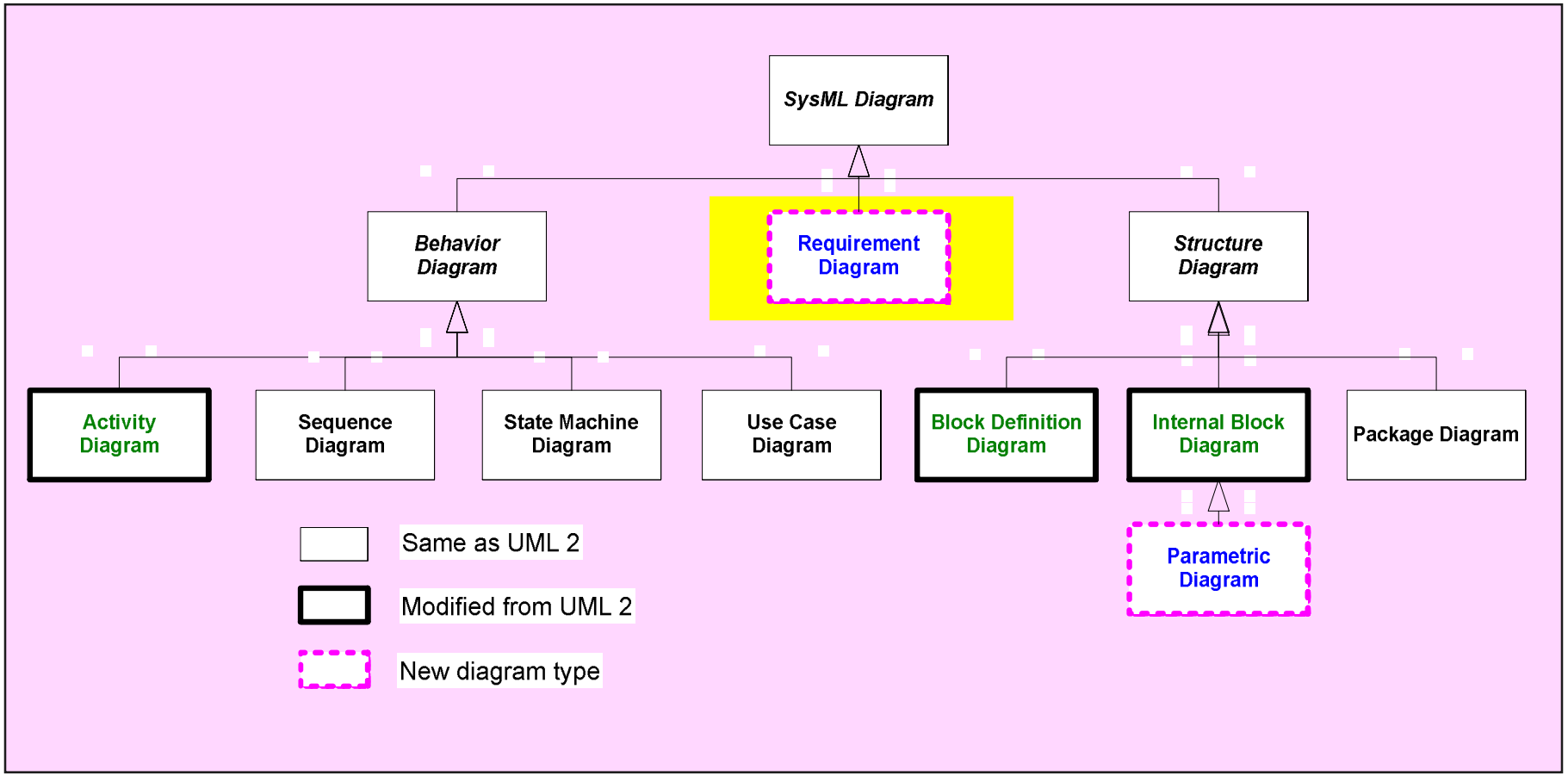
Integrated Product Development (IPD) is essential to improve communications

A Recursive V process that can be applied to multiple levels of the system hierarchy

Typical Systems Modeling Activities

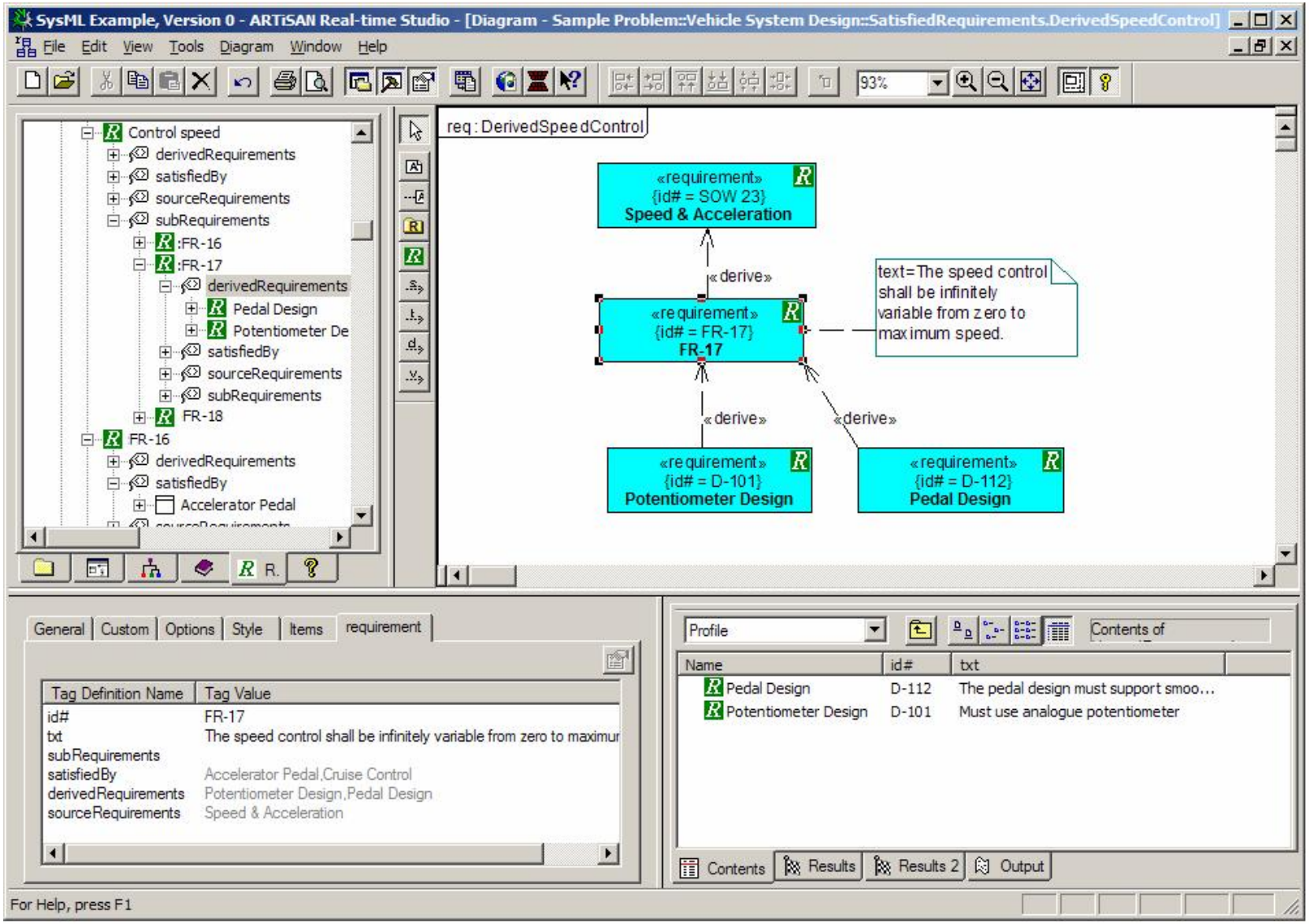


SysML Diagram Taxonomy

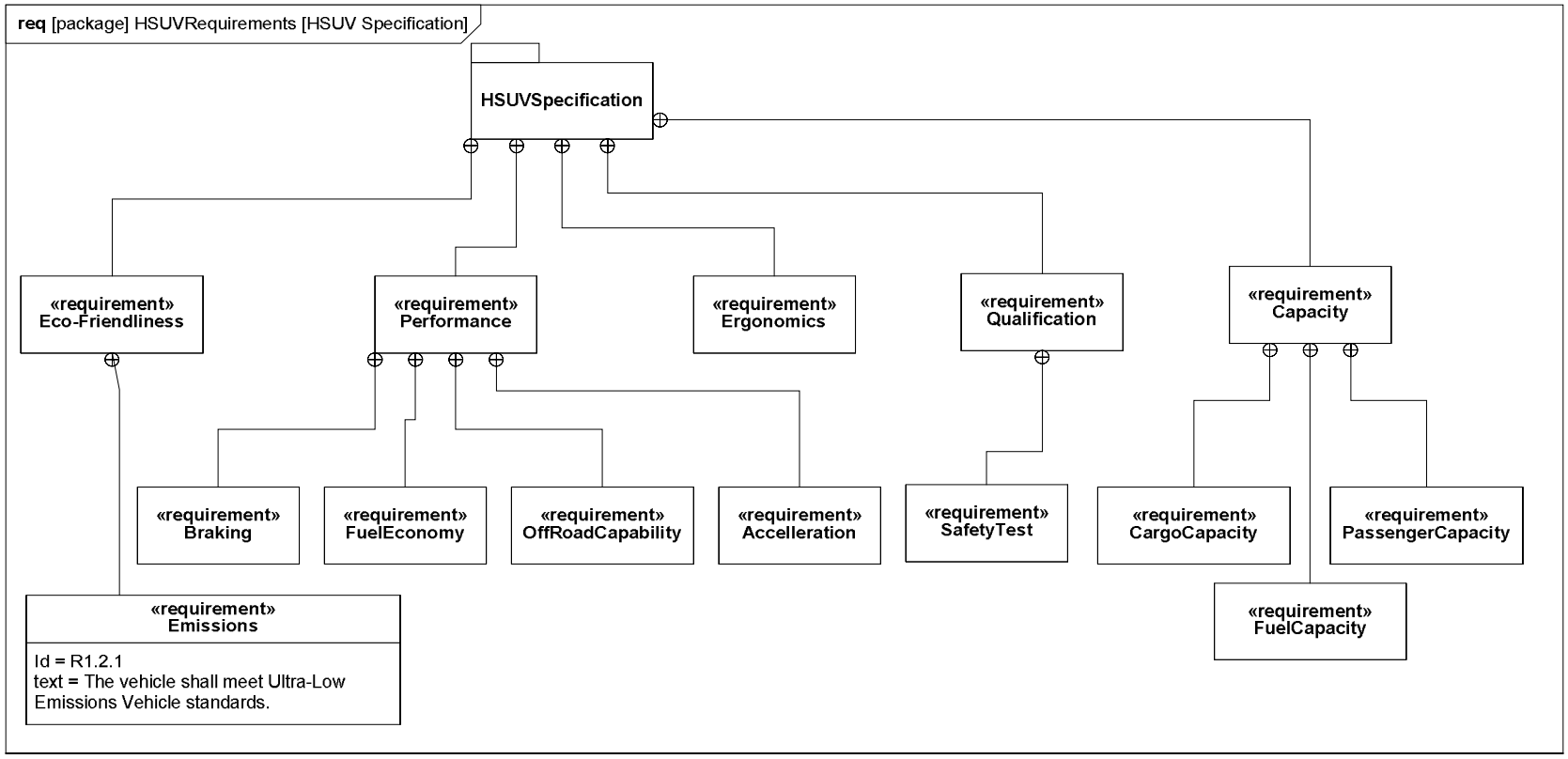


Capturing Requirements in the Model

Artisan Tool

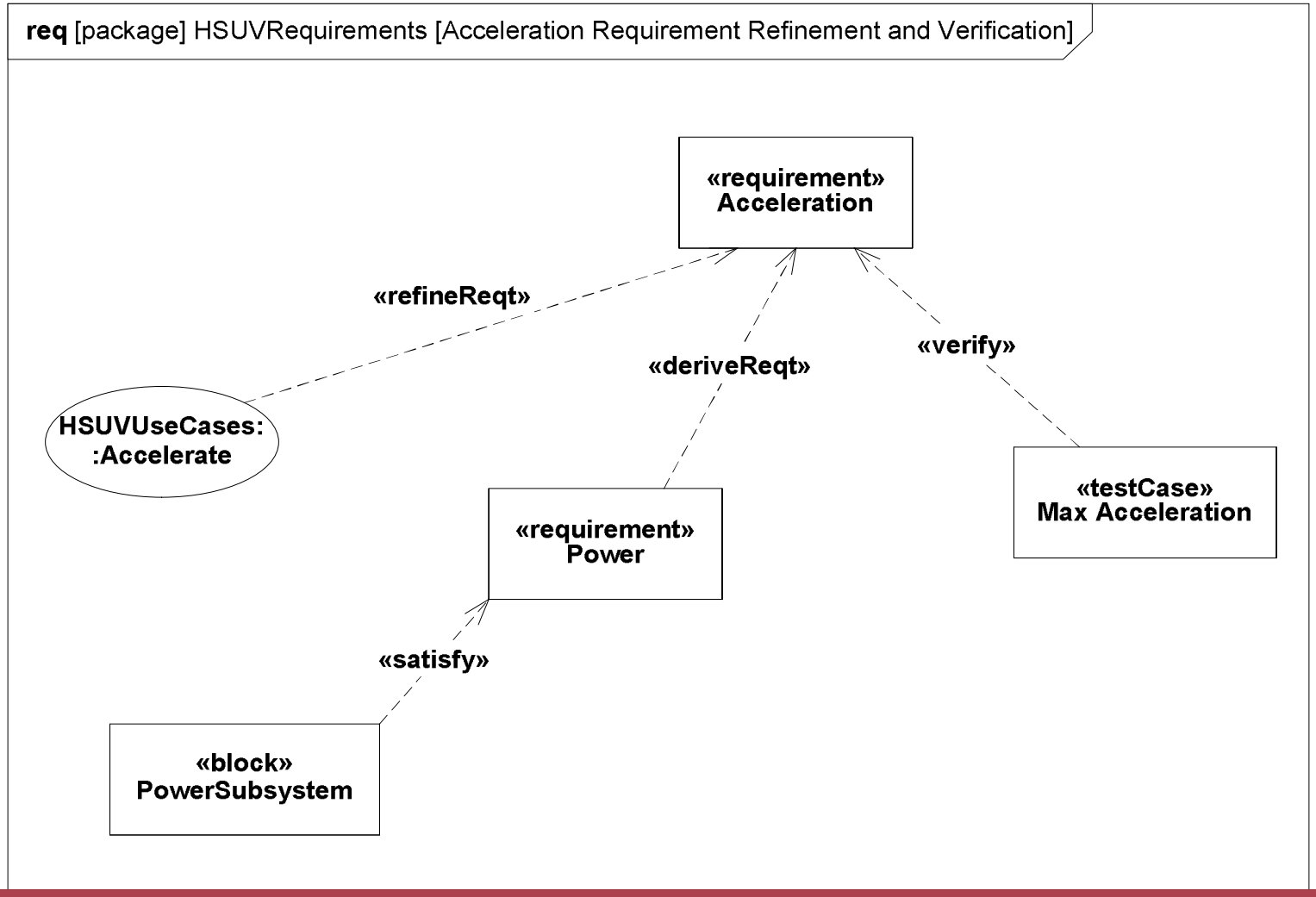


Requirements Breakdown



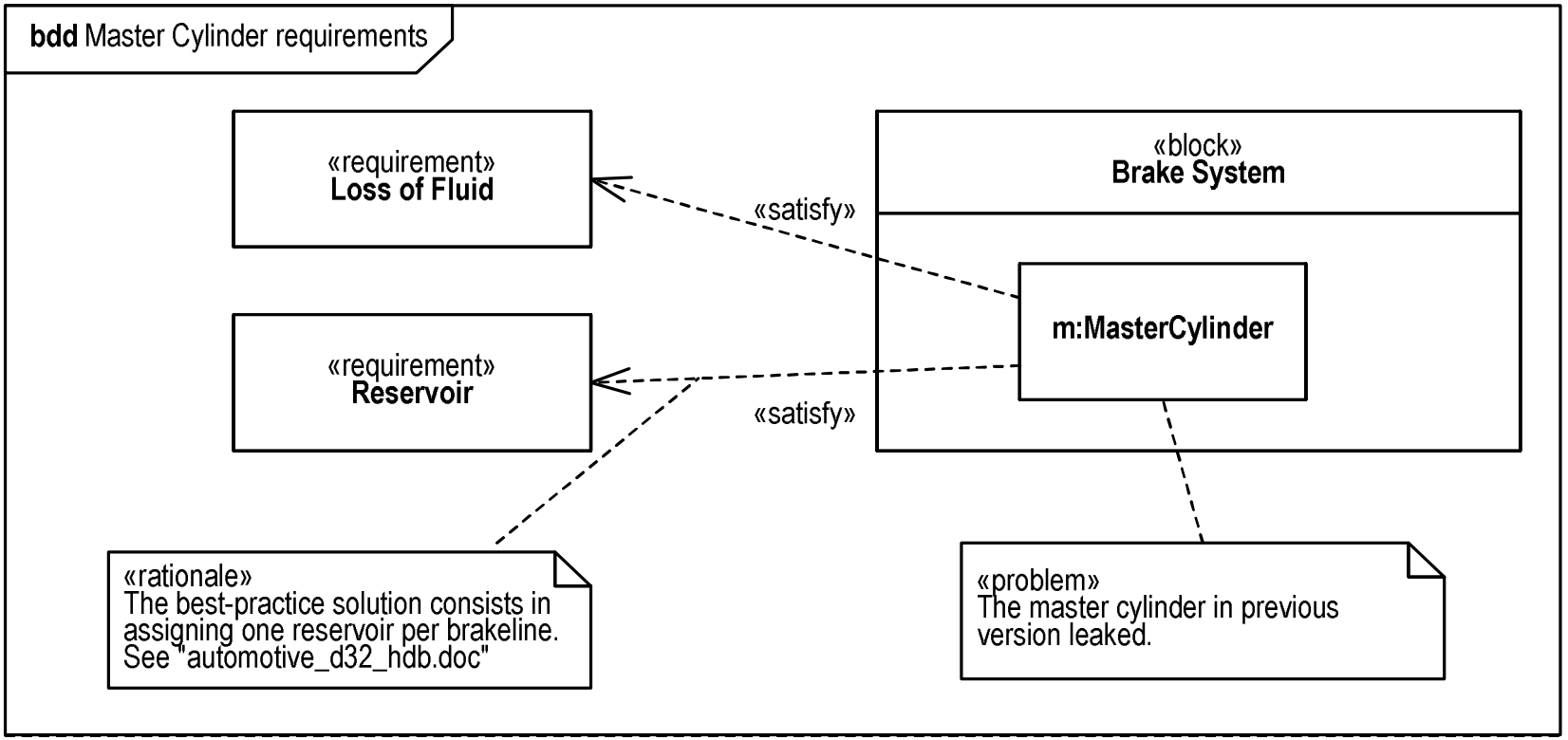
Containment Used to Model the Content of a Specification

Requirements Relationships



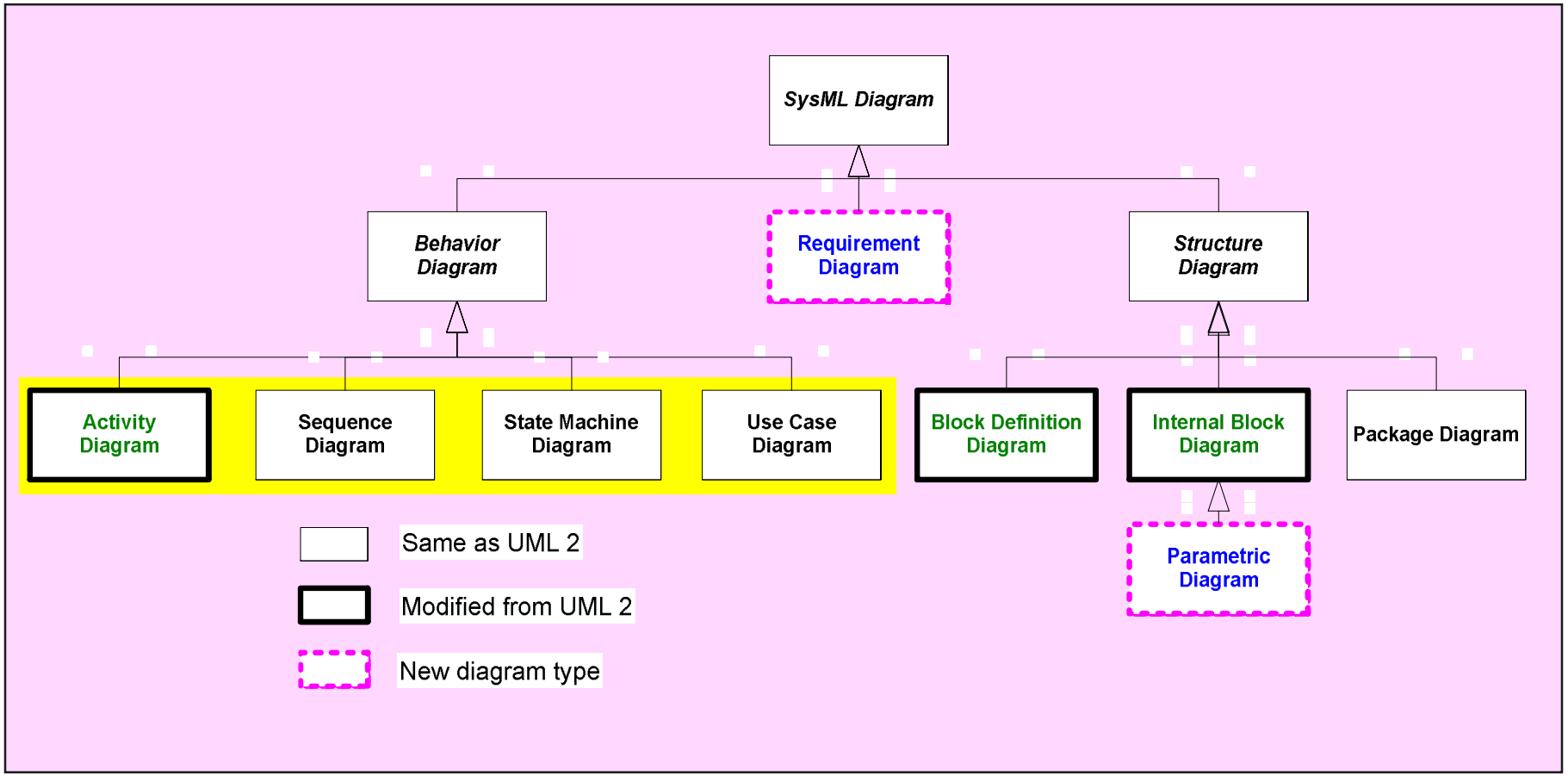
Use of Derive, Satisfy, Verify, & Refine Relationships

Problem and Rationale

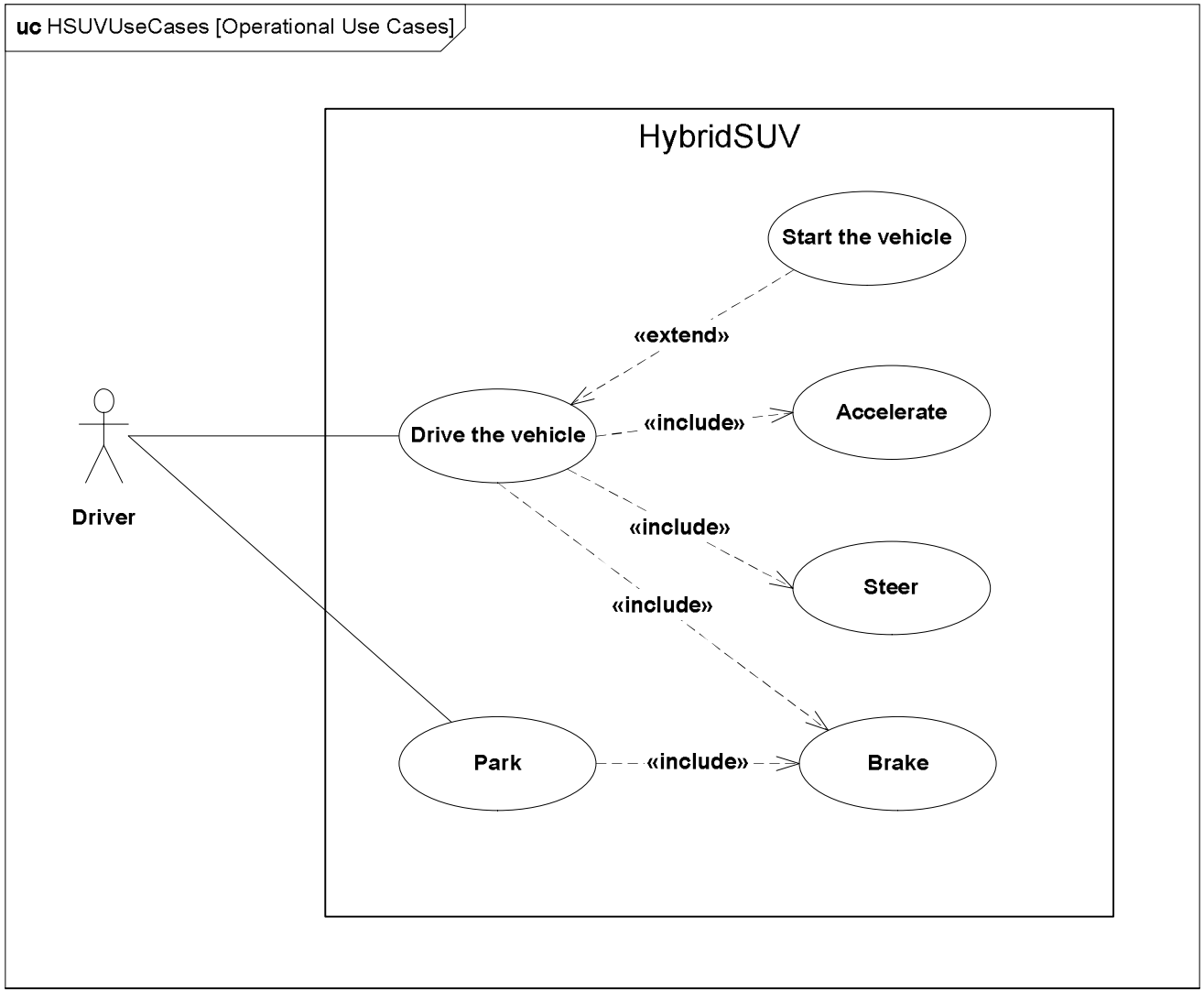


Problem and Rationale can be attached to any Model Element to Capture Issues and Decisions

SysML Diagram Taxonomy



Operational Use Cases

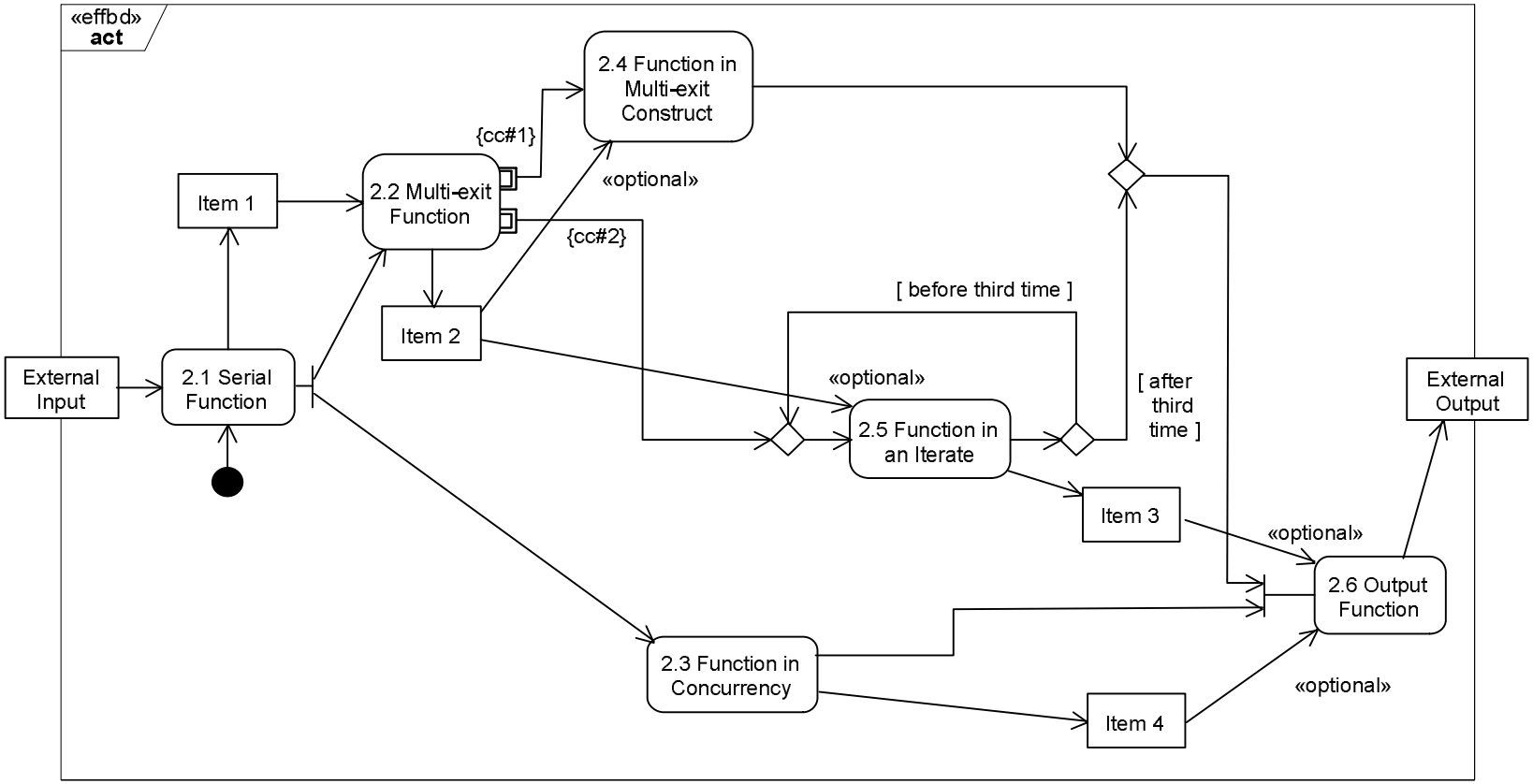


Activities

- Activities used to specify flow of I/O and control
- SysML extensions to Activities
  - Support for continuous flow modeling
  - Alignment of activities with Enhanced Functional Flow Block Diagram

SysML EFFBD Profile

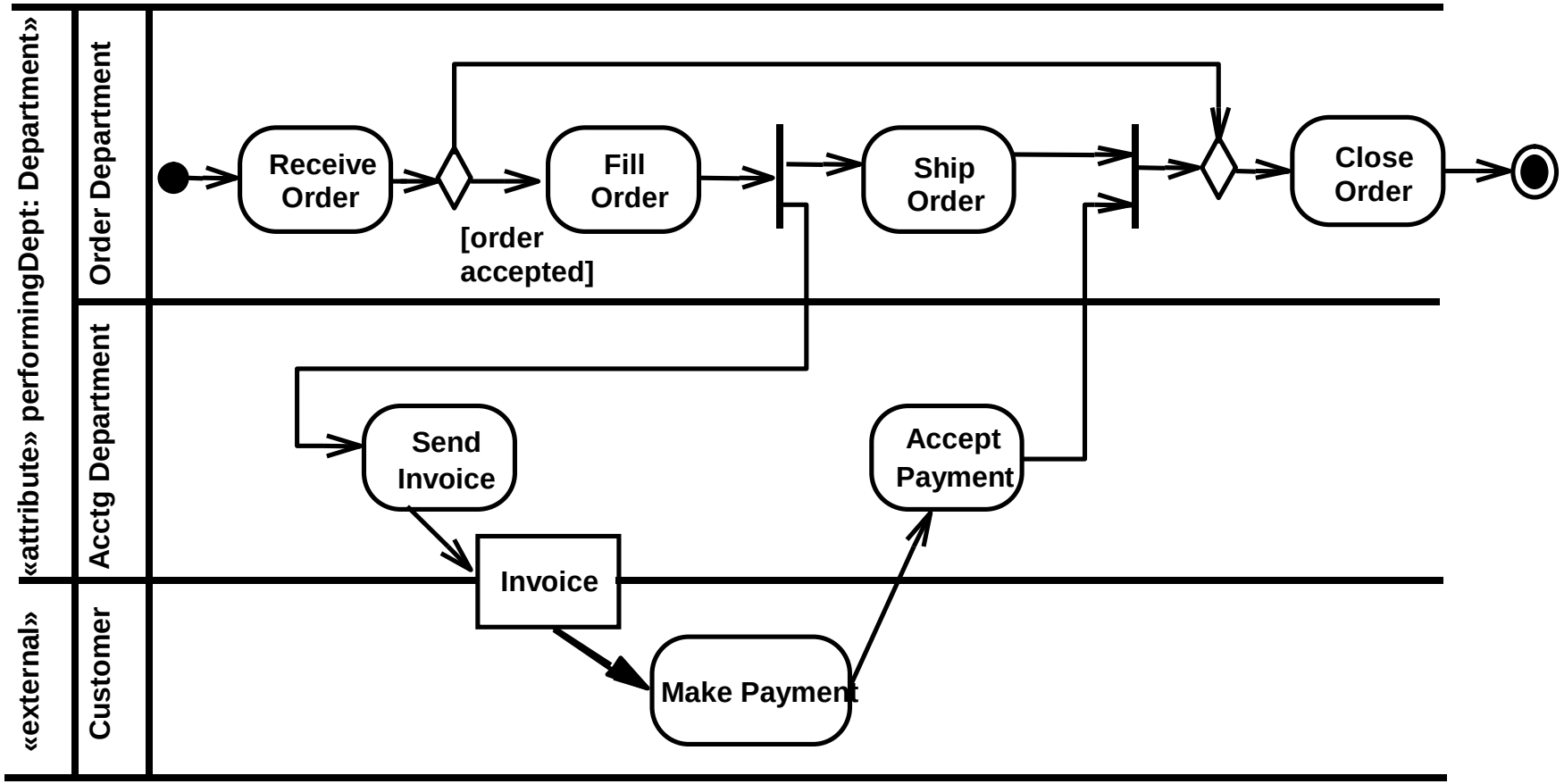
EFFBD - Enhanced Functional Flow Block Diagram



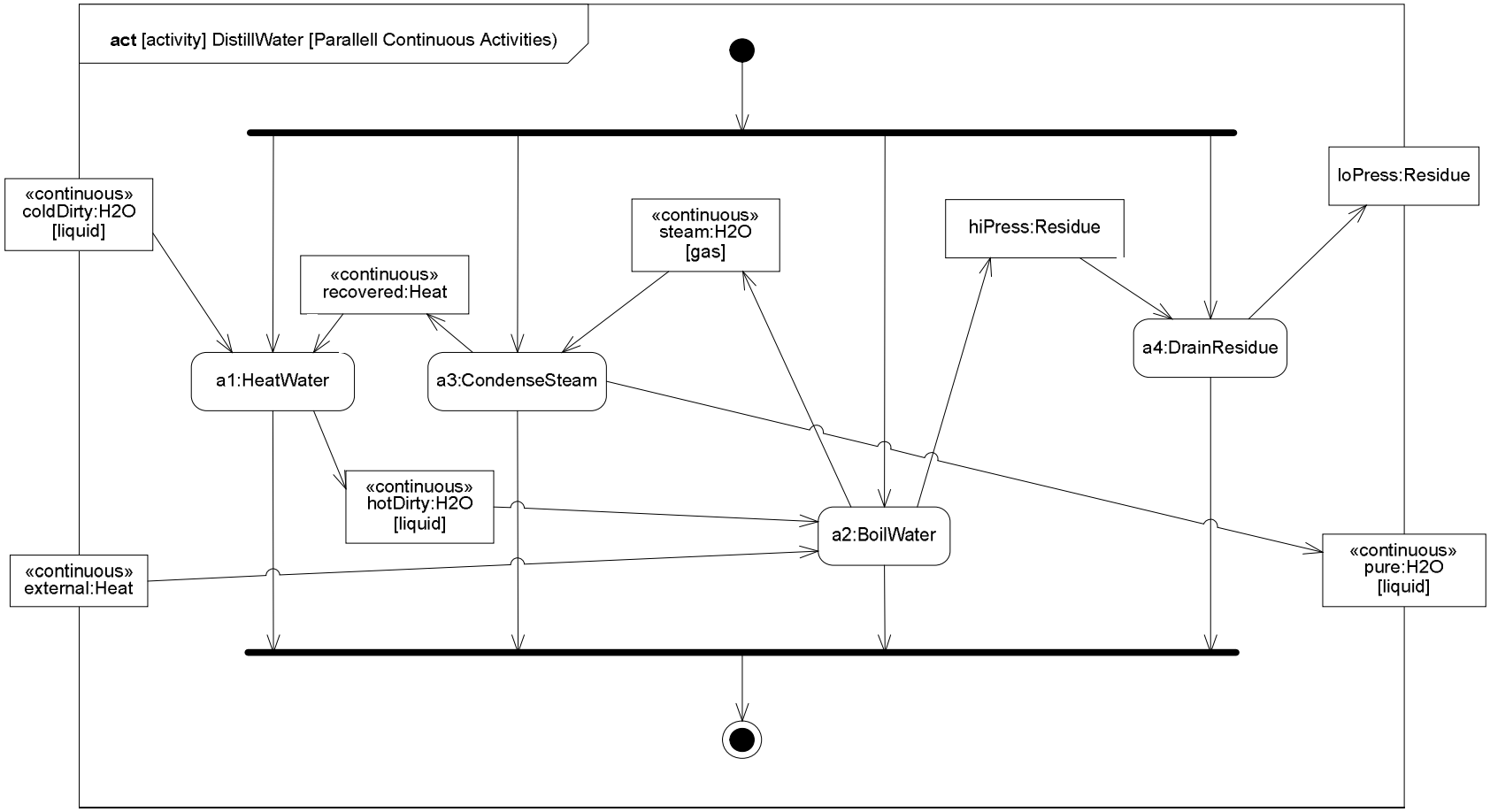
Aligning SysML with Classical Systems Engineering Techniques

Activity Modeling with Swimlanes

- allocation of parts via swim lanes



Distill Water Activity Diagram (Continuous Flow Modeling)

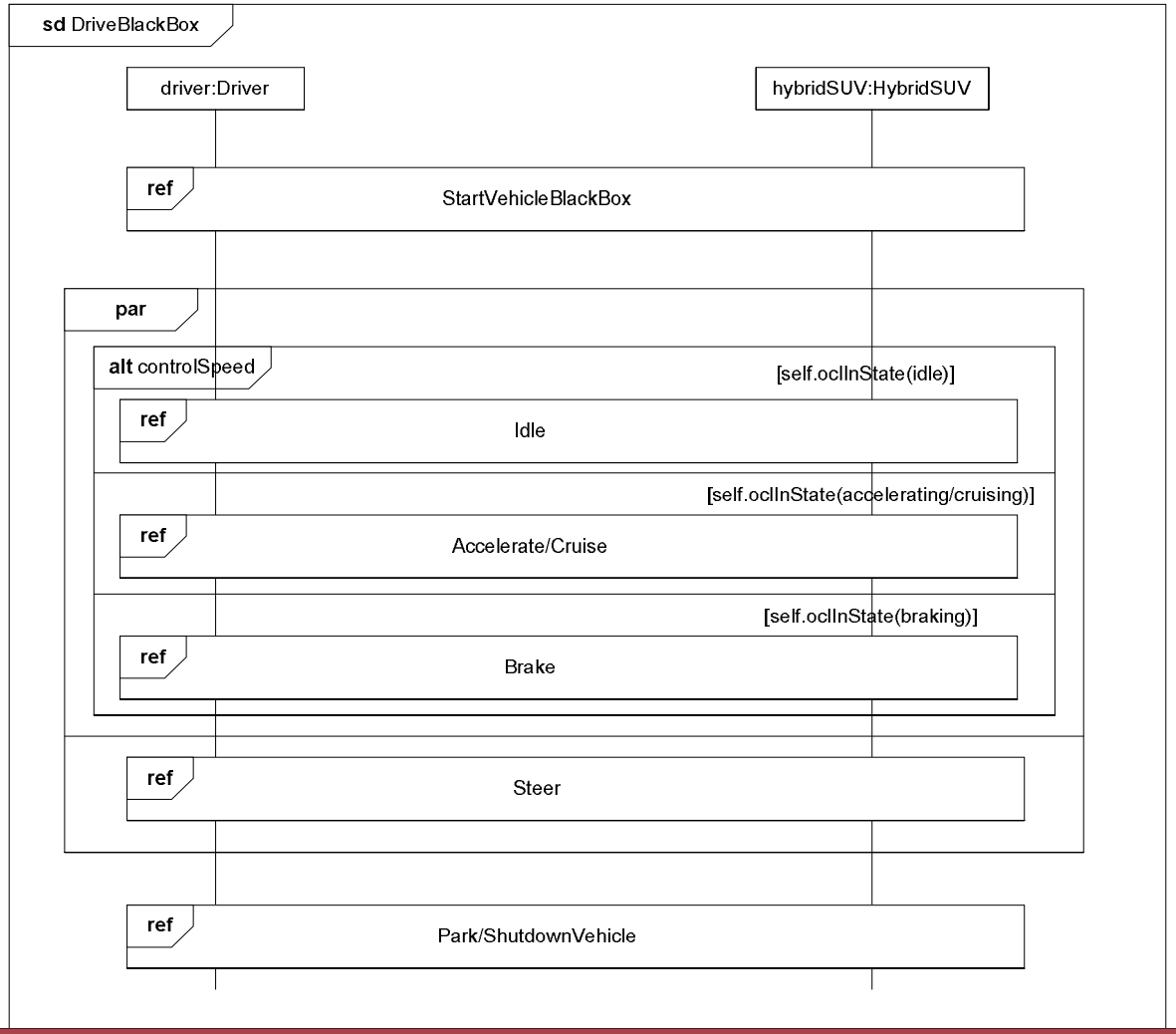


Representing Distiller Example in SysML Using Continuous Flow Modeling

Interactions

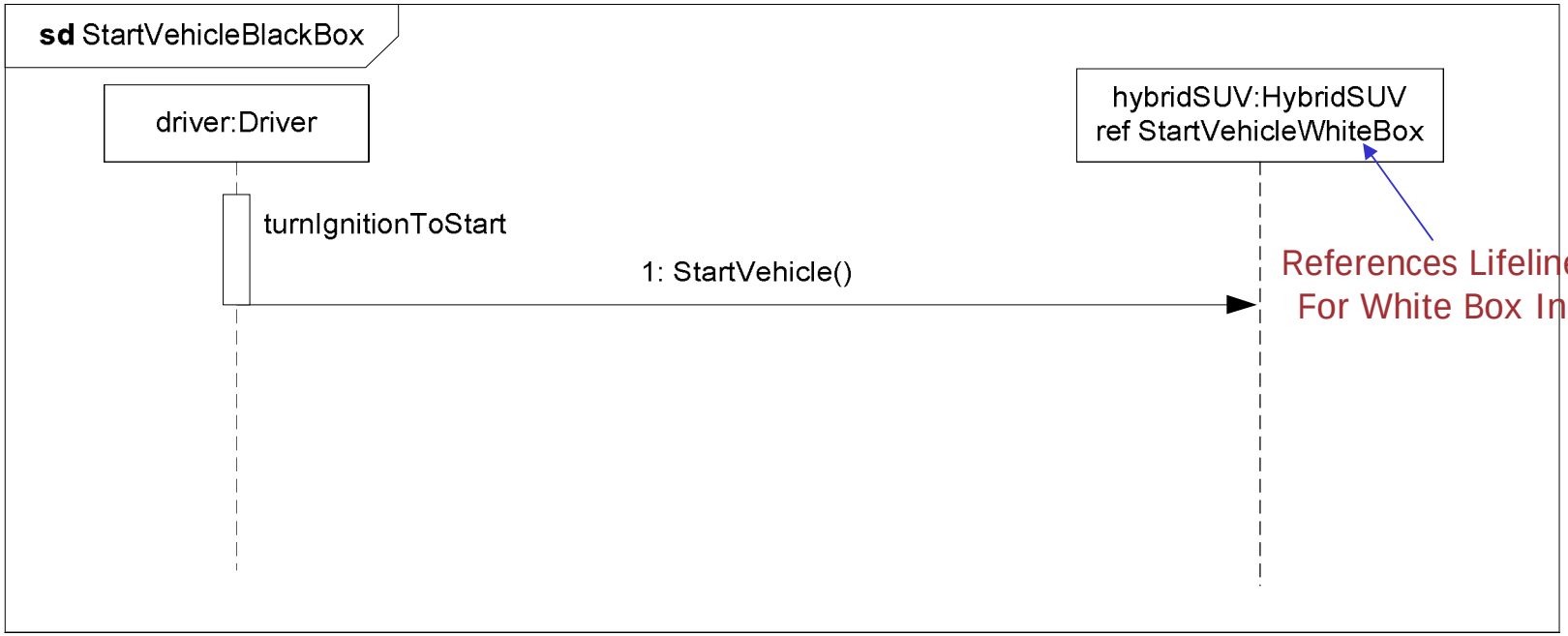
- Sequence diagrams provide representation for message based behavior
  - represents flow of control
- Sequence diagrams provide key mechanisms for representing complex behavior
  - reference sequences
  - control logic
  - lifeline decomposition

Black Box Interaction (Drive)



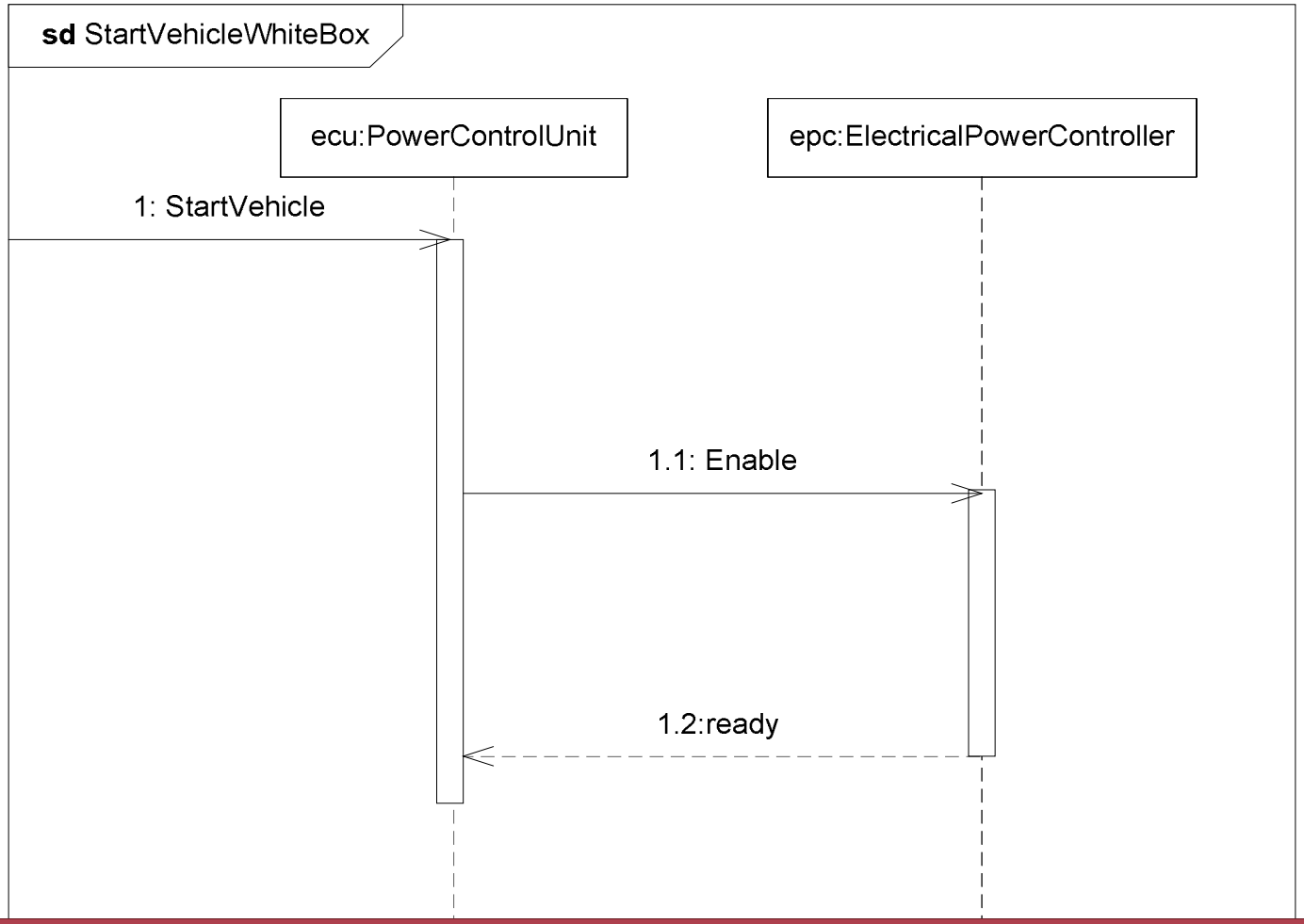
UML 2 Sequence Diagram More Scalable by Supporting Control Logic and Reference Sequences

Black Box Sequence (StartVehicle)



Simple Black Box Interaction

White Box Sequence (StartVehicle)

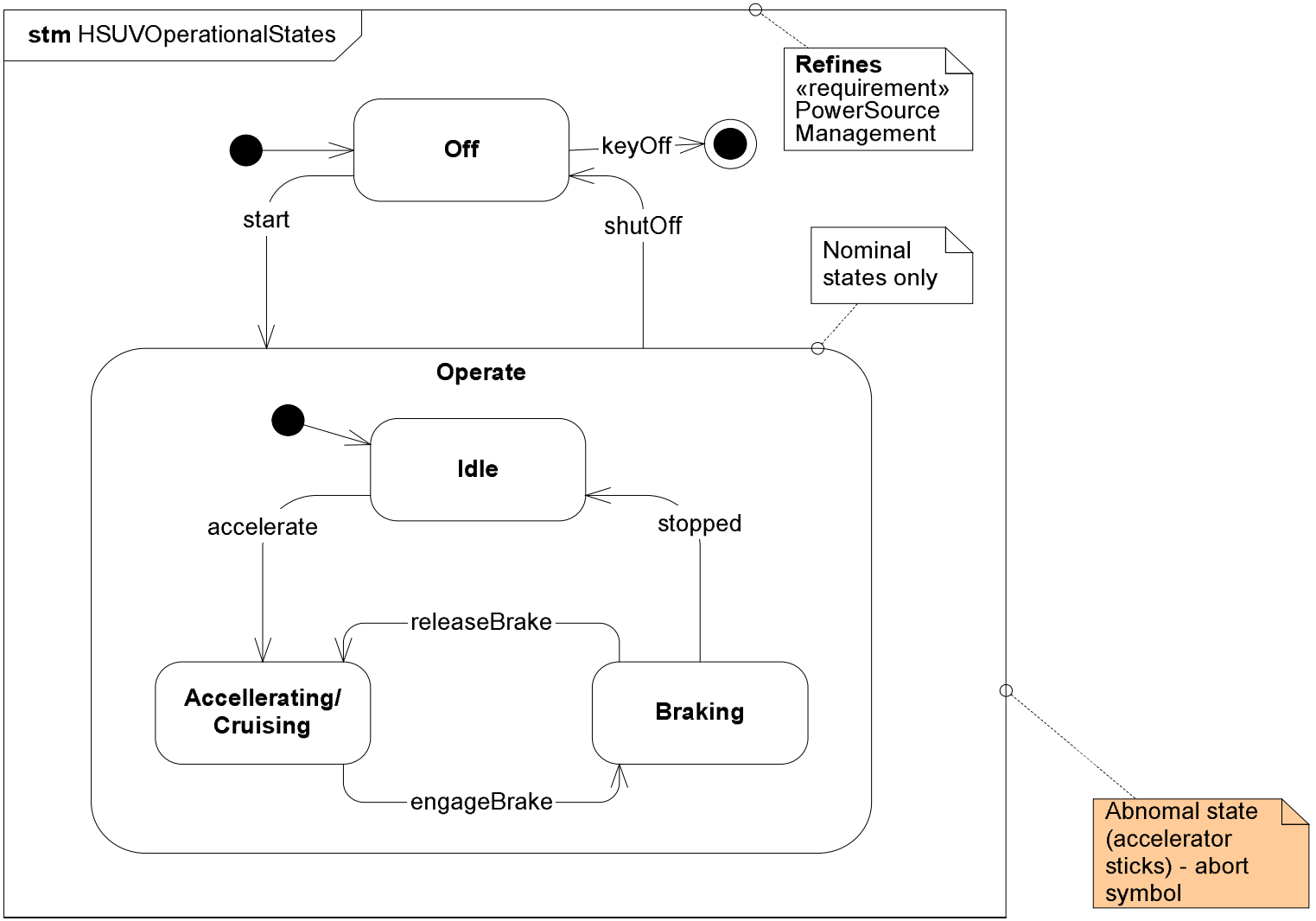


Decomposition of Black Box
Into White Box Interaction

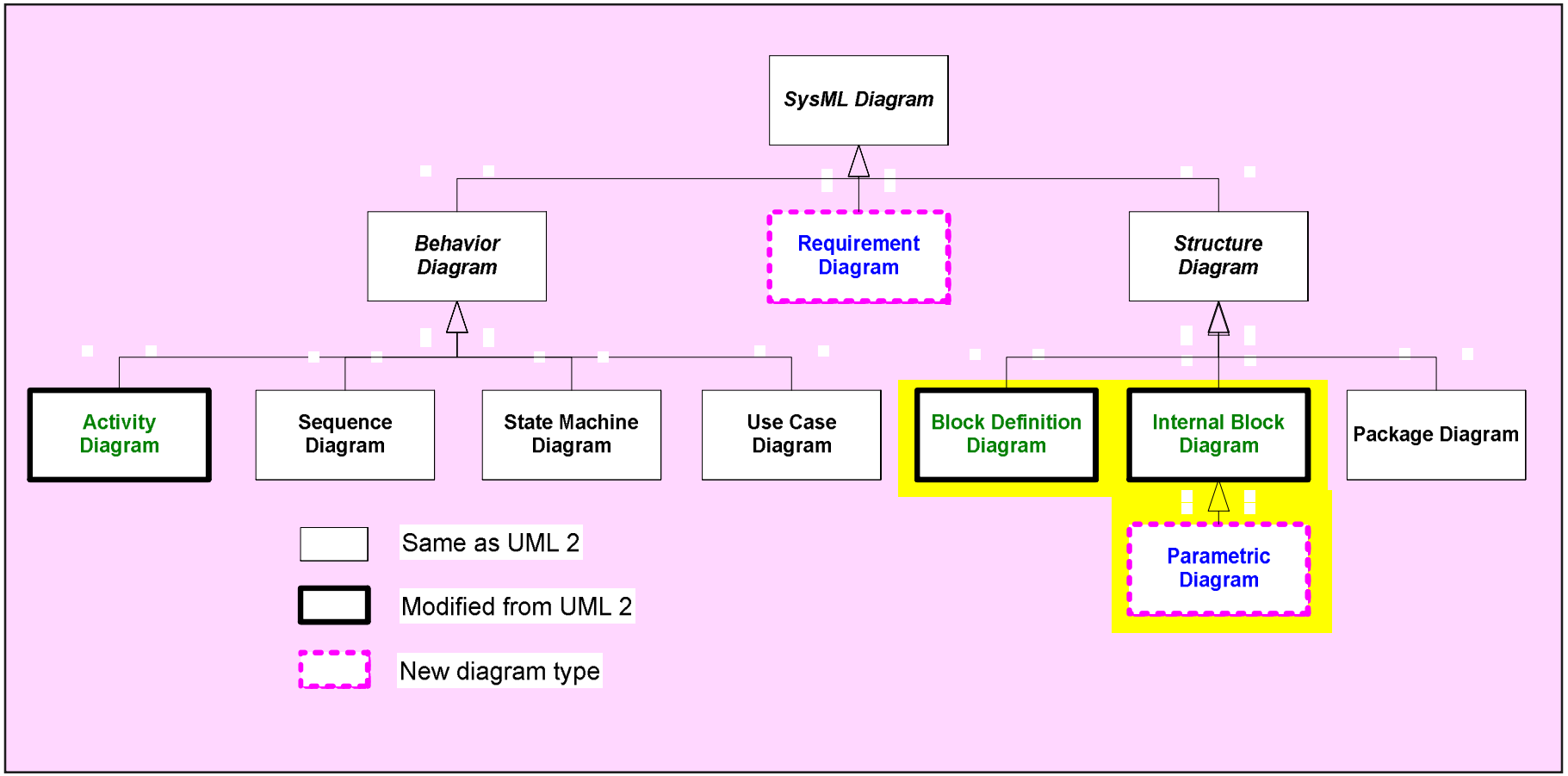
State Machines

- Supports event based behavior (generally asynchronous)
  - Transition with event, guard, action
  - State with entry, exit and do-activity
  - Can include nested sequential or concurrent states
  - Can send/receive signals to communicate between blocks during state transitions, etc

Operational States (Drive)



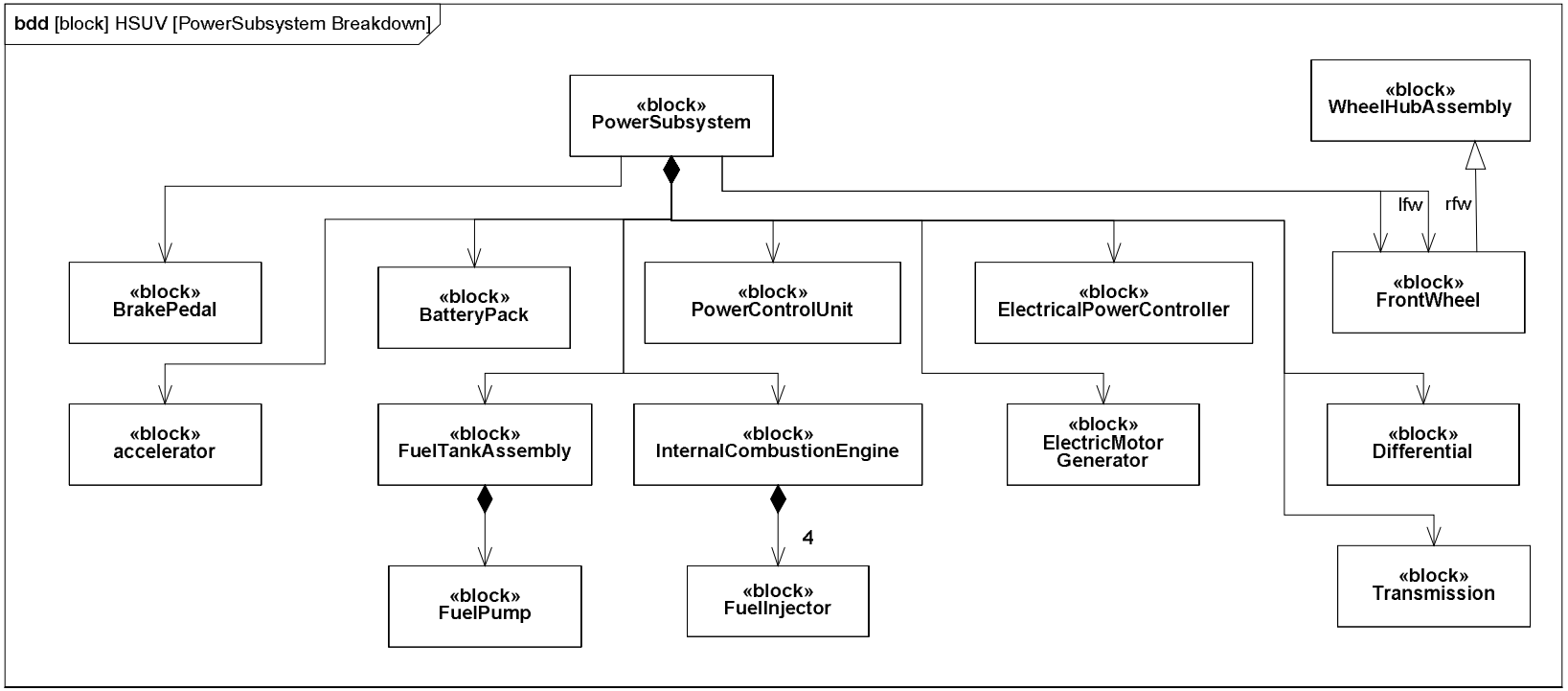
SysML Diagram Taxonomy



Blocks

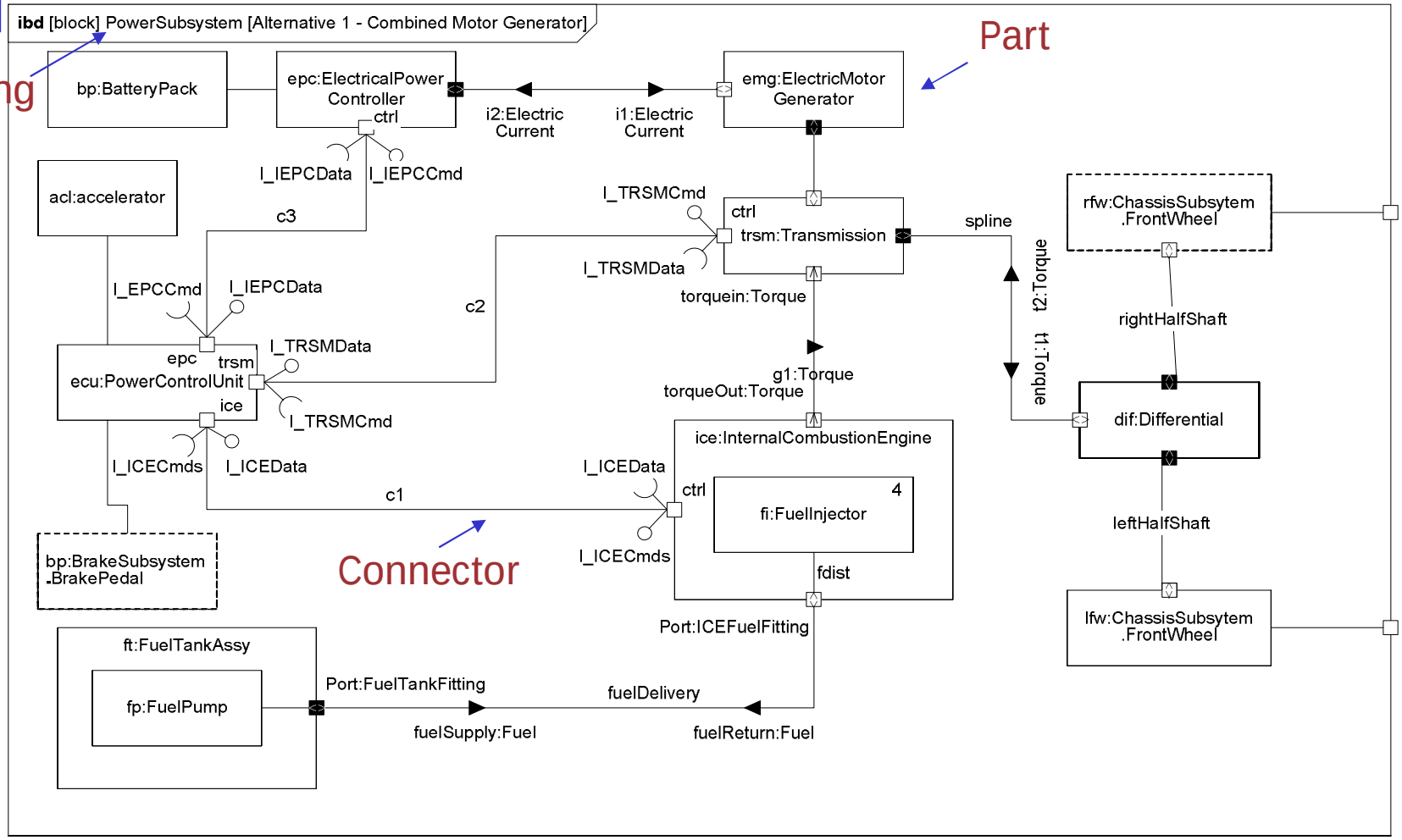
- Used to express structure of system
  - Backbone description of system hierarchy
  - Either white- or black-box description
  - Includes internal relationships and connectivity in addition to system decomposition

Power Subsystem Breakdown



Block Definition Diagram Used to Specify System Hierarchy and Classification

Power Subsystem IBD



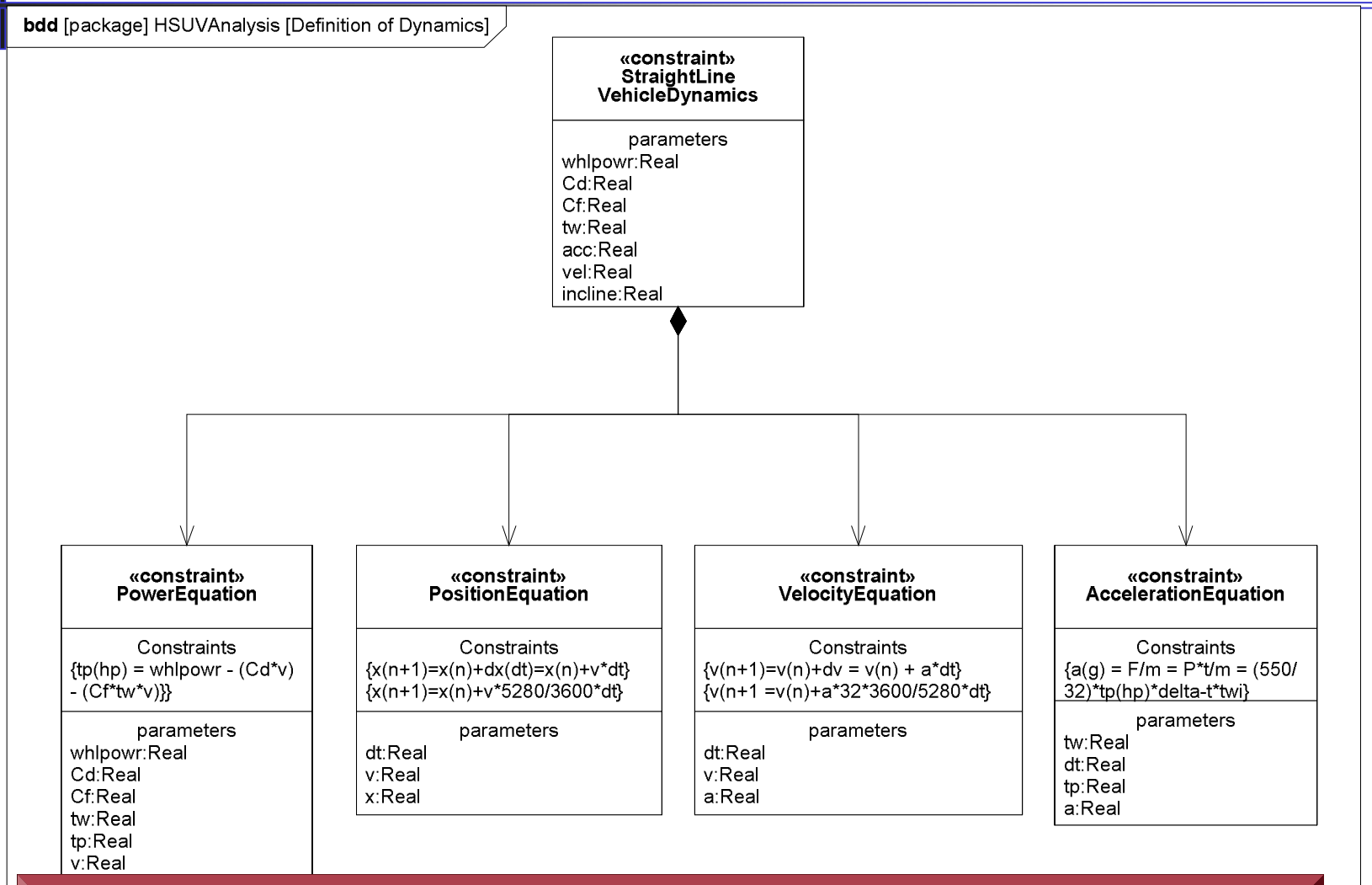
Internal Block Diagram Used to Specify Interconnection Among Parts in Context of Enclosing Block

Parametrics

- Used to express constraints (equations) between value properties
  - Provides support to engineering analysis (e.g. performance, reliability, etc)
- Constraint block captures equations
  - Expression language can be formal (e.g. MathML, OCL …) or informal
  - Computational engine is defined by applicable analysis tool and not by SysML
- Parametric diagram represents the usage of the constraints in an analysis context
  - Binding of constraint usage to value properties of blocks (e.g. vehicle mass bound to F= m * a)

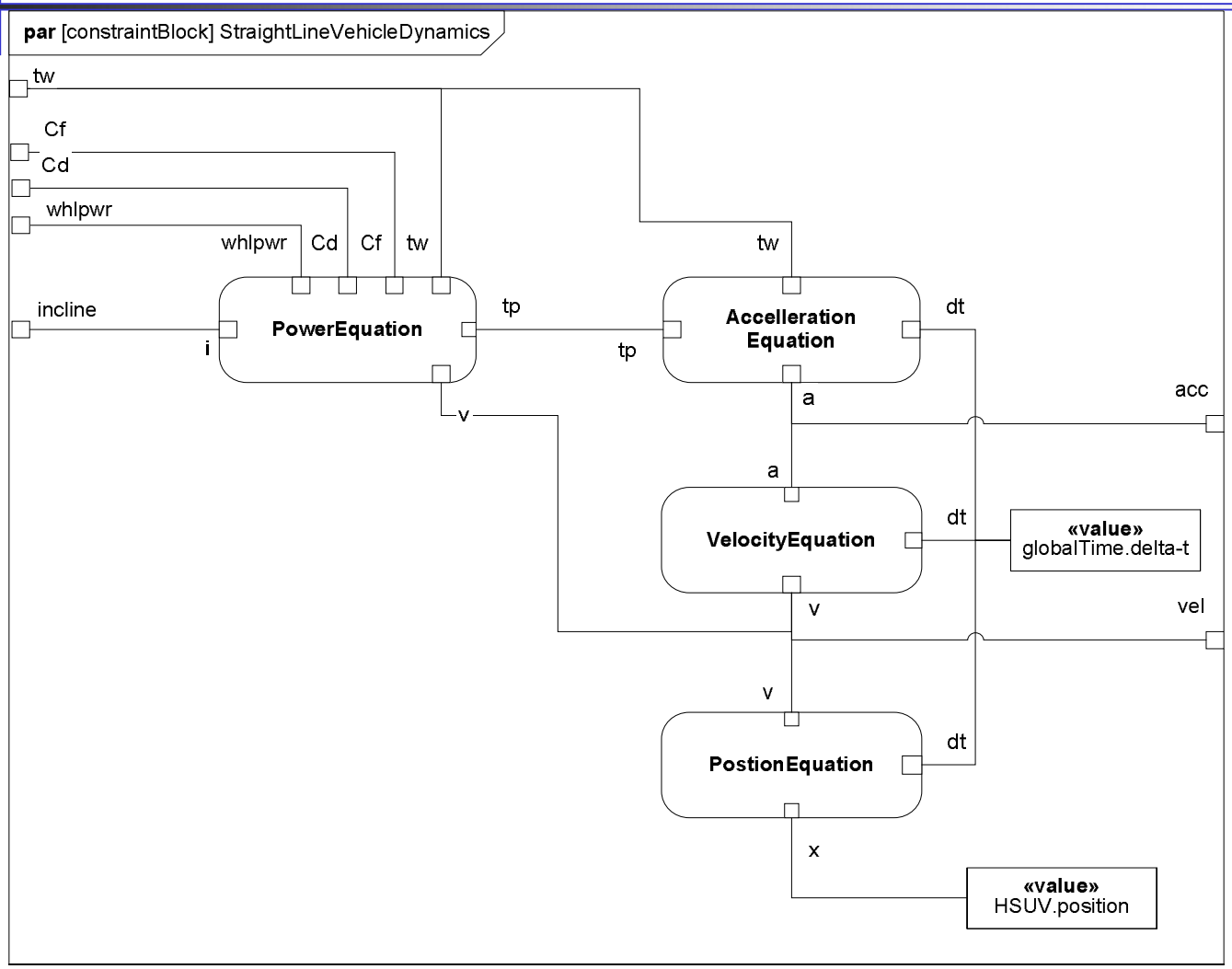
Parametrics Enable Integration of Engineering Analysis with Design Models

Defining Vehicle Dynamics



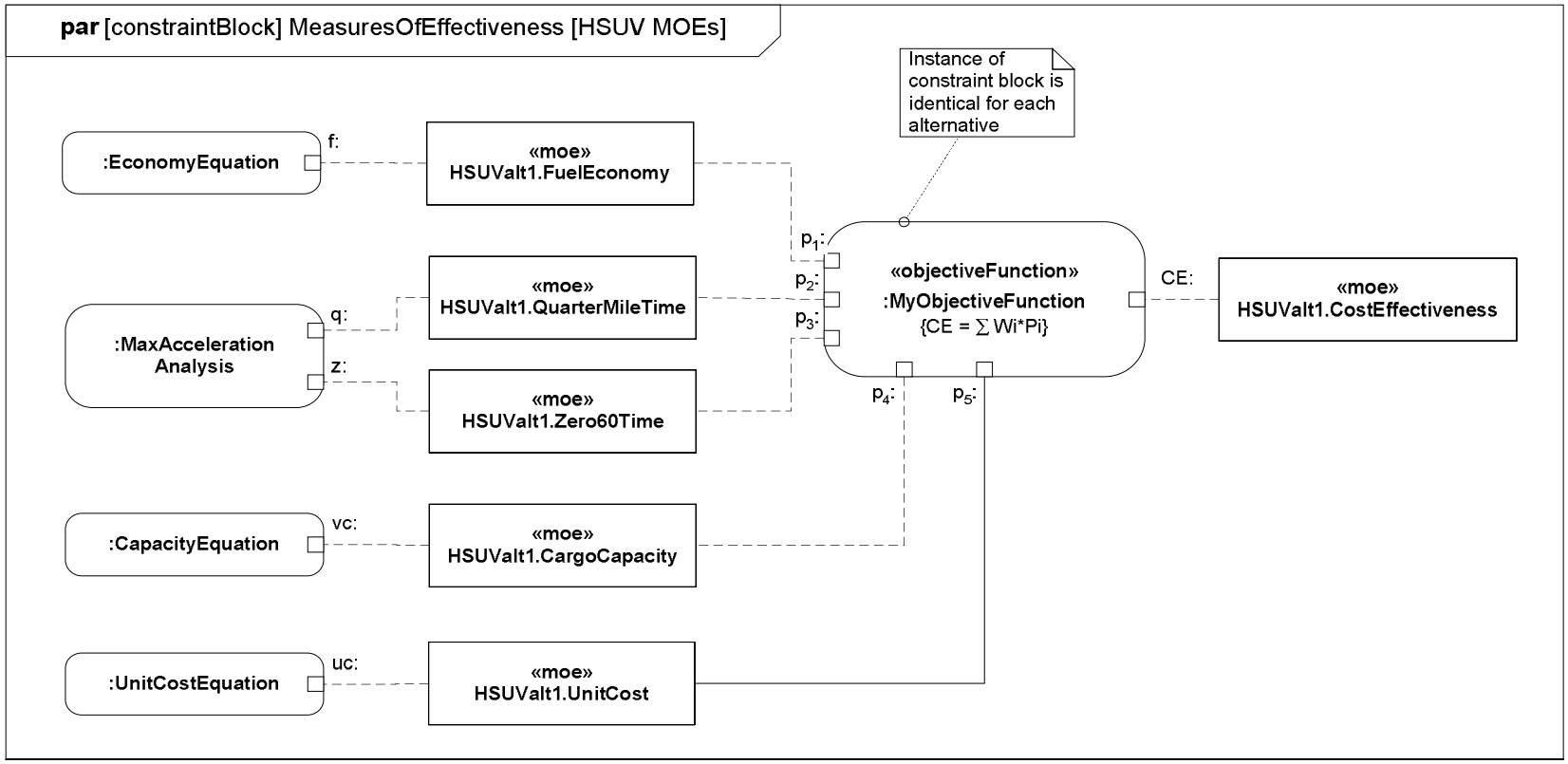
Defining Reusable Equations for Parametrics

Evaluating Vehicle Dynamics



Using the Equations in a Parametric Diagram to Constrain the Value Properties

Evaluating Measures of Effectiveness

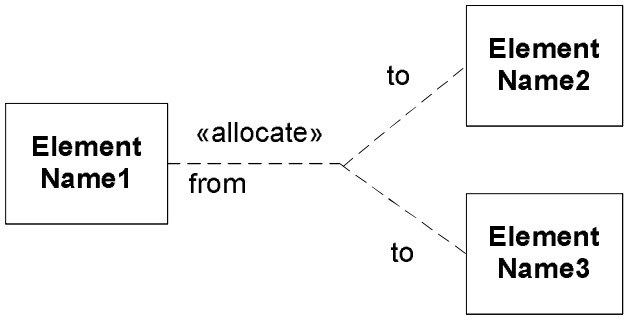


MOE's and objective function provide flexible support for trade study analysis that is fully integrated with parametrics

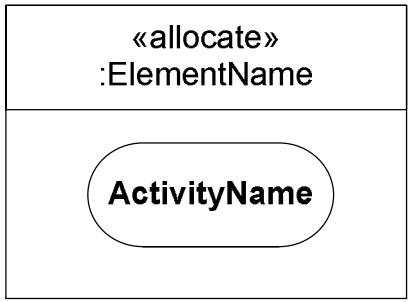
Allocations

- Provides general relationship to map one model element to another
- Includes specific subclasses of allocation with constraints on their usage
  - Behavioral
  - Structural
  - Flow
- Explicit allocation of activities to swim lanes (e.g. activity partitions)
- Graphical and/or tabular representations

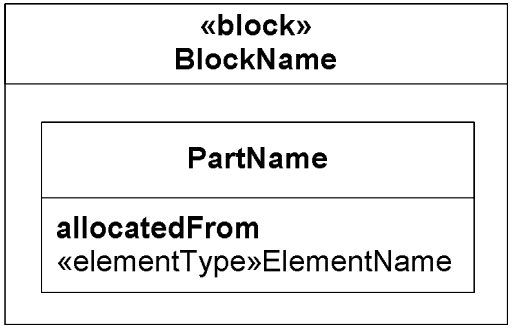
Different Allocation Representations
(Tabular Representation Not Shown)



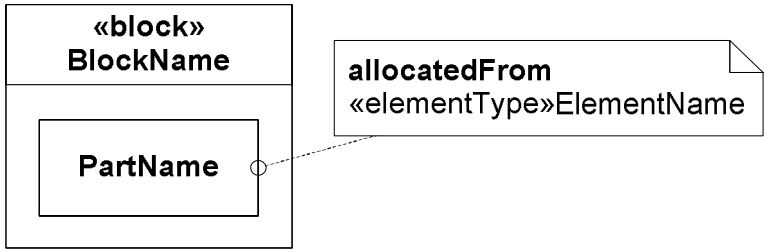
Allocate Relationship



Explicit Allocation of Activity to Swim Lane



Compartment Notation

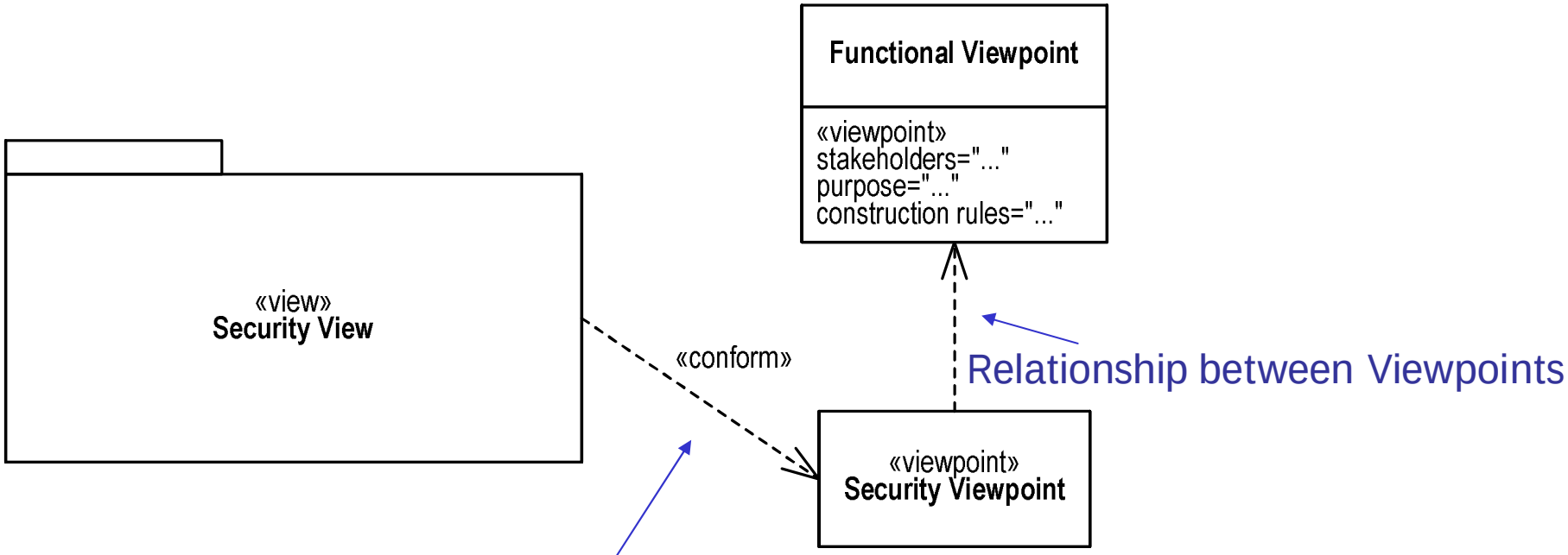


Callout Notation

View/Viewpoint

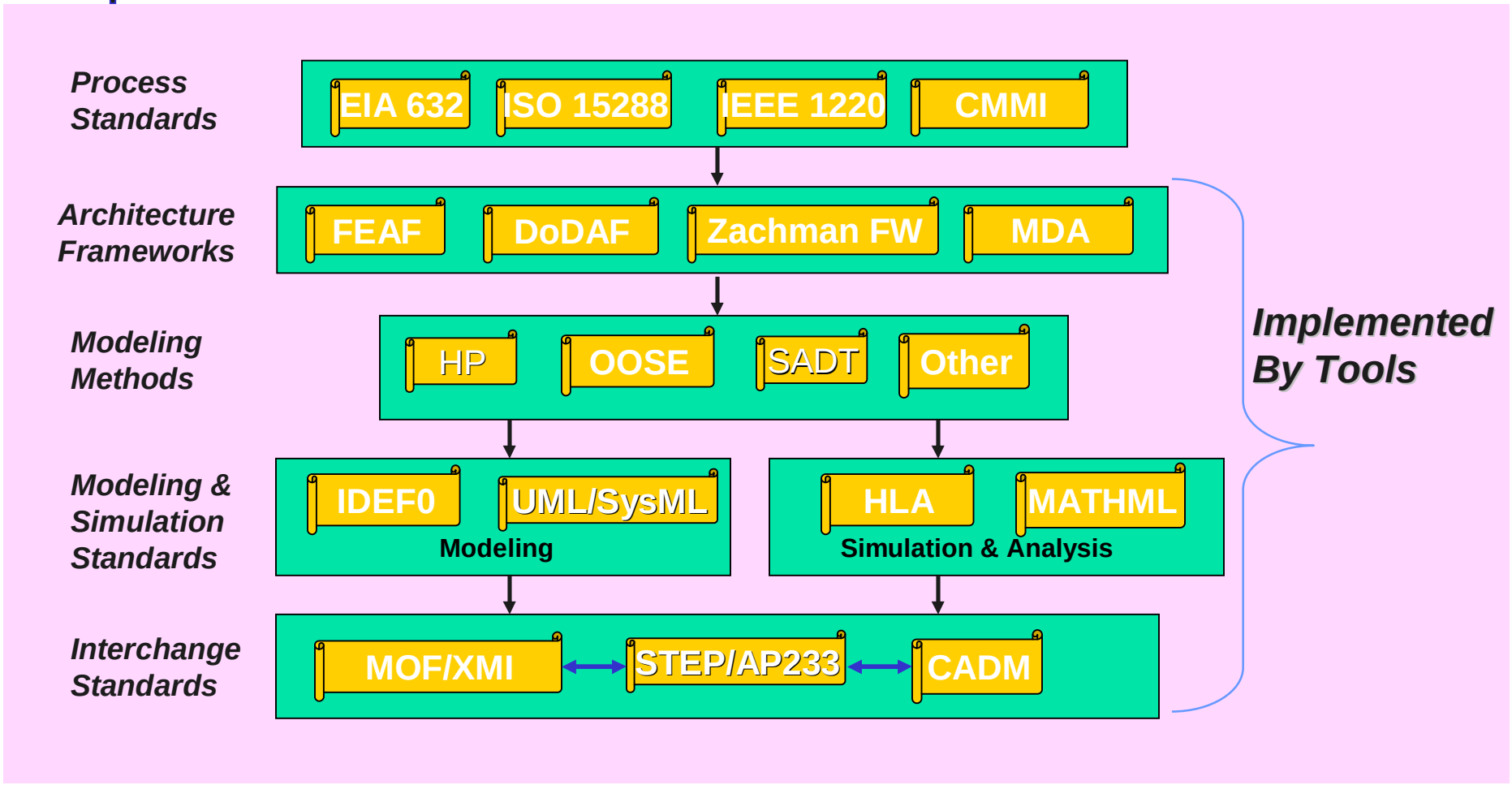
Viewpoint captures stakeholder concerns

- express concerns as requirements
- construction rules describe view which satisfies reqts

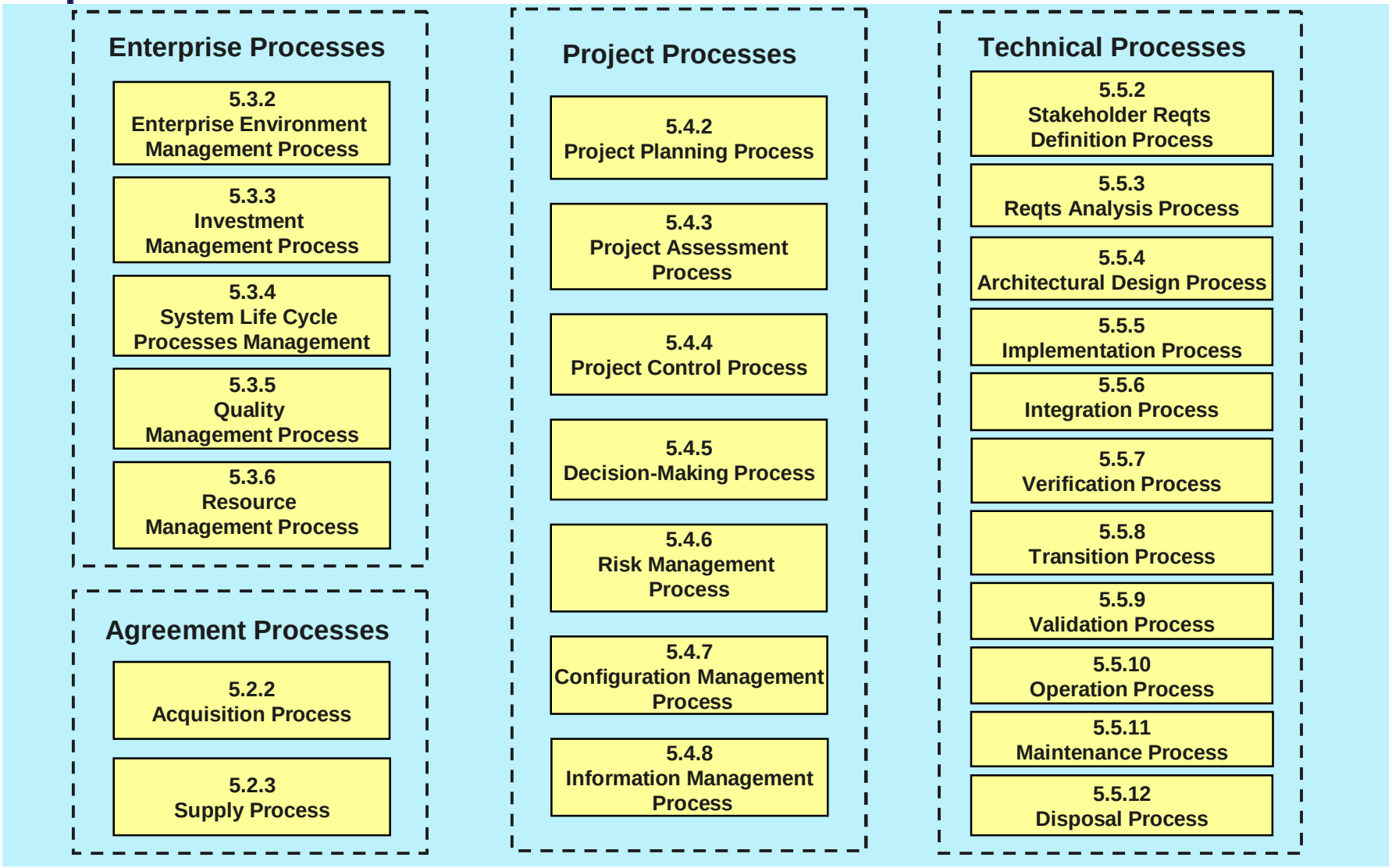


SysML in a Standards Framework

Systems Engineering Standards & Architecture Frameworks

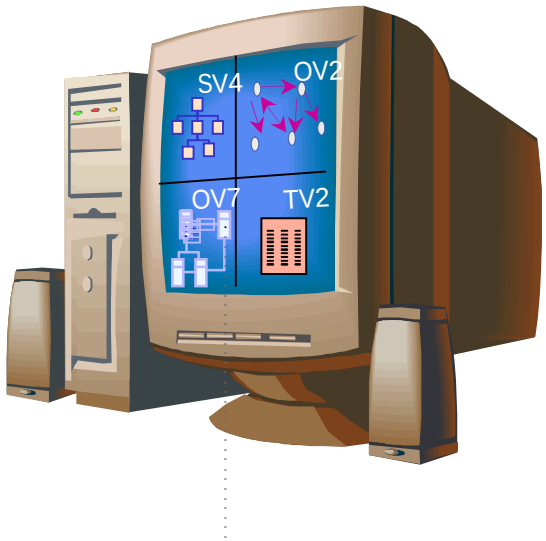


ISO/IEC 15288
System Life Cycle Processes



Example Standards-based Tool Integration

Systems Modeling Tool



Model/Data Interchange

AP233/XMI

AP233/XMI

Engineering Repository

Other SE Engineering Tools

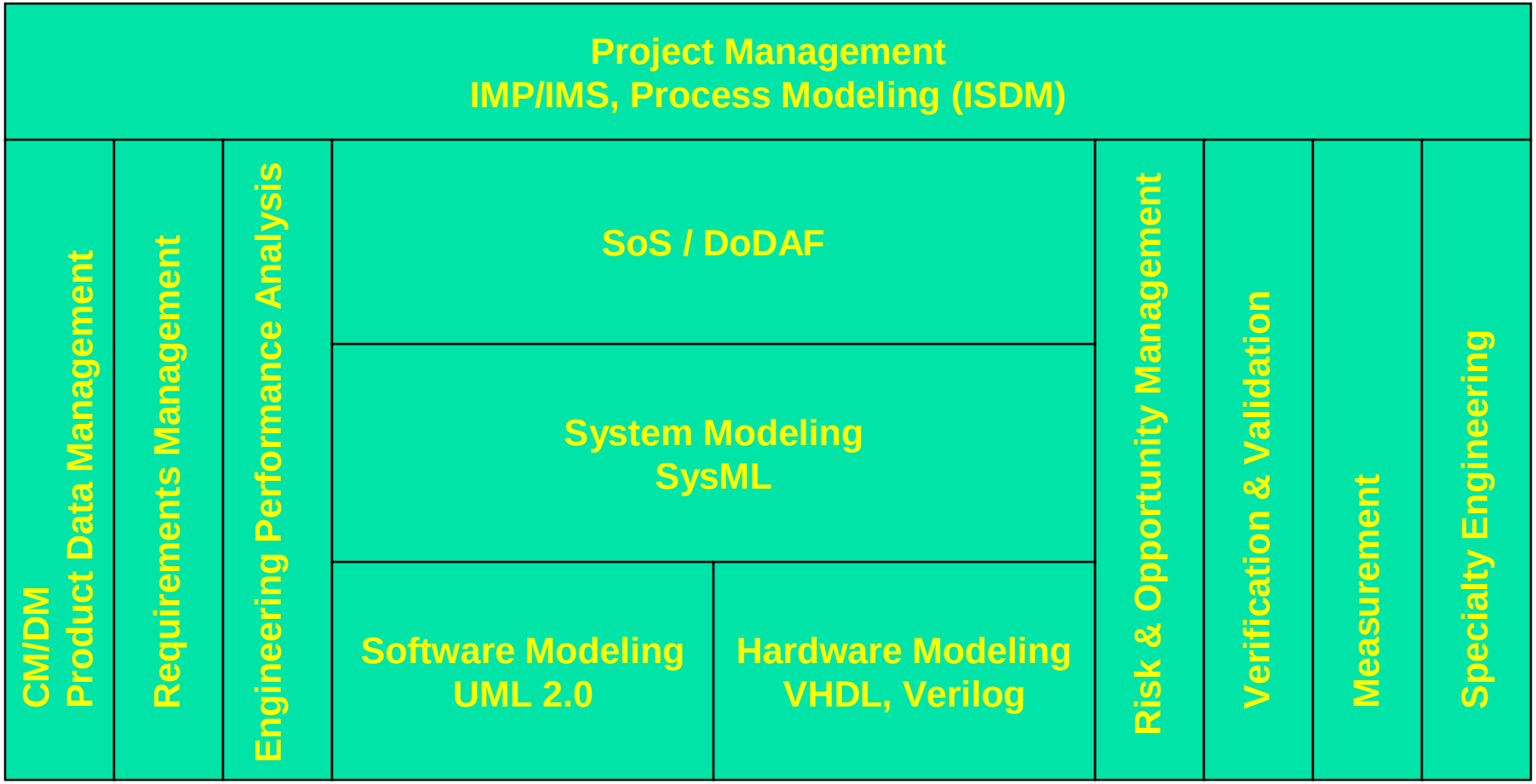
Participating SysML Tool Vendors

- Artisan
- EmbeddedPlus
- IBM
- I-Logix
- Sparx Systems
- Telelogic
- Vitech

UML Profile for DoDAF/MODAF Standardization

- Current initiative underway to develop standard profile for representing DODAF and MODAF products
  - Requirements for profile issued Sept 05
  - Final submissions expected Dec 06
- Multiple vendors and users participating
- Should leverage SysML

Tool Support



Summary

- SysML sponsored by INCOSE/OMG with broad industry and vendor participation
- SysML provides general purpose modeling language to support specification, analysis, design and verification of complex systems
  - Subset of UML 2 with extensions
- Multiple vendor implementations announced
- Adoption expected to begin in April 2006
- Standards based modeling approach for SE expected to improve communications, tool interoperability, and design quality

References

- UML for SE RFP
  - OMG doc# ad/03-03-41
- SysML specification v0.99
  - http://syseng.omg.org/SysML.htm
- UML 2 Superstructure
  - OMG doc# formal/05-07-04
- UML 2 Infrastructure
  - OMG doc# ptc/04-10-14