



# SysML-Based Systems Engineering Using a Model-Driven Development Approach

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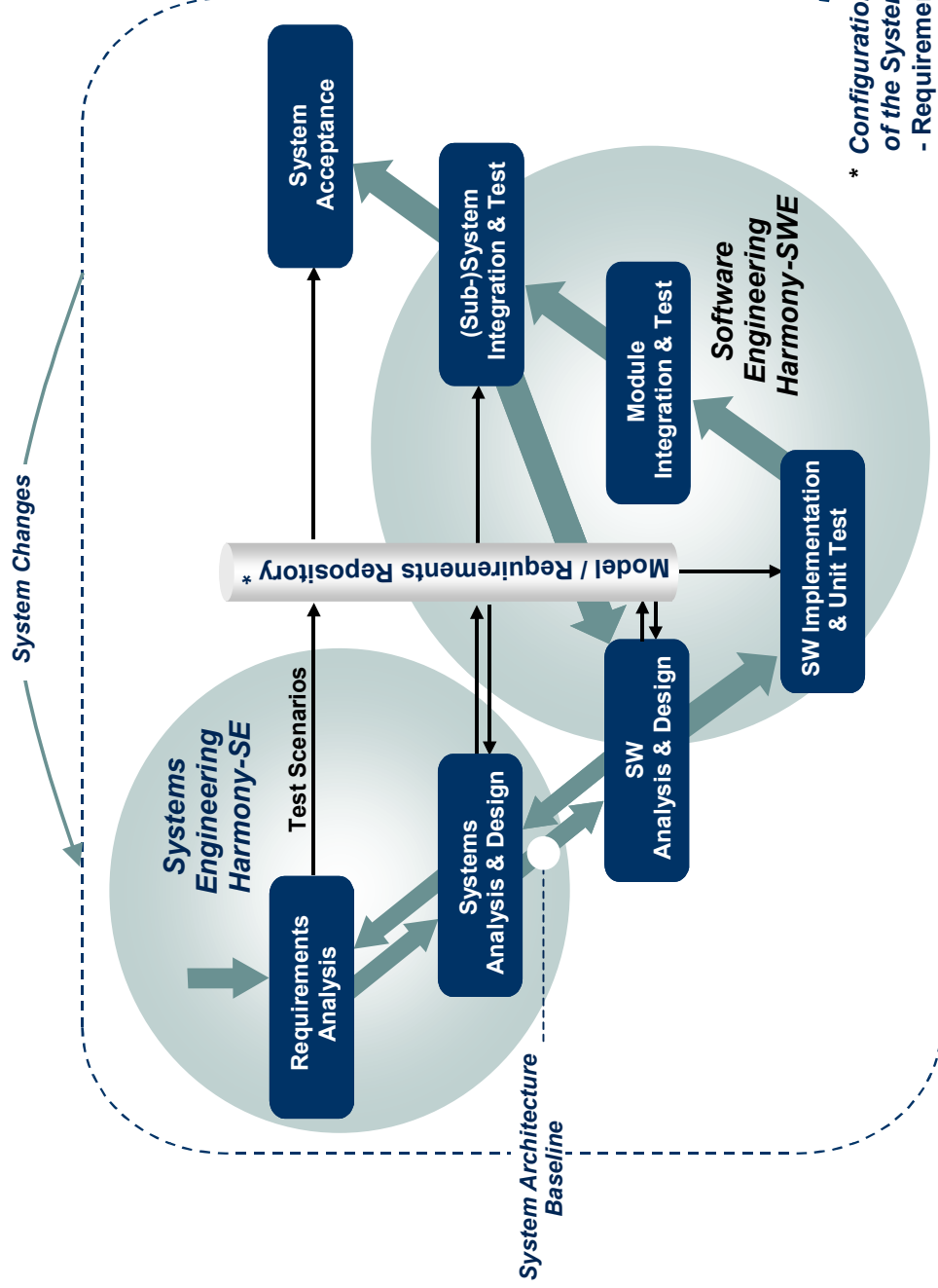
# SysML-Based Systems Engineering

## Using a Model-Driven Development Approach

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- Integrated System / Software Development Process *Harmony*®
- Fundamentals of SysML-Based Systems Engineering
  - Essential SysML Artifacts
  - Service Request-Driven Modeling Approach
- Task Flow and Work Products in the SysML-Based SE Process *Harmony-SE*
  - Requirements Analysis
  - System Functional Analysis
  - Architectural Design
- Handoff to Hardware / Software Development

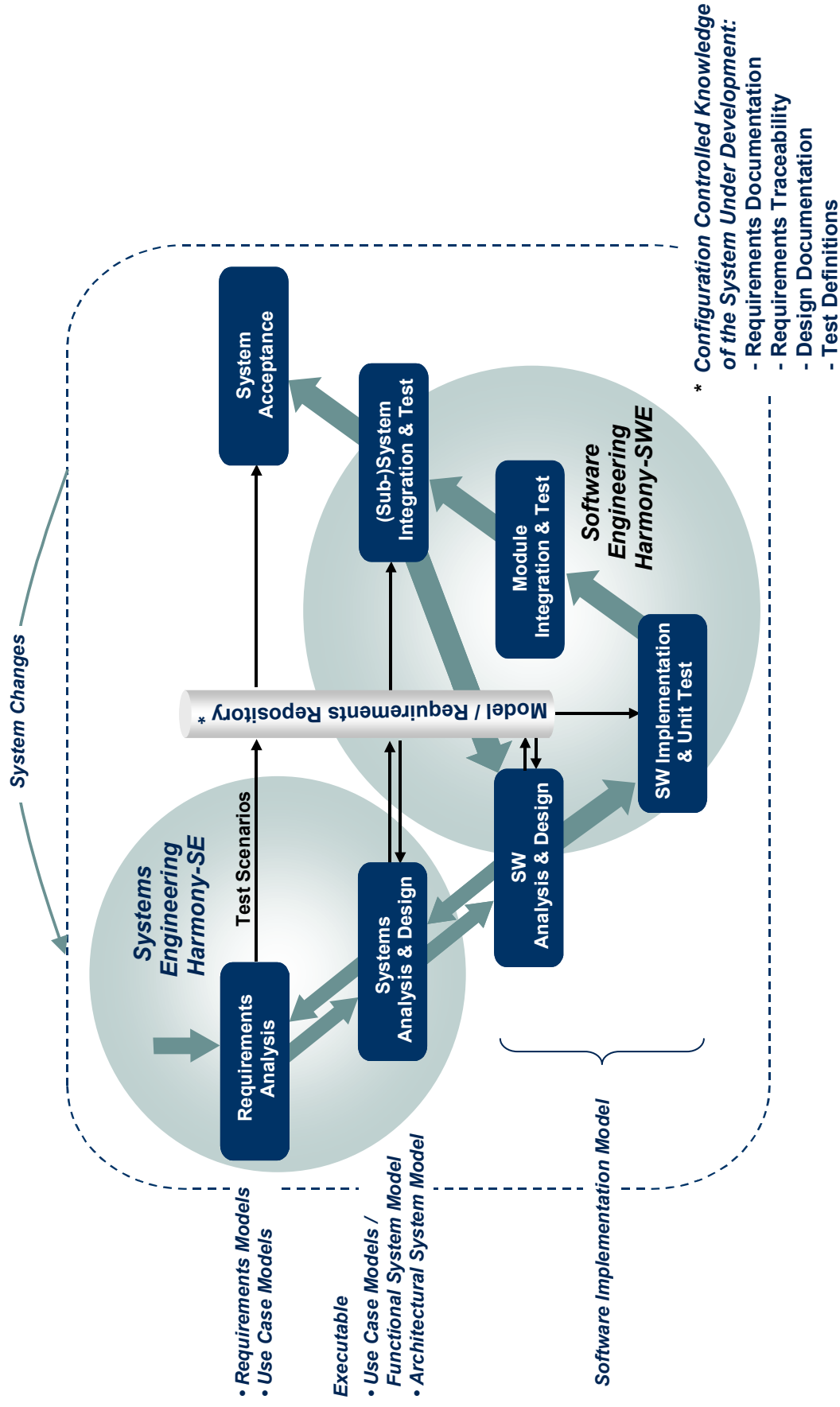
# Integrated Systems / Software Development Process Harmony®



\* Configuration Controlled Knowledge of the System Under Development:

- Requirements Documentation
- Requirements Traceability
- Design Documentation
- Test Definitions

# Model-Driven Development of Embedded Systems



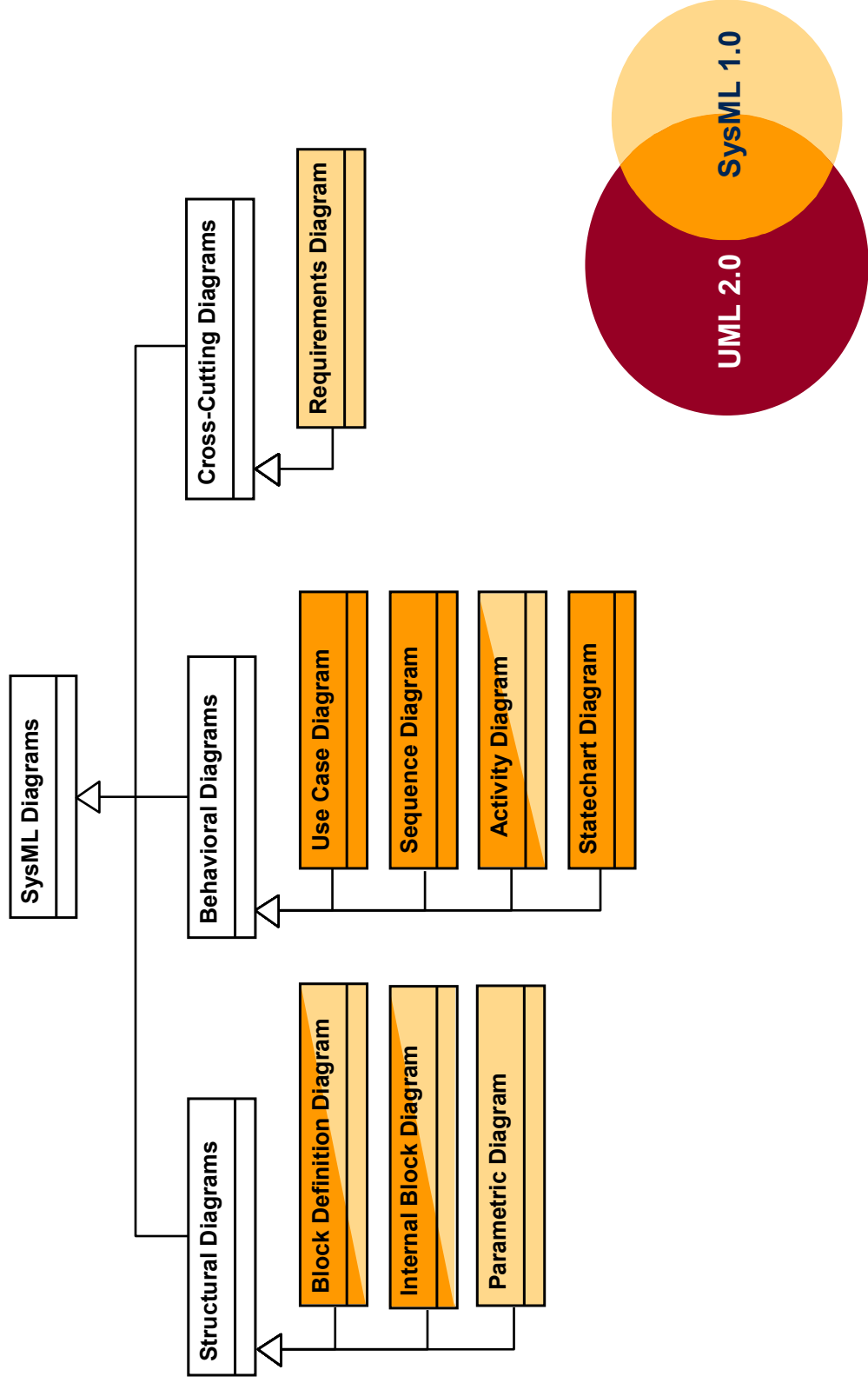
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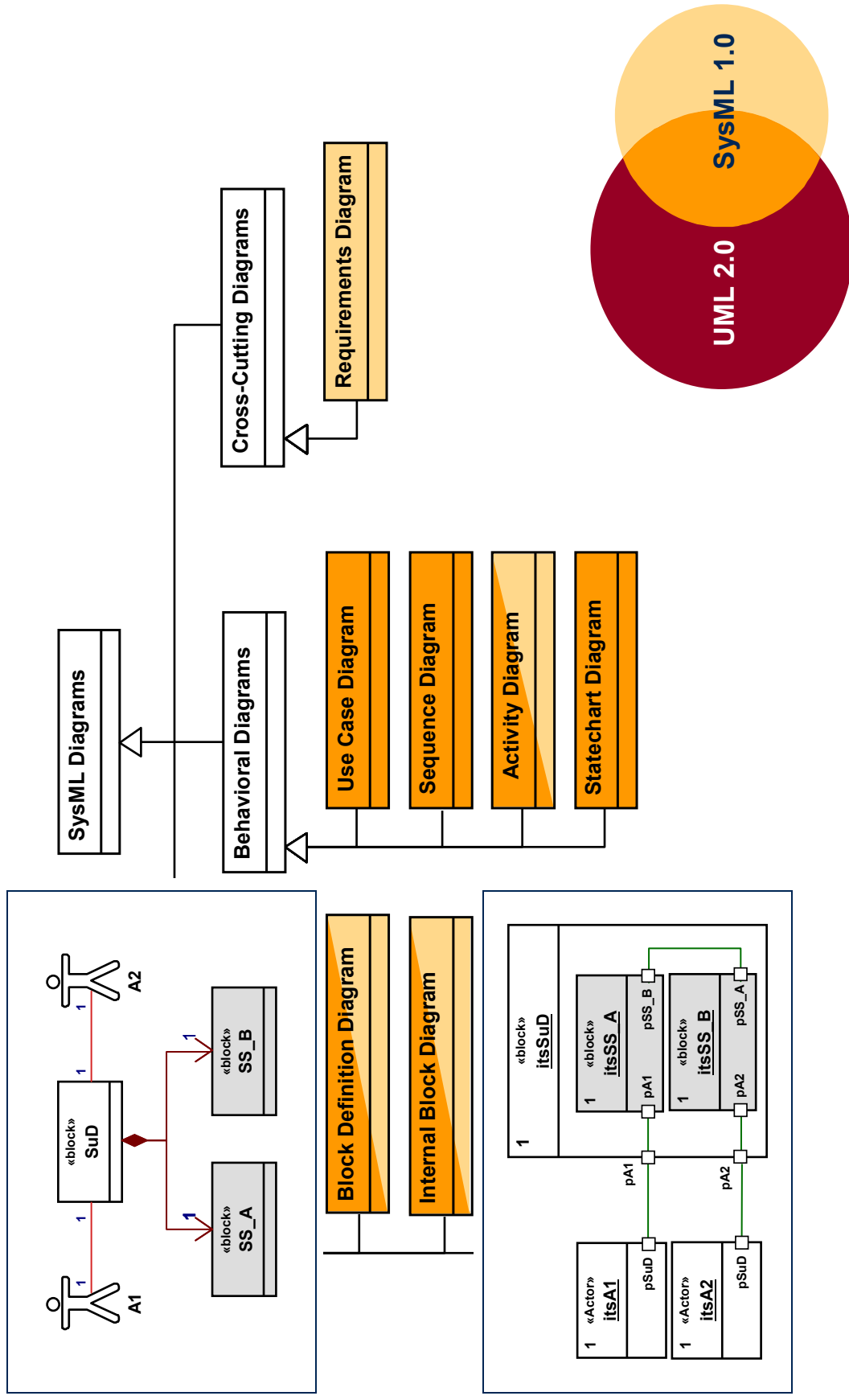
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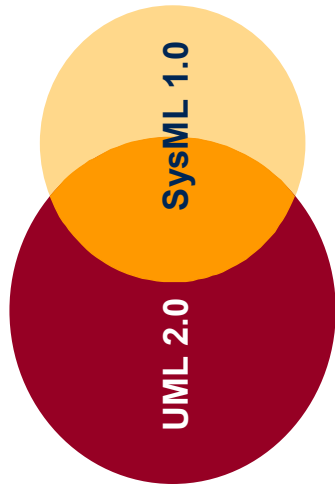
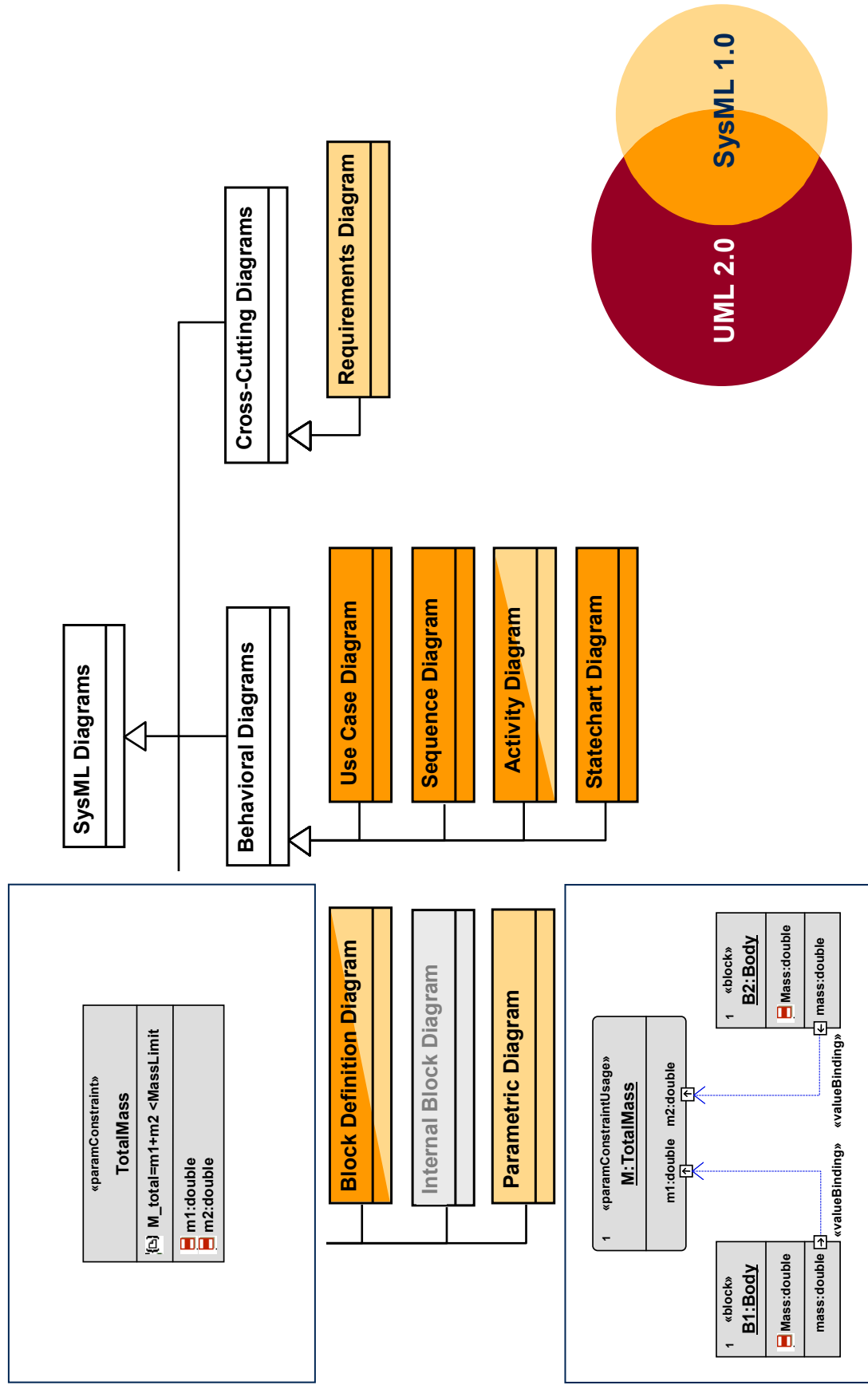
# Essential SysML Artifacts for Model-Based Systems Engineering



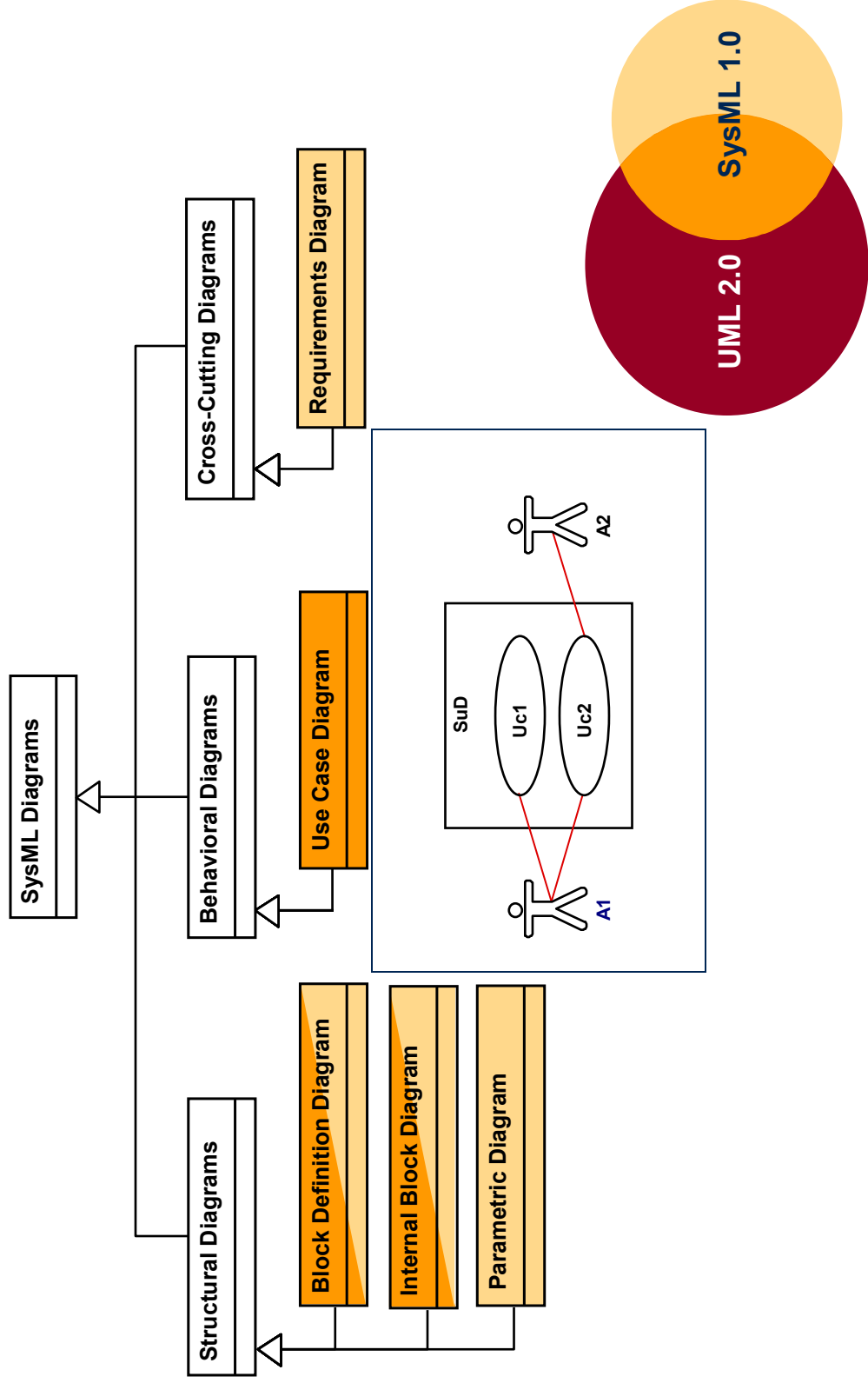
# Essential SysML Artifacts for Model-Based Systems Engineering



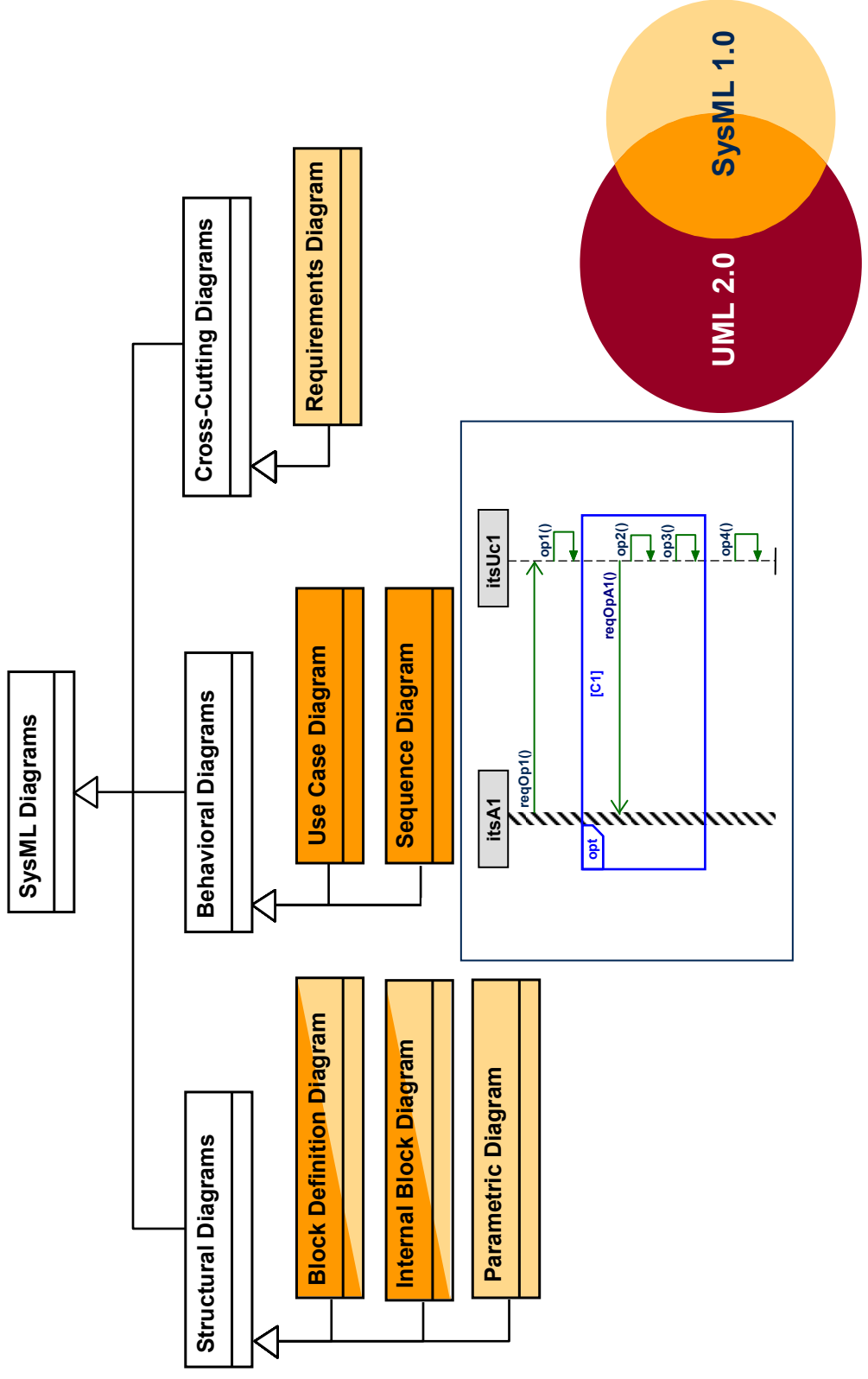
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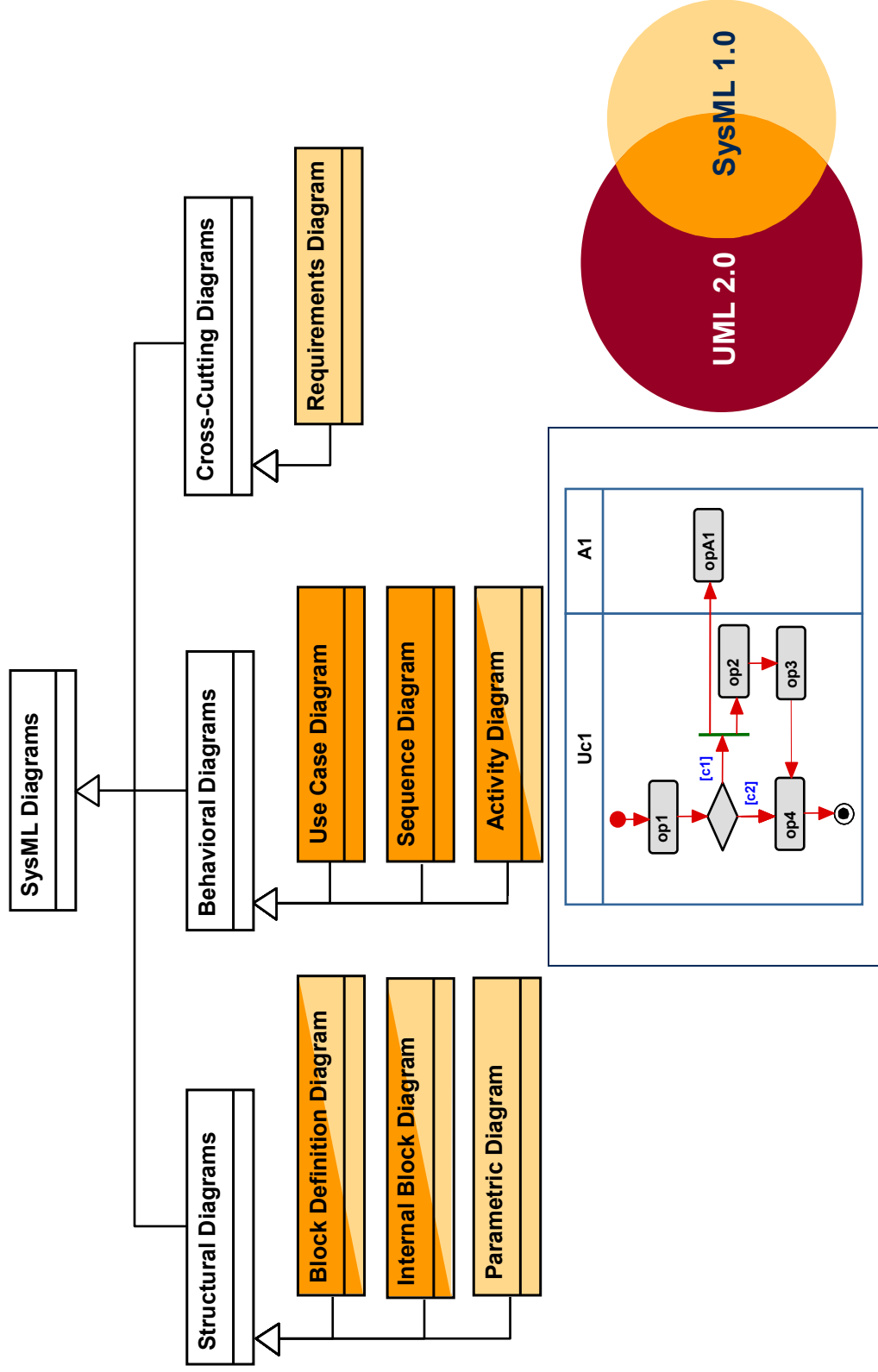
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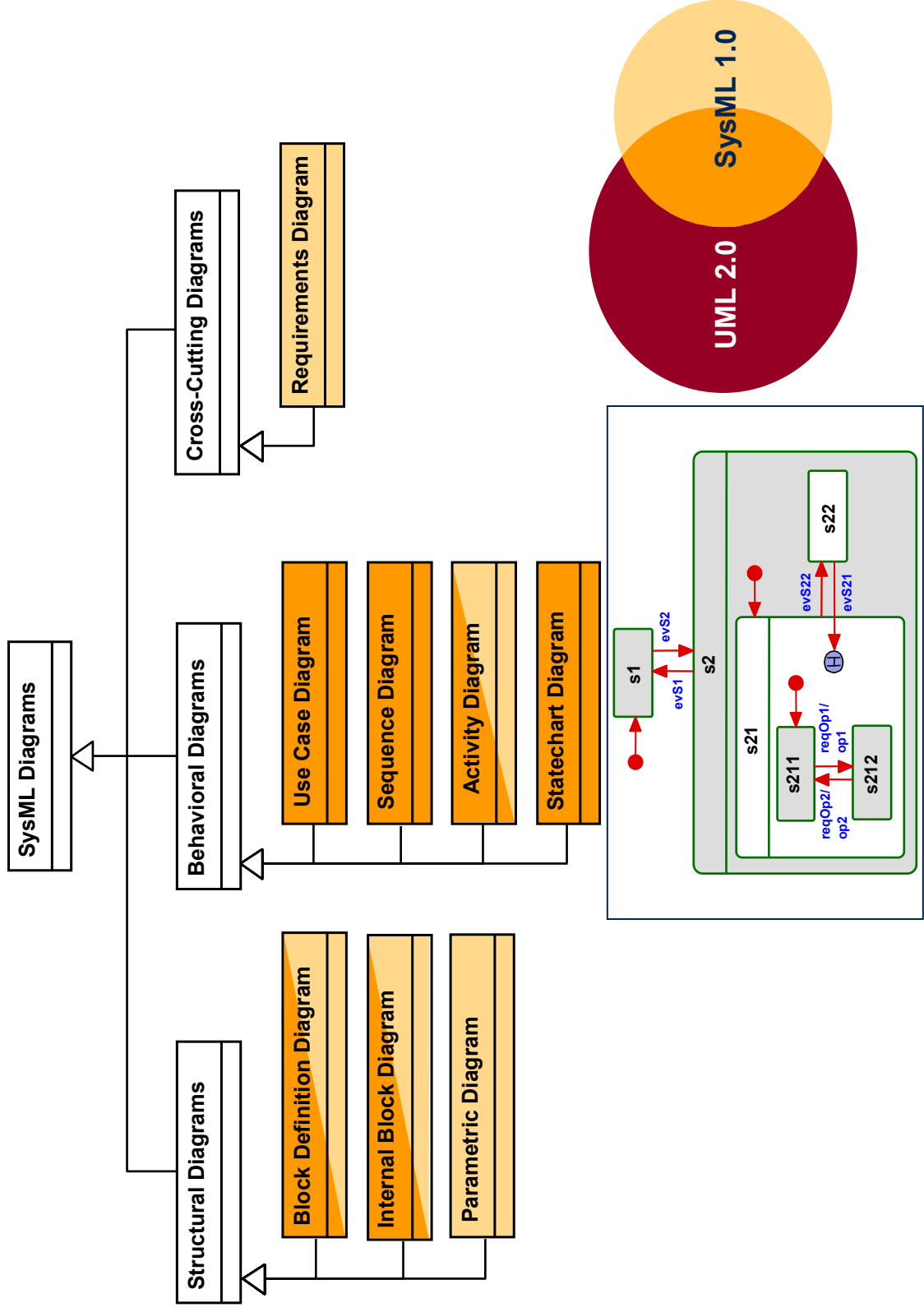
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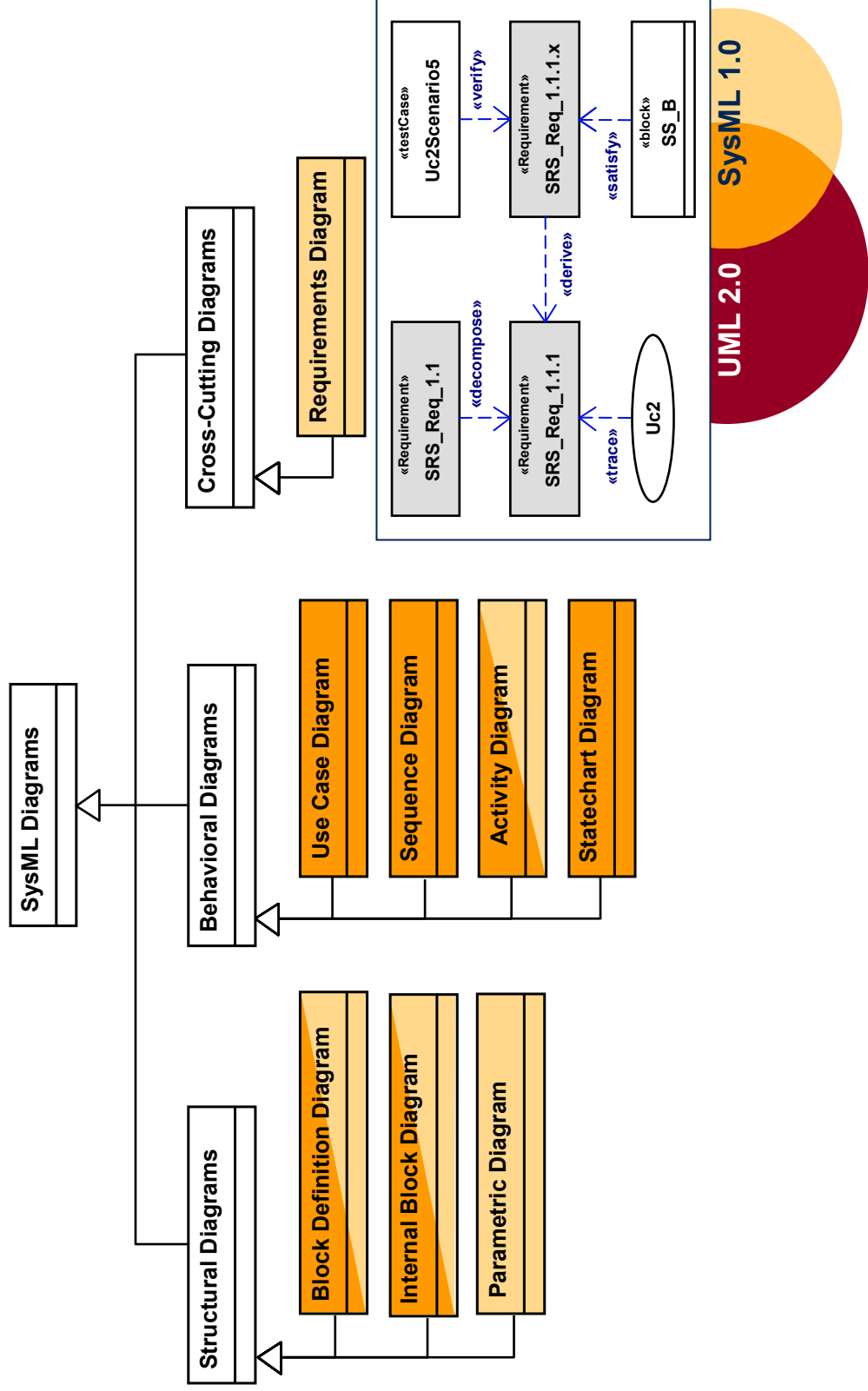
# Essential SysML Artifacts for Model-Based Systems Engineering



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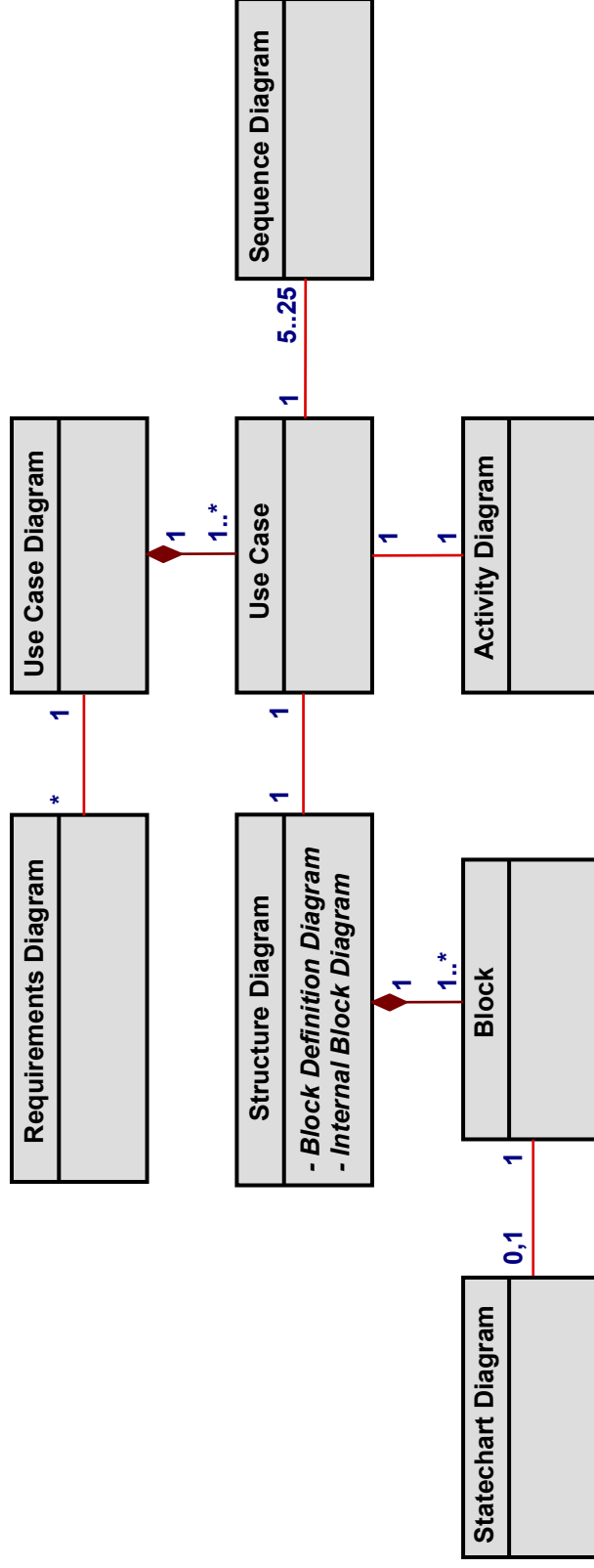


# Essential SysML Artifacts for Model-Based Systems Engineering



# Essential SysML Artifacts for Model-Based Systems Engineering

## Artifact Relationships at the Functional Analysis Level



# SysML-Based Systems Engineering

## Using a Model-Driven Development Approach

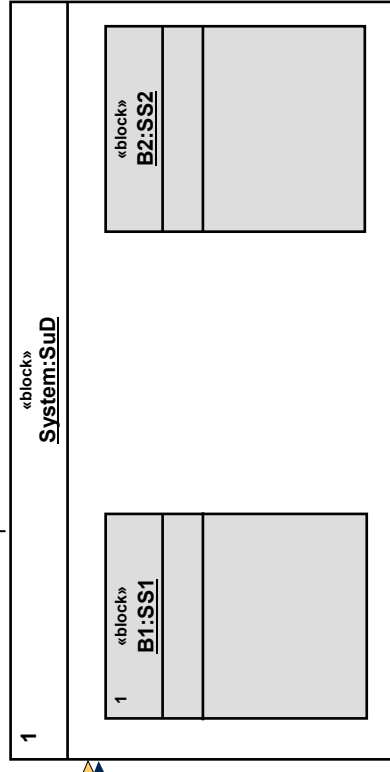
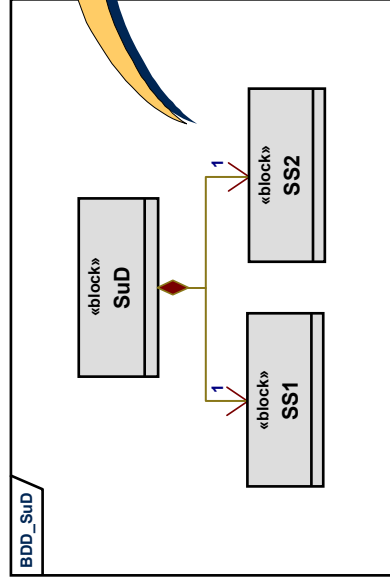
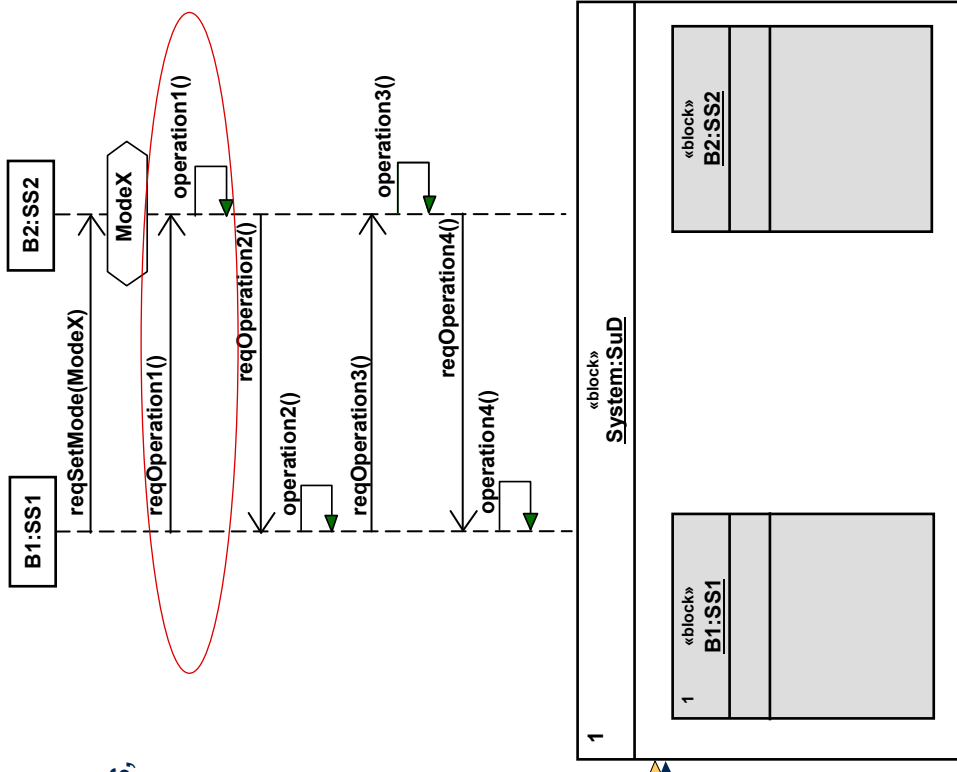
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# Service Request-Driven Modeling Approach (1)

Definition of System Structure and Blocks Communication

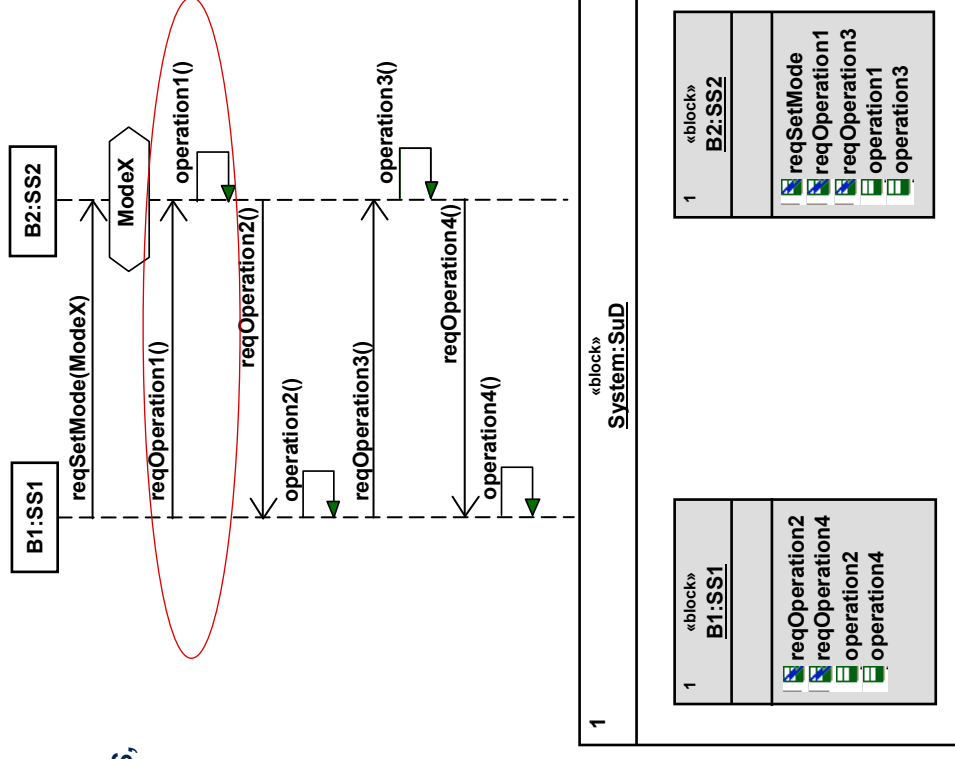
- System structure described by means of SysML *Block Definition Diagrams and Internal Block Diagrams*, using *Blocks* as basic structural elements.
- Communication described by means of *operational contracts (OpCon)*, i.e.
  - (asynchronous) *service requests* via *SysML Service Ports*, followed by
  - provided services at the receiving part (state/mode changes or operations)



# Service Request-Driven Modeling Approach (2)

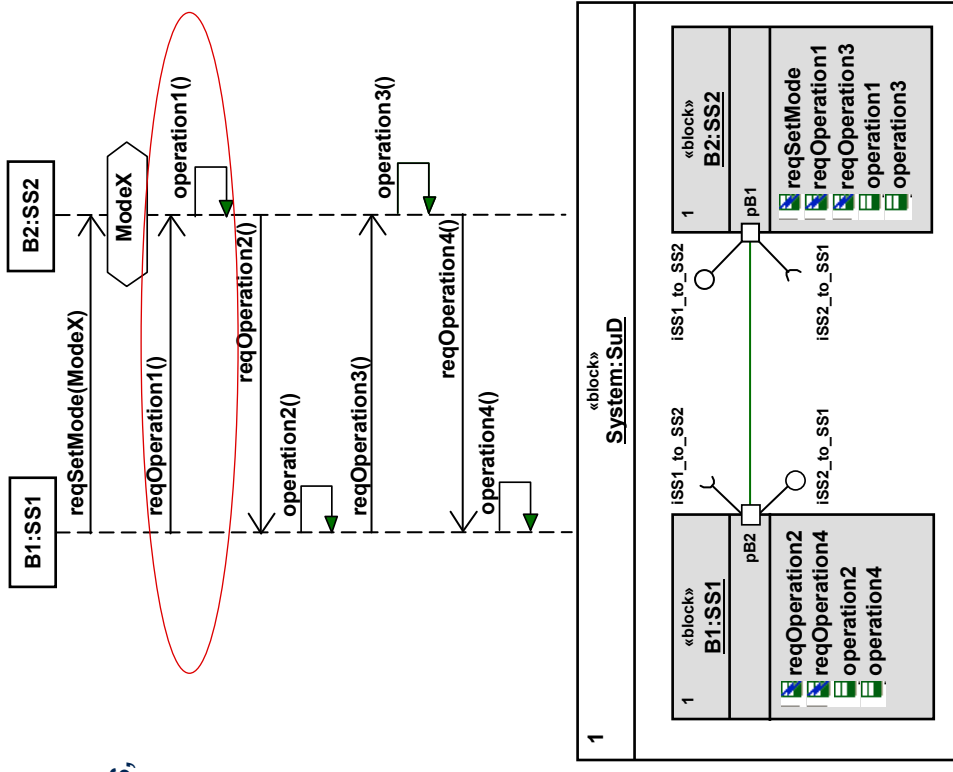
## Allocation of Operational Contracts

- System structure described by means of SysML *Block Definition Diagrams and Internal Block Diagrams*, using *Blocks* as basic structural elements.
- Communication described by means of *operational contracts (OpCon)*, i.e.
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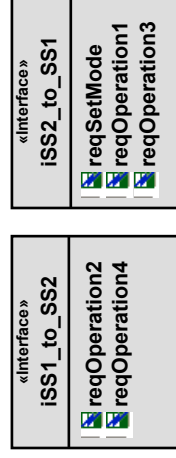


# Service Request-Driven Modeling Approach (3)

## Definition of Ports and Interfaces



- System structure described by means of SysML *Block Definition Diagrams and Internal Block Diagrams*, using *Blocks* as basic structural elements.
- Communication described by means of *operational contracts (OpCon)*, i.e.
  - (asynchronous) *service requests* via SysML *Service Ports*, followed by
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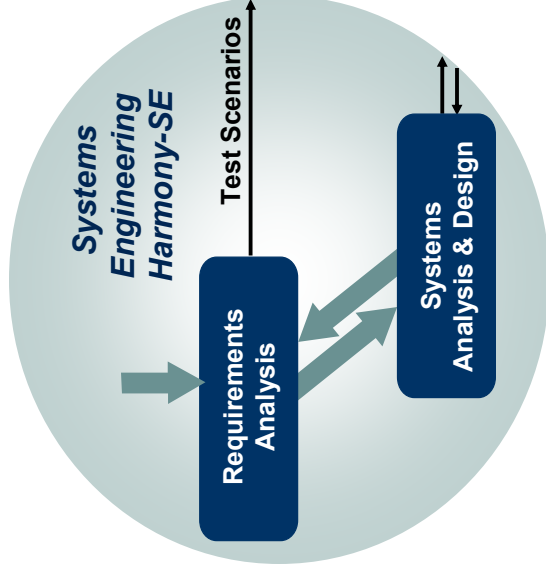
# SysML-Based Systems Engineering

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- Handoff to Hardware / Software Development

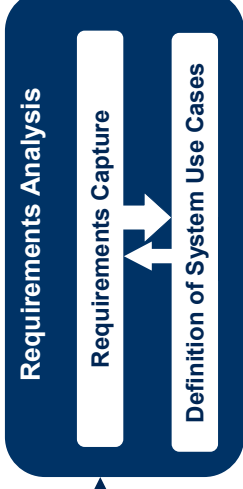
# Key Objectives of the SysML-Based Systems Engineering Process *Harmony-SE*



- Identify / derive required system functionality
- Identify associated system states and modes
- Allocate system functionality / modes to a physical architecture

# SysML-Based Systems Engineering (Harmony-SE)

## Requirements Analysis

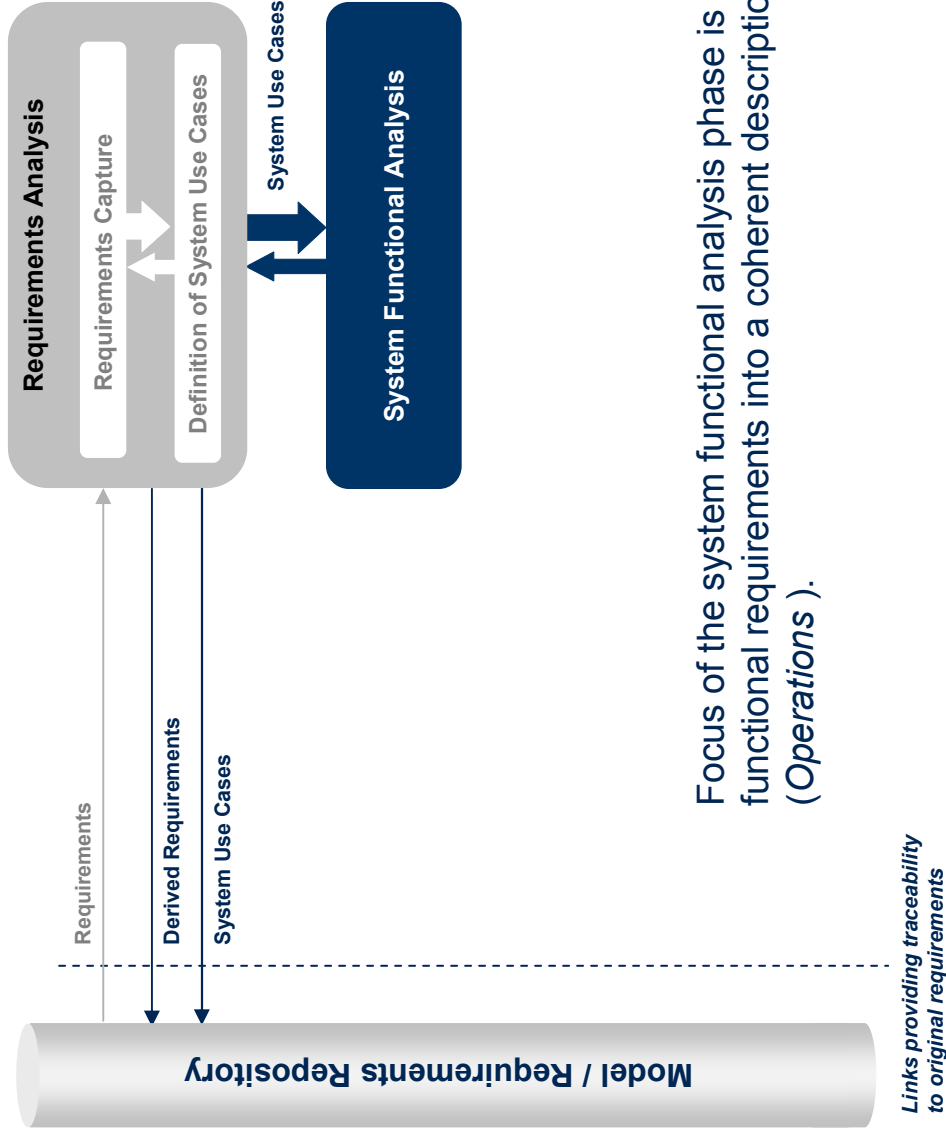


Model / Requirements Repository

- Requirements analysis starts with the analysis of the process inputs.  
Customer requirements are translated into a set of requirements that define
  - what the system must do (*functional requirements*) and
  - how well it must perform (*quality of service requirements*).
- SysML *Requirements Diagrams* may be used to create a taxonomy of the captured requirements.
- Once the requirements are sufficiently understood they are clustered in *use cases*.

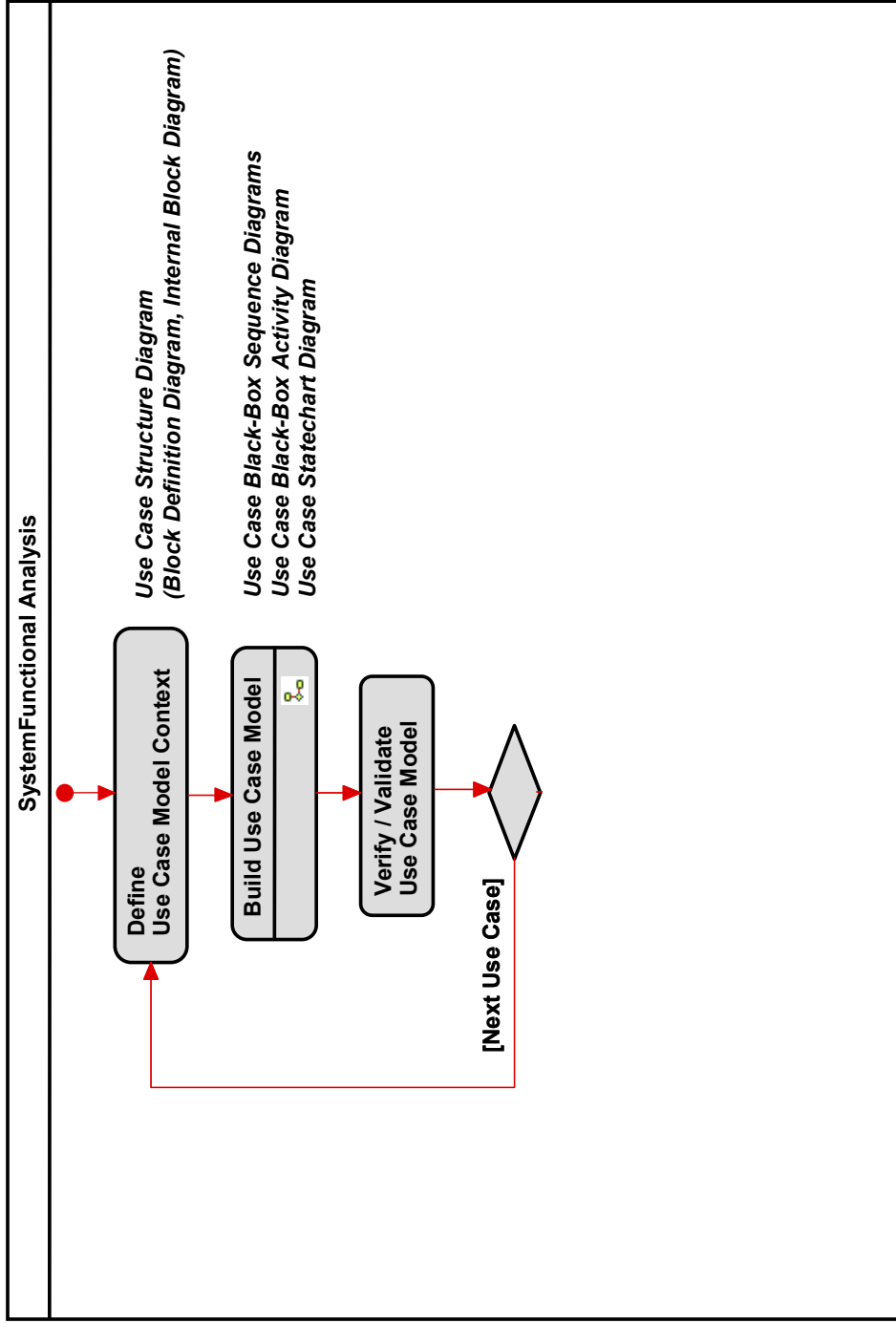
# SysML-Based Systems Engineering (Harmony-SE)

## System Functional Analysis

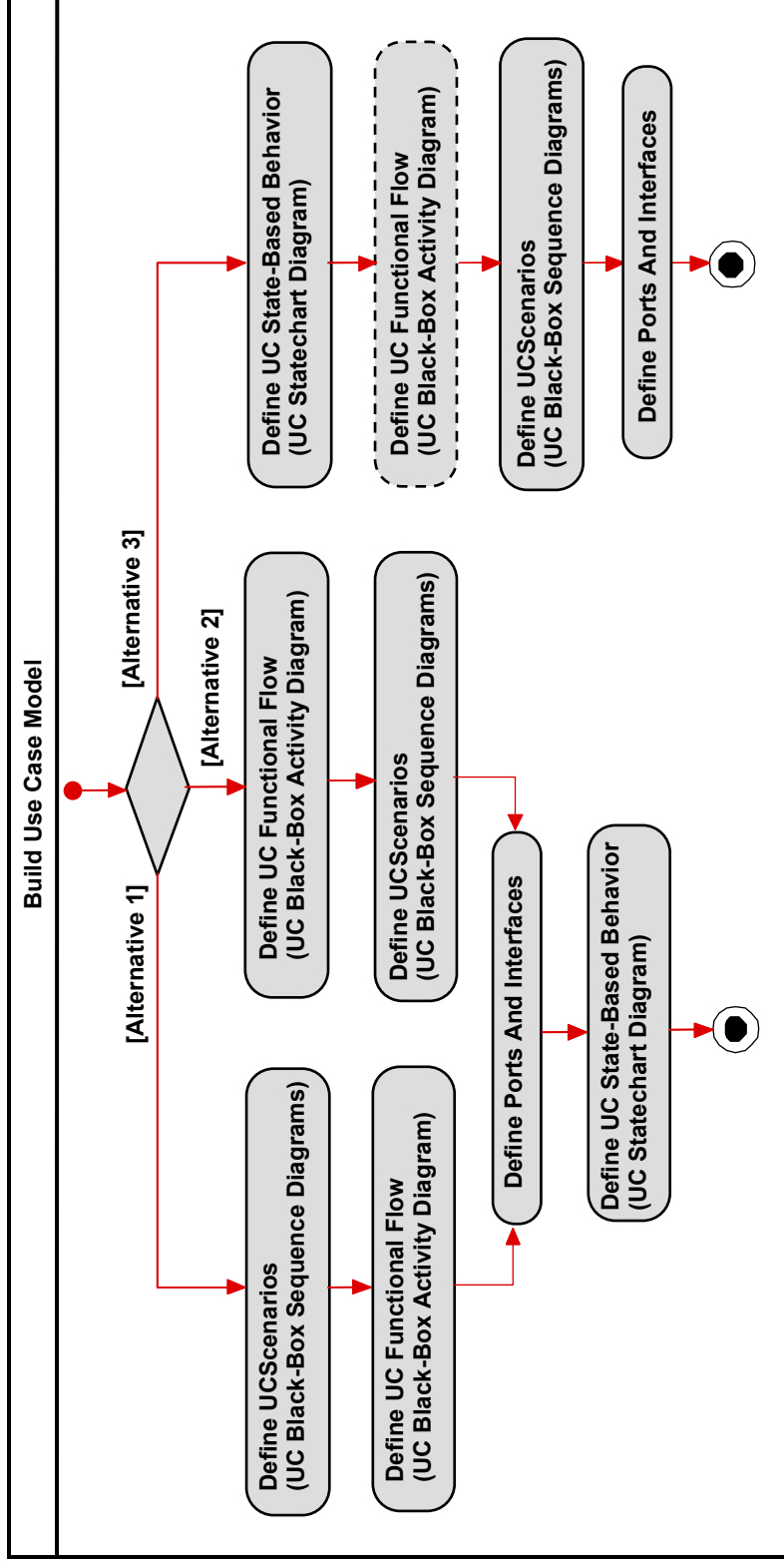


Focus of the system functional analysis phase is the translation of the functional requirements into a coherent description of system functions (*Operations*).

# Task Flow and Work Products in System Functional Analysis

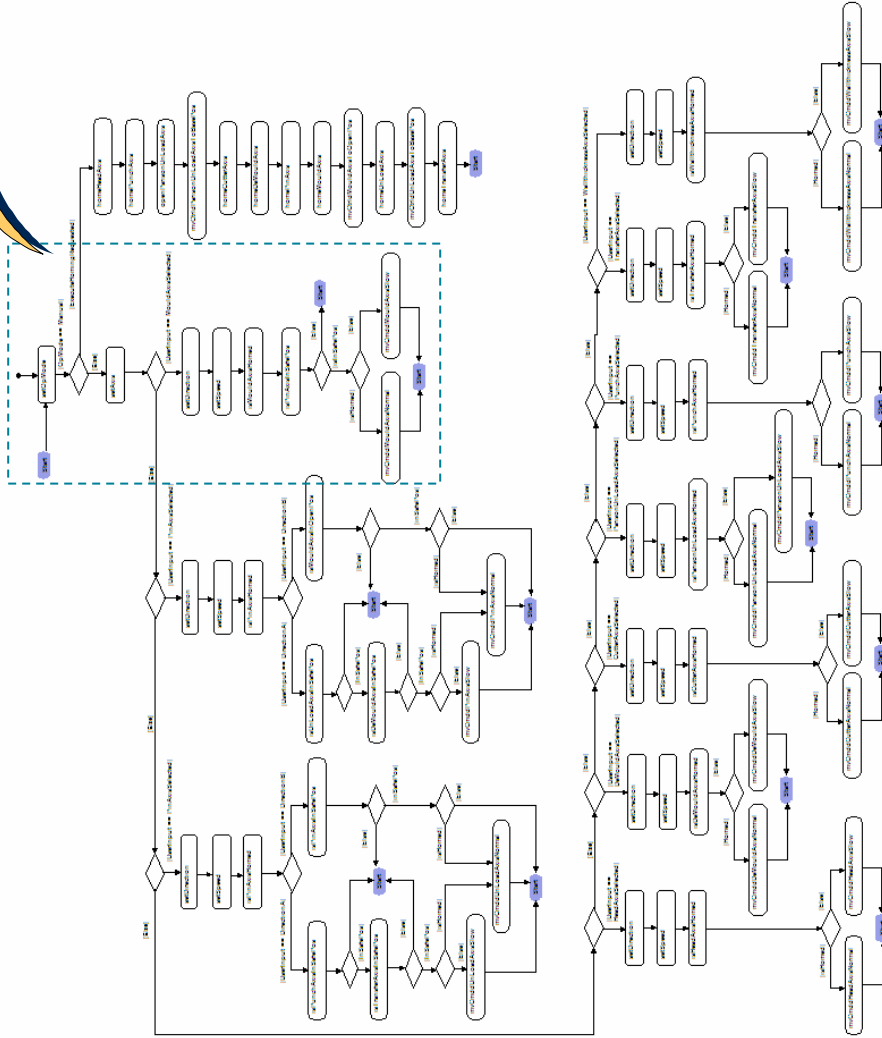
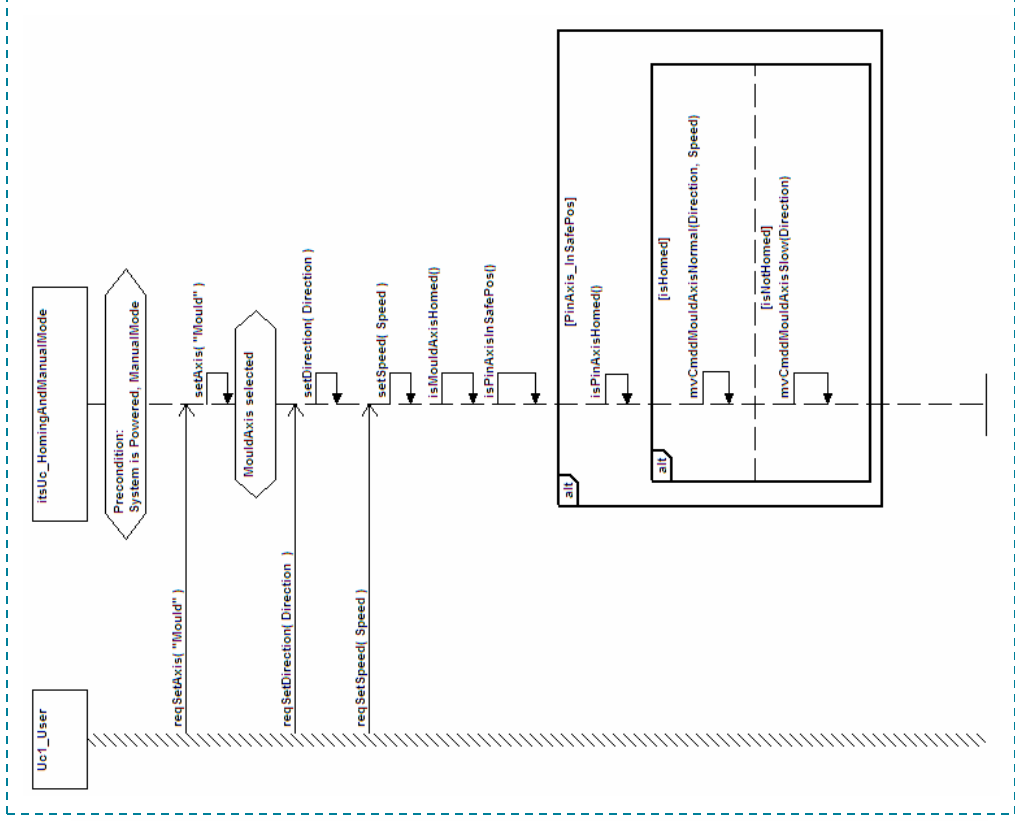


# Task Flow and Work Products in System Functional Analysis

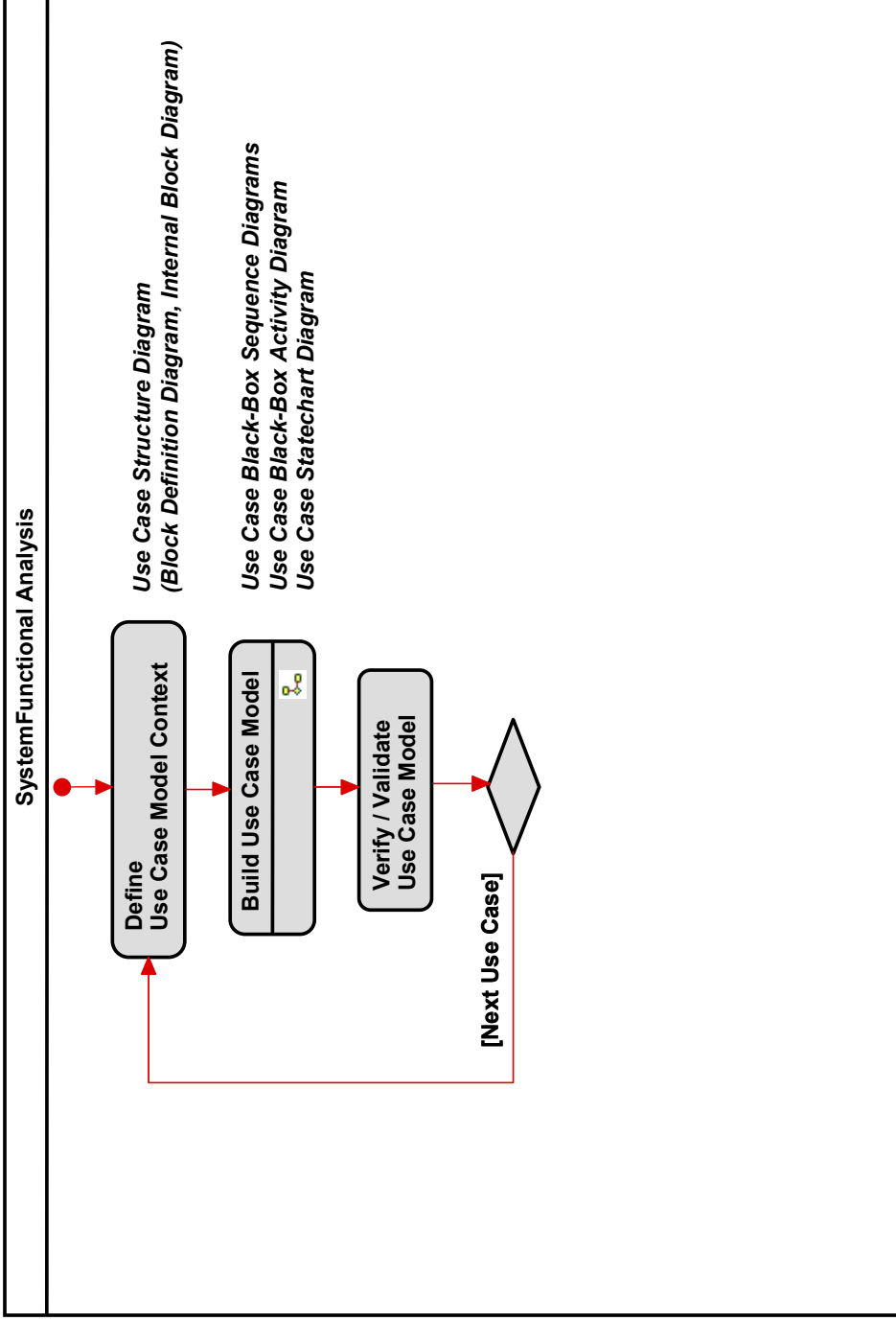


# System Functional Analysis

## Derivation of Use Case Scenarios from a UC Black-Box Activity Diagram

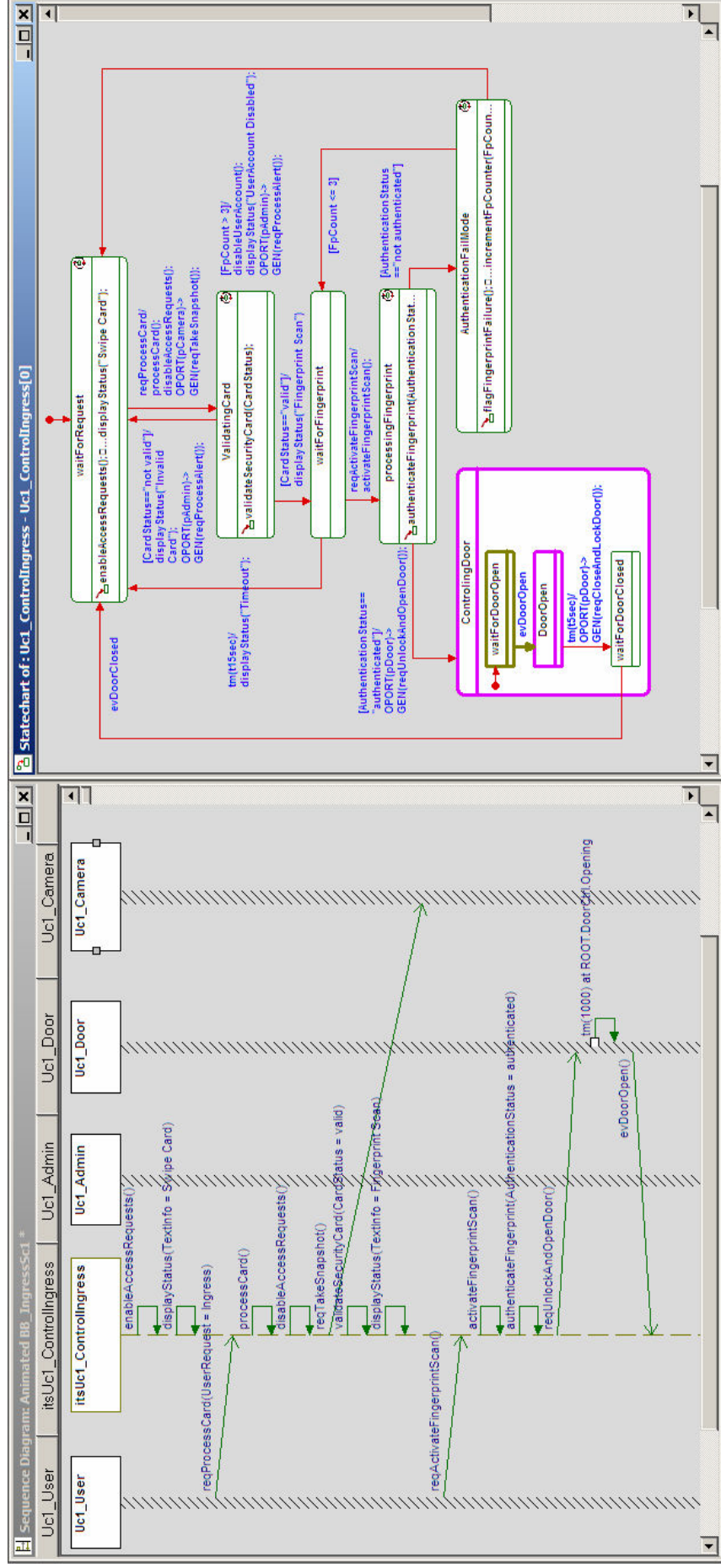


# Task Flow and Work Products in System Functional Analysis



# Model Verification and Validation Through Model Execution

## Example: Use Case Controlling Ingress (ref. *Rhapsody Deskbook*)



SecuritySystem

- User[0]
- Ucl\_ControllingIngress[0]

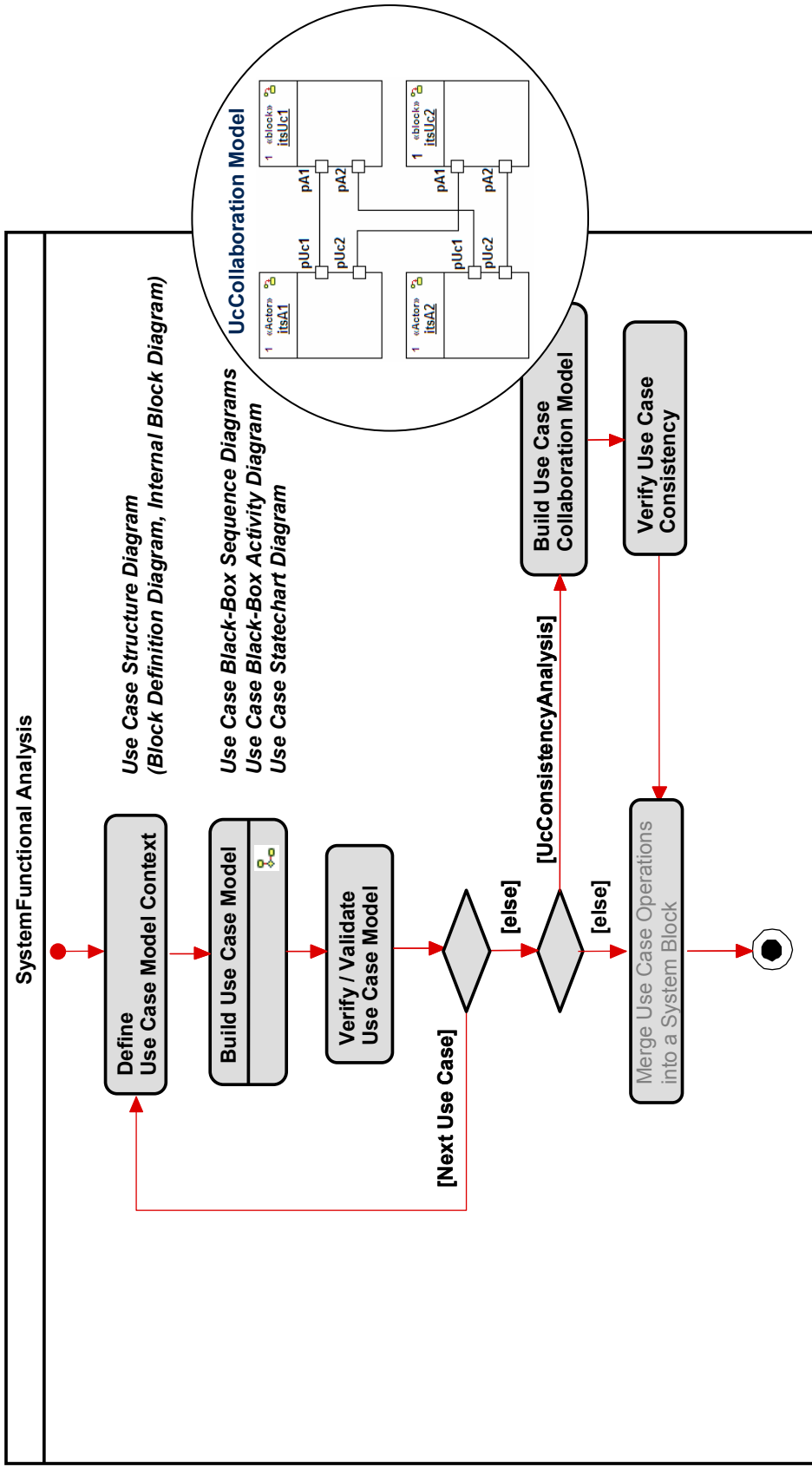
Ucl_ControllingIngress[0]	
AuthenticationStatus	authenticated
CardStatus	valid
FpCount	1

SecuritySystem

- User[0]
- Ucl\_ControllingIngress[0]

User[0]	
RequestIngress	Activate
ScanFingerprint	Activate
RequestEgress	Activate

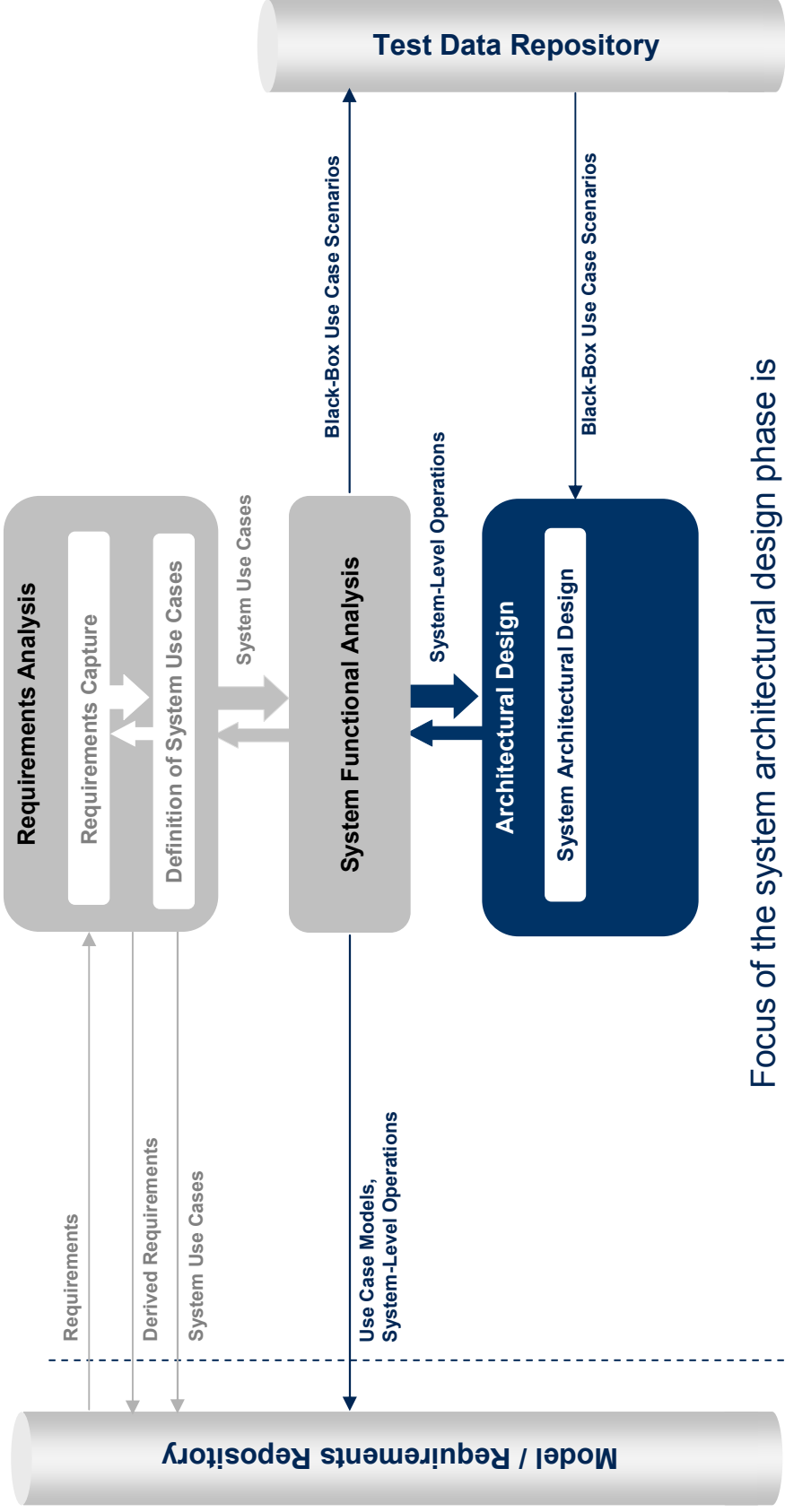
# Task Flow and Work Products in System Functional Analysis





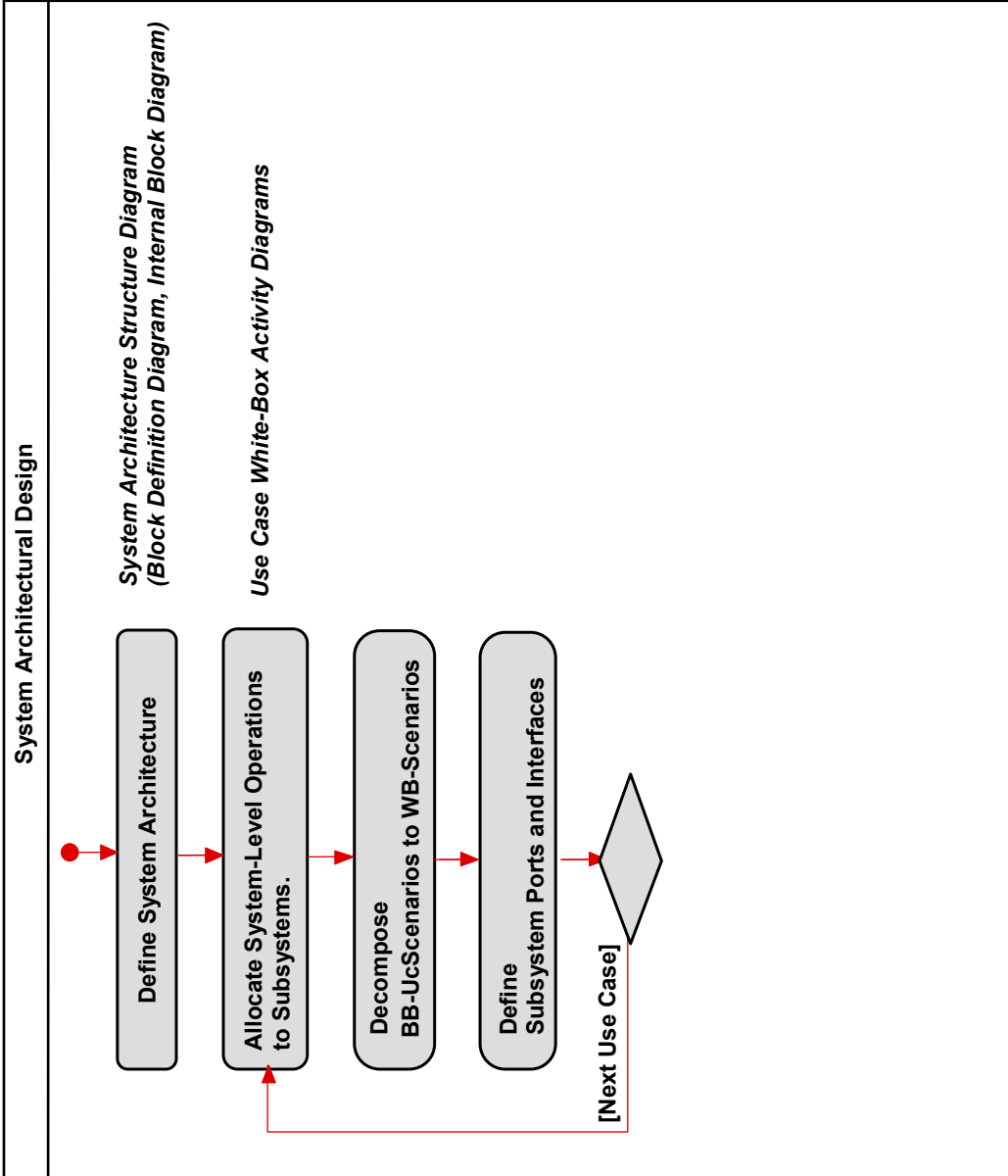
# SysML-Based Systems Engineering (Harmony-SE)

## Architectural Design Phase: System Architectural Design



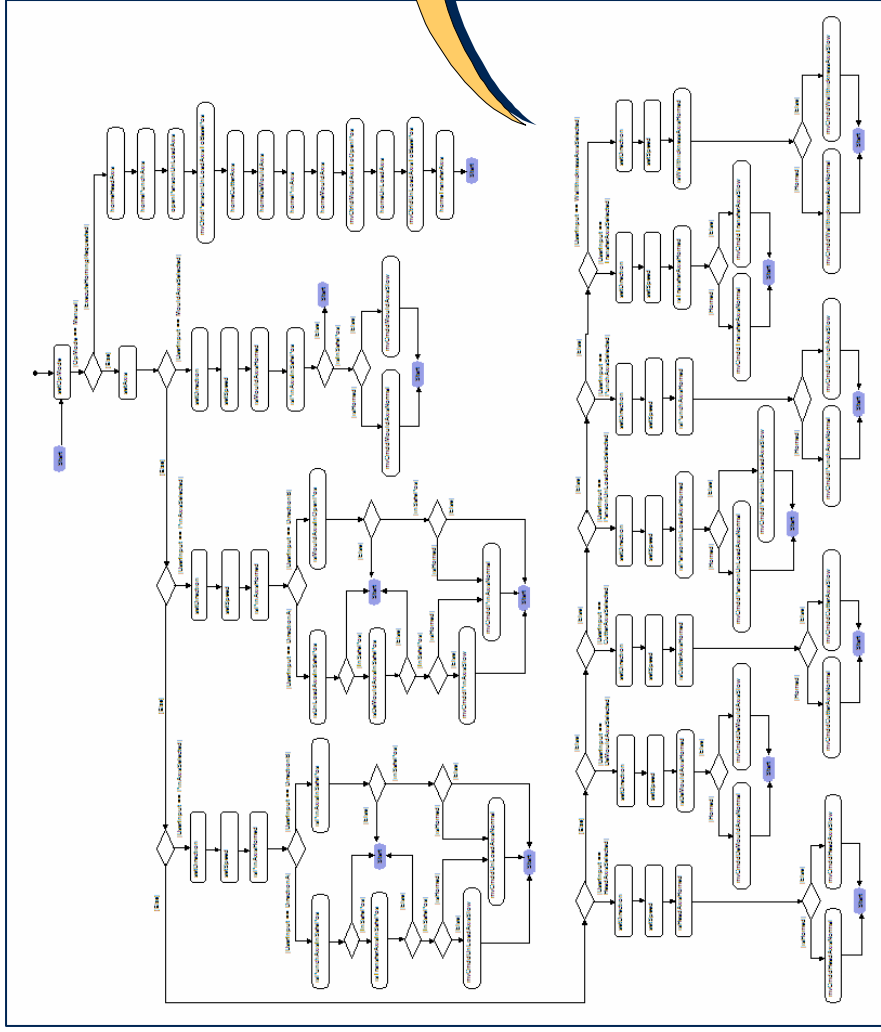
Focus of the system architectural design phase is the allocation of the verified and validated system-level operations to a system architecture.

# Task Flow and Work Products in System Architectural Design

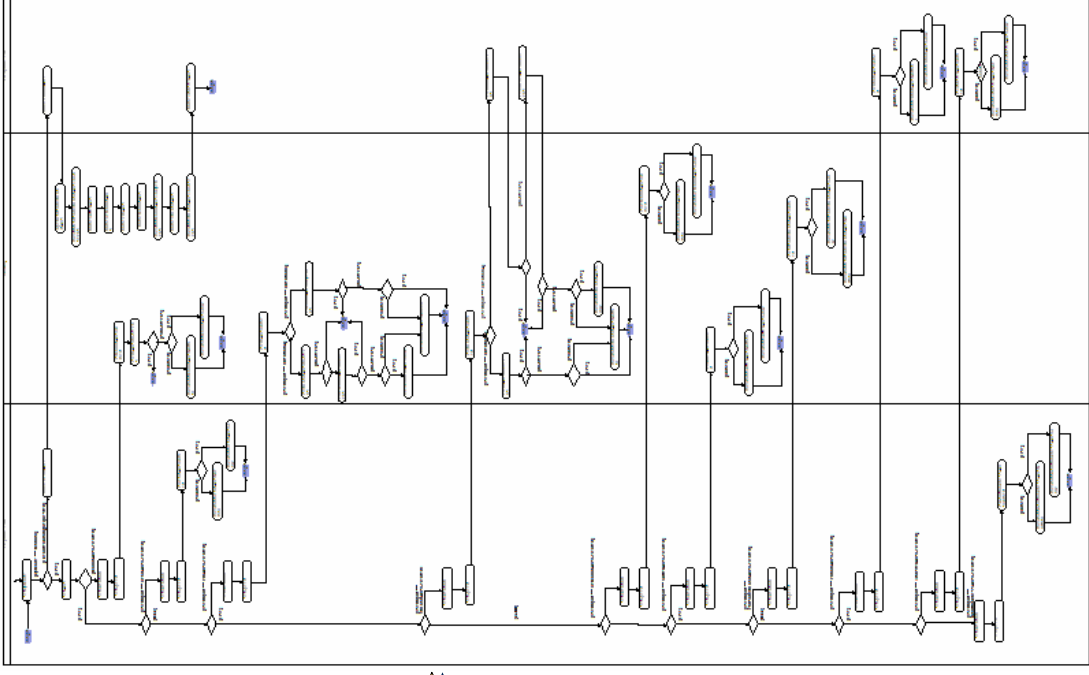


# System Architectural Design

## Allocation of OpCons/Operations to Subsystems



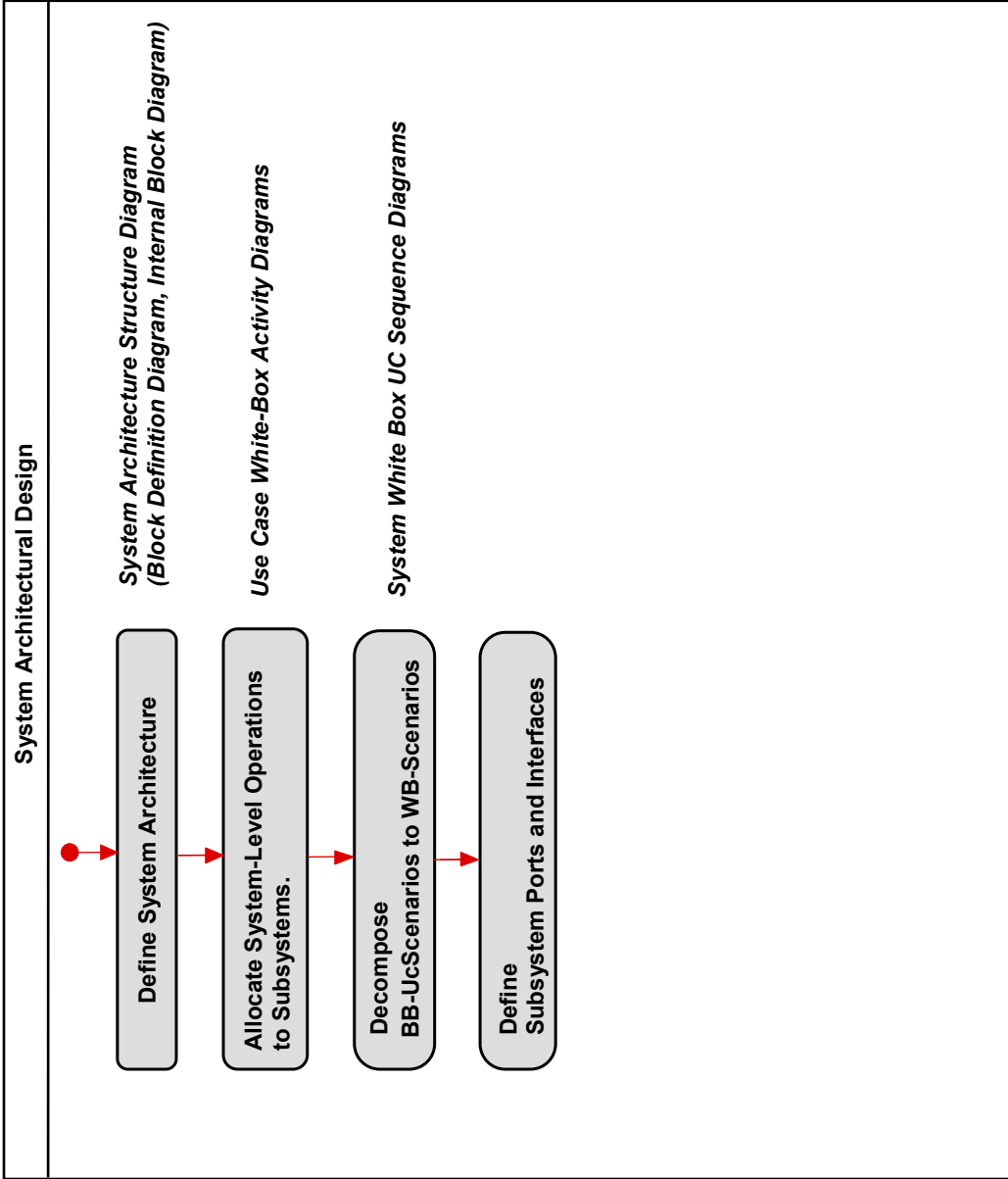
Use Case Black-Box Activity Diagram



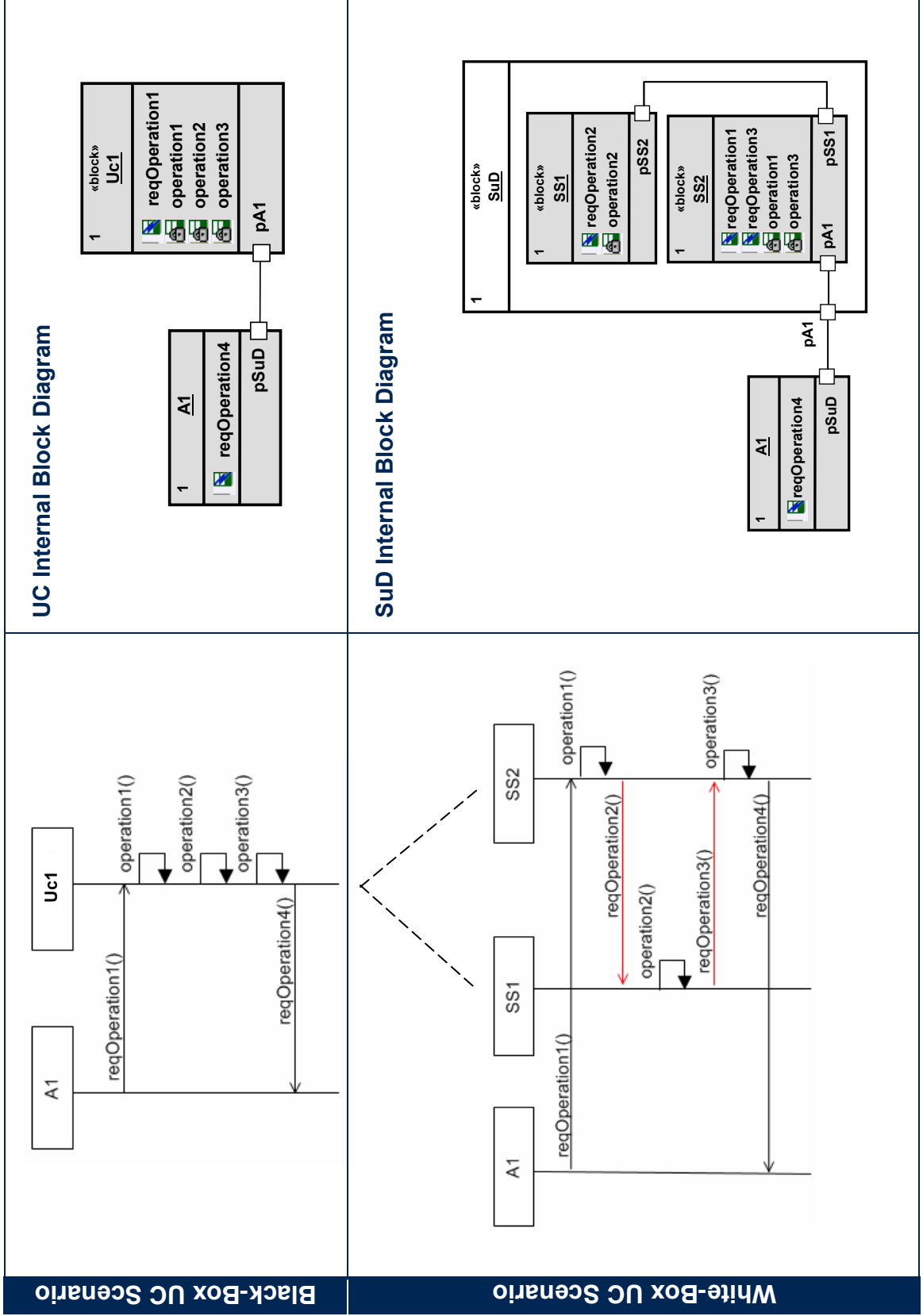
Use Case White-Box Activity Diagram



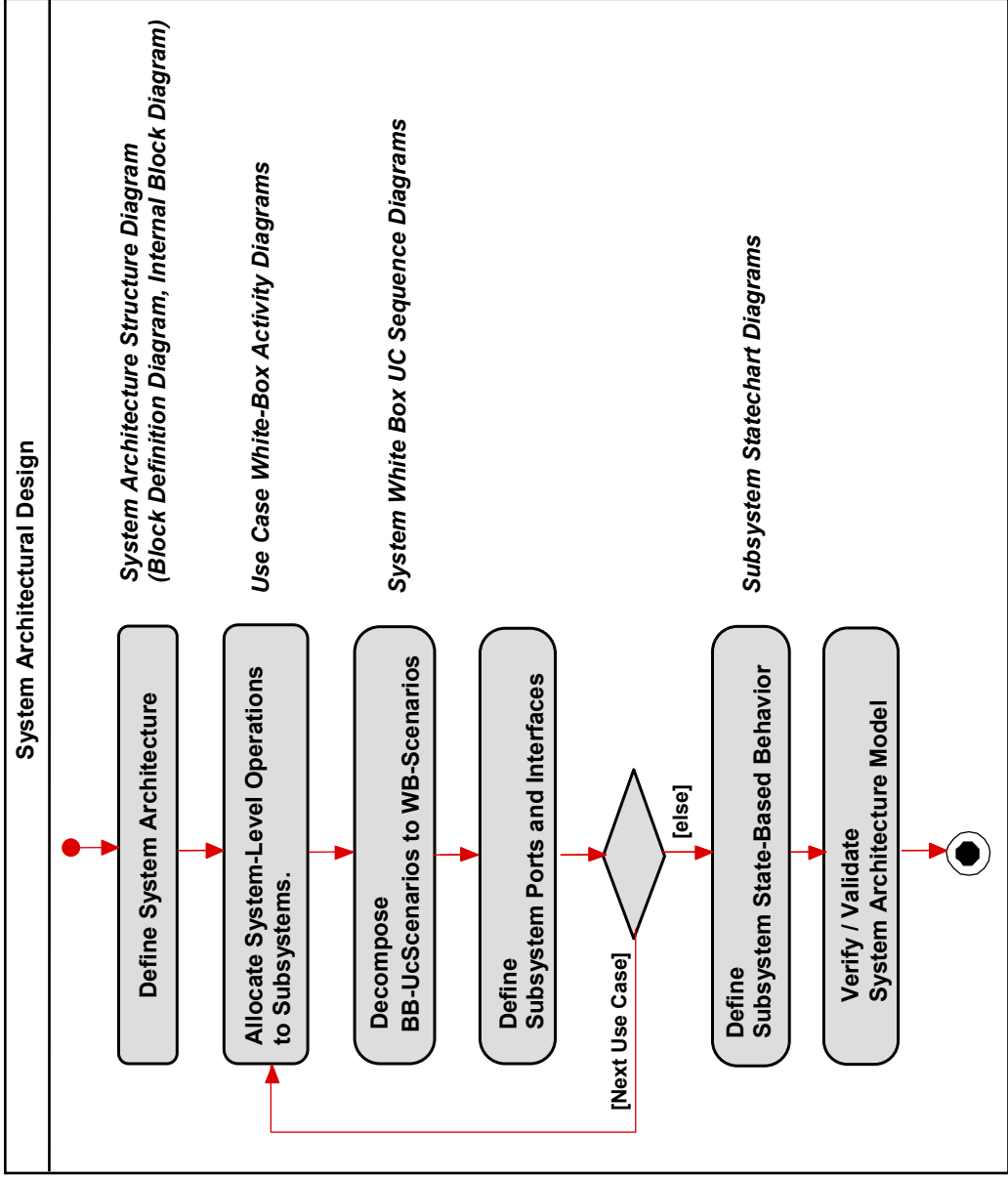
# Task Flow and Work Products in System Architectural Design



# Decomposition of BB-UcScenarios and Definition of Subsystem Ports / Interfaces

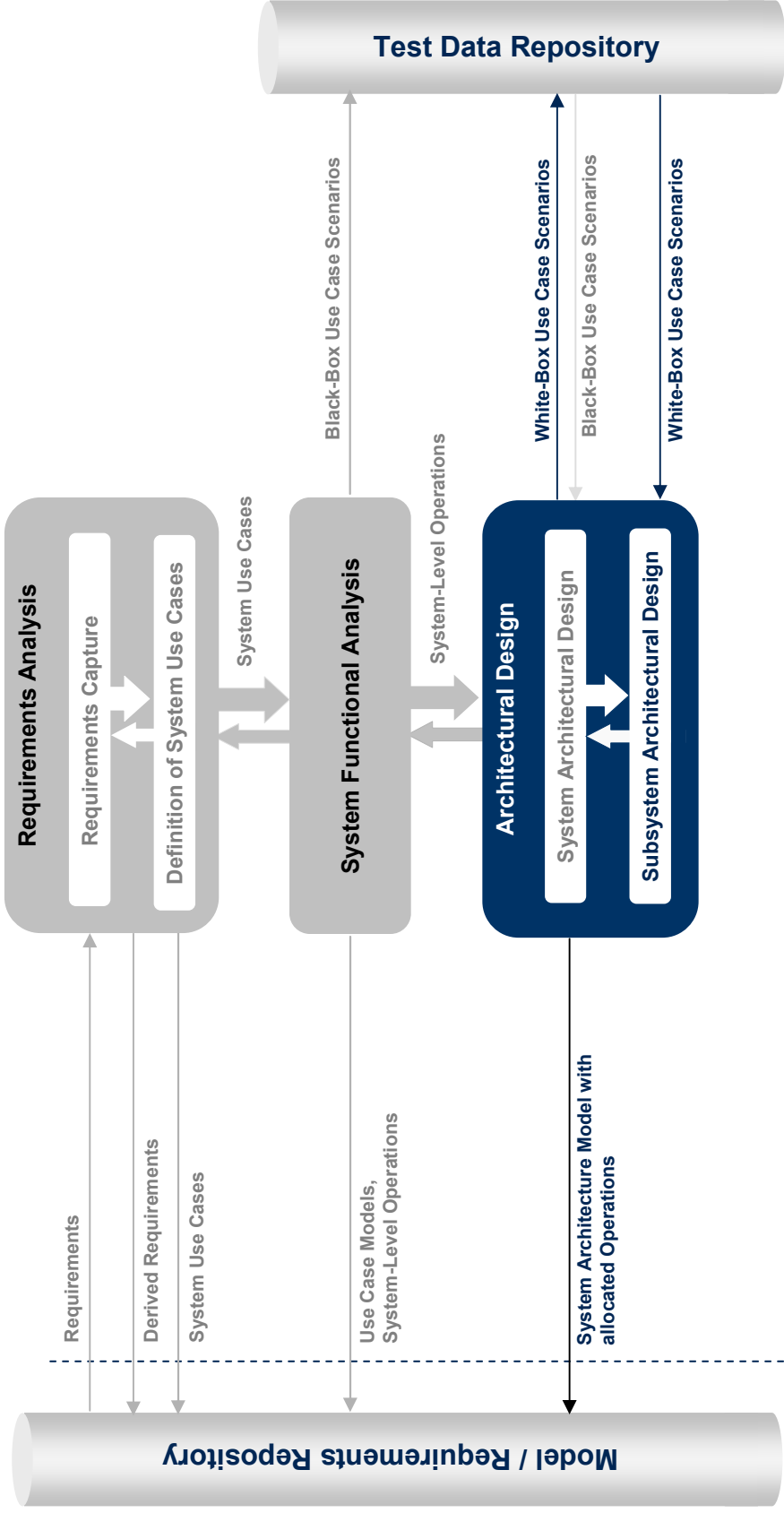


# Task Flow and Work Products in System Architectural Design



# SysML-Based Systems Engineering (Harmony-SE)

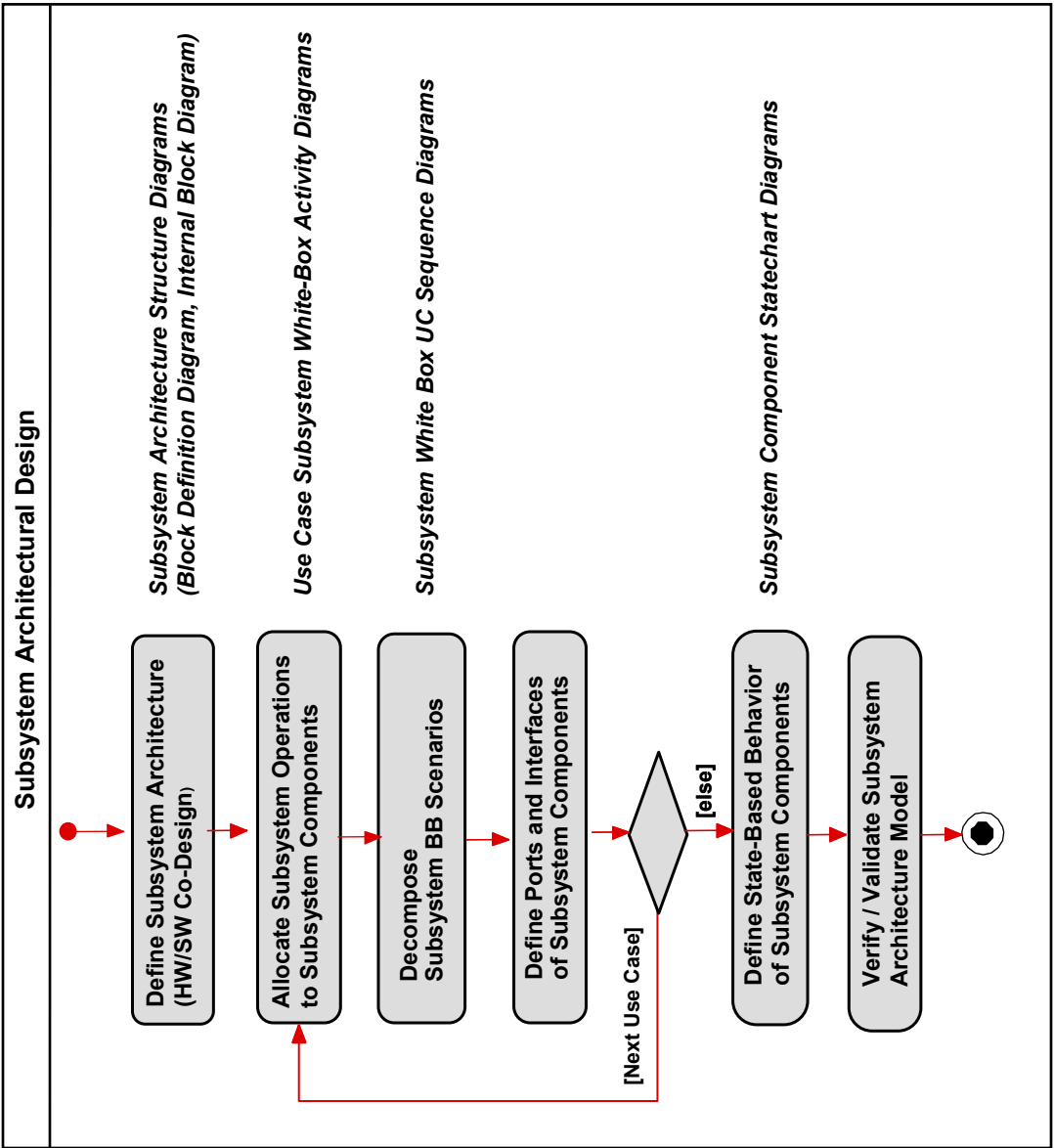
## Architectural Design Phase: Subsystem Architectural Design



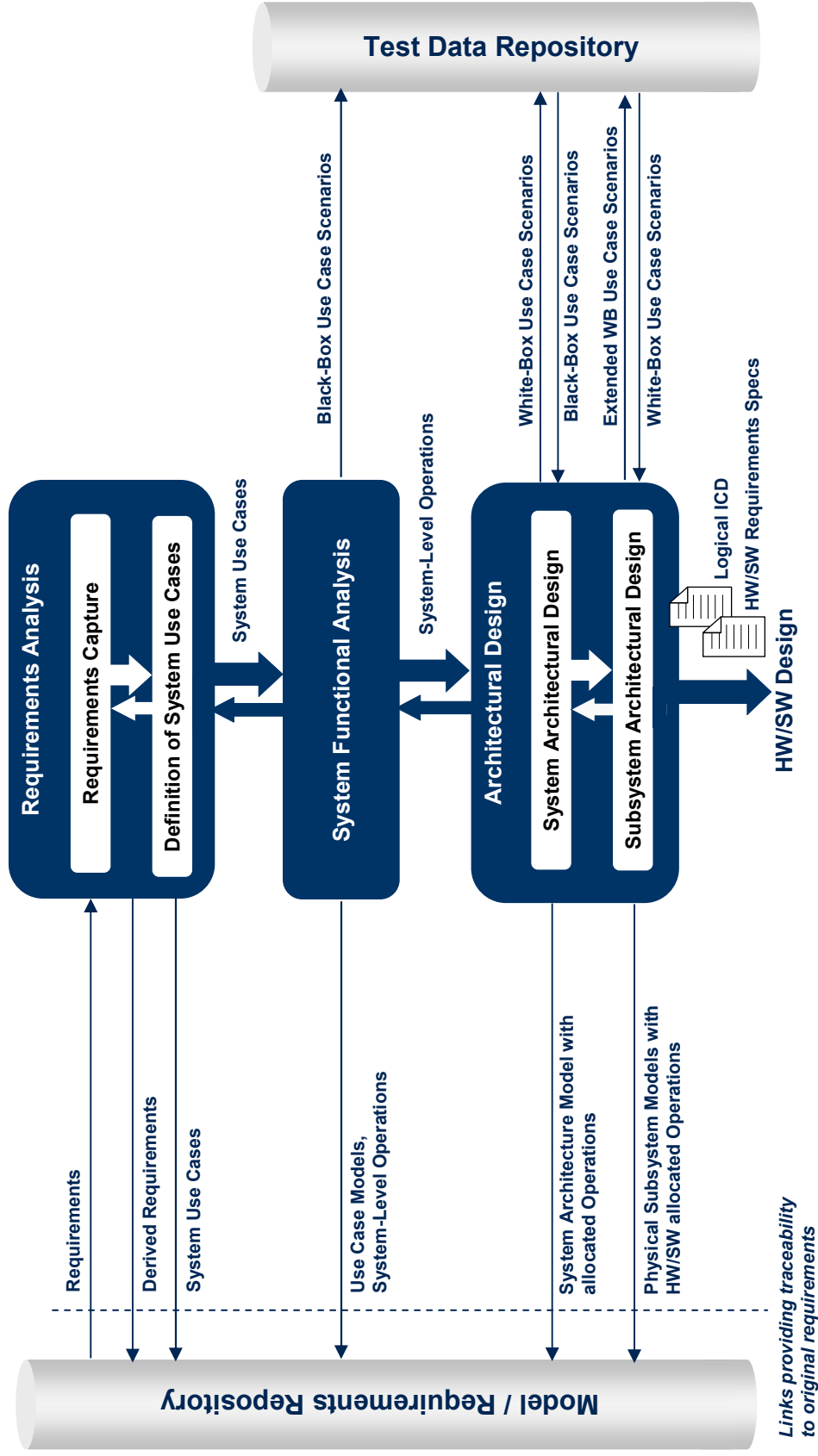
Links providing traceability to original requirements

Focus of the subsystem architectural design phase is the **realization** of the allocated operations (hardware/software trade-off).

# Task Flow and Work Products in Subsystem Architectural Design



# SysML-Based Systems Engineering (Harmony-SE)



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## Handoff to Hardware and Software Development

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For each subsystem the essential handoff artifacts to the subsequent hardware and software development are:

- **Executable HW / SW Requirements Specifications**
  - Allocated hardware / software requirements, i.e. functional requirements (Operations) and non-functional requirements
  - Links to original system-level requirements (RT database)
  - Hardware / software component behavioral descriptions (statechart diagrams)
- **Logical Interface Control Document**
  - System level interfaces
  - Subsystem level interfaces
- **Subsystem / Subsystem Components Test Vectors**

derived from the system-level use case scenarios

# SysML-Based Systems Engineering Using a Model-Driven Development Approach

