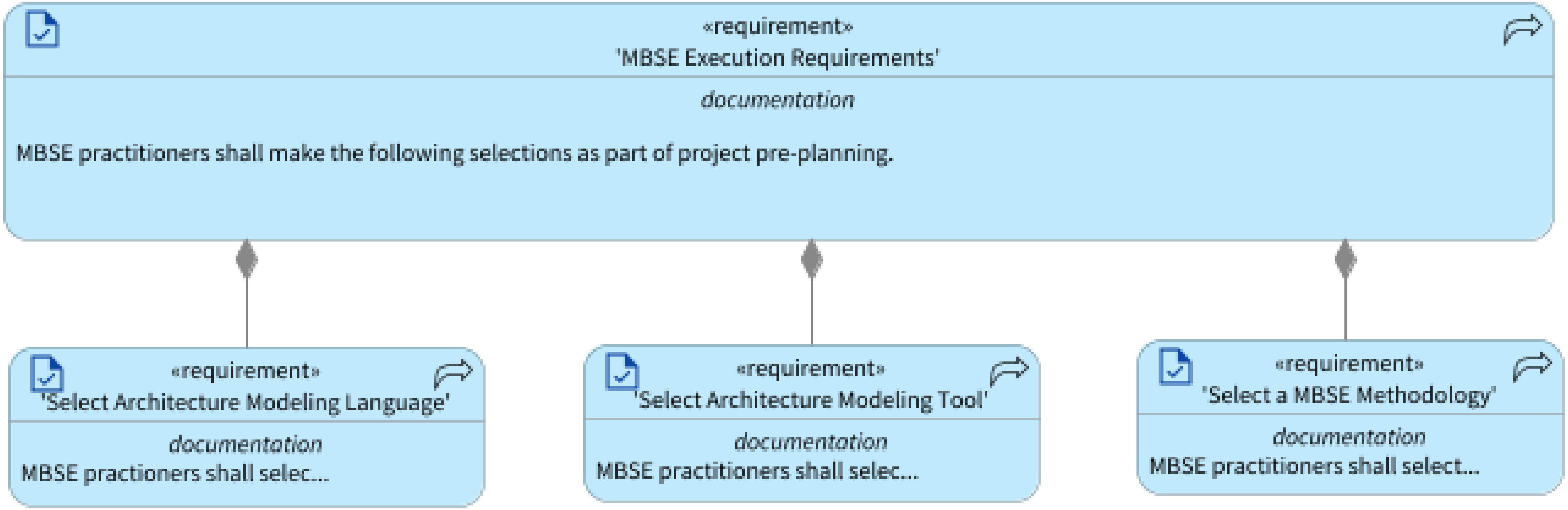
Using SysML v2 to Define a Digital Engineering Methodology

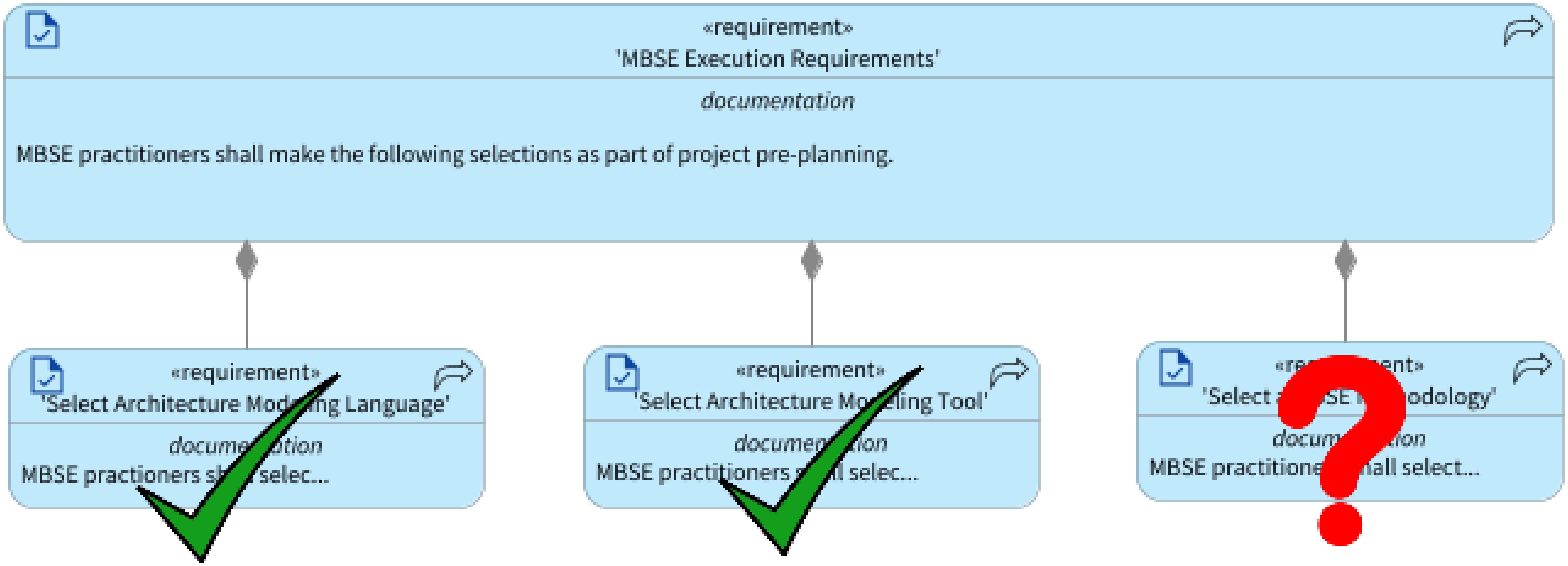
GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2024

J. Simmons, Ph.D.

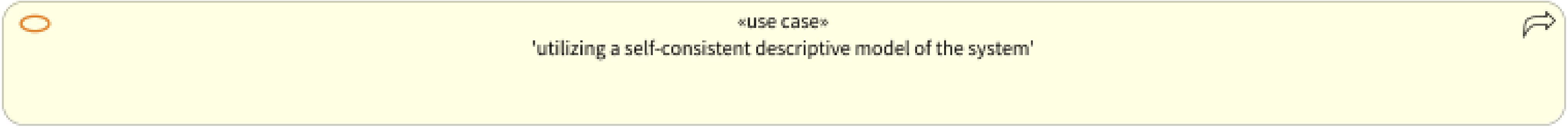
It Takes Three Things to Execute MBSE



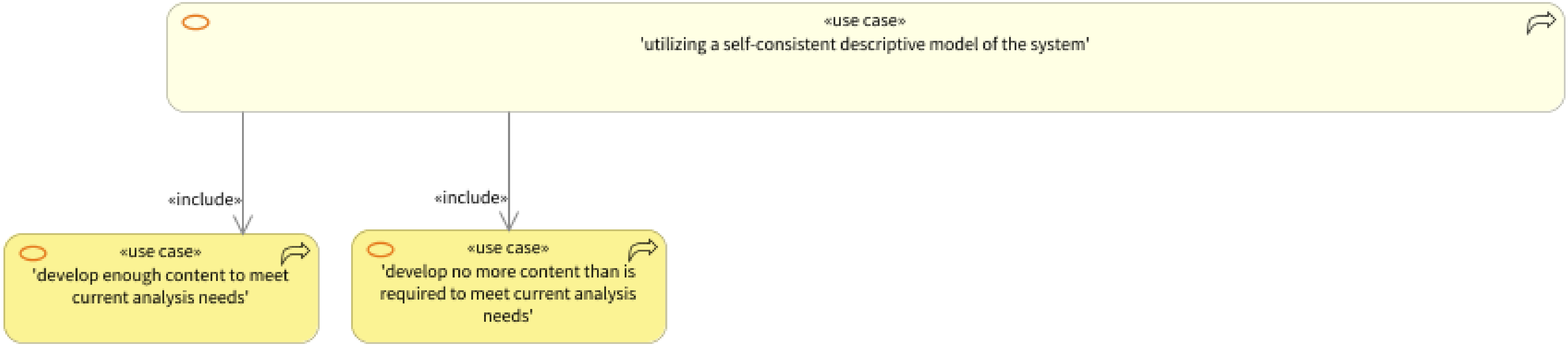
It Takes Three Things to Execute MBSE



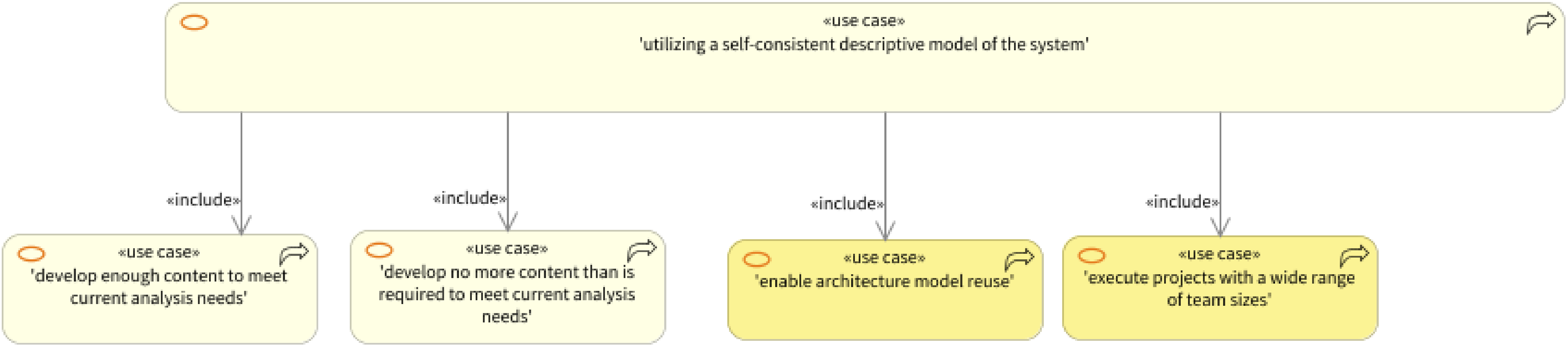
Formalizing the Use of the Architecture Model



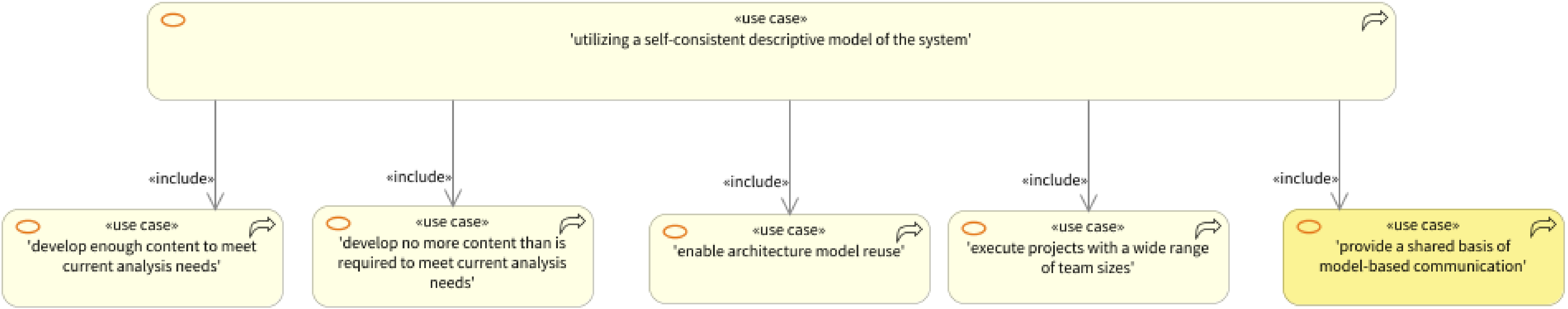
Formalizing the Use of the Architecture Model



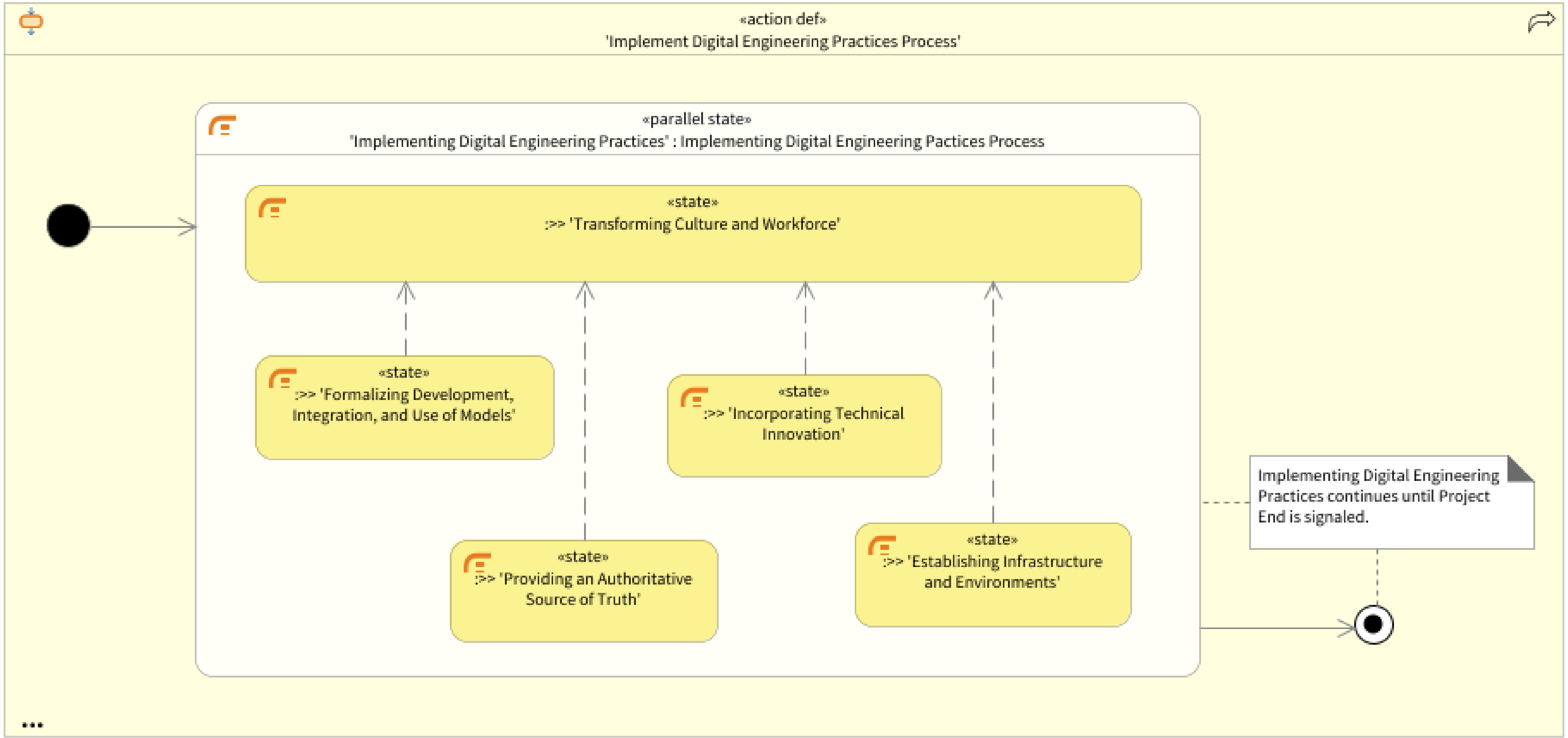
Formalizing the Use of the Architecture Model



Formalizing the Use of the Architecture Model

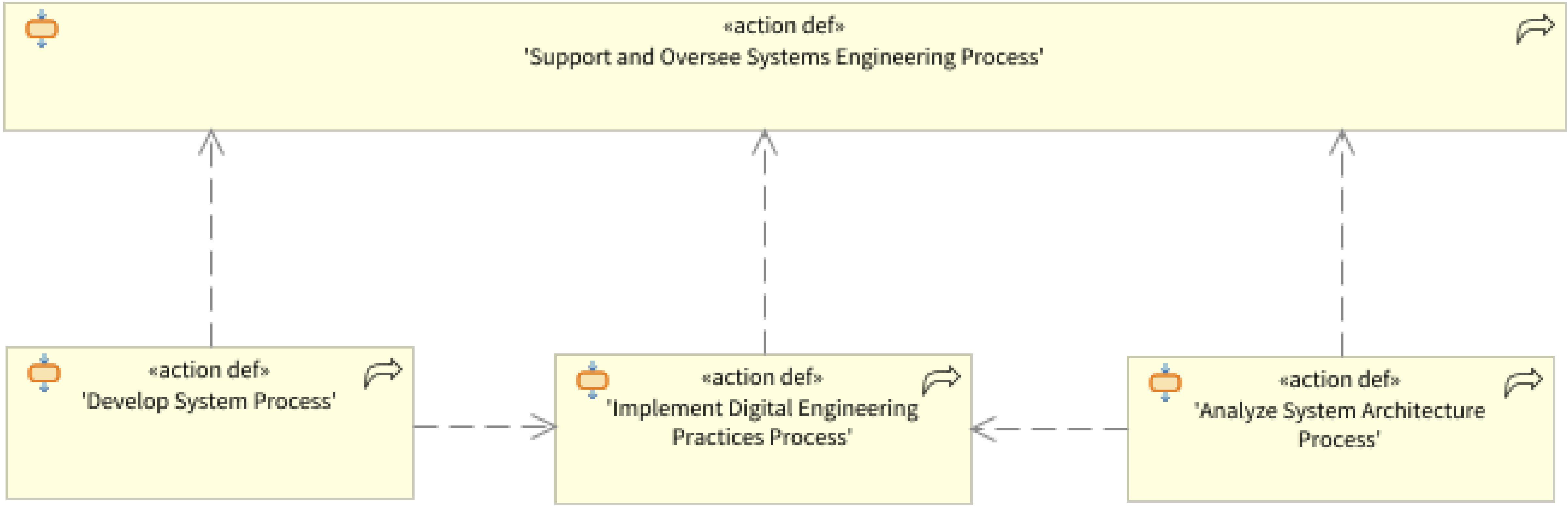


The Need for a Methodology Is Even Greater…



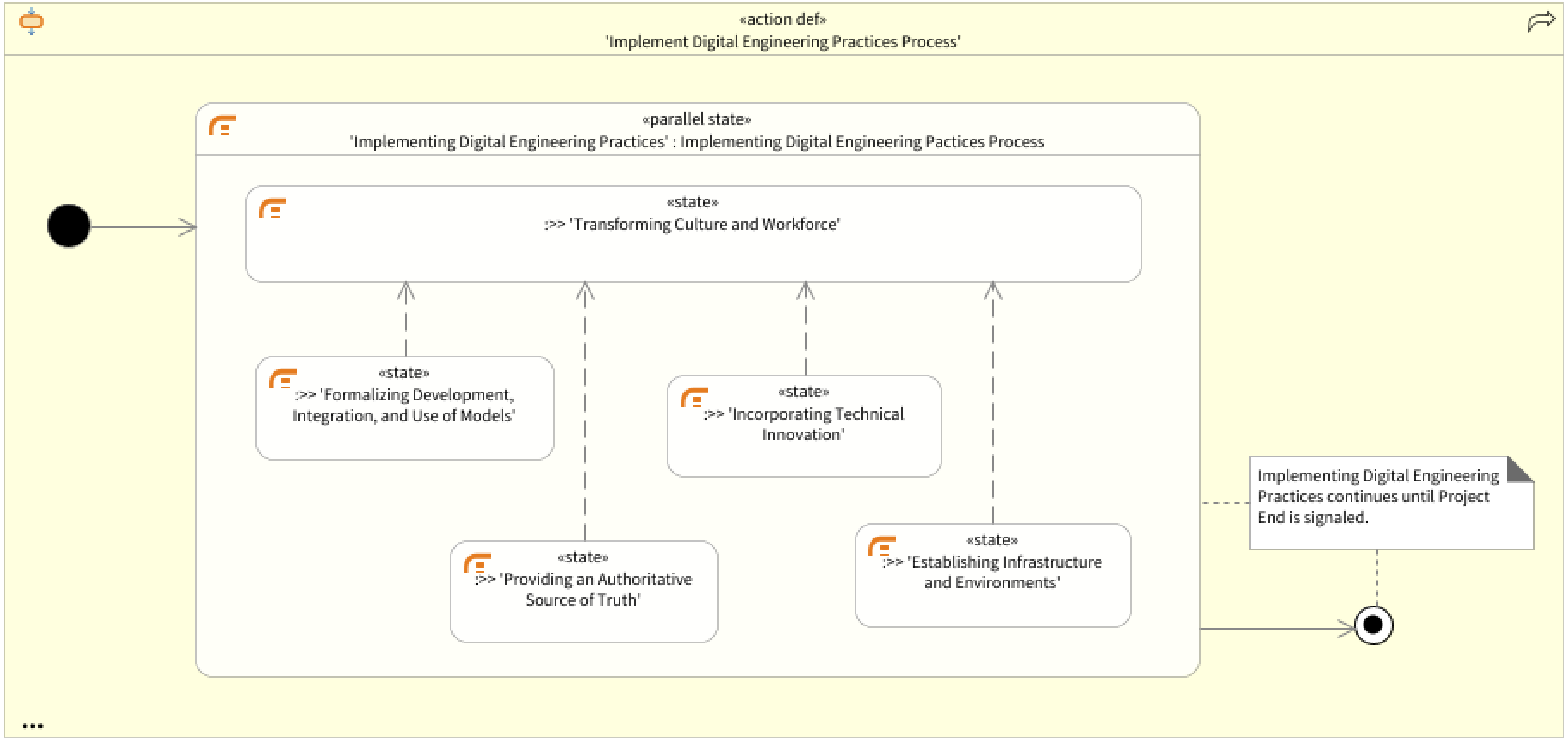
Digital Engineering Consultant

The Ansys Digital Engineering Methodology

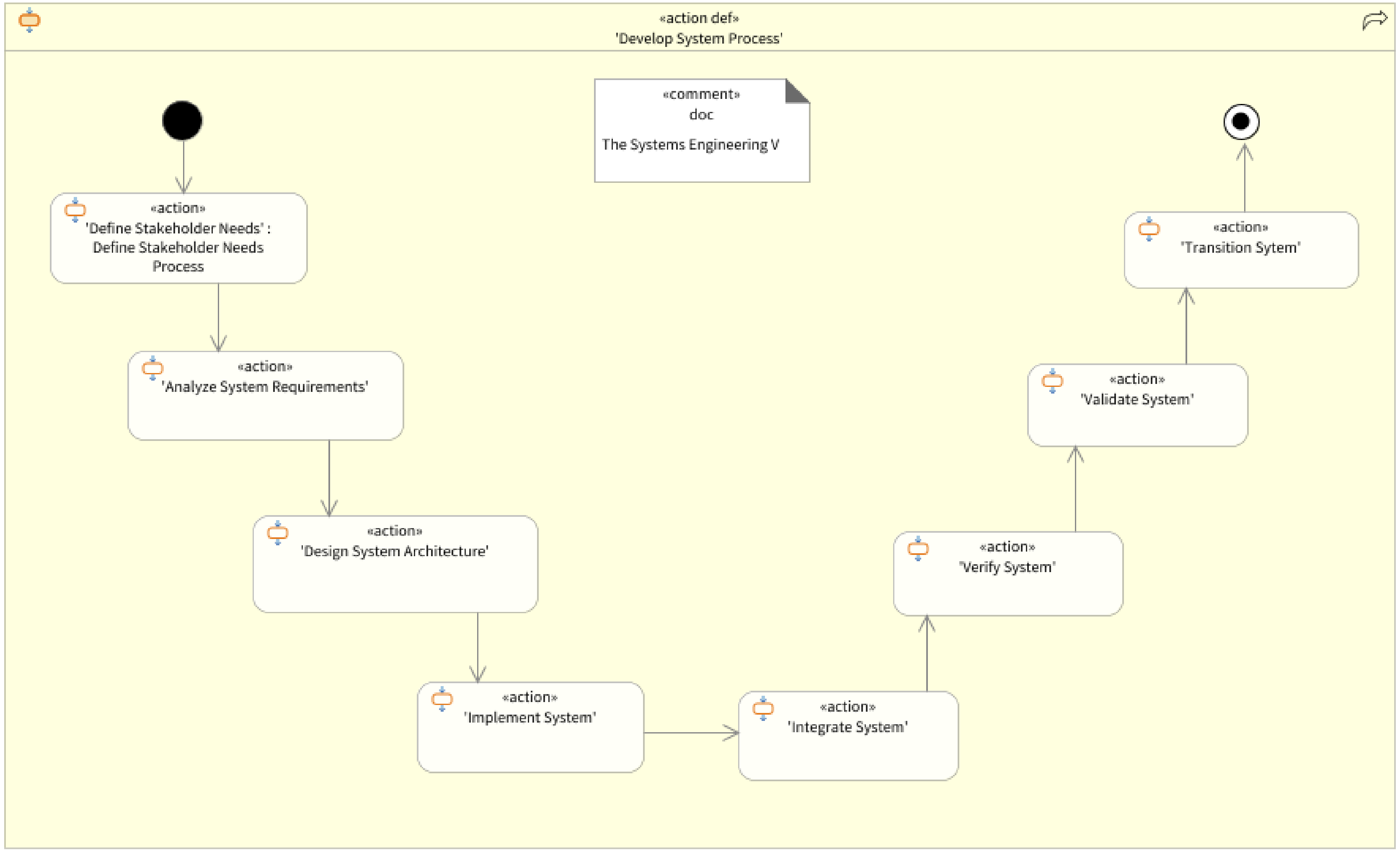


Implement Digital Engineering Practices Process

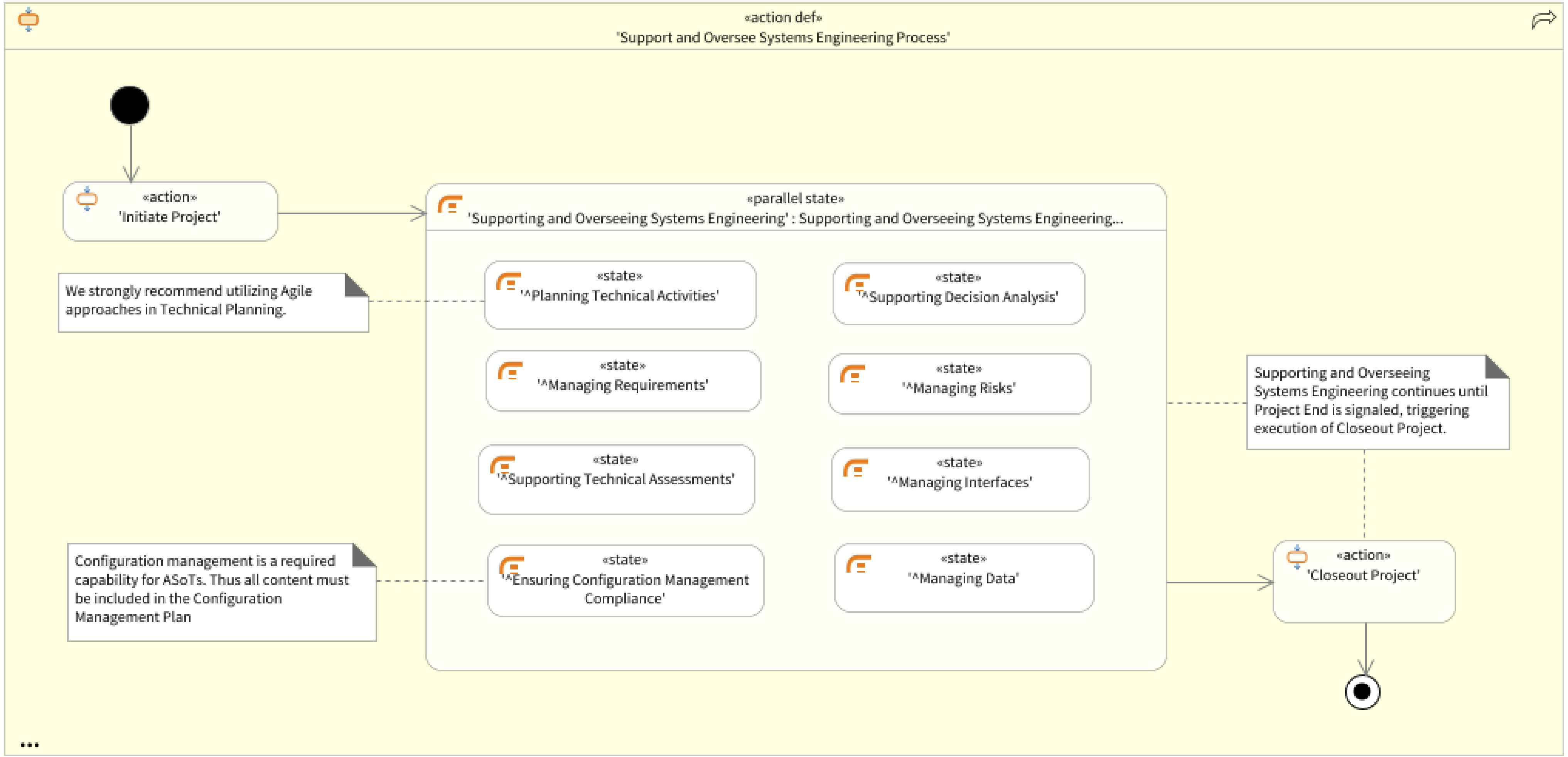
Global Product Data Interoperability Summit | **2024**



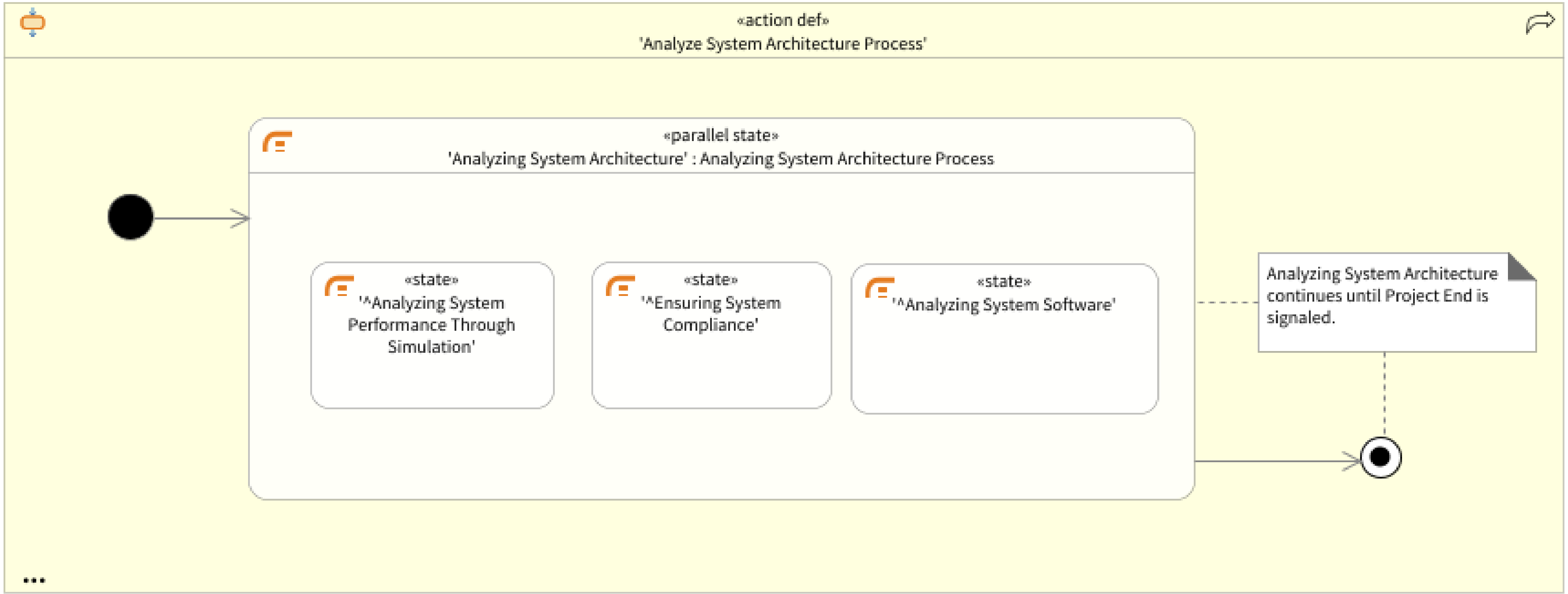
Develop System Process



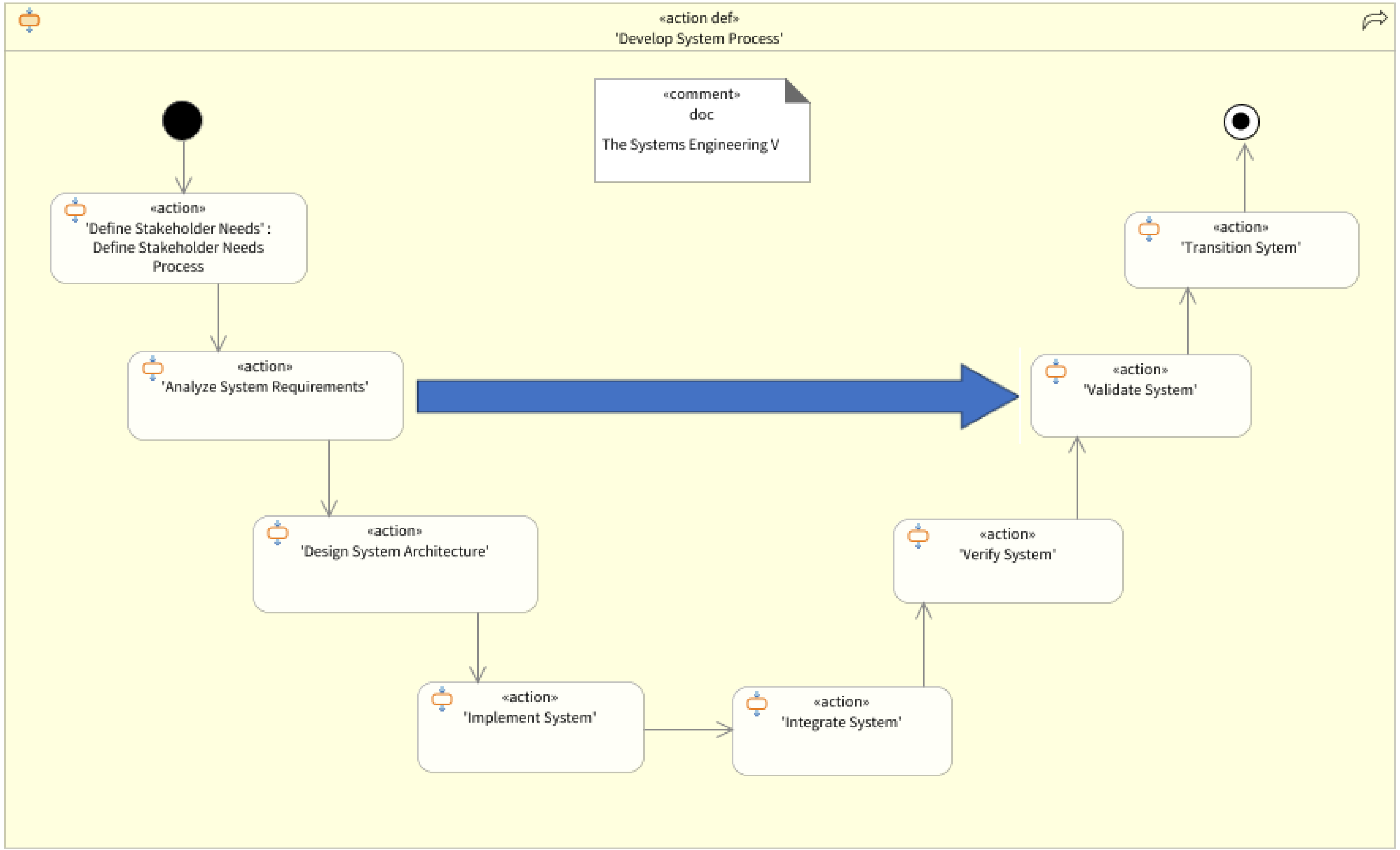
Support & Oversee Systems Engineering Process



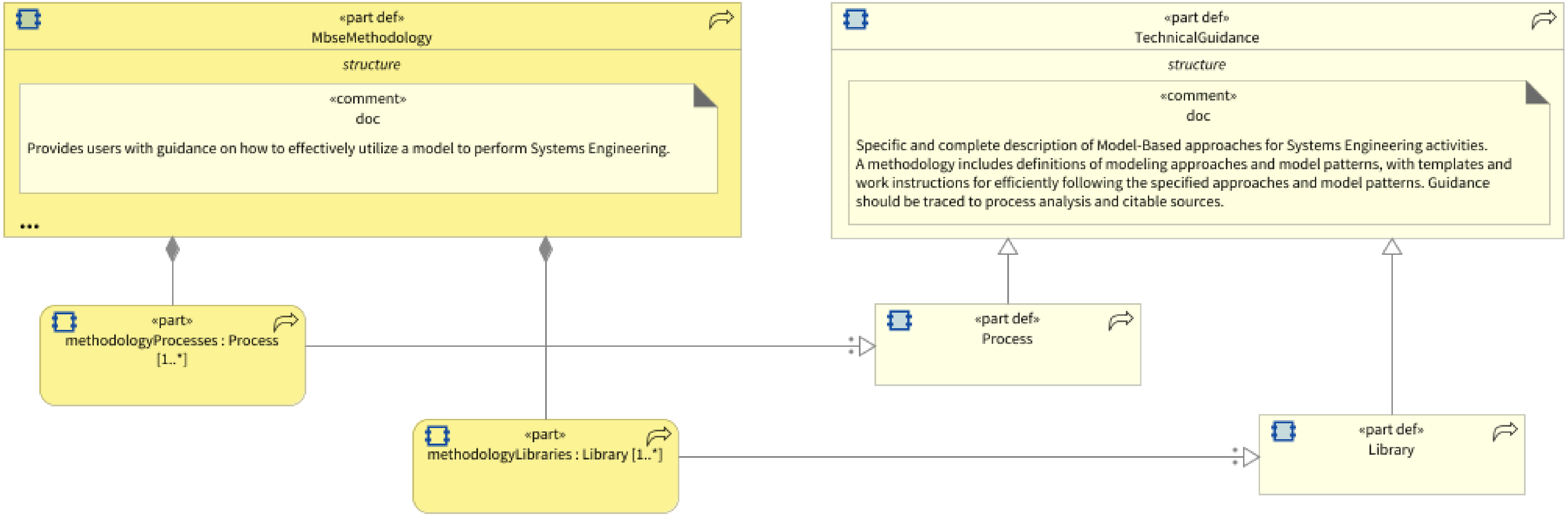
Analyze System Architecture Process



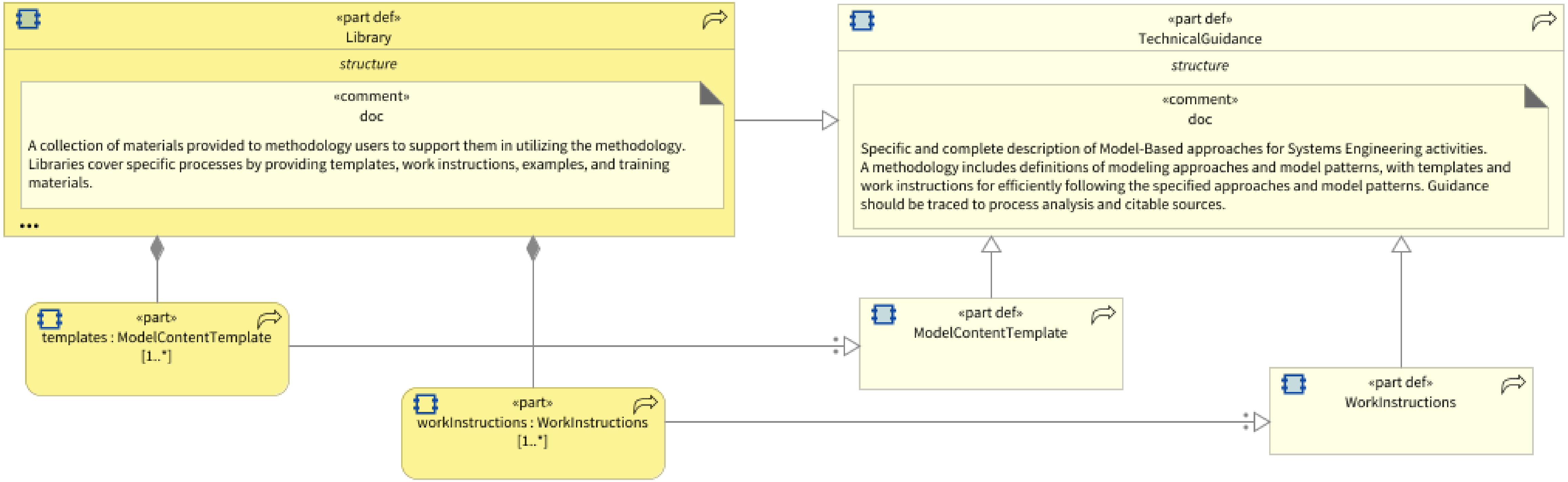
Perform Early Validation



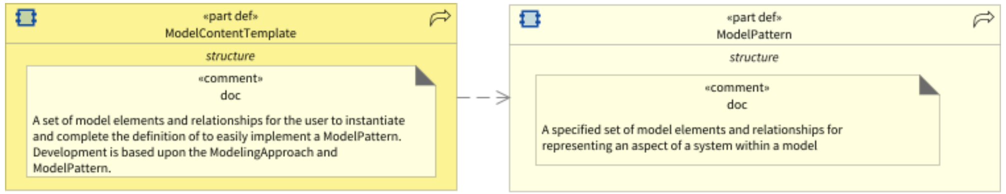
What is a Well-Defined Methodology?



Methodology Libraries



Templates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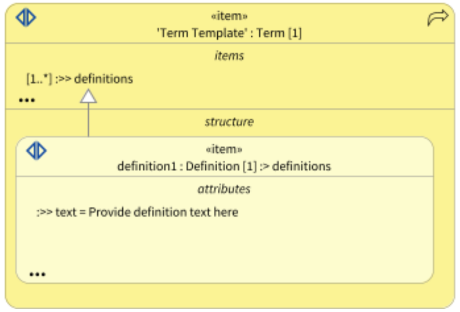
ModelContentTemplate
structure
«comment»
doc
A set of model elements and relationships for the user to instantiate and complete the definition of to easily implement a ModelPattern. Development is based upon the ModelingApproach and ModelPattern.
«part def»
ModelPattern
structure
«comment»
doc
A specified set of model elements and relationships for representing an aspect of a system within a model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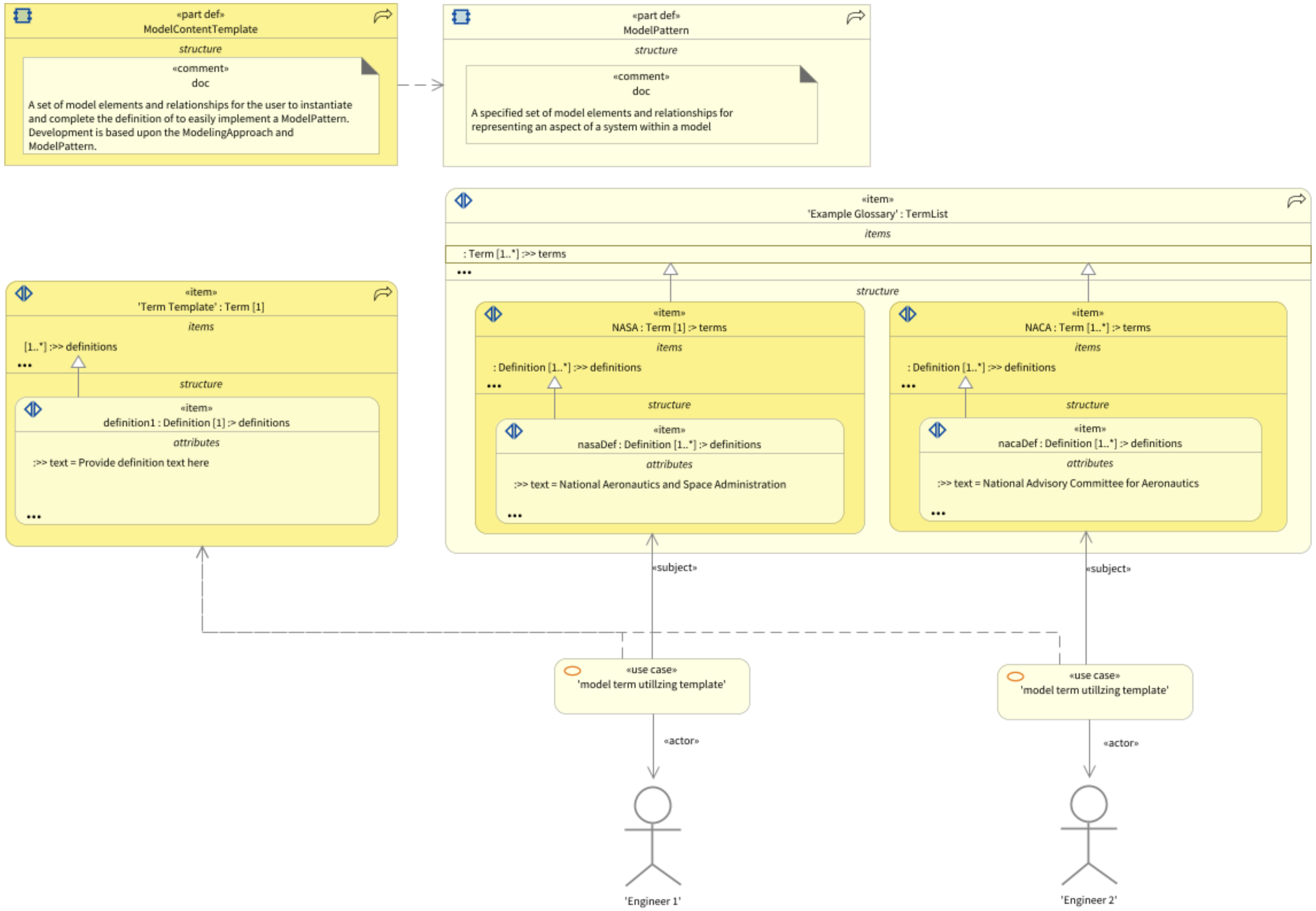
'Term Template' : Term [1]
items
[1..*] :>> definitions
structure
«item»
definition1 : Definition [1] :> definitions
attributes
:>> text = Provide definition text here

Templates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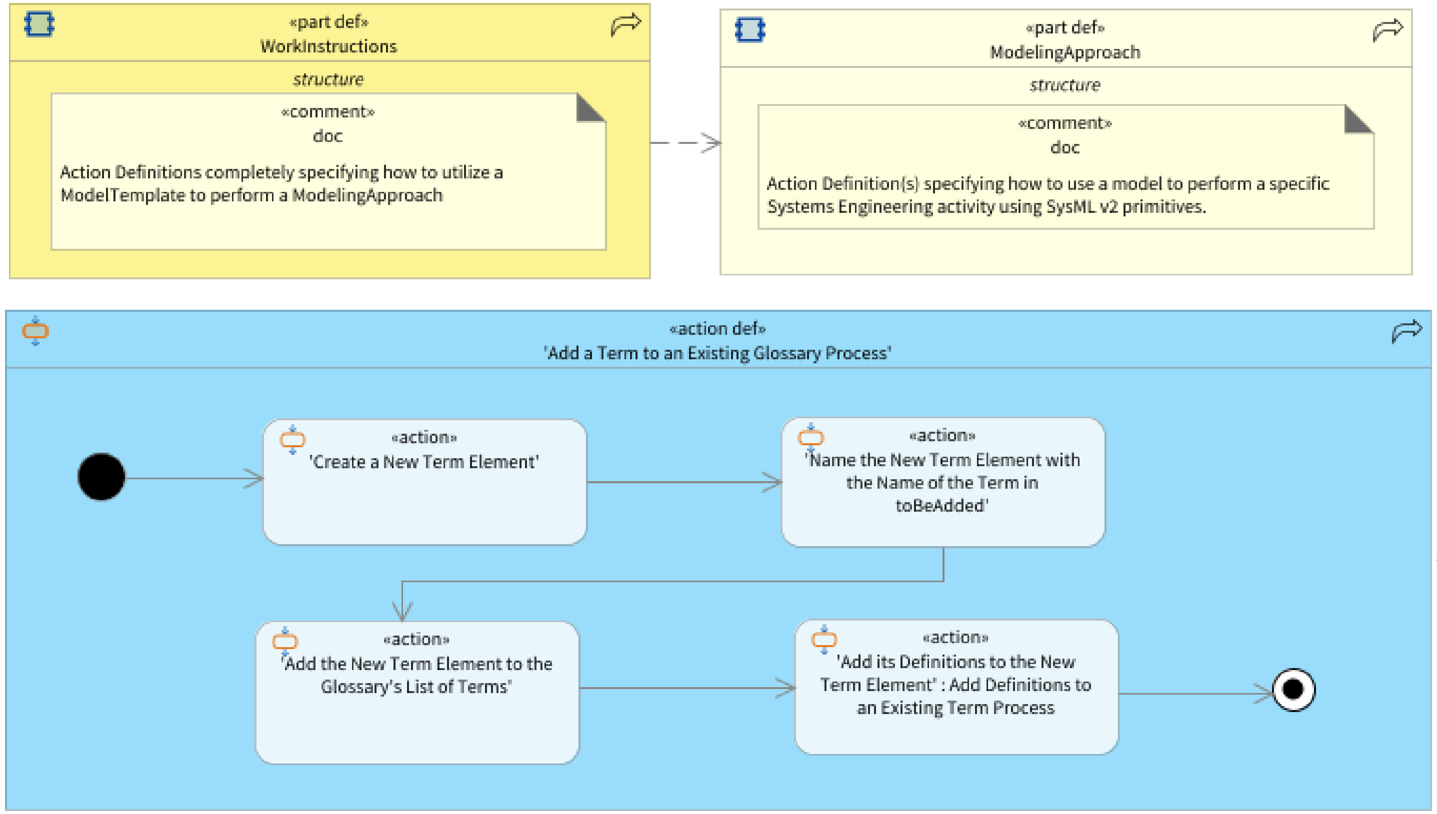
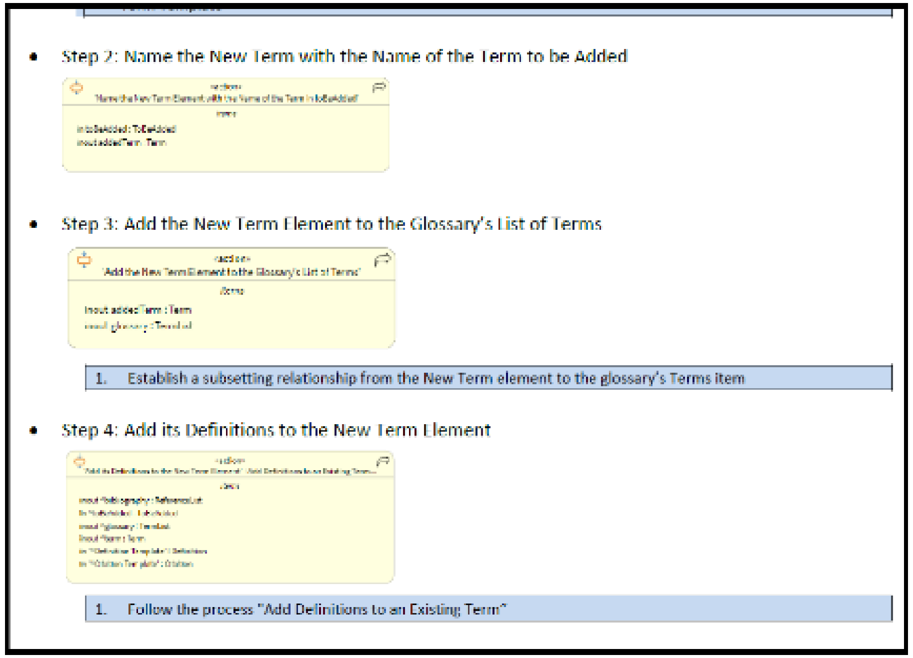
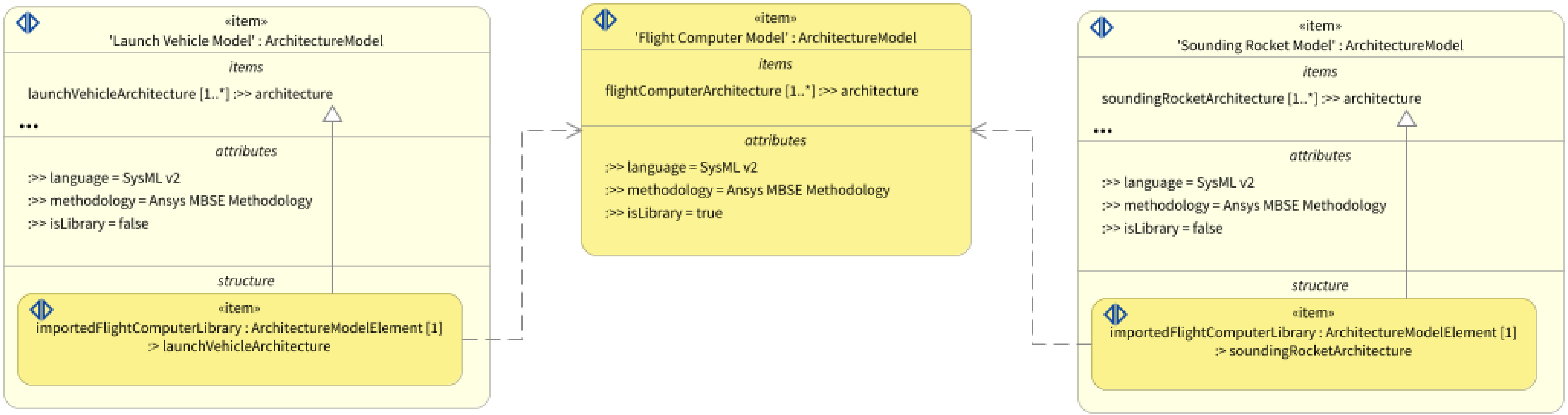
ModelContentTemplate
structure
«comment»
doc
A set of model elements and relationships for the user to instantiate and complete the definition of to easily implement a ModelPattern. Development is based upon the ModelingApproach and ModelPattern.
«part def»
ModelPattern
structure
«comment»
doc
A specified set of model elements and relationships for representing an aspect of a system within a model
«item»
'Example Glossary' : TermList
items
: Term [1..*] :>> terms
structure
«item»
'Term Template' : Term [1]
items
[1..*] :>> definitions
structure
«item»
definition1 : Definition [1] :> definitions
attributes
:>> text = Provide definition text here
«item»
NASA : Term [1] :> terms
items
: Definition [1..*] :>> definitions
structure
«item»
nasaDef : Definition [1..*] :> definitions
attributes
:>> text = National Aeronautics and Space Administration
«item»
NACA : Term [1..*] :> terms
items
: Definition [1..*] :>> definitions
structure
«item»
nacaDef : Definition [1..*] :> definitions
attributes
:>> text = National Advisory Committee for Aeronautics
«subject»
«subject»
«use case»
'model term utillzing template'
«use case»
'model term utillzing template'
«actor»
«actor»
'Engineer 1'
'Engineer 2'

Work Instructions

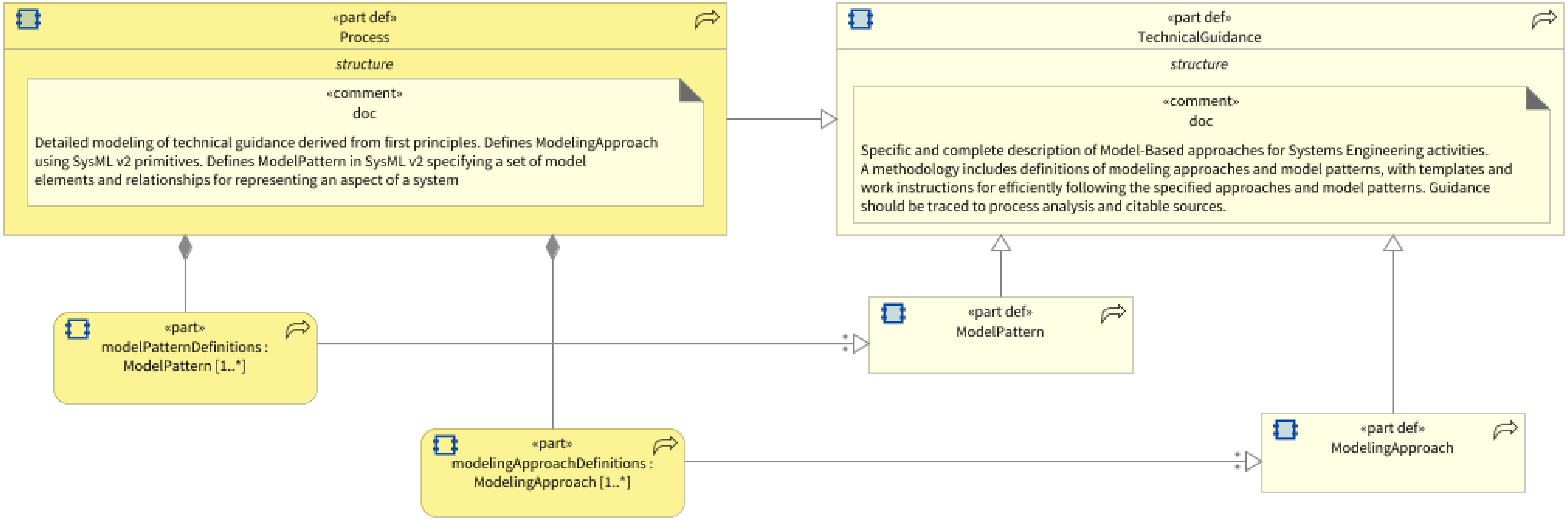



- Step 2: Name the New Term with the Name of the Term to be Added
- Step 3: Add the New Term Element to the Glossary's List of Terms
  1. Establish a subsetting relationship from the New Term element to the glossary's Terms item
- Step 4: Add its Definitions to the New Term Element
  1. Follow the process "Add Definitions to an Existing Term"

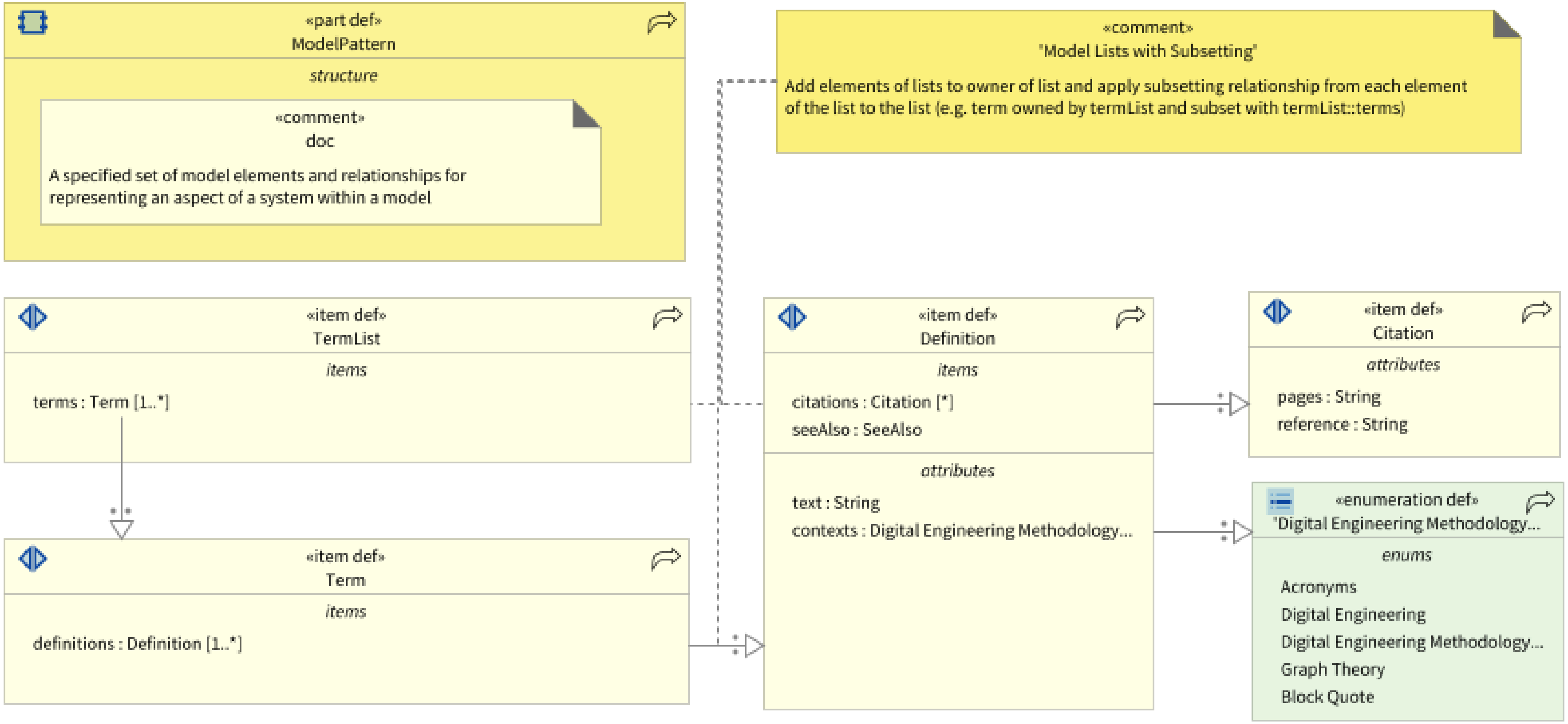
Reusable Libraries



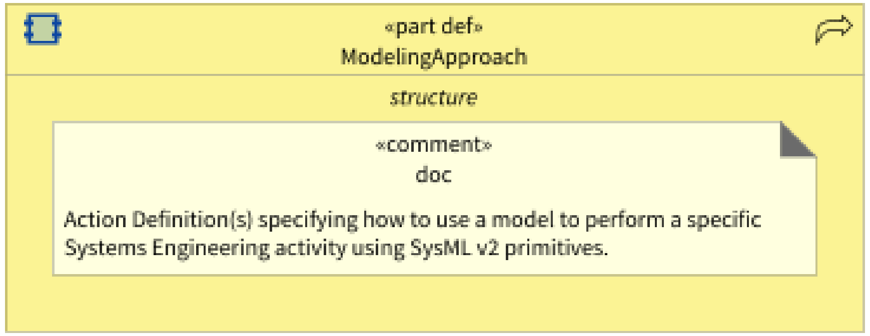
Methodology Processes

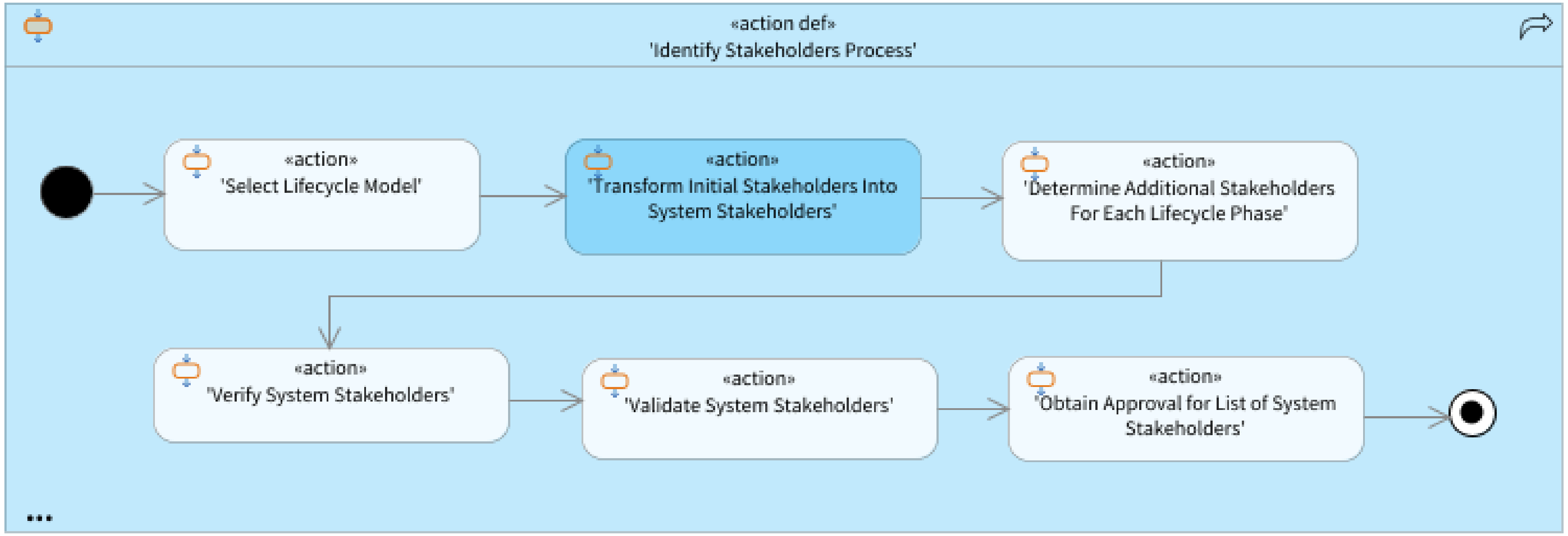


Modeling Patterns

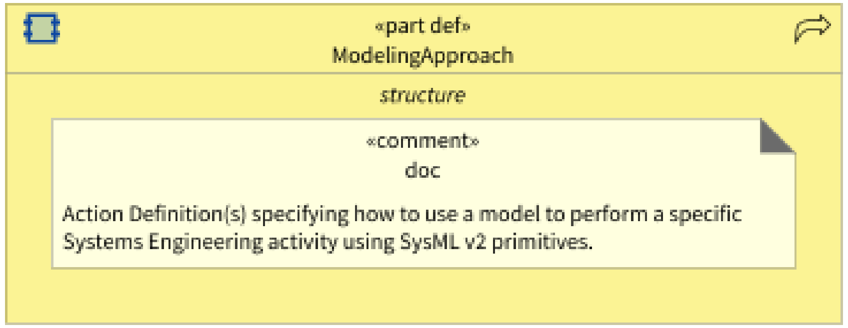


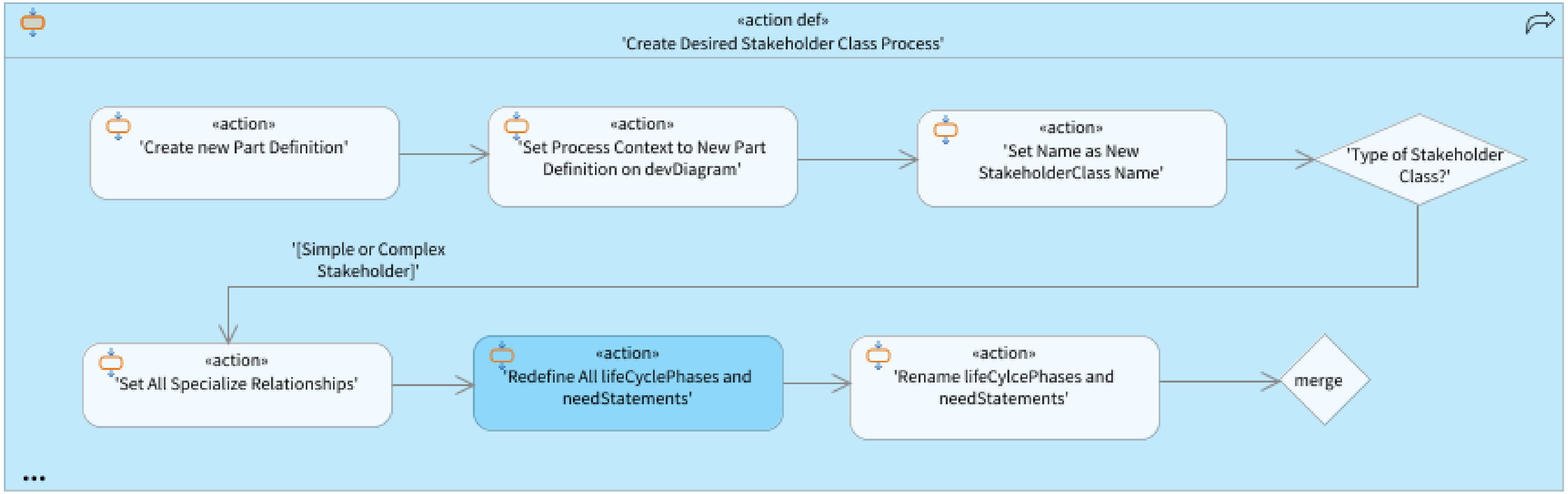
Modeling Approaches



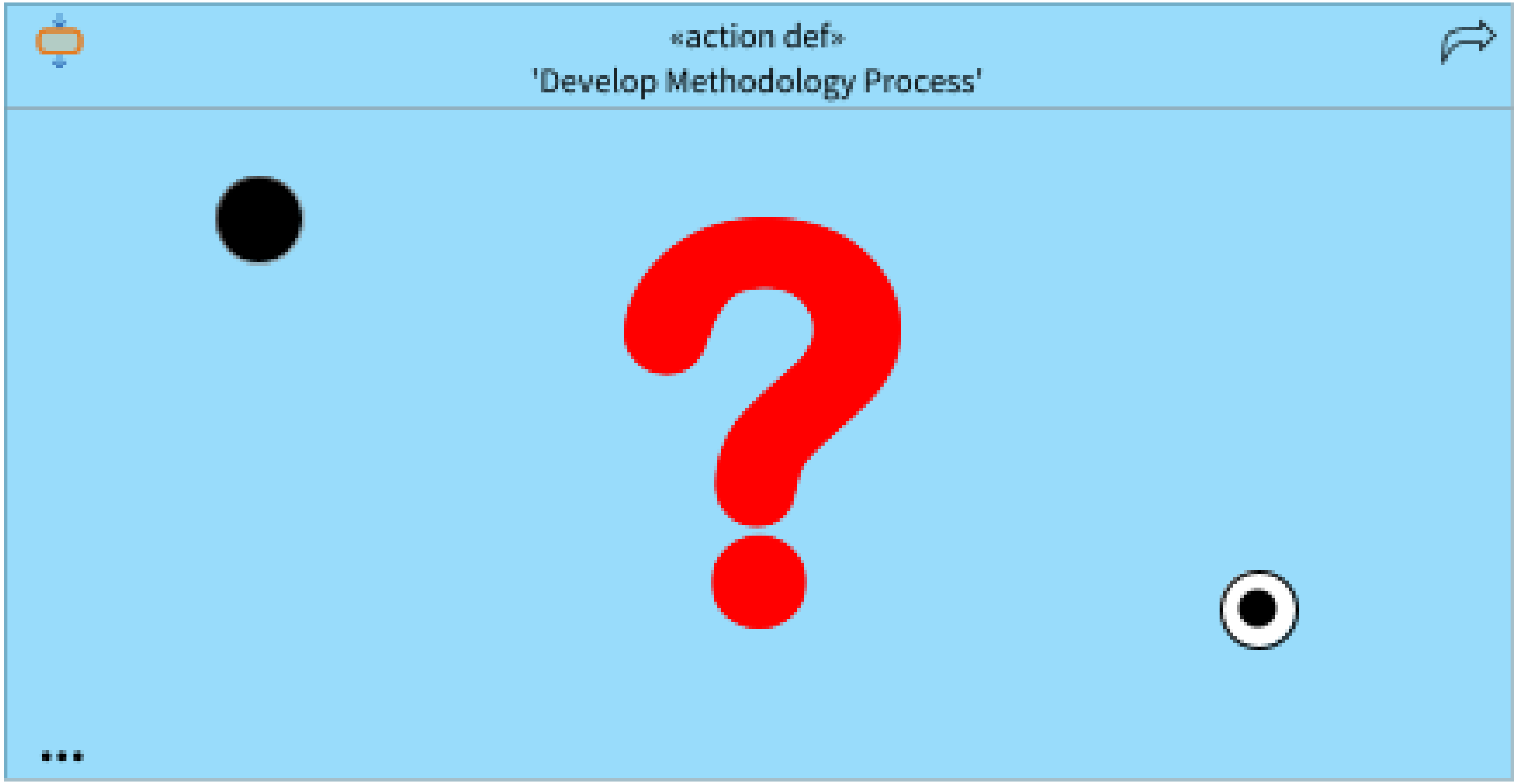


Modeling Approaches

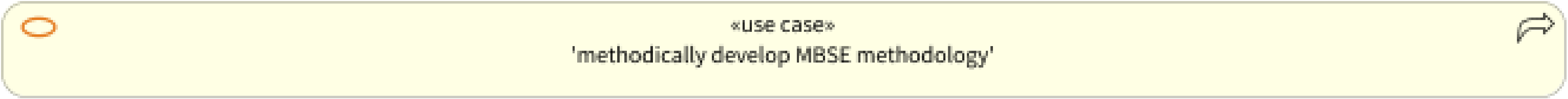




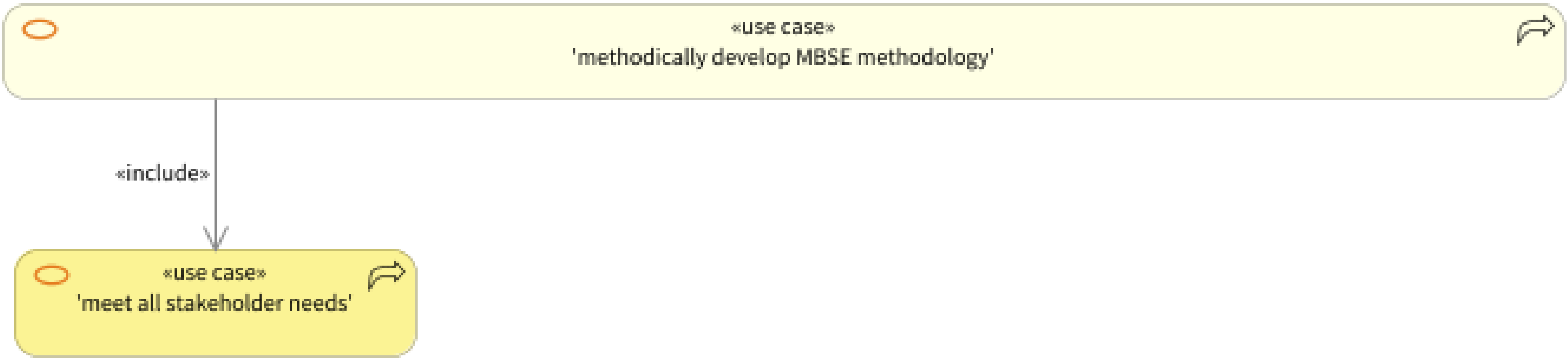
How Does One Go About Developing a Methodology?



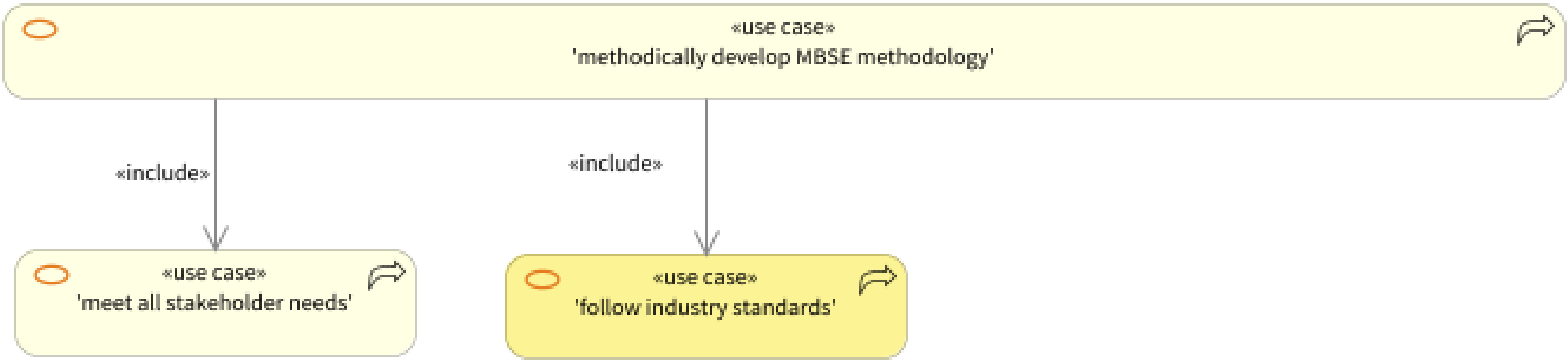
Methodically Develop MBSE Methodology



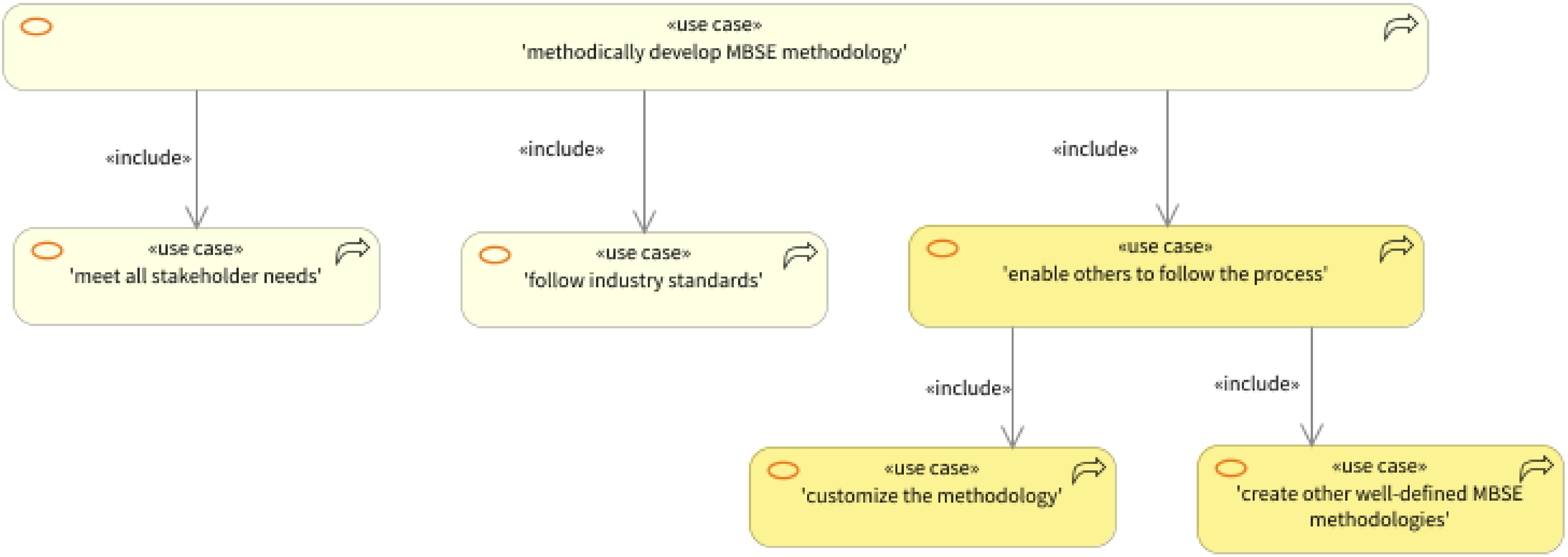
Methodically Develop MBSE Methodology



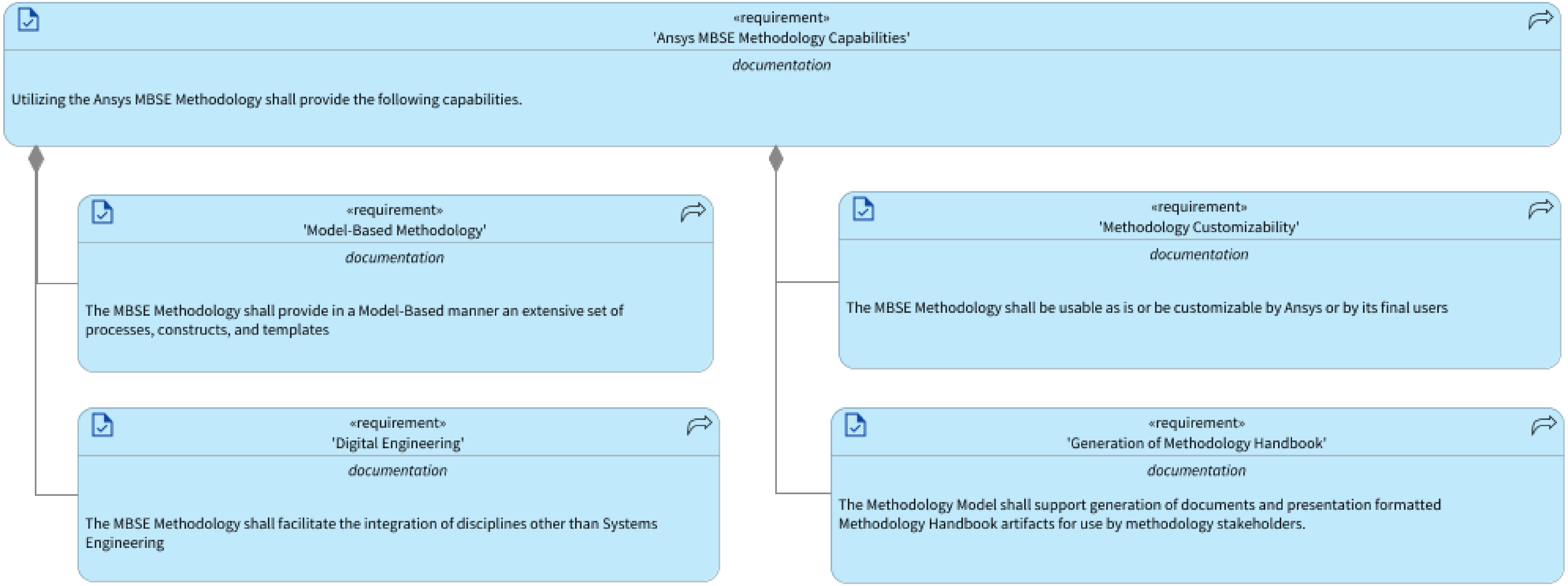
Methodically Develop MBSE Methodology



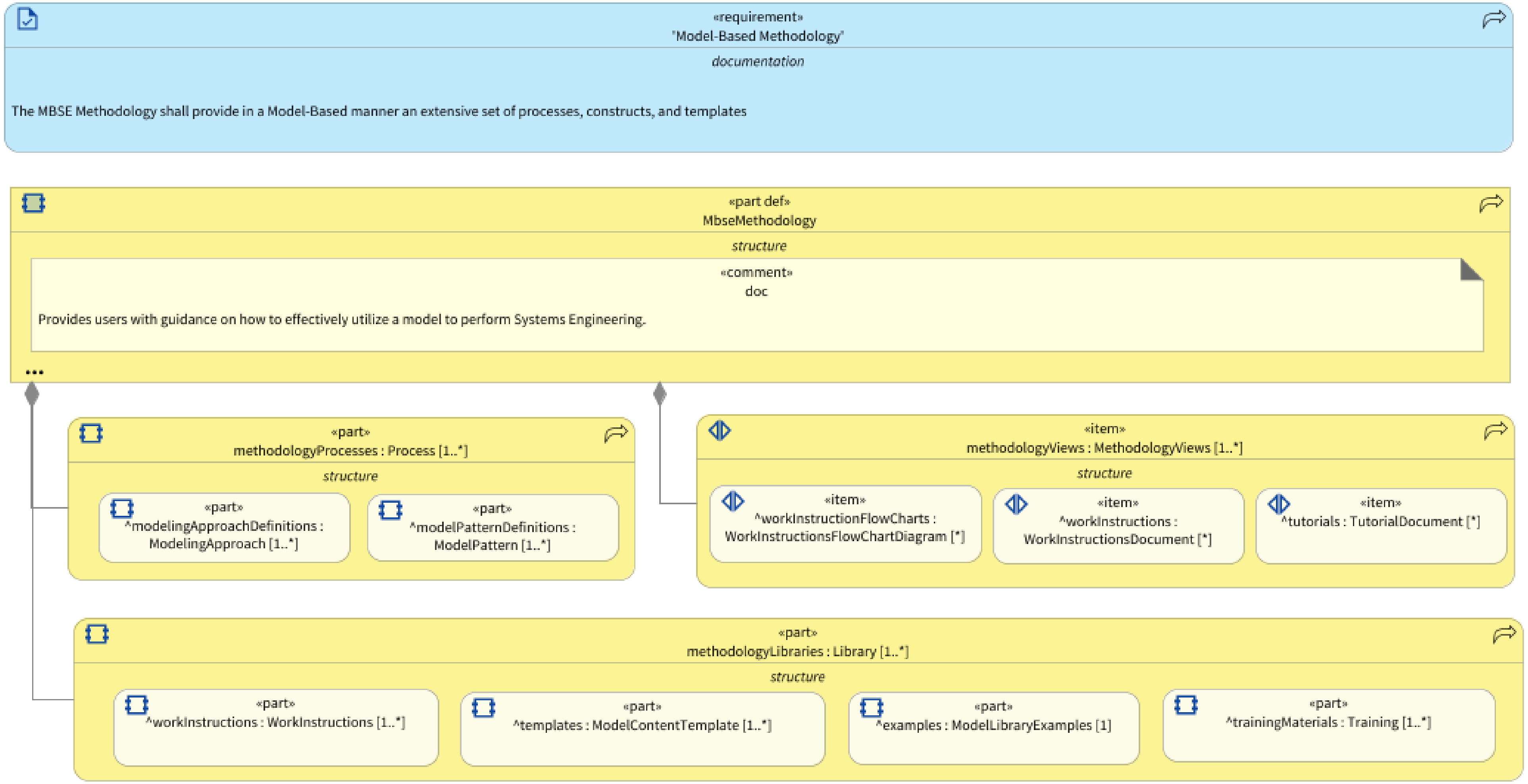
Methodically Develop MBSE Methodology



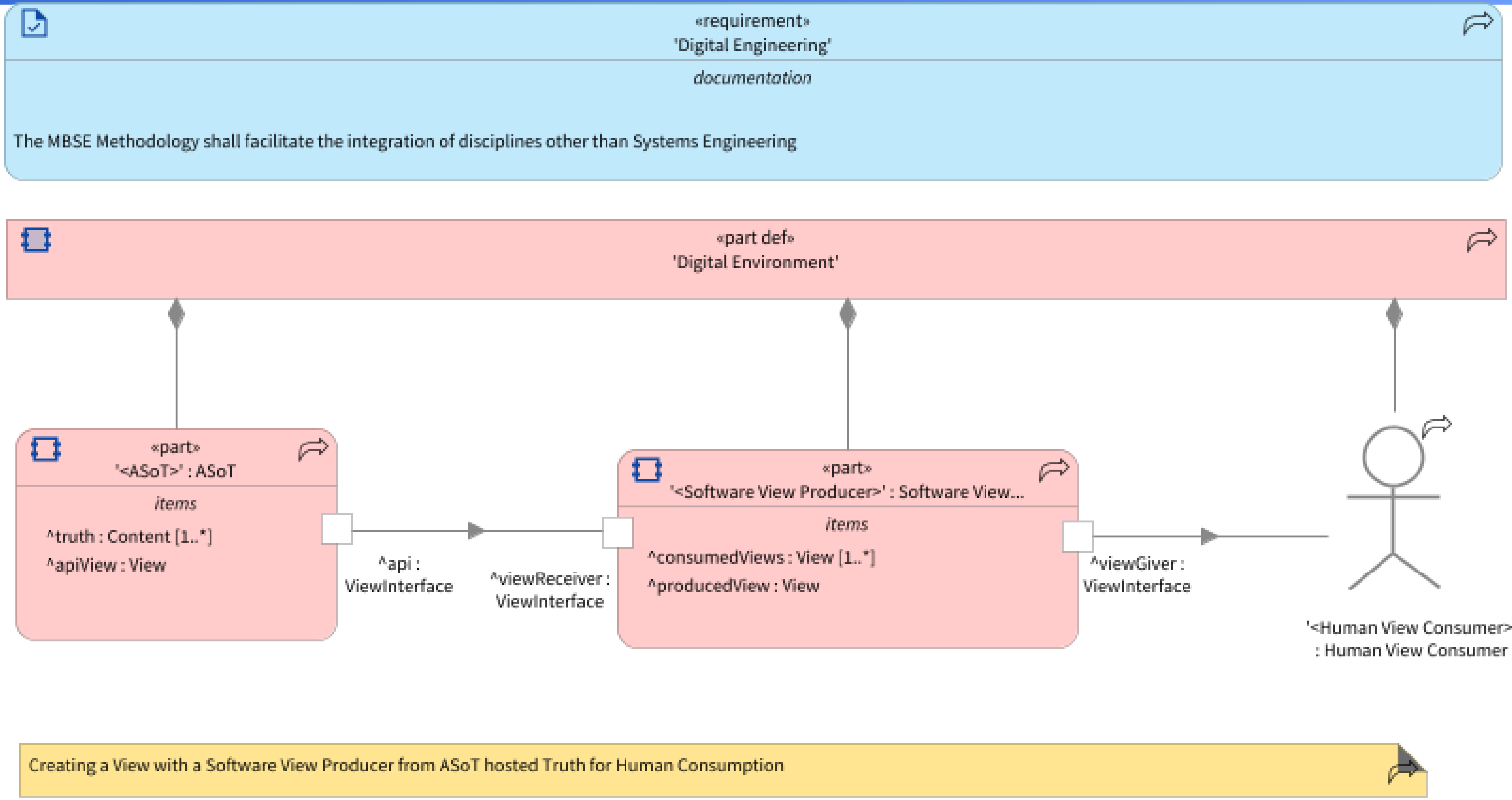
Ansys MBSE Methodology Capabilities



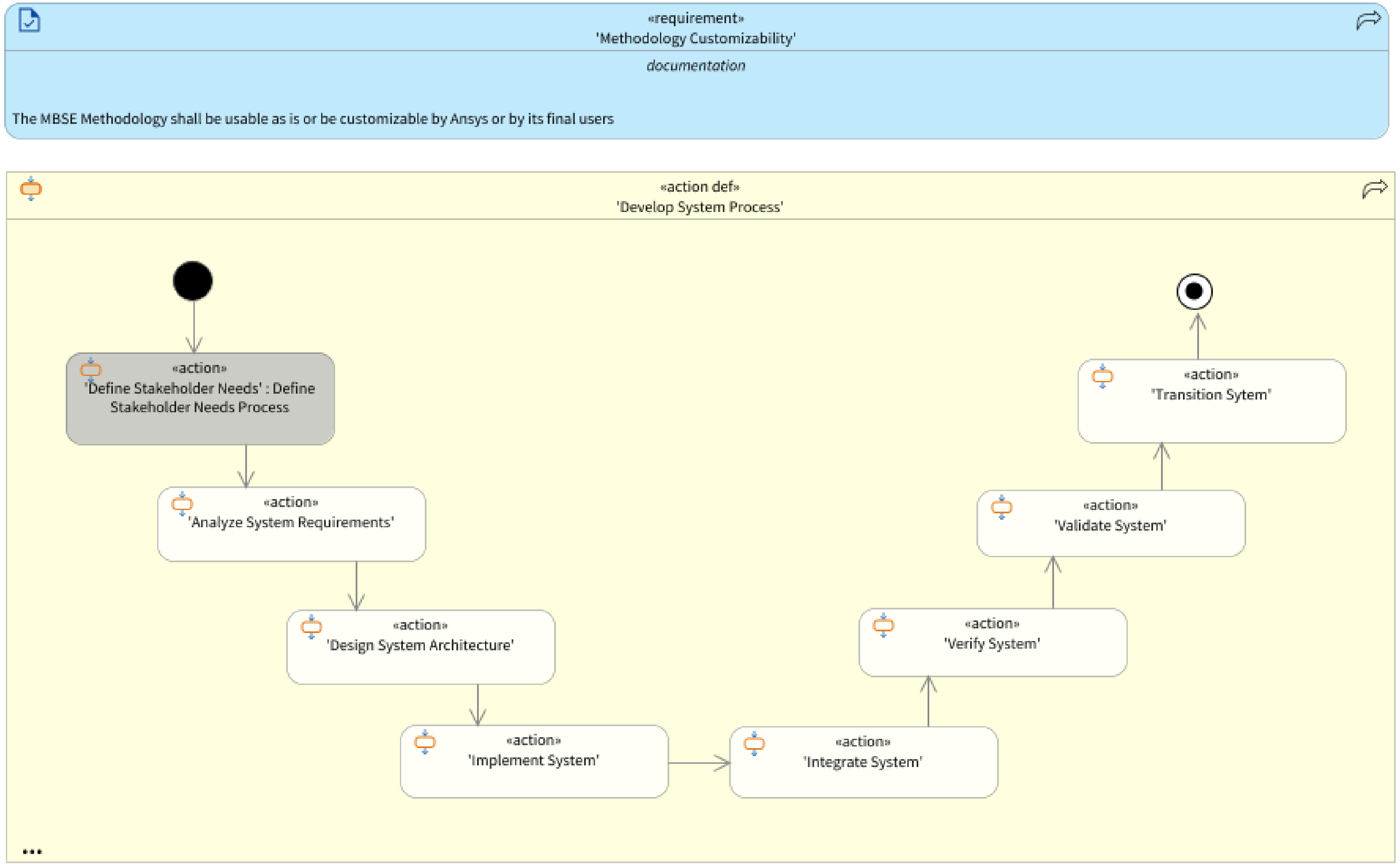
Model-Based Methodology



Digital Engineering



Methodology Customizability



Generation of Methodology Handbook

«requirement»
'Generation of Methodology Handbook'

documentation

The Methodology Model shall support generation of documents and presentation formatted Methodology Handbook artifacts for use by methodology stakeholders.

«item»
defineStakeholdersNeedsProcessView : NarrativeView

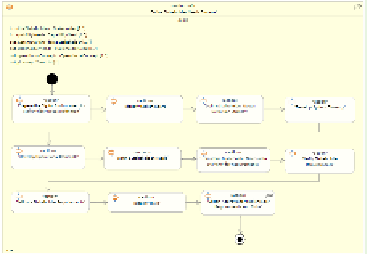
structure

«item»
prelude : Narrative [1] :> prelude

structure

«comment»
prelude

The following action definition describes the process to be followed to define the Stakeholders Needs.
The inputs to this process are:
- an initial list of stakeholders
- the capability needs, as expressed...

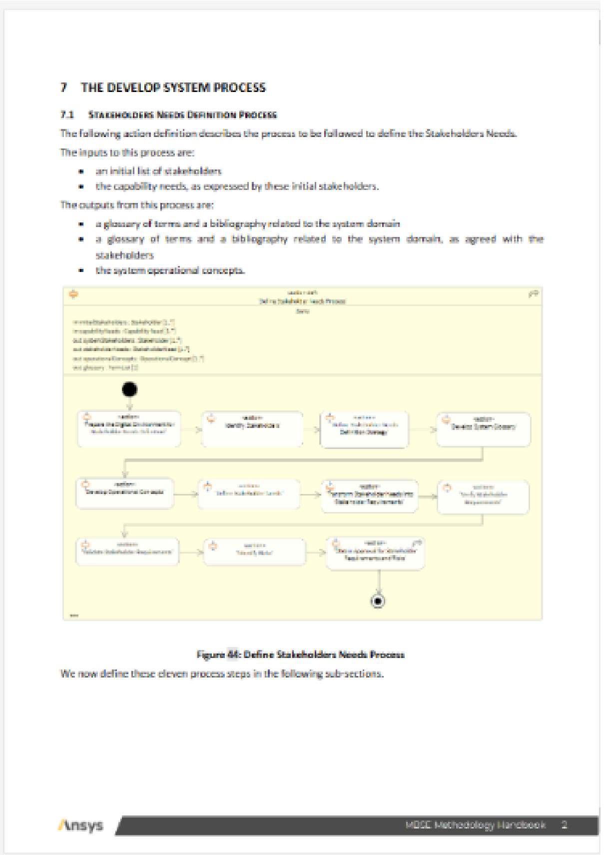


«item»
postlude : Narrative [1] :> postlude

structure

«comment»
postlude

We now define these eleven process steps in the following sub-sections.



7 THE DEVELOP SYSTEM PROCESS

7.1 Stakeholders Needs Definition Process

The following action definition describes the process to be followed to define the Stakeholders Needs.

The inputs to this process are:

- an initial list of stakeholders
- the capability needs, as expressed by these initial stakeholders.

The outputs from this process are:

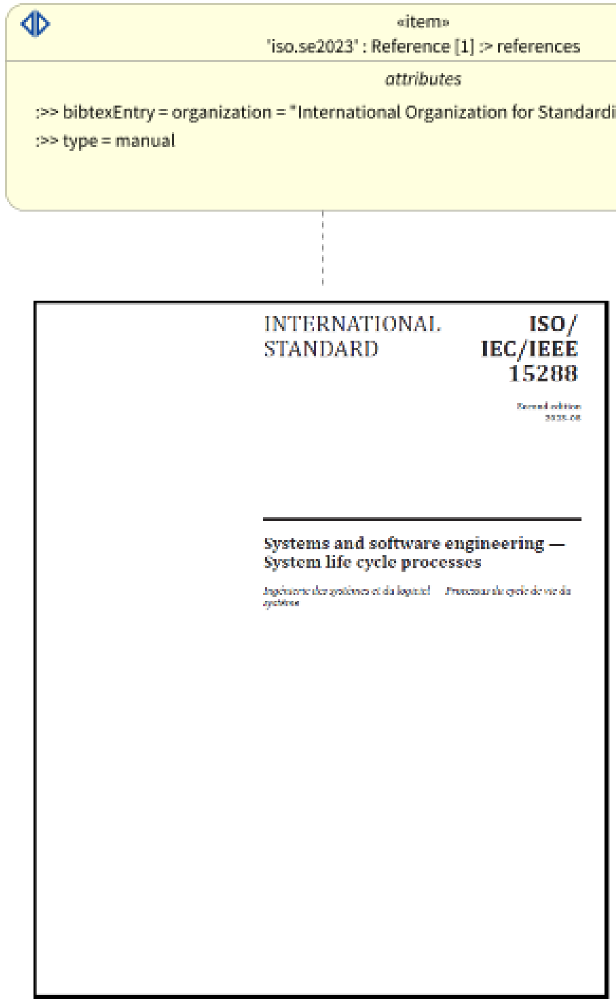
- a glossary of terms and a bibliography related to the system domain
- a glossary of terms and a bibliography related to the system domain, as agreed with the stakeholders
- the system operational concepts.

Figure 44: Define Stakeholders Needs Process

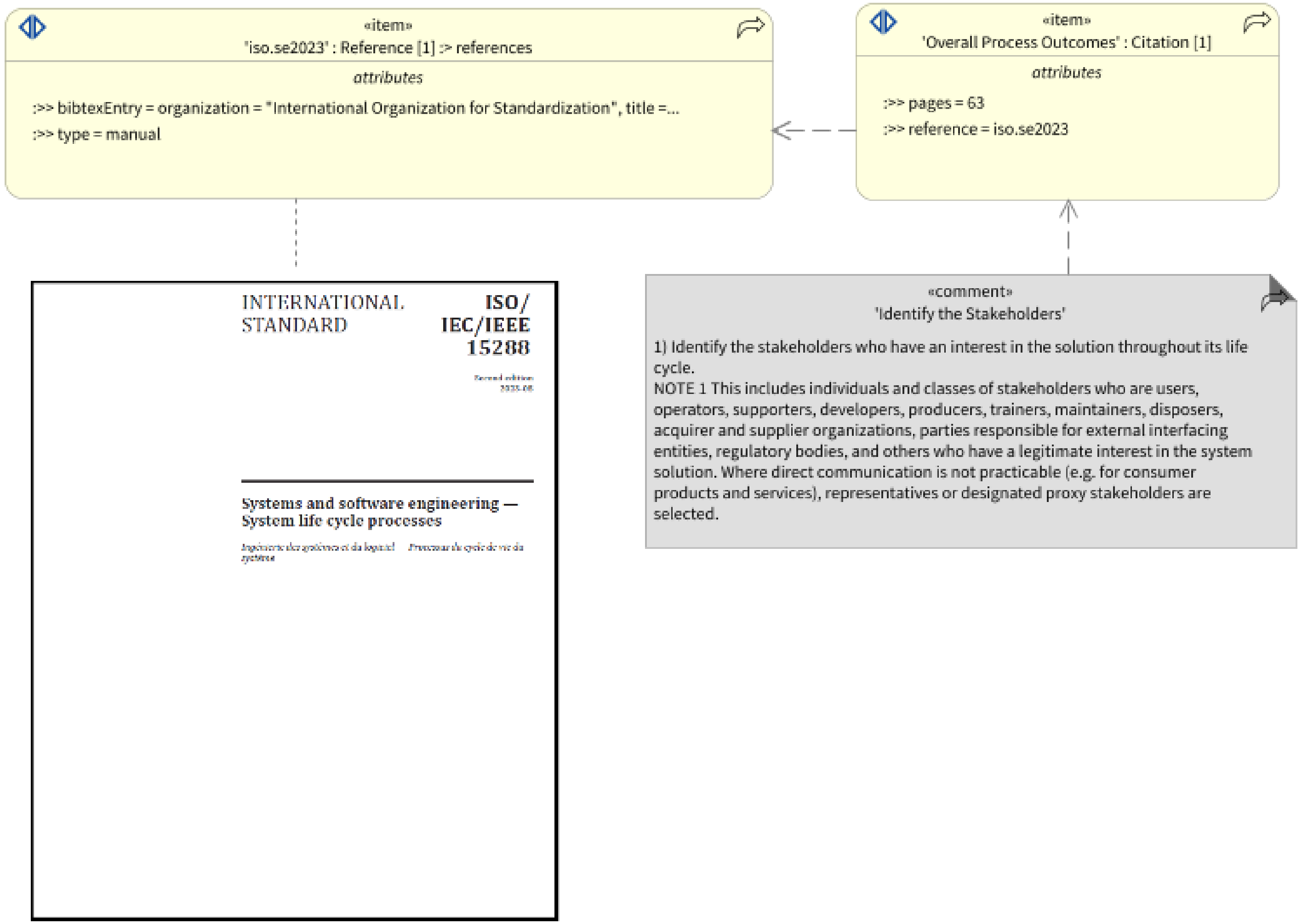
We now define these eleven process steps in the following sub-sections.

Ansys MBSE Methodology Handbook 2

Begin with Review of Existing Standards



Taking Notes in the Model



Analyzing Research Notes

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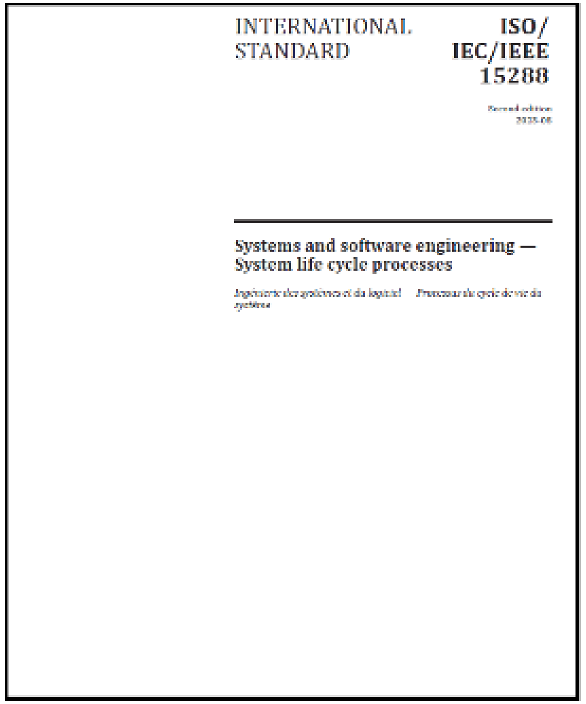

INTERNATIONAL STANDARD

ISO/IEC/IEEE 15288

Systems and software engineering — System life cycle processes

«comment»
'Identify the Stakeholders'

1) Identify the stakeholders who have an interest in the solution throughout its life cycle.
NOTE 1 This includes individuals and classes of stakeholders who are users, operators, supporters, developers, producers, trainers, maintainers, disposers, acquirer and supplier organizations, parties responsible for external interfacing entities, regulatory bodies, and others who have a legitimate interest in the system solution. Where direct communication is not practicable (e.g. for consumer products and services), representatives or designated proxy stakeholders are selected.

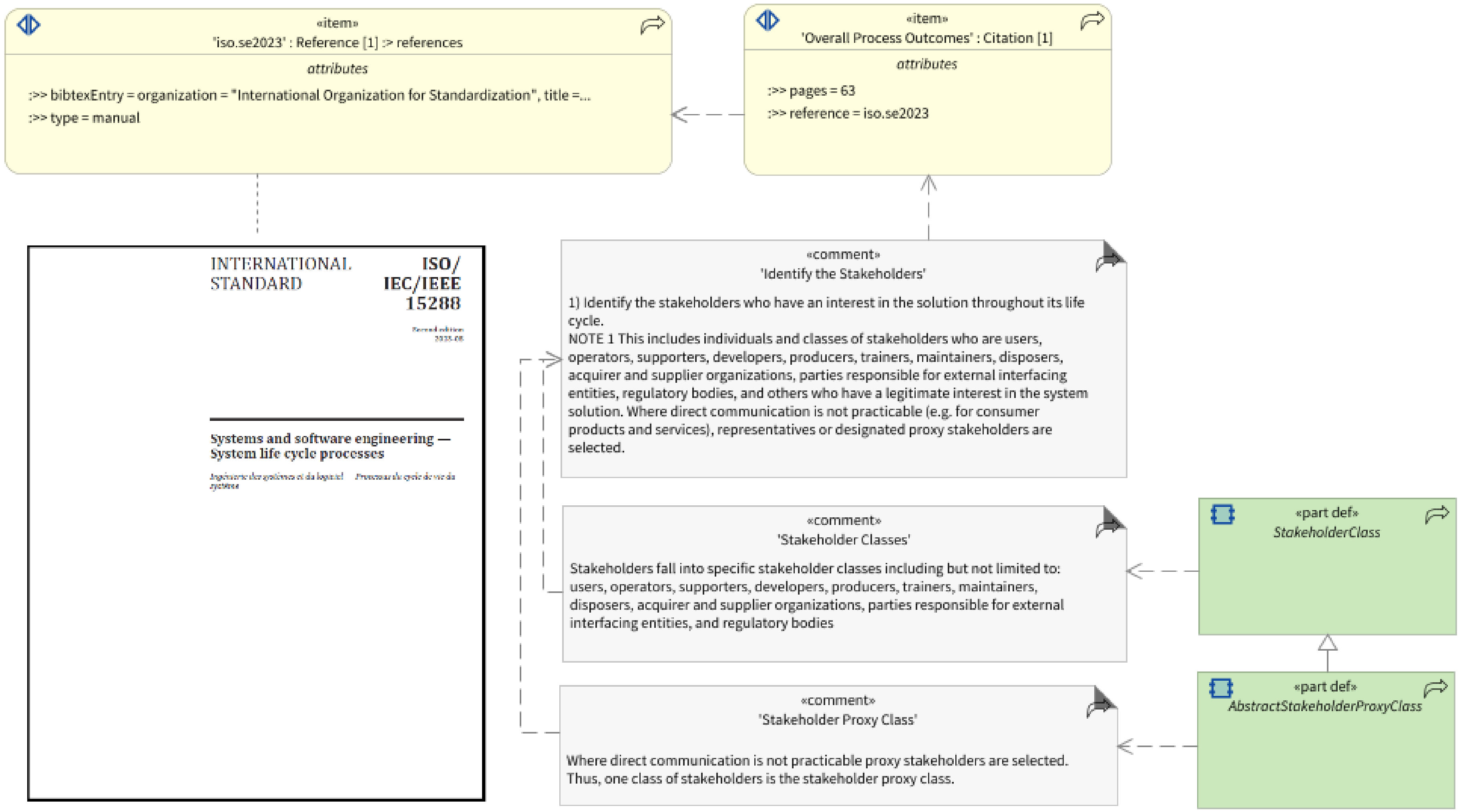
«comment»
'Stakeholder Classes'

Stakeholders fall into specific stakeholder classes including but not limited to: users, operators, supporters, developers, producers, trainers, maintainers, disposers, acquirer and supplier organizations, parties responsible for external interfacing entities, and regulatory bodies

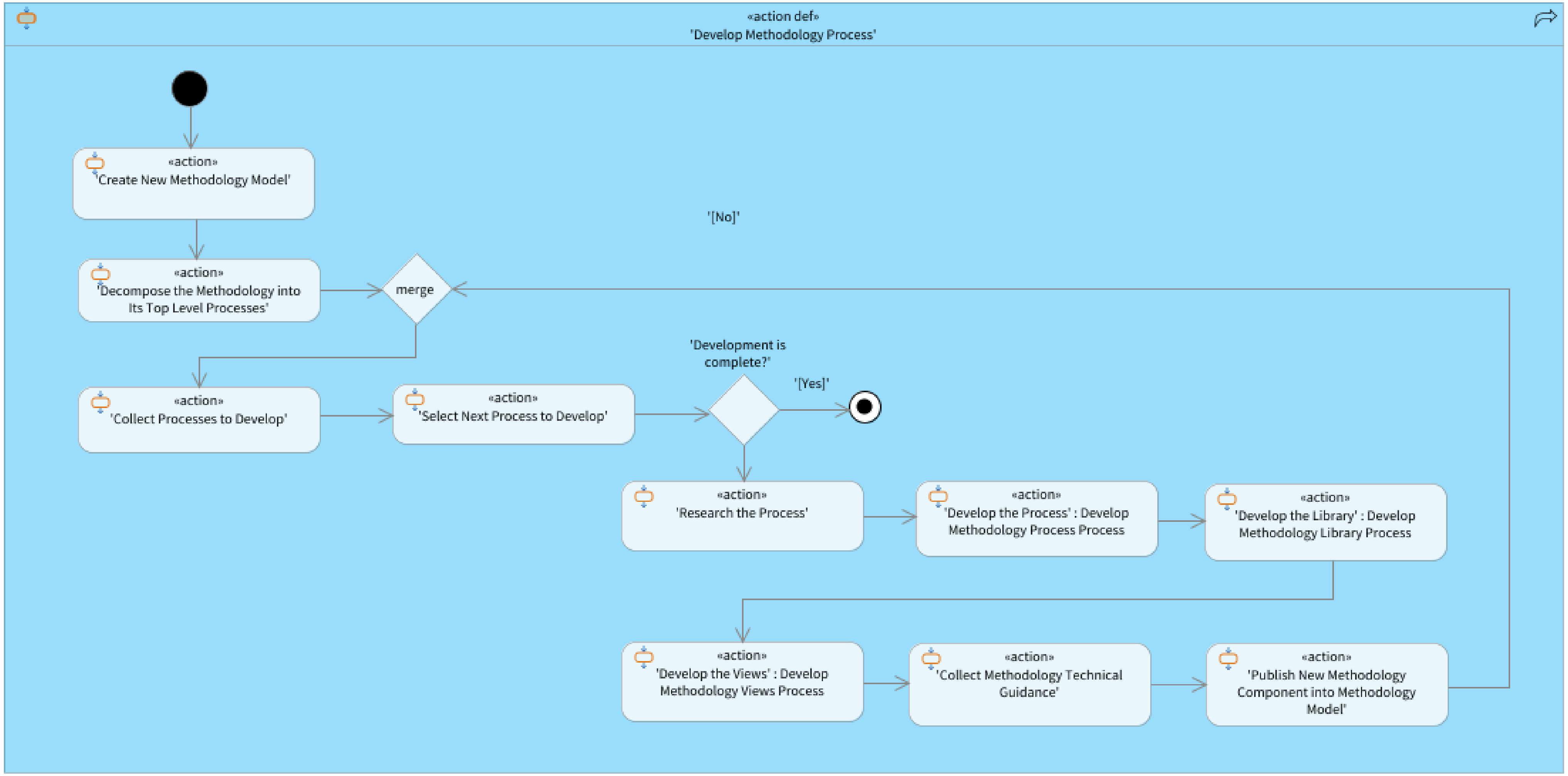
«comment»
'Stakeholder Proxy Class'

Where direct communication is not practicable proxy stakeholders are selected. Thus, one class of stakeholders is the stakeholder proxy class.

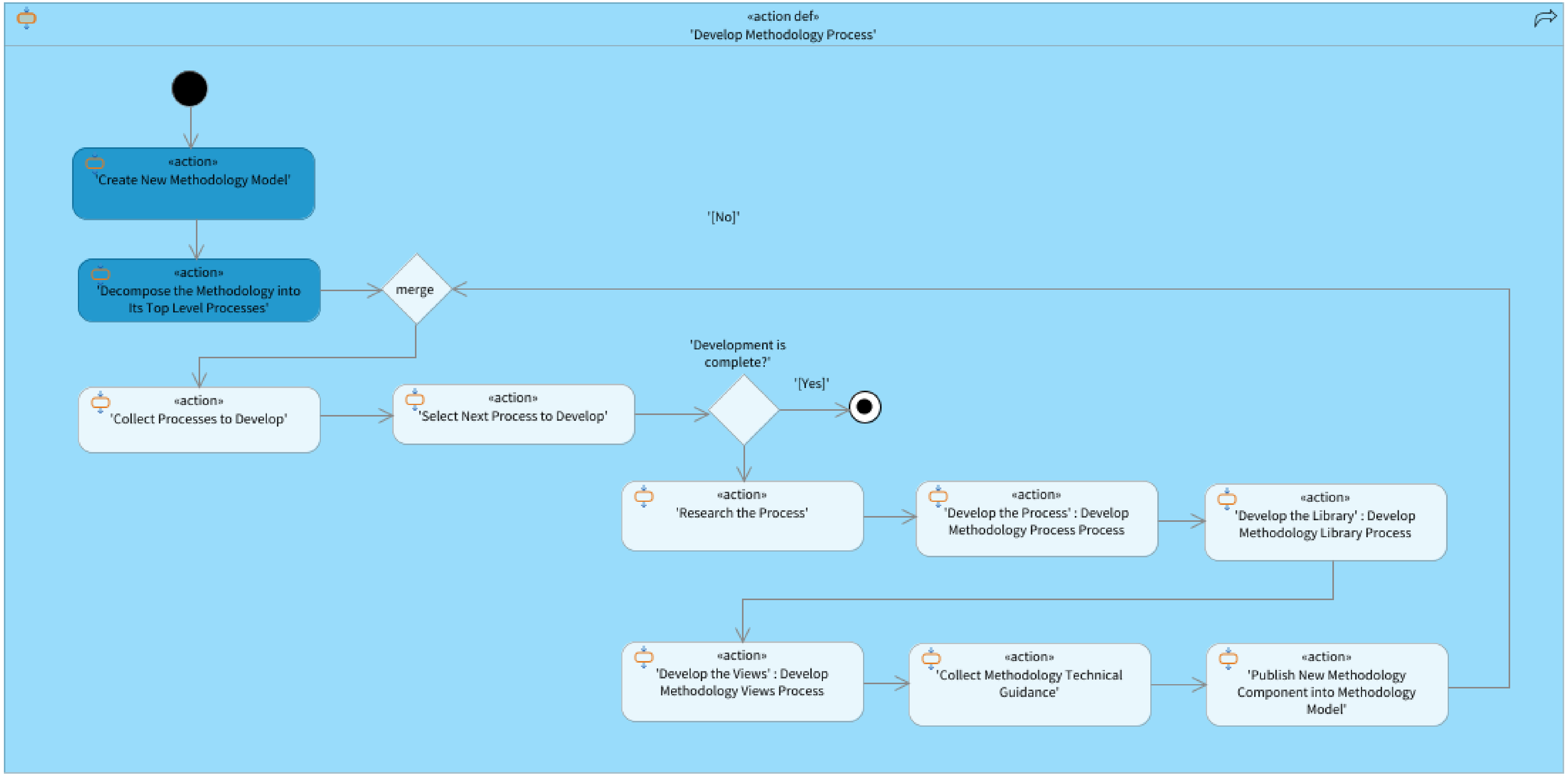
Creating Methodology Content Based on Research



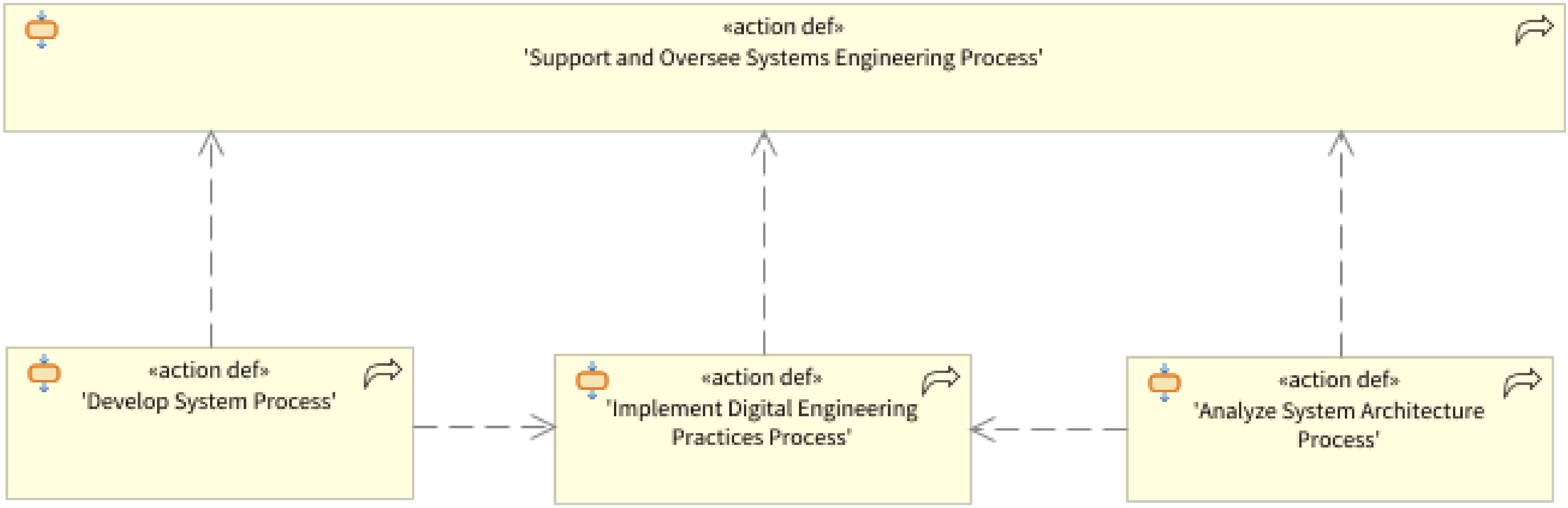
The Develop Methodology Process



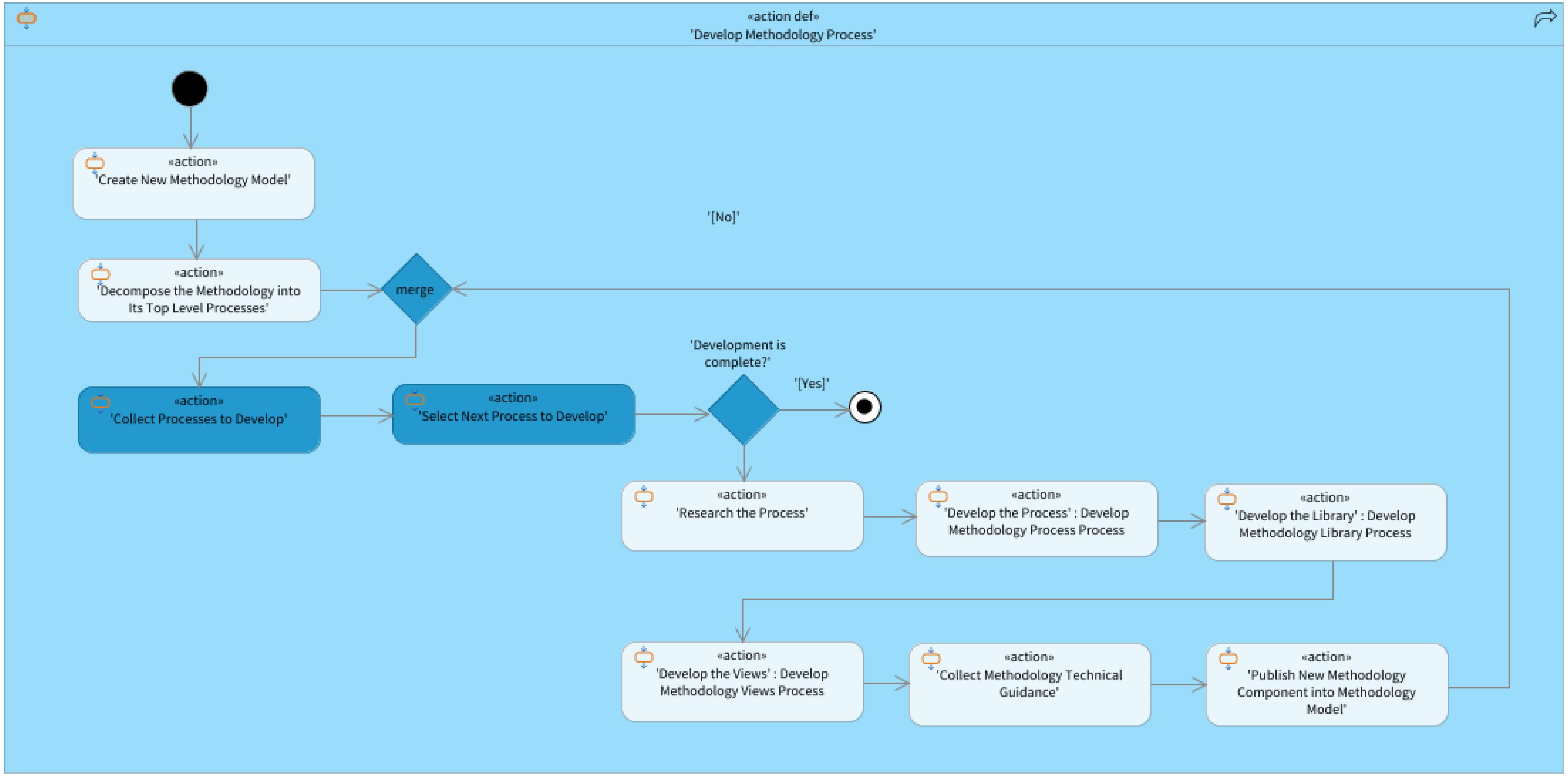
Process Setup



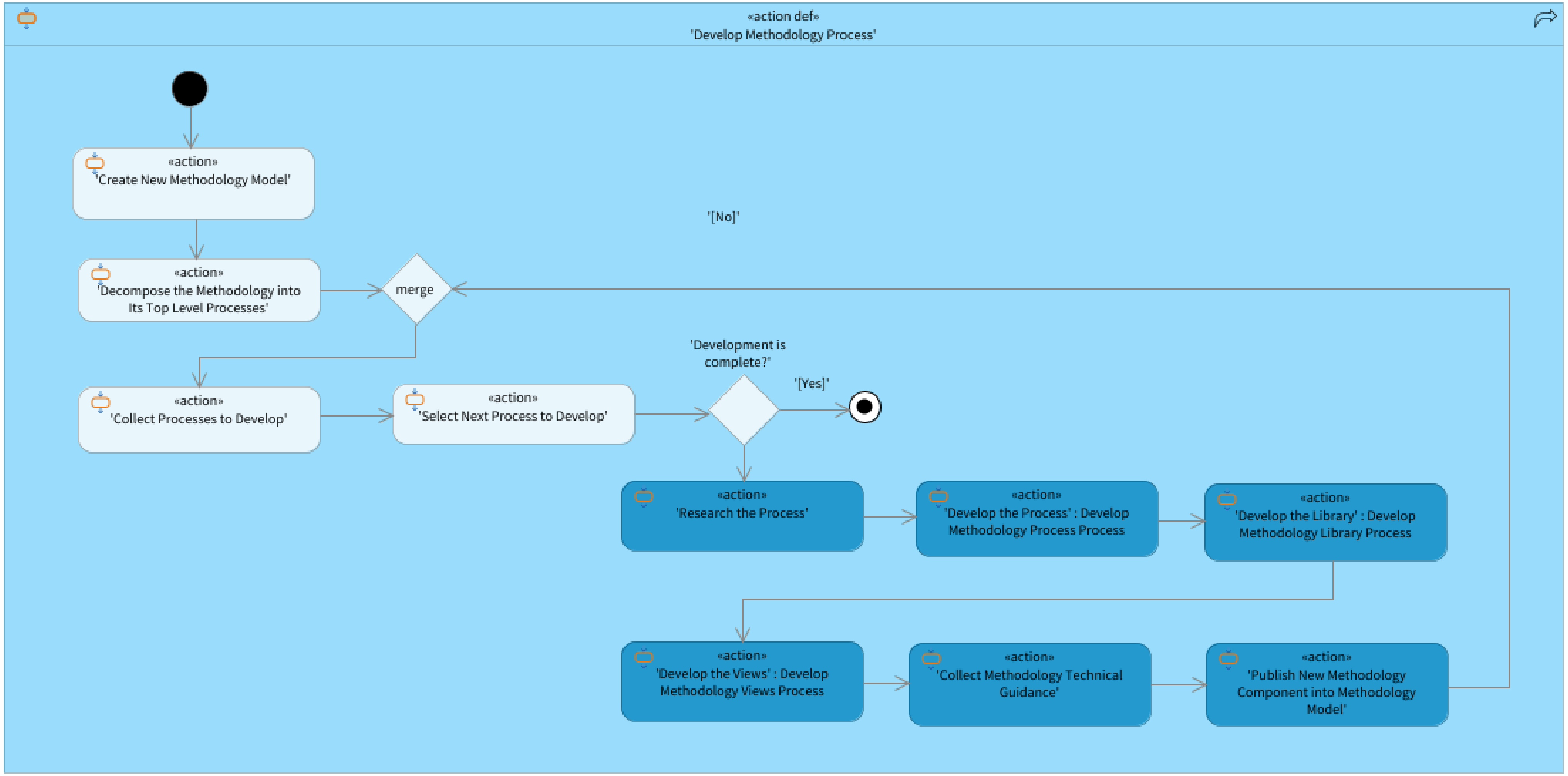
Top-Level Decomposition of the Ansys MBSE Methodology



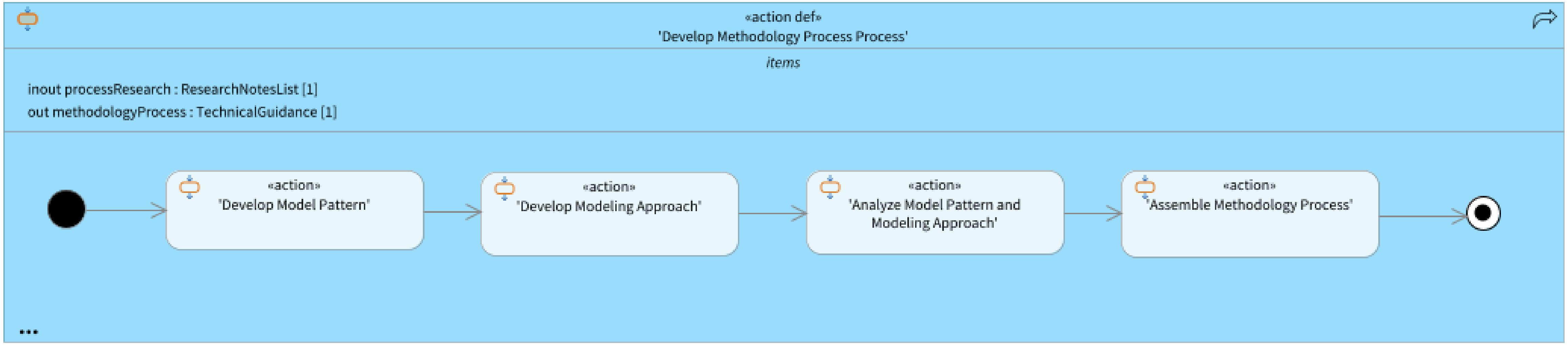
Top of the Develop Methodology Loop

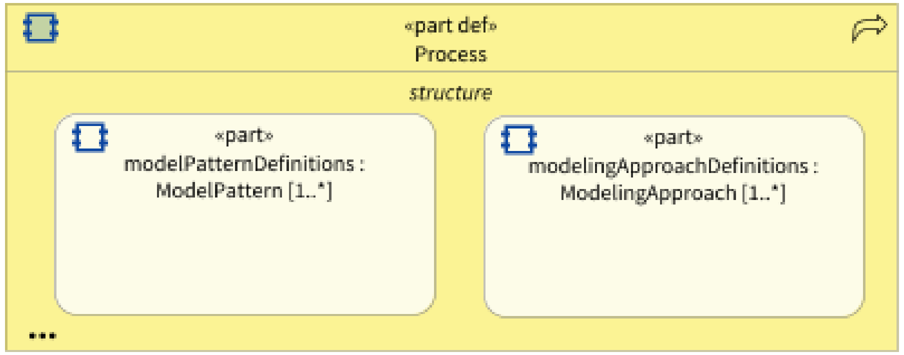


Core of the Develop Methodology Loop

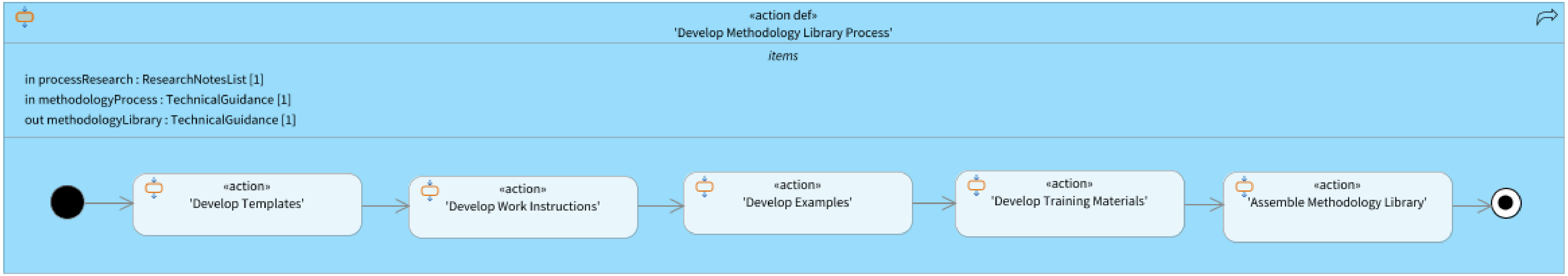


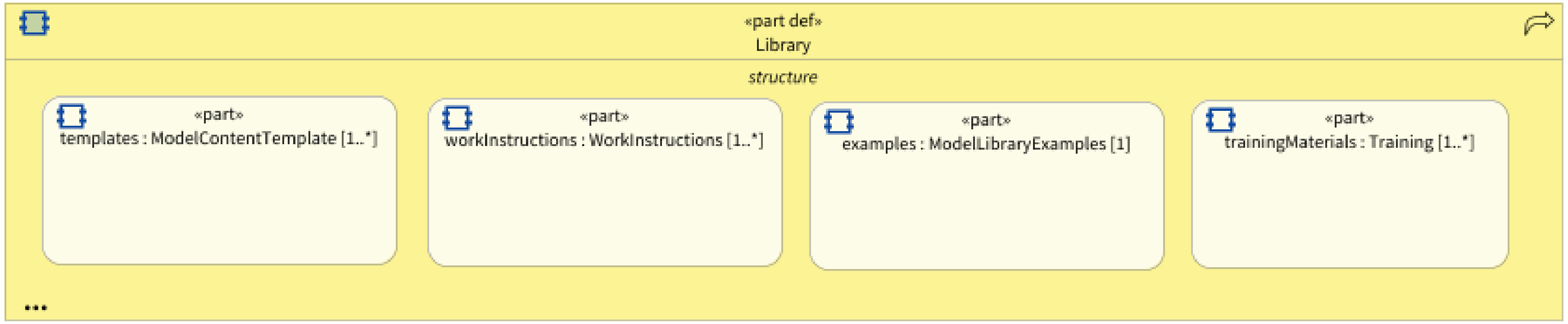
Develop Methodology Process Process



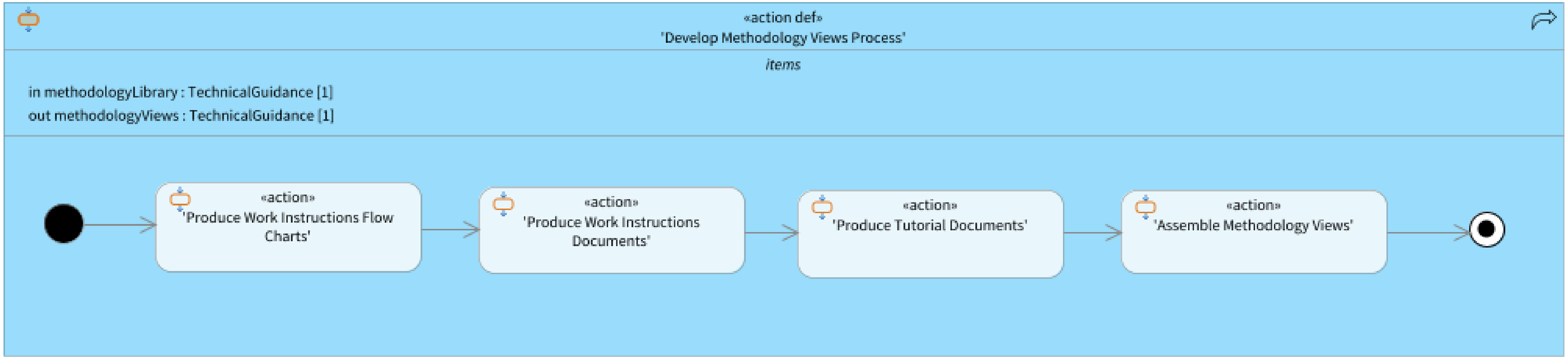


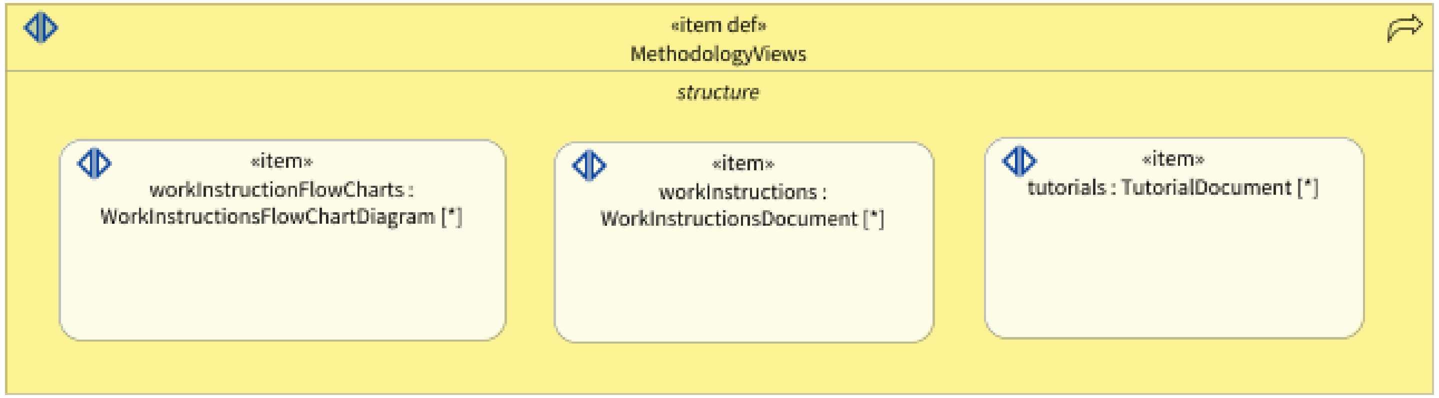
Develop Methodology Library Process



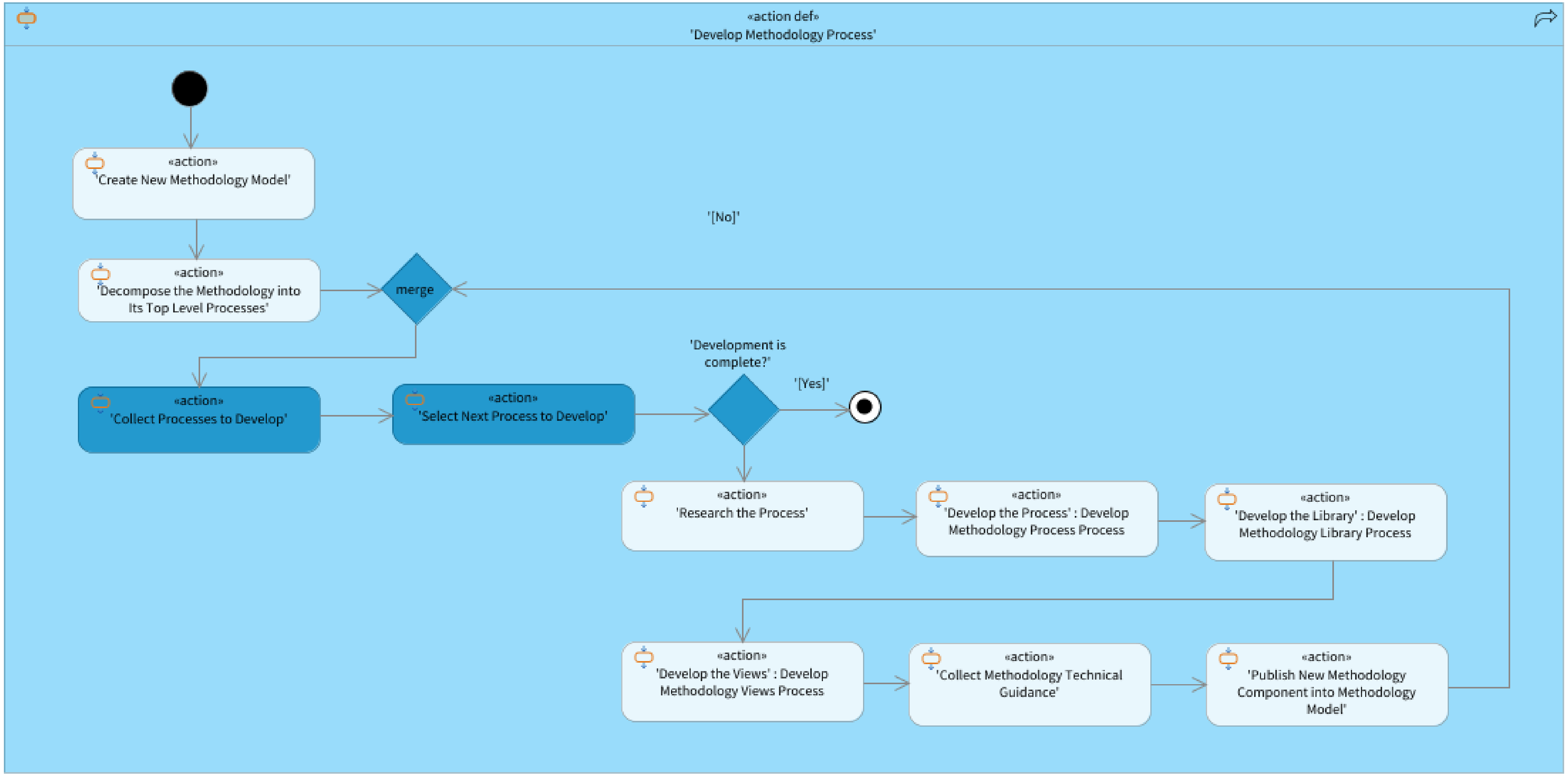


Develop Methodology Views Process





Return to the Top of the Loop



Falsely Reporting MBSE

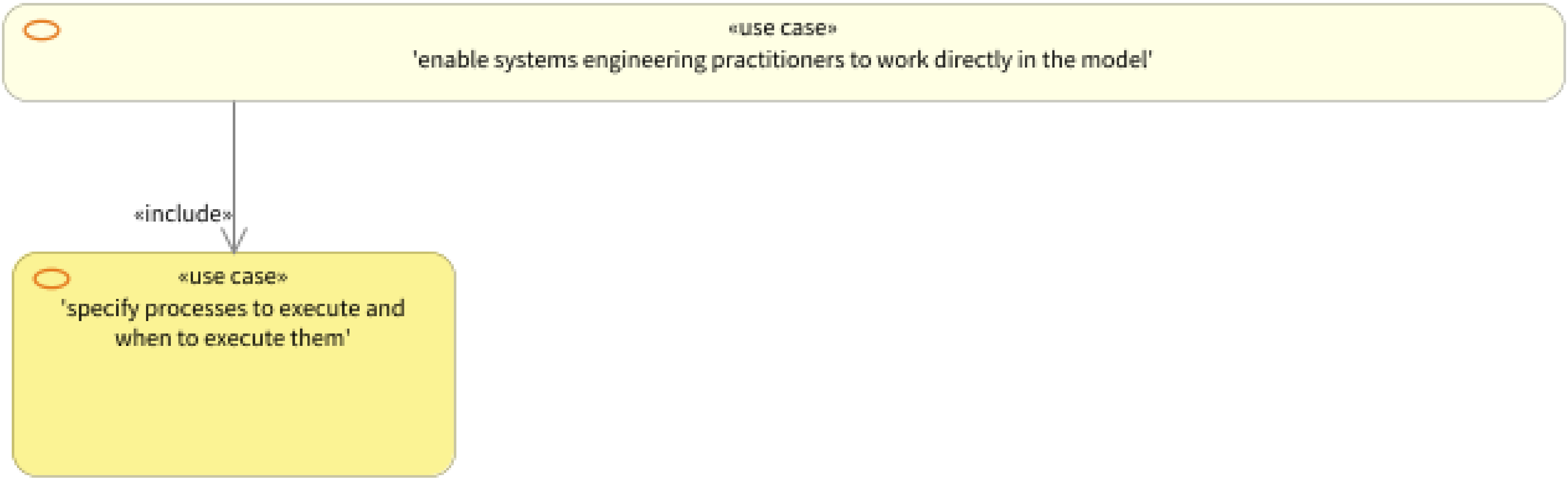
Posted to LinkedIn
by The School of Systems Engineering

https://www.linkedin.com/feed/update/urn:li:activity:7176893545742553089/

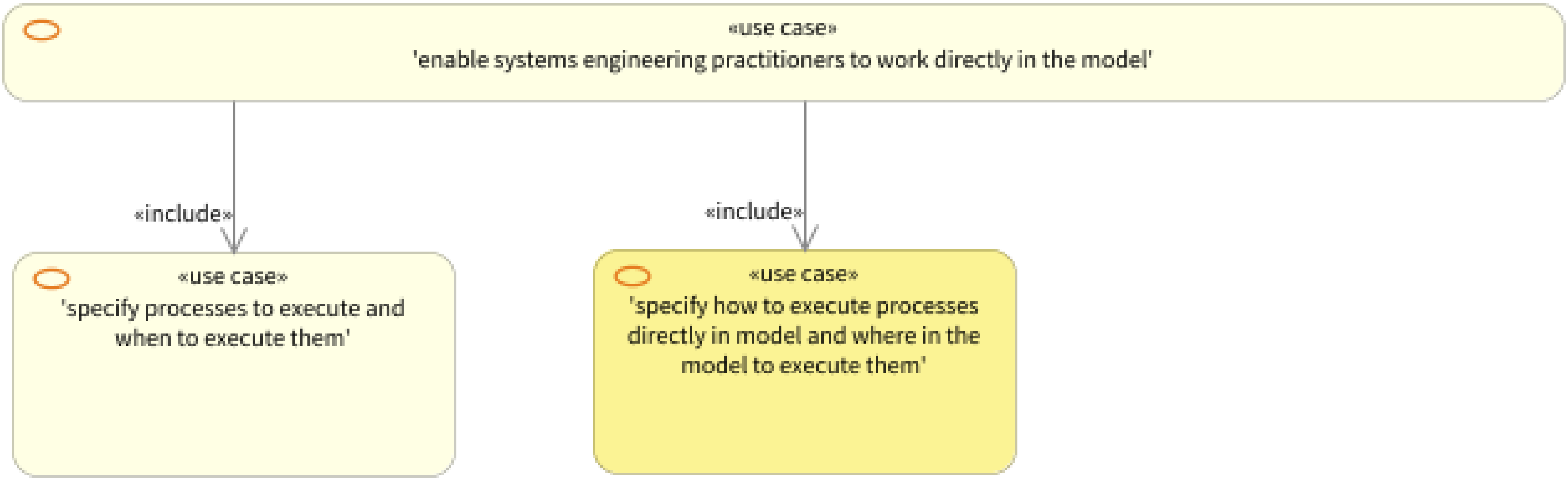
Enable Systems Engineering Practitioners

«use case»
'enable systems engineering practitioners to work directly in the model'

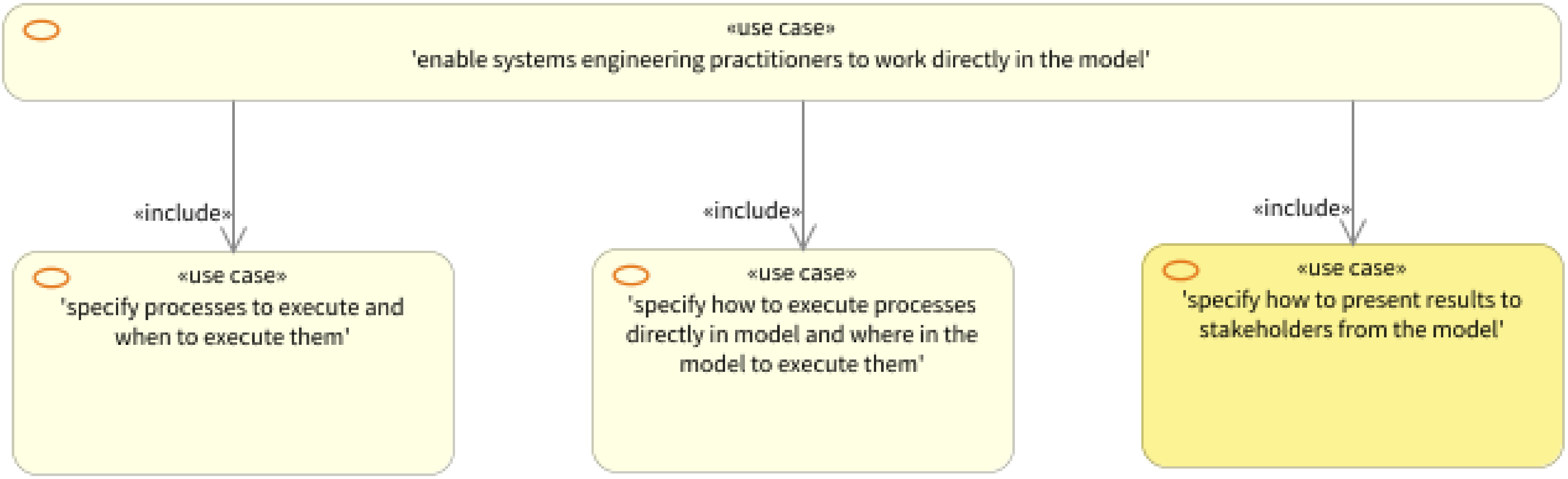
Enable Systems Engineering Practitioners



Enable Systems Engineering Practitioners



Enable Systems Engineering Practitioners



The Methodology Drives Planning

6 THE DEVELOP SYSTEM PROCESS

6.1 STAKEHOLDERS NEEDS DEFINITION PROCESS

The following action definition describes the process to be followed to define the Stakeholders Needs.

The inputs to this process are:

- an initial list of stakeholders
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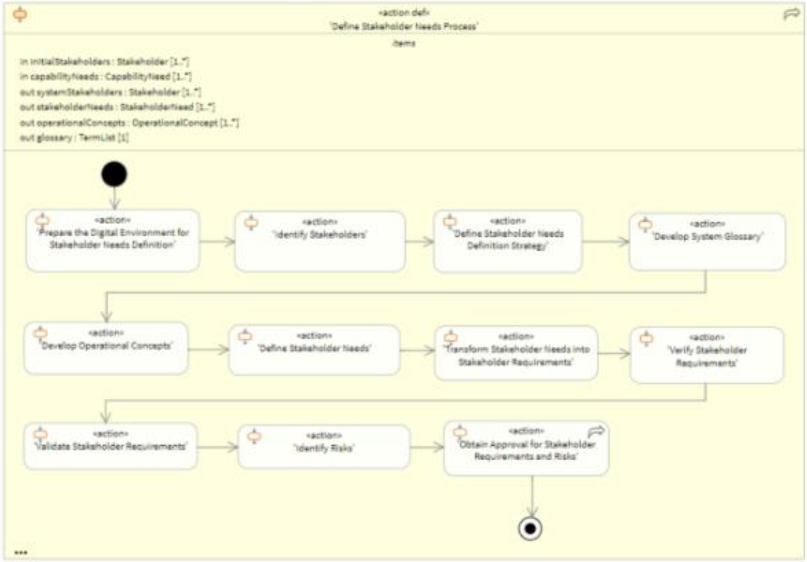


Figure 44: Define Stakeholders Needs Process

Develop System Glossary Example

6 THE DEVELOP SYSTEM PROCESS

6.1 STAKEHOLDERS NEEDS DEFINITION PROCESS

The following action definition describes the process to be followed to define the Stakeholders Needs.

The inputs to this process are:

- an initial list of stakeholders
- the capability needs, as expressed by these initial stakeholders.

The outputs from this process are:

- a glossary of terms and a bibliography related to the system domain
- a glossary of terms and a bibliography related to the system domain, as agreed with the stakeholders
- the system operational concepts.

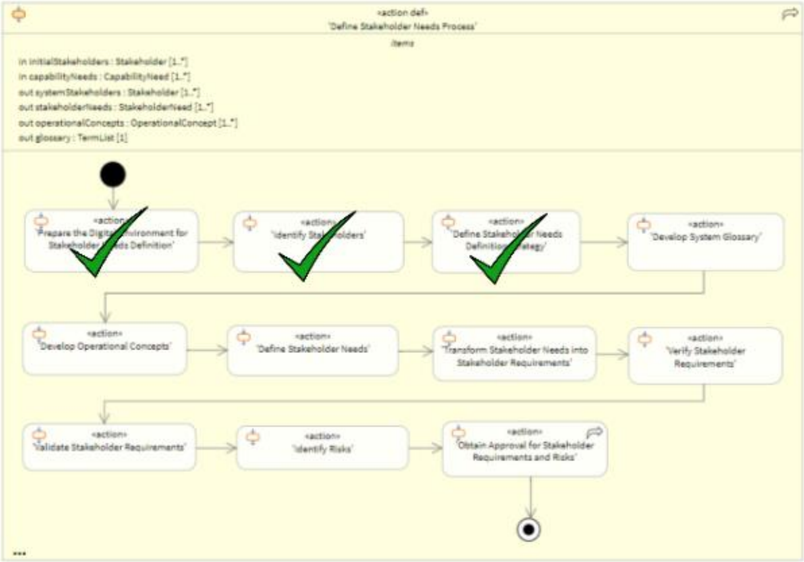
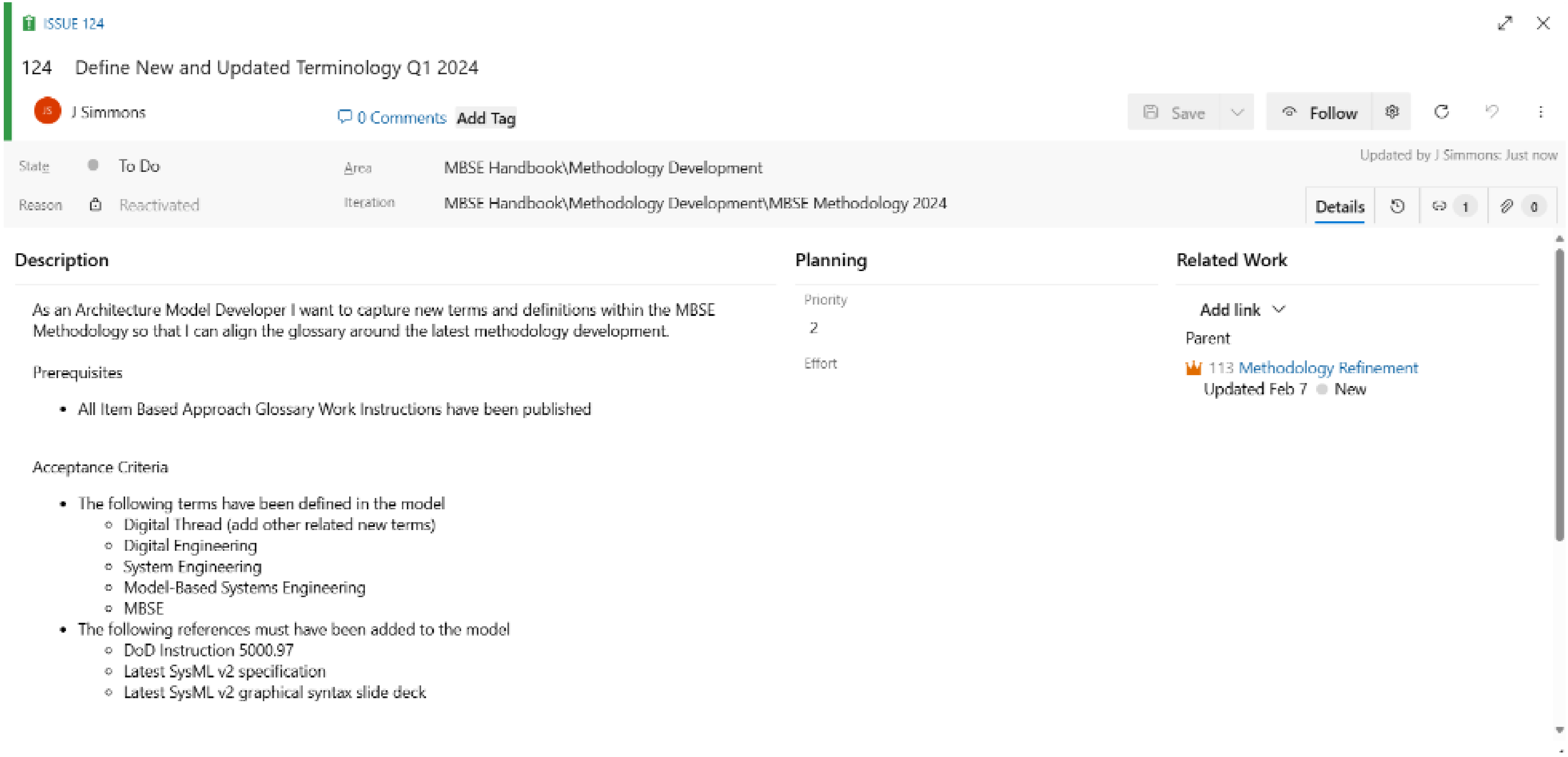
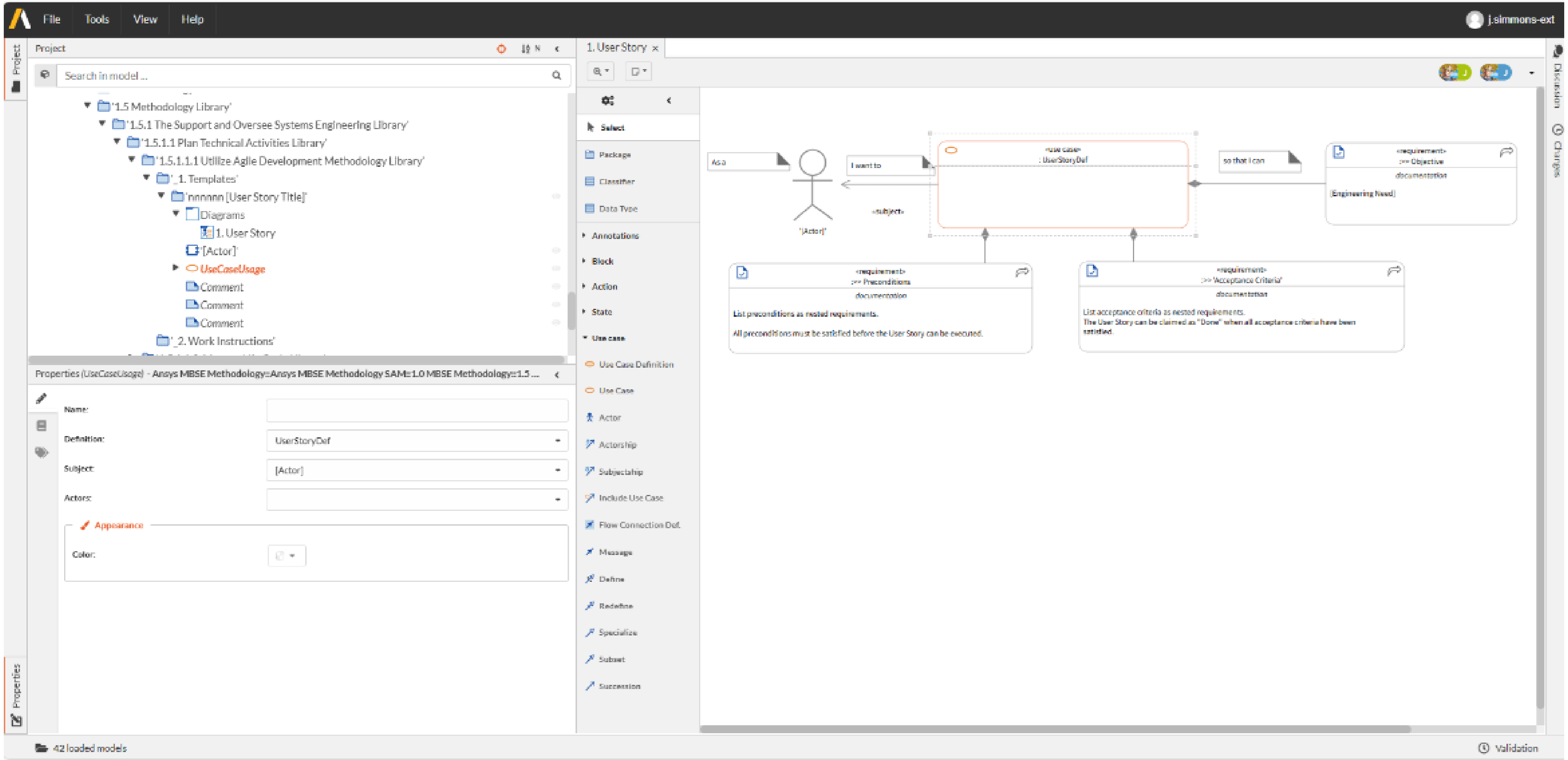


Figure 44: Define Stakeholders Needs Process

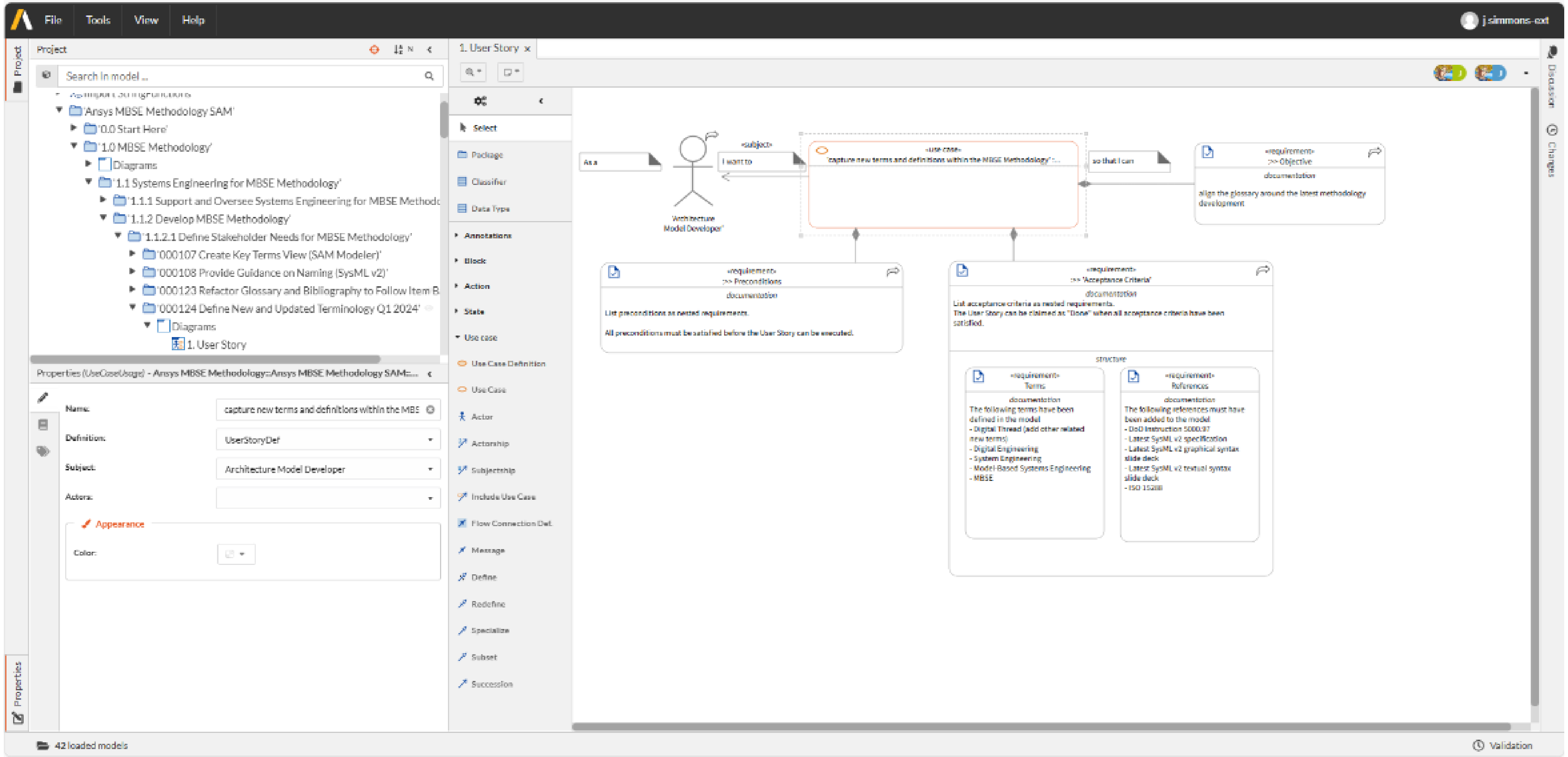
Utilizing Agile Approaches in Project Planning



Rendering User Story in Model



Rendering User Story in Model



Now We Follow the Work Instructions

Process: Add Definitions to an Existing Term

This process must be followed to add one or more definitions to an existing term. The necessary information regarding these definitions is contained in toBeAdded. The process iterates on the creation of the new definitions within the term's list of definitions and the association of the citations and seealso's to each definition, until all definitions have been added.

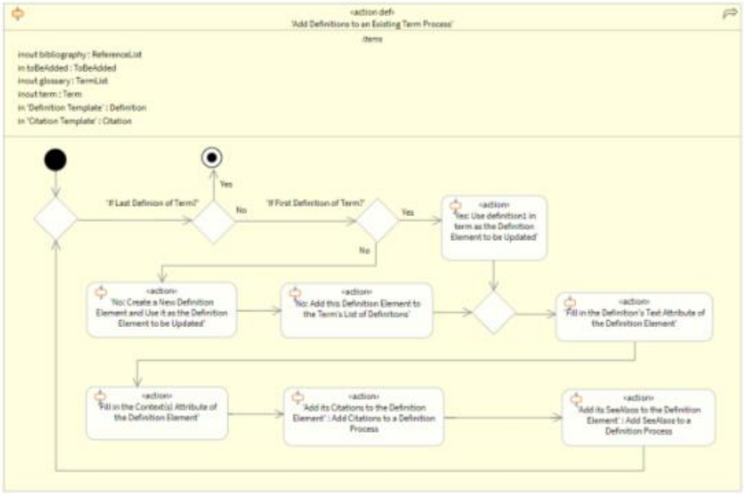


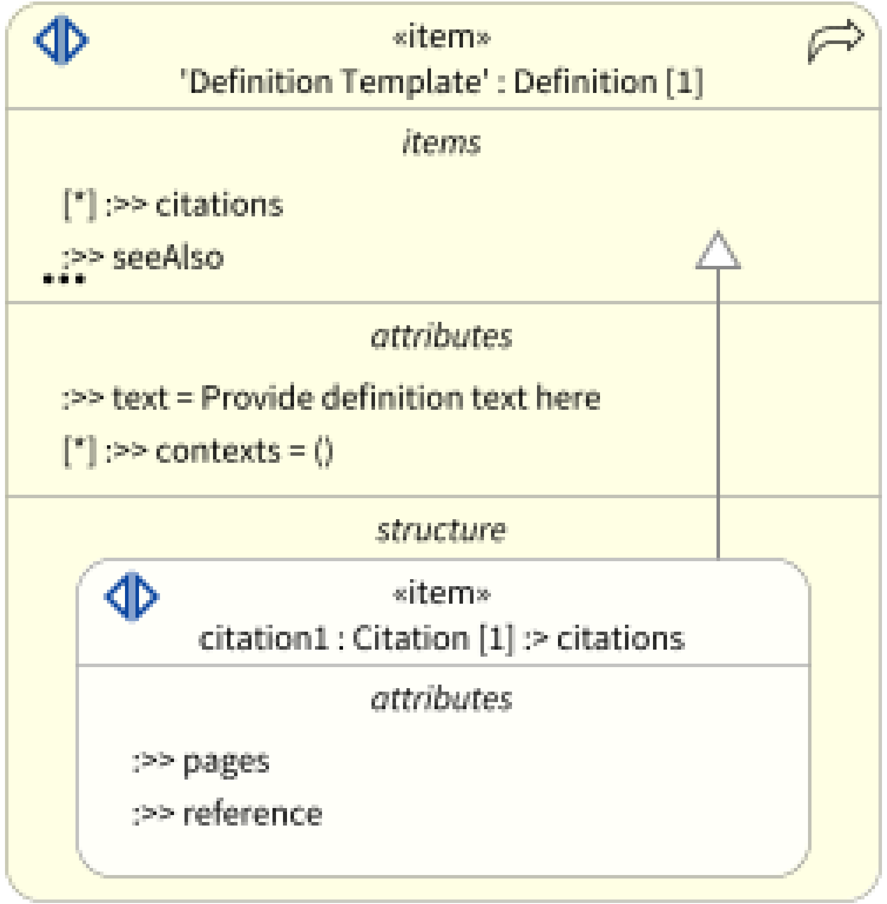
Figure 49: Add Definitions to an Existing Term Process

This process involves 6 elementary steps that we detail below:

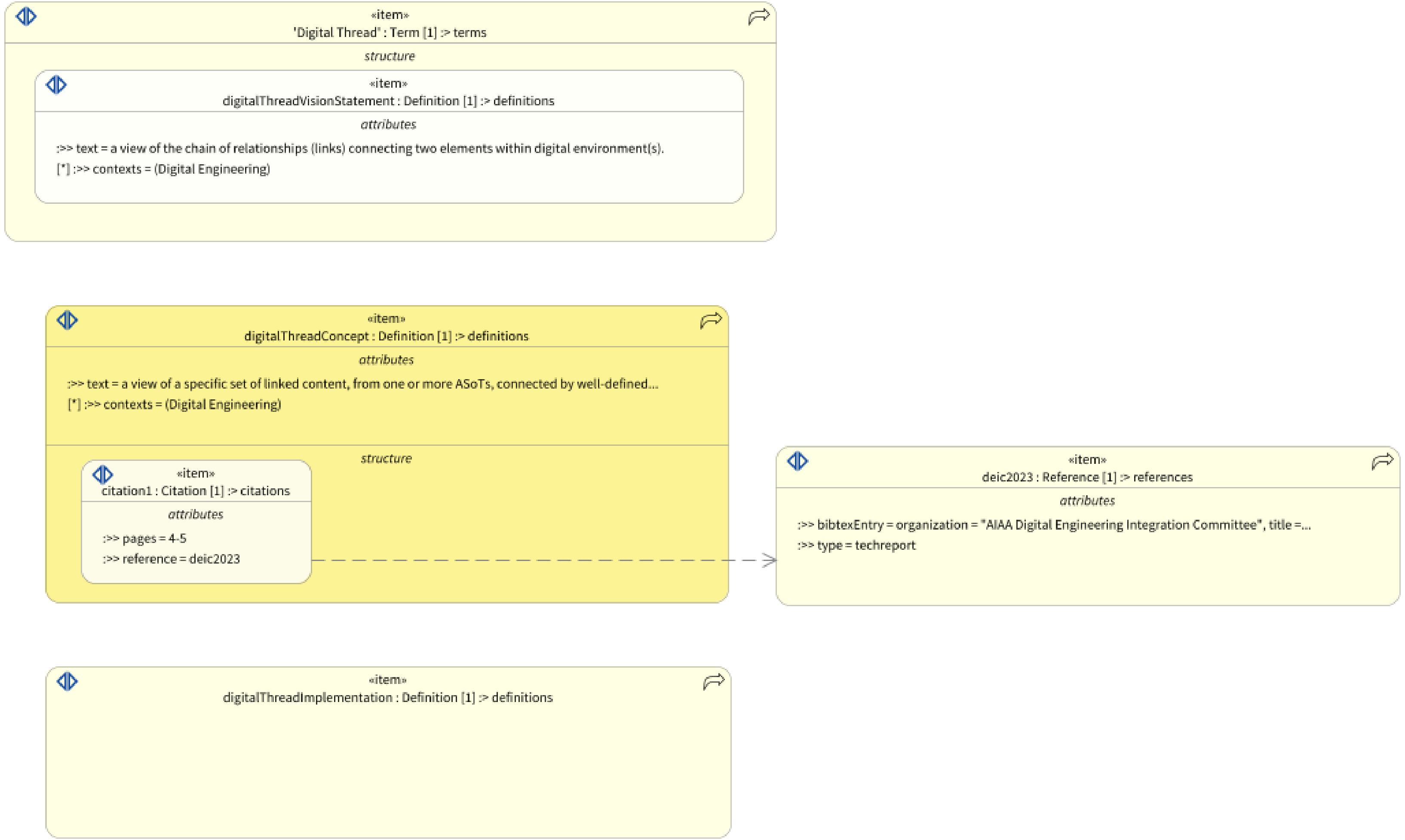
- Process Step 1: If First Definition of Term?
- Process Step 1.1: Use definition1 in term as the Definition Element to be Updated

- Process Step 2: If Not First Definition of Term?
- Process Step 2.1: Create a New Definition Element and Use it as the Definition Element to be Updated

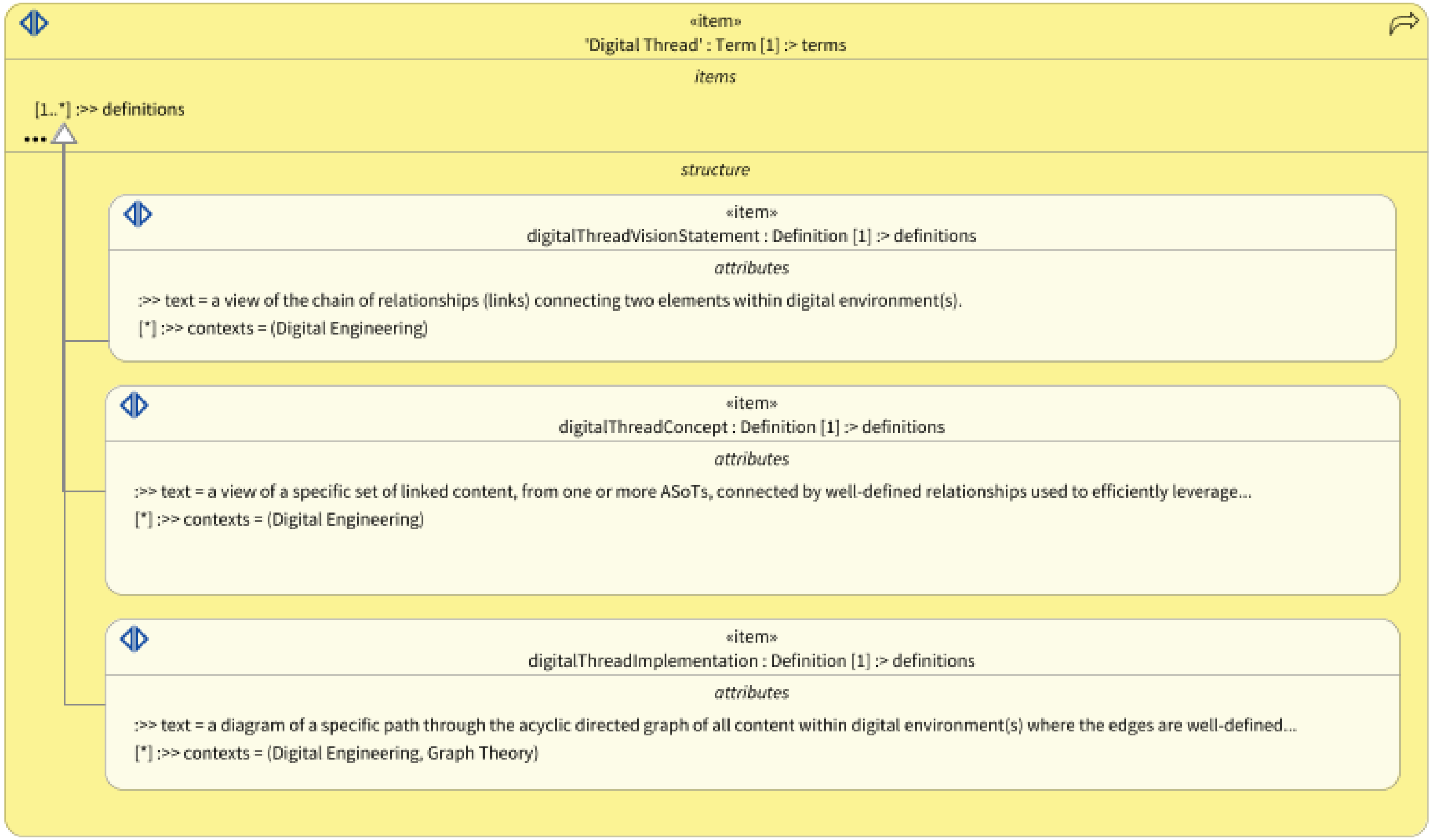
Adding a Definition Utilizes the Definition Template



Adding Second Definition to Digital Thread



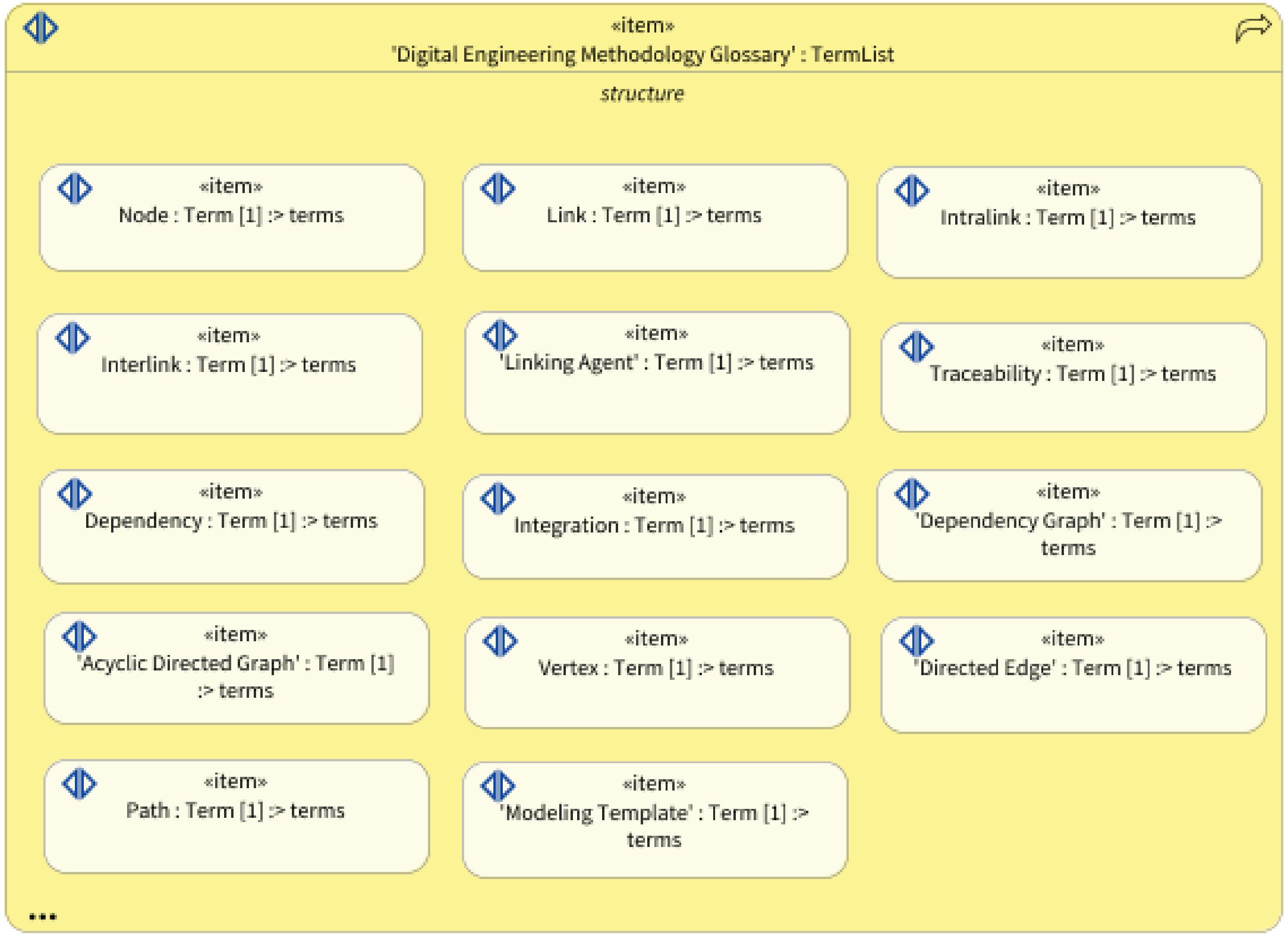
Completed Work to Add Definitions to Digital Thread



Creating a View of Updated Glossary for Stakeholder Review

Term	Contexts	Definition	Citations	See Also
DevSecOps Pipeline	Digital Engineering	an automated set of "jobs" run within a digital environment for building and deploying products (e.g. software, artifacts) to a production environment to foster collaboration across teams (e.g. developers, operations, security, other stakeholders)	halldevopspipeline2023	
DevSecOps View Producer Pipeline	Digital Engineering	a composite view producer implemented as a DevSecOps pipeline		DevSecOps Pipeline
Digital Engineering	Digital Engineering, Block Quote	an integrated digital approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through disposal	digeng2018 (p. 3)	Authoritative Source of Truth
Digital Environment	Digital Engineering	IT infrastructure designed and implemented to support collaborative execution of Model-Based/Digital Engineering methods through integration; provides hosting for ASoTs and views and manages access for stakeholders	digeng2018 (p. 15)	View, Authoritative Source of Truth
Digital Thread	Digital Engineering	[Vision Statement] a view of the chain of relationships (links) connecting two elements within digital environment(s).	deic2023 (p. 4-5)	View, Digital Environment, Digital Thread [Concept]
	Digital Engineering	[Concept] a view of a specific set of linked content, from one or more ASoTs, connected by well-defined relationships used to efficiently leverage enterprise knowledge in support of a systems engineering activity	deic2023 (p. 4-5)	ASoT, Content, Systems Engineering, Link [Concept]
	Digital Engineering, Graph Theory	[Implementation] a diagram of a specific path through the acyclic directed graph of all content within digital environment(s) where the edges are well-defined relationships (Links) and the vertices are elements of ASoT managed content (Nodes)		Node, Link, Digital Thread [Concept], Acyclic Directed Graph, Path
Digital Thread Stakeholder	Digital Engineering	a human directly involved in the creation, maintenance, or use of a digital thread		Digital Thread
Directed Edge	Graph Theory	an edge which connects two vertices as an ordered pair pointing from the tail vertex to the head vertex	bondy1979 (p. 171)	Vertex, Edge
Directed Graph	Graph Theory	a graph where the vertices are connected by directed edges	bondy1979 (p. 171)	Directed Edge, Vertex, Graph
DRY	Acronym, Digital Engineering	Don't Repeat Yourself (an approach to software development that focuses on reuse of code over duplicated code)		
Edge	Graph Theory	the set of elements within a graph connecting the graph's vertices	bondy1979	Graph, Vertex
Giver ASoT	Digital Engineering	ASoT containing content consumed by an Interlink Agent to be rendered as a View in the Receiver ASoT		Interlink Agent, Receiver ASoT, ASoT
Giver ASoT Manager	Digital Engineering	an ASoT Manager for an ASoT participating as a giver for an Interlink Agent		ASoT Manager, Giver ASoT, Interlink Agent

New and Updated Terms Published into the System Glossary



Moving onto Developing Operational Concepts

6 THE DEVELOP SYSTEM PROCESS

6.1 STAKEHOLDERS NEEDS DEFINITION PROCESS

The following action definition describes the process to be followed to define the Stakeholders Needs.

The inputs to this process are:

- an initial list of stakeholders
- the capability needs, as expressed by these initial stakeholders.

The outputs from this process are:

- a glossary of terms and a bibliography related to the system domain
- a glossary of terms and a bibliography related to the system domain, as agreed with the stakeholders
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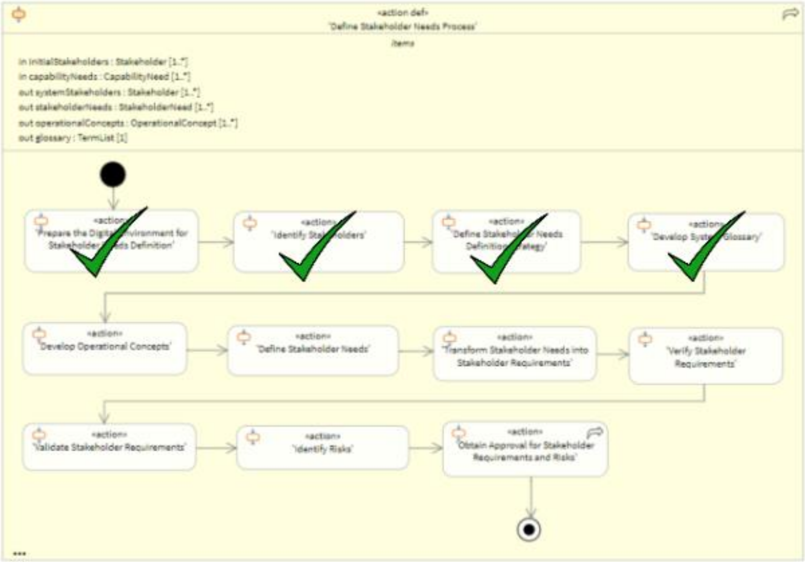
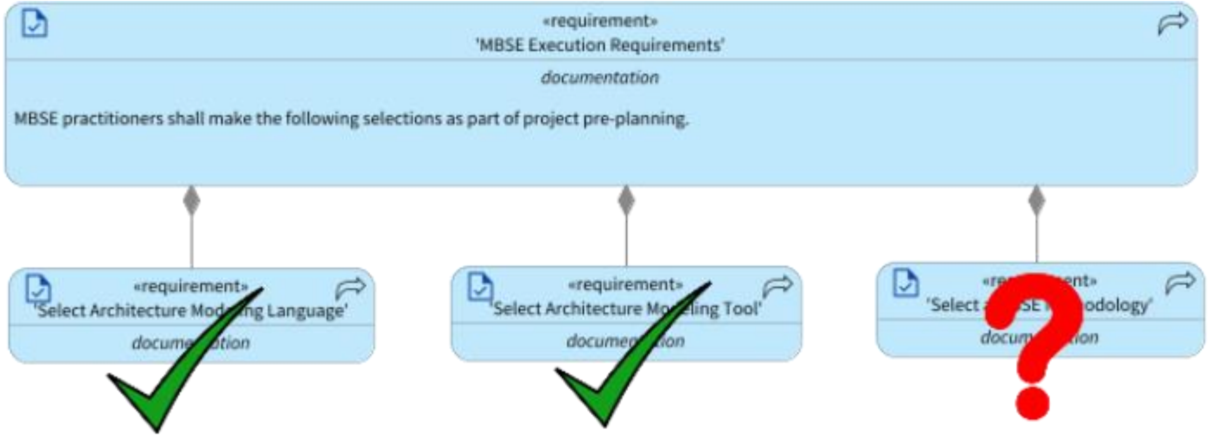


Figure 44: Define Stakeholders Needs Process

Using the Methodology

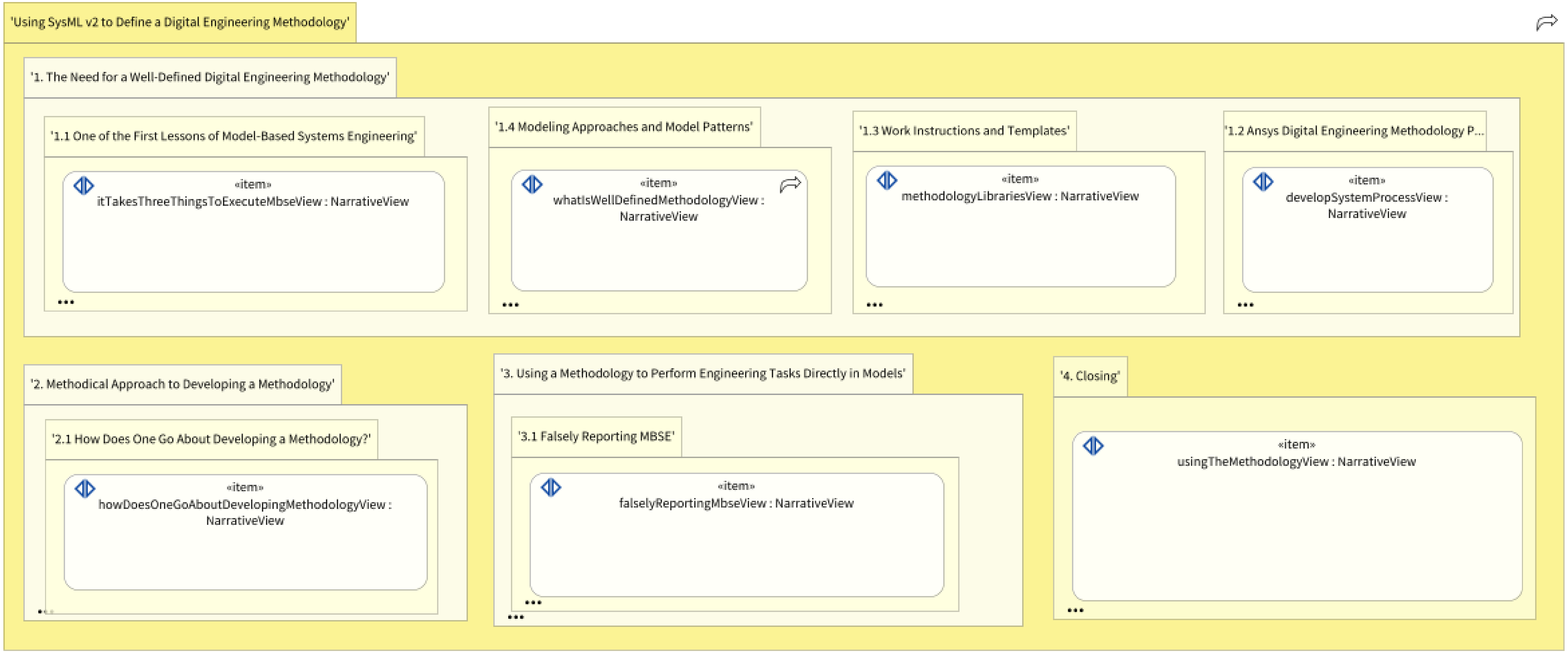
The Methodology Development Process

The Need for a Well-Defined Methodology

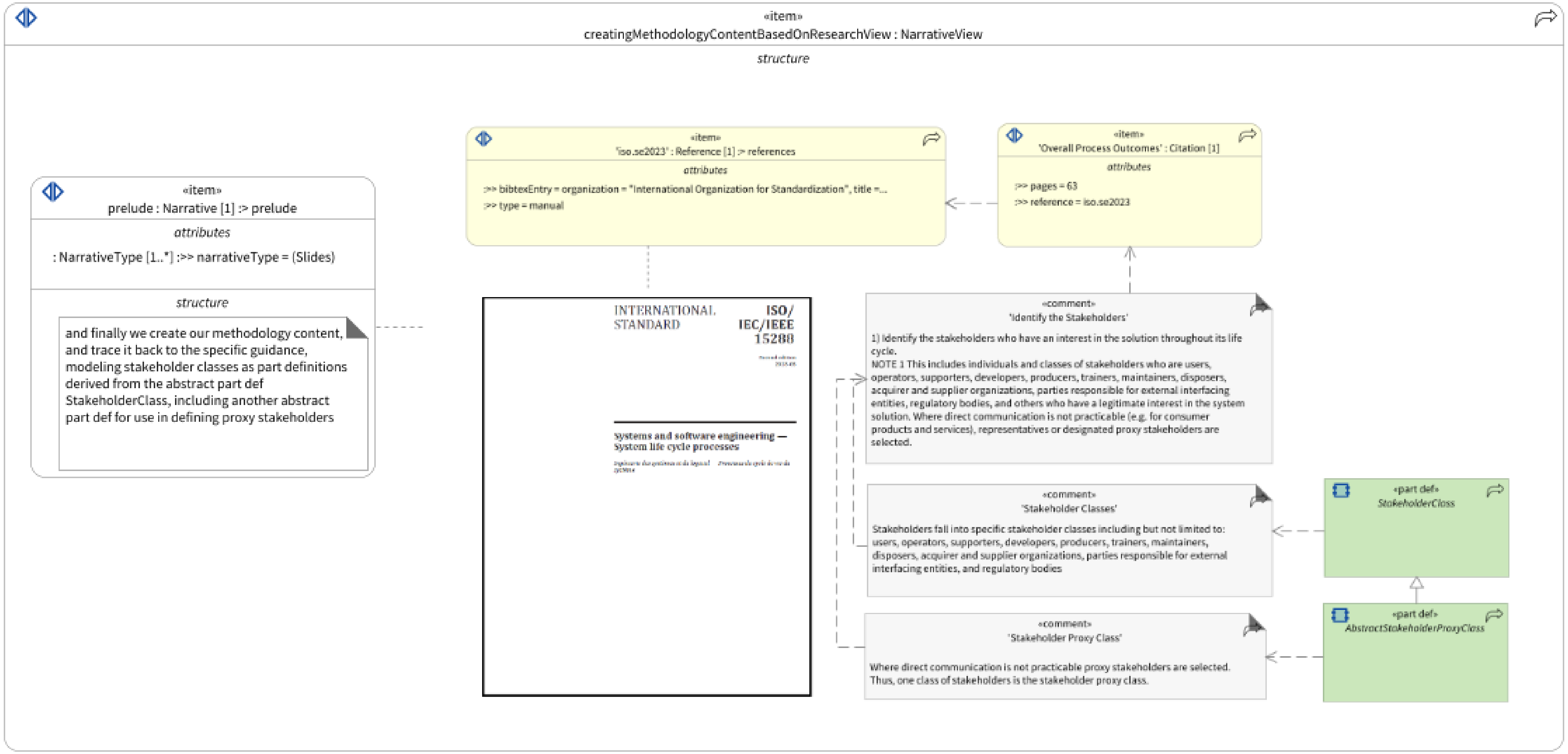


One More Thing

The Collection of Views



An Example Narrative View



Narrative View Work Instructions

Process: Create a Narrative View in a Narrative Views Package

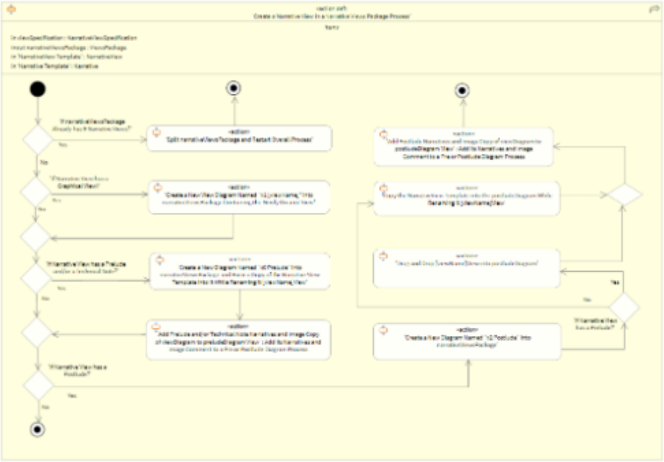
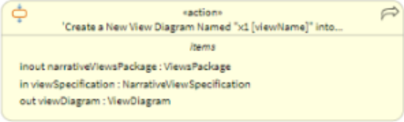


Figure 54: Create a Narrative View in a Narrative Views Package Process

This process involves 8 elementary steps that we detail below:

- Process Step 1: if narrativeViewsPackage Already has 9 Narrative Views?
- Process Step 1.1: Split narrativeViewsPackage and Restart Overall Process

- Process Step 2: if Narrative View has a Graphical View?
- Process Step 2.1: Create a New View Diagram Named "x1. [viewName]" into narrativeViewsPackage Containing the Newly Created View



- Process Step 3: if Narrative View has a Prelude and/or a Technical Note?

Running the Slides View Producer

Command Prompt

```
C:\Users\simmo\handbook view producer>python main.py
Start JVM with jar path : C:\Users\simmo\AppData\Local\Programs\Python\Python312\Lib\site-packages\sam_api\jar\*
Picked up JAVA_TOOL_OPTIONS: -Dfile.encoding=UTF8
Connecting to Ansys System Architecture Modeler
Loading the Ansys Digital Engineering Methodology Model
Getting view content
Adding section: One of the First Lessons of Model-Based Systems Engineering
Adding section: Ansys Digital Engineering Methodology Pillars
Adding section: Work Instructions and Templates
Adding section: Modeling Approaches and Model Patterns
Adding section: How Does One Go About Developing a Methodology?
Adding section: Top Level Requirements
Adding section: Traceability from Research to Implementation
Adding section: Repeatable Process
Adding section: Falsely Reporting MBSE
Adding section: Planning
Adding section: Execution
Adding section: Review and Approval
Done

C:\Users\simmo\handbook view producer>
```

What Do You Think?