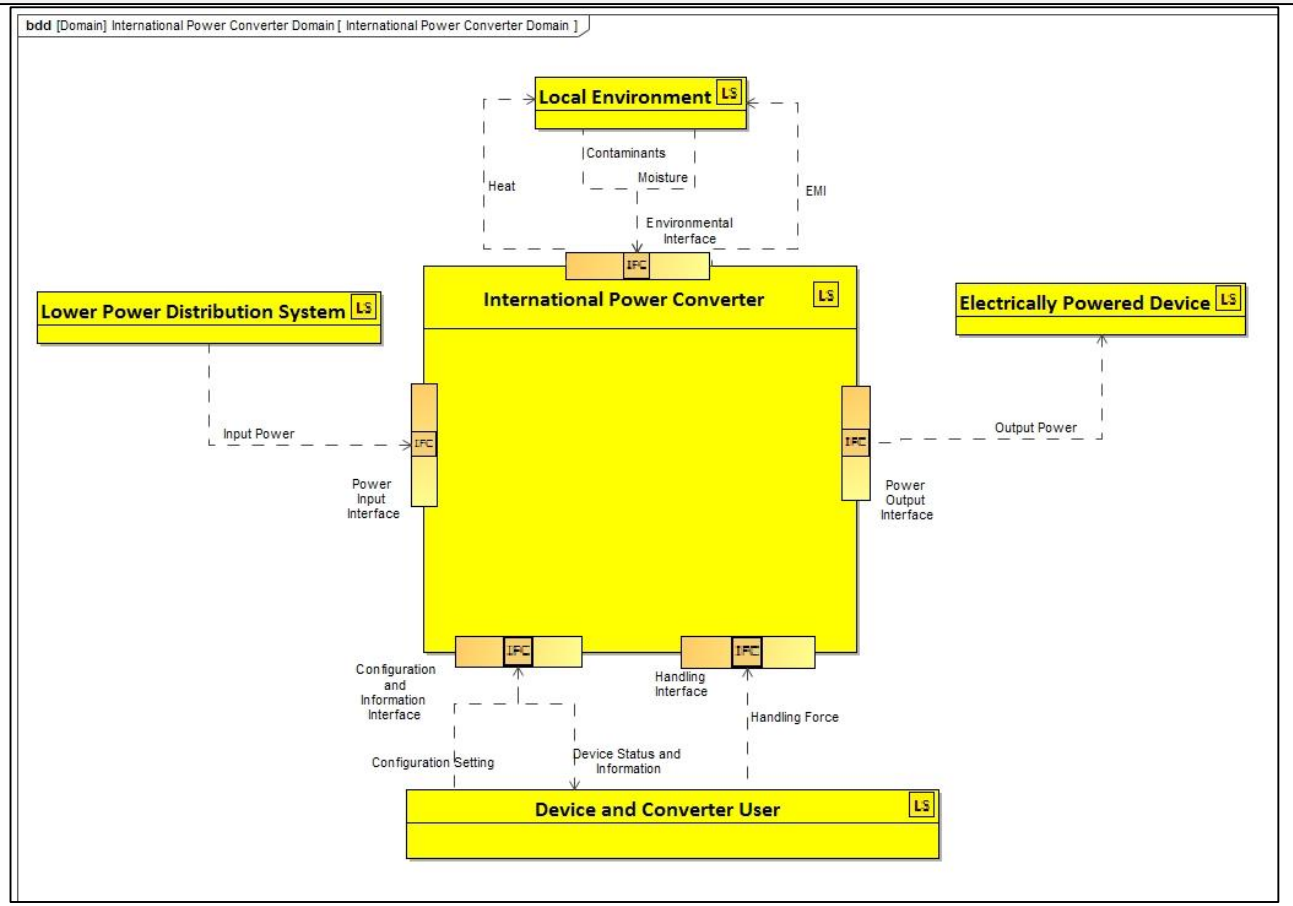
Applying an S*Pattern to Generate a Configured S*Model: Simple Example with Multiple Configured Interfaces



ST4SE
team meeting of
June 29, 2021

V1.5.7
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Contents

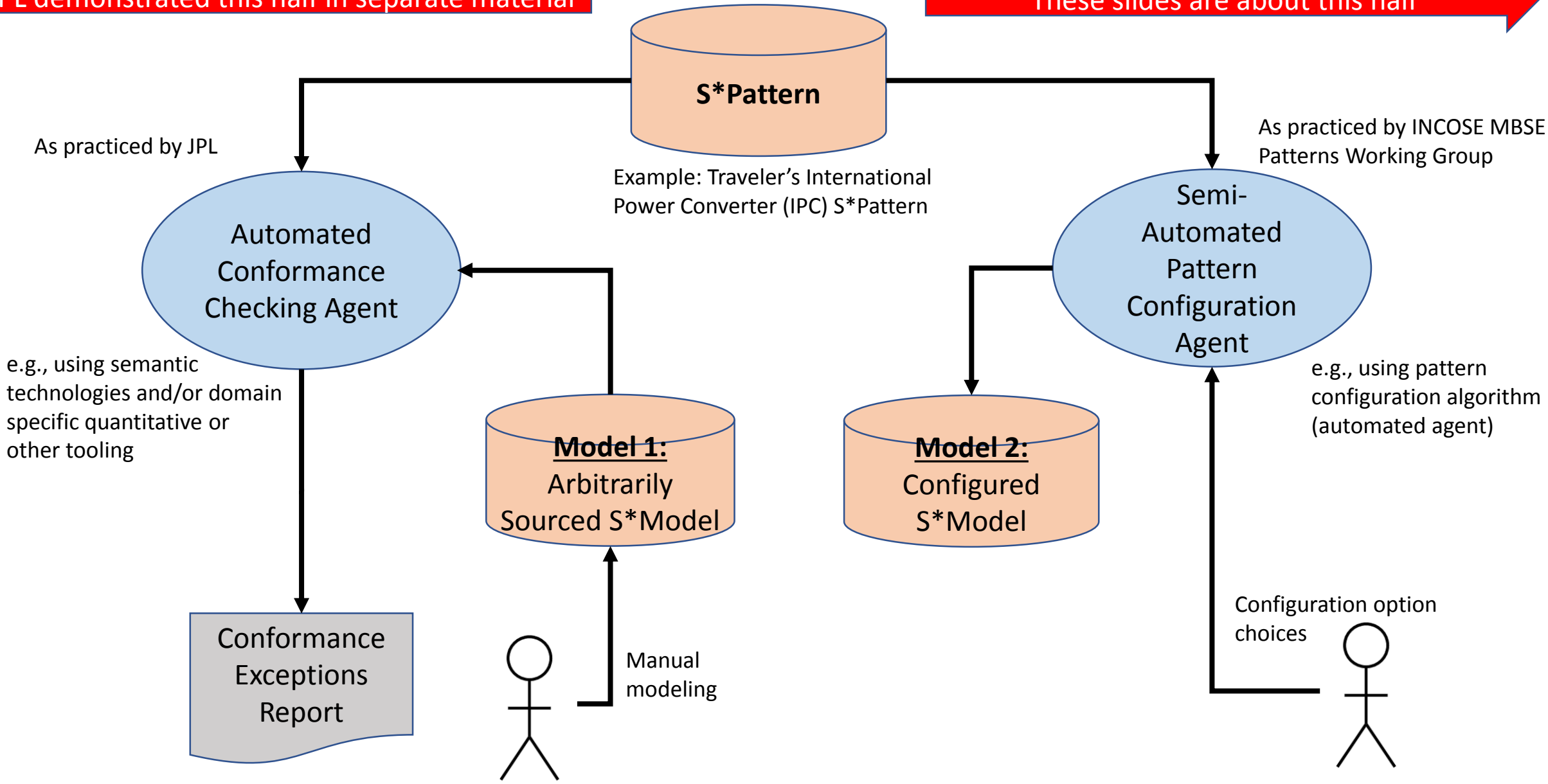
Background

- Reminder of project goal: Illustrate model checking vs. model generation using a common (shared) pattern for both.
- Focus on Interface Pattern subset, using small International Power Converter Pattern as basis for examples of both.
- Recent JPL demonstrations of checking.
- This material is about configured model generation from pattern, the structure of related pattern configuration rules, and generation of a configured model from the rules plus choices.
- The current version includes further additions to the example application pattern (travel power converter), including the external actors, pattern configuration rules, and use of a configuration agent interacting with a SysML Pattern and Configured Model in Cameo Systems Modeler.

JPL demonstrated this half in separate material

Common Shared Pattern

These slides are about this half

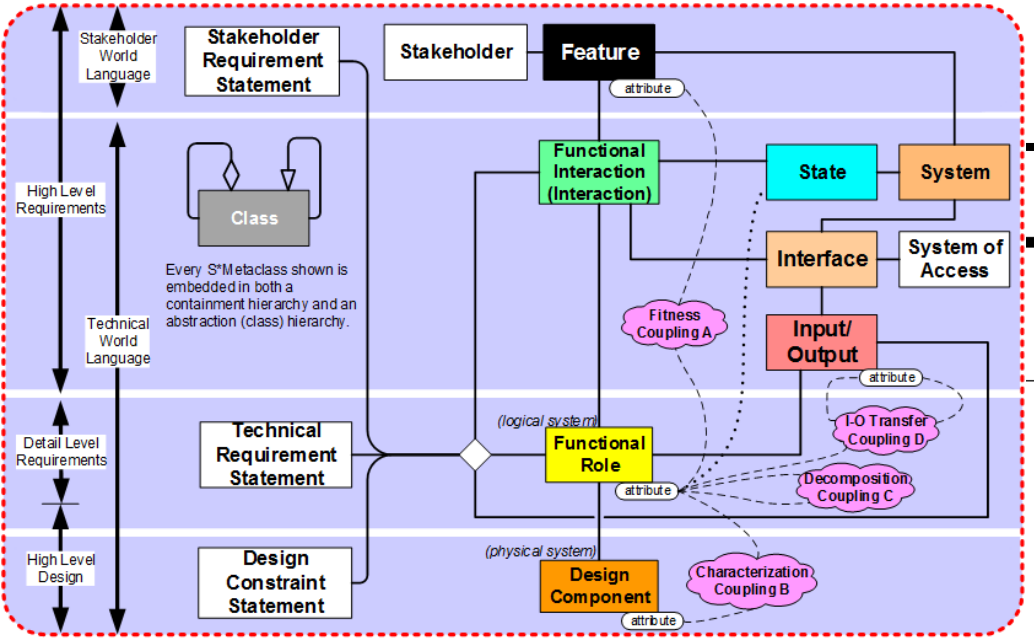


The models and pattern shown may be expressed in SysML, OWL, OML, or other language, but in any case map to S*Metamodel – so they are referred to as an S*Model and an S*Pattern.

Scope of S*Patterns

- Recall the conceptual definition of S*Model:
  - Any model conforming to the S*Metamodel.
  - Guiding S*Metamodel principle: The smallest model content necessary to describe a system, across its life cycle, for the purposes of engineering or science.
- S*Pattern: A configurable, reusable S*Model of a family of systems.
- During our ST4SE project, we have frequently used the term “Pattern” to describe what users of an S*Pattern would consider to be a recurring part (subset) of the “whole system” pattern – in this case, Interfaces.
- This example therefore illustrates generation of the “whole system” model for a Power Converter, from a Power Converter Pattern.
- Including the S*Interface subset: Input-Outputs, Interfaces, Systems of Access, relationships between them, and attributes.
- Model generation from the pattern is driven by stakeholder selections, mostly from Stakeholder Feature level, which then cascade through the Pattern to generate the Configured Model.

https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:systematica_mapping_for_magicdraw_csm_v1.9.1a.pdf

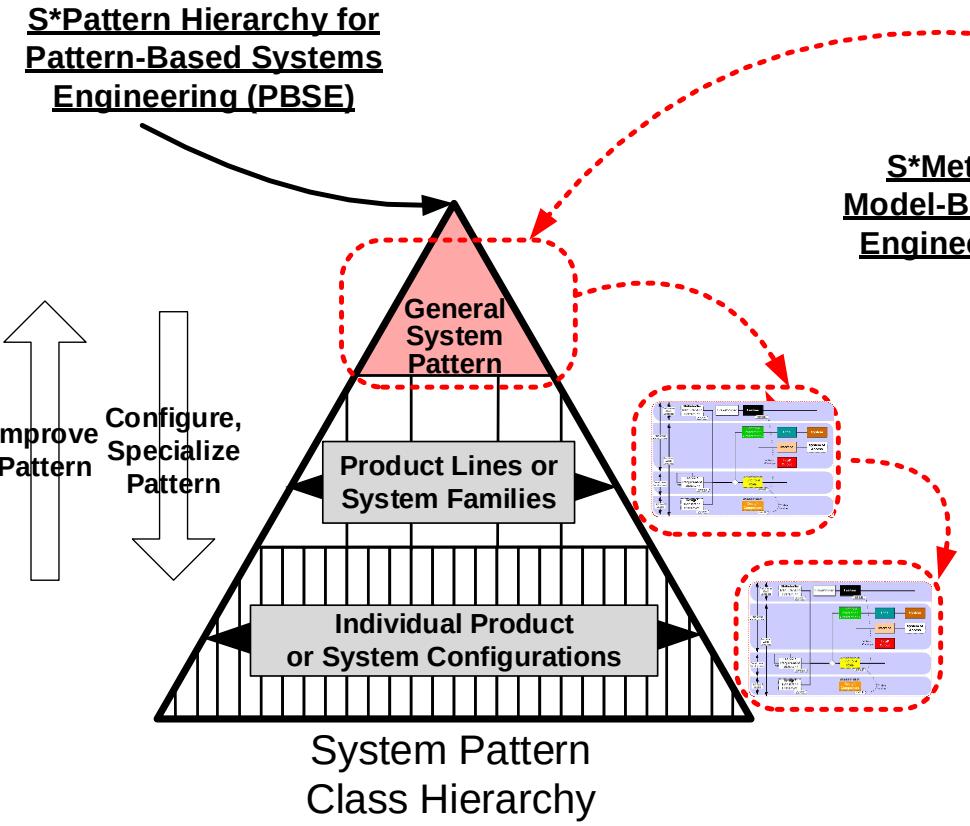


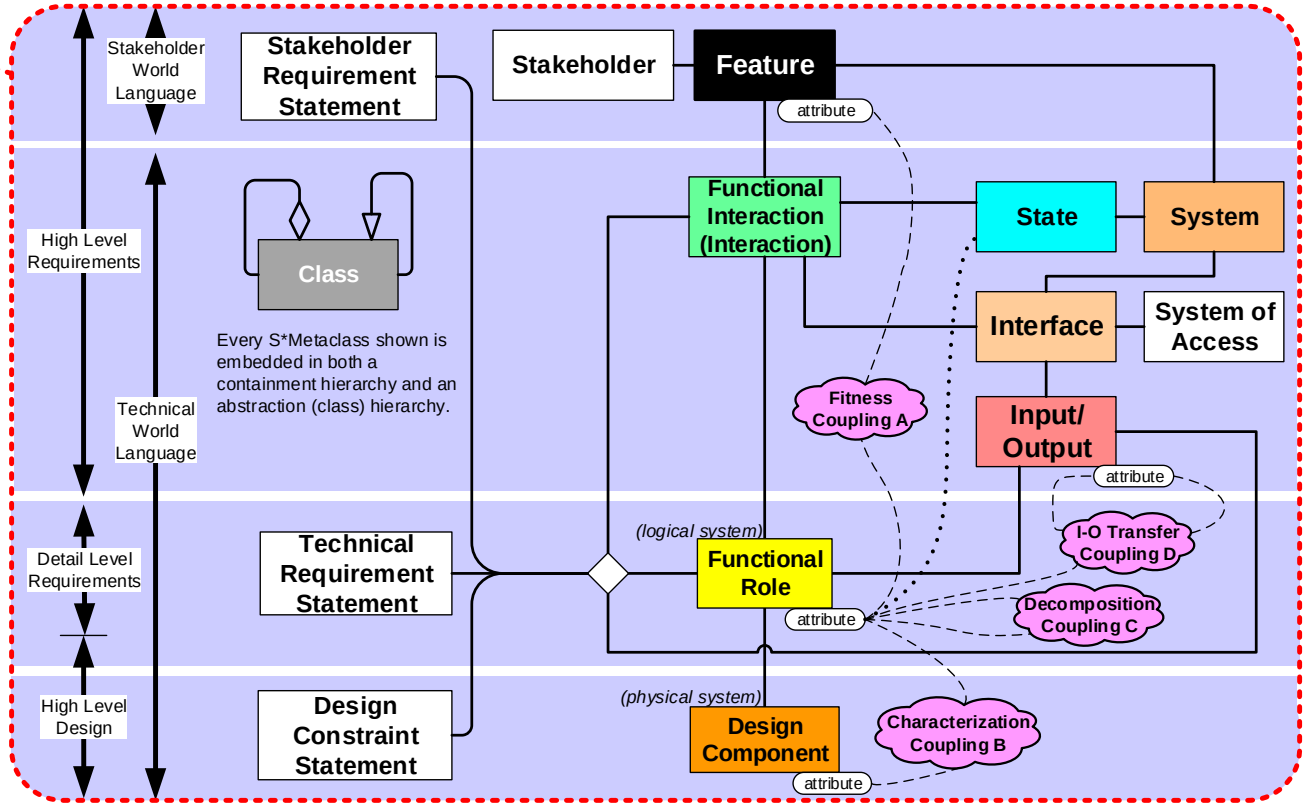
S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

Informal versus formal S*Metamodel (100 pages);
Mappings to individual languages, 3rd party COTS tools.

https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:systematica_5_metamodel_v7.1.6a.pdf

Model generation: Configured S*Model from S*Pattern





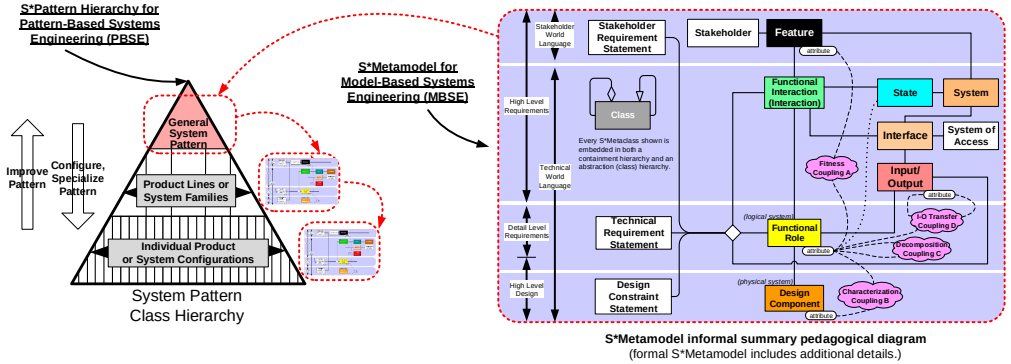
S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

S*Patterns vs. Patterns in General

- How related to other kinds of engineering patterns?
  - Some patterns are expressed short of explicit models—S*Patterns are model-based; in fact, they are models based on the S*Metamodel.
  - Some patterns are about importable components—S*Patterns are usually focused on “whole systems”, but certainly may include subsystems, and components.
  - Some patterns are design patterns—S*Patterns are about the whole range of product life cycle content, not limited to design
- How related to Product Line Engineering (PLE)?
  - This is a form of PLE.
- It is further specialized PLE, in that it leverages the content of the S*Metamodel:
  - Instead of allowing that the pattern owner might insert variation points anywhere, it restricts the points of variation.
  - These constraints are inherent to the nature of engineering models.

S*Patterns: Configuration vs. Specialization

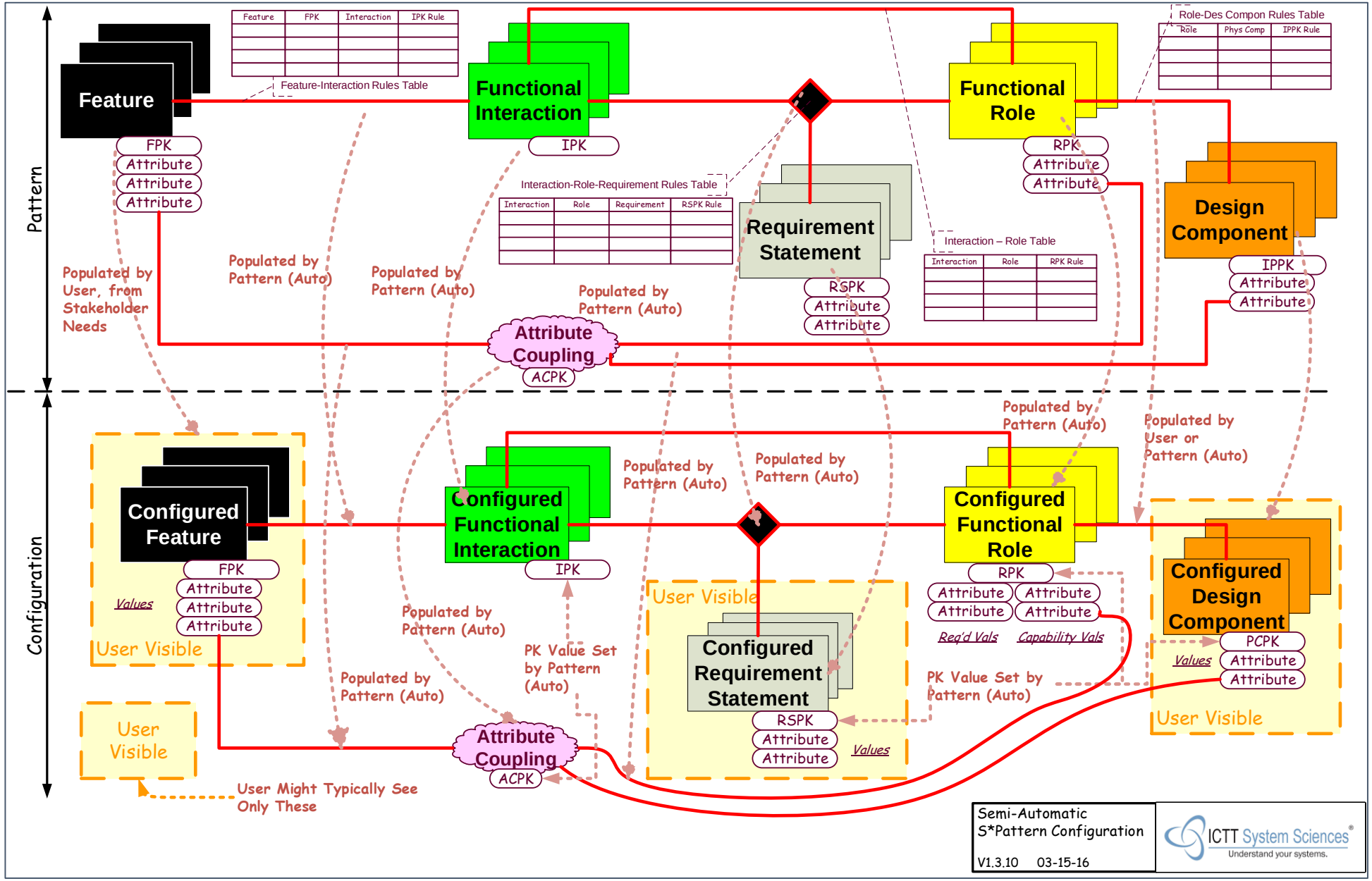
- The modeling skills necessary to “specialize” a general pattern into a specific model are greatly reduced if the pattern has been built out enough that only “configuration” is required to create a model.
- By “configure”, we mean here that the only operations necessary to convert a pattern into a model are two:
  1. Population/depopulation of pattern components (this creates the structure of the model).
  2. Set attribute values (this sets the quantitative or parametric aspects of variable attributes populated by (1)).



S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

- Note that this is somewhat different than the notions sometimes called “150% models” or similar, in that the S*Pattern elements typically expand instead of reducing:
  - The pattern has only single instances of things that are multiply populated in the configured model.
  - For example, power circuits in a factory might occur hundreds of times in the configured S*Model, but only once in the S*Pattern.
  - So, the “percentage” relationship runs the opposite direction—configuring is expansion.

What configuring S*Pattern means (before extension to Interfaces)

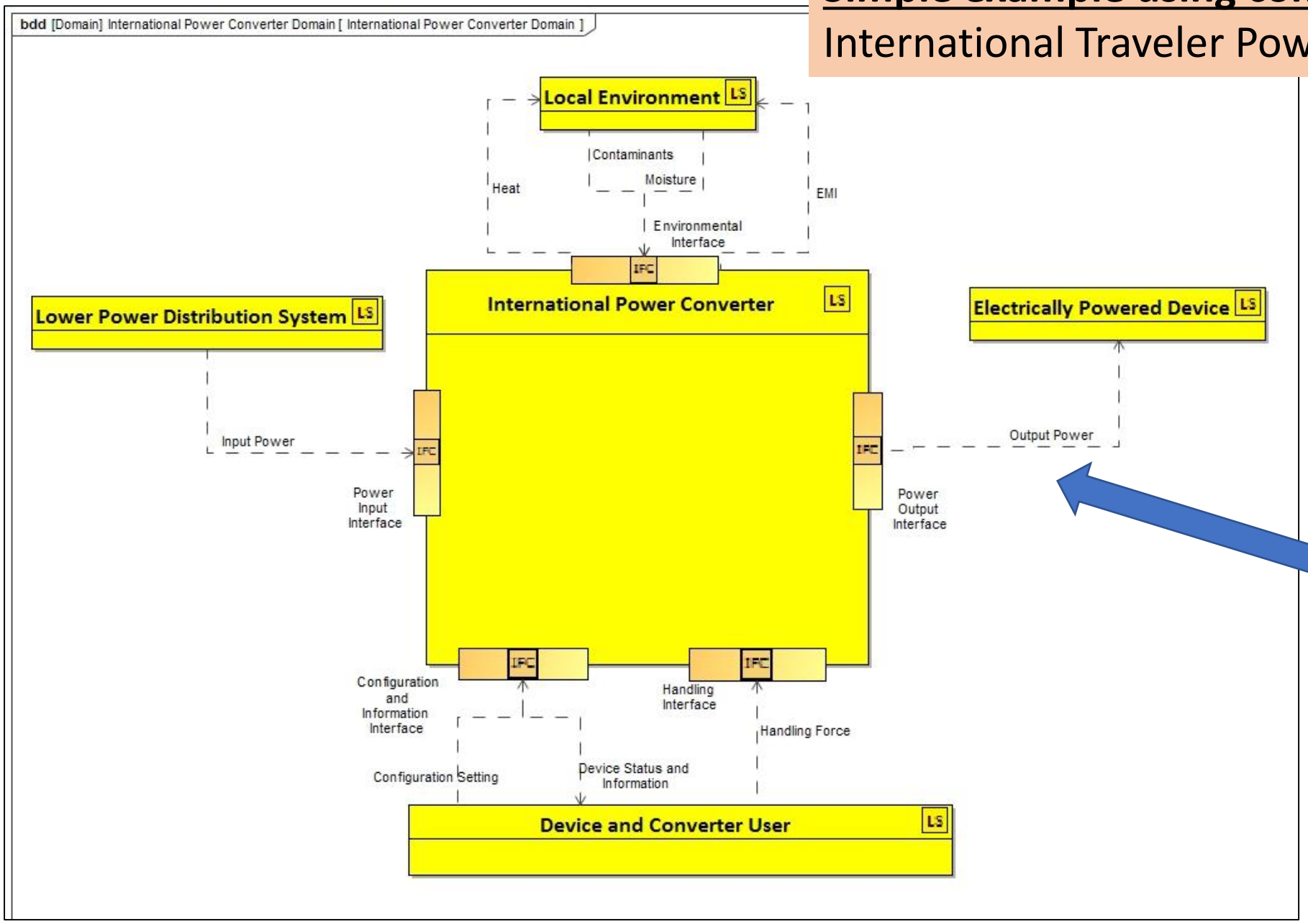


1. Stakeholder selects Features and Feature PK values to populate.
2. Configuration algorithm uses configured Features and FPK Values to selectively (per Configuration Rules) populate Interactions and Interaction PK values, along with relationship between them.

Configured Power Converter Model Example

- Using product line-oriented Power Converter Feature allowing different numbers of Power Output Interfaces for different configurations.
- Running these configurations using prototype of third generation configuration agent (S*Pattern Wizard) attached to Cameo Systems Modeler SysML model authoring and repository tool

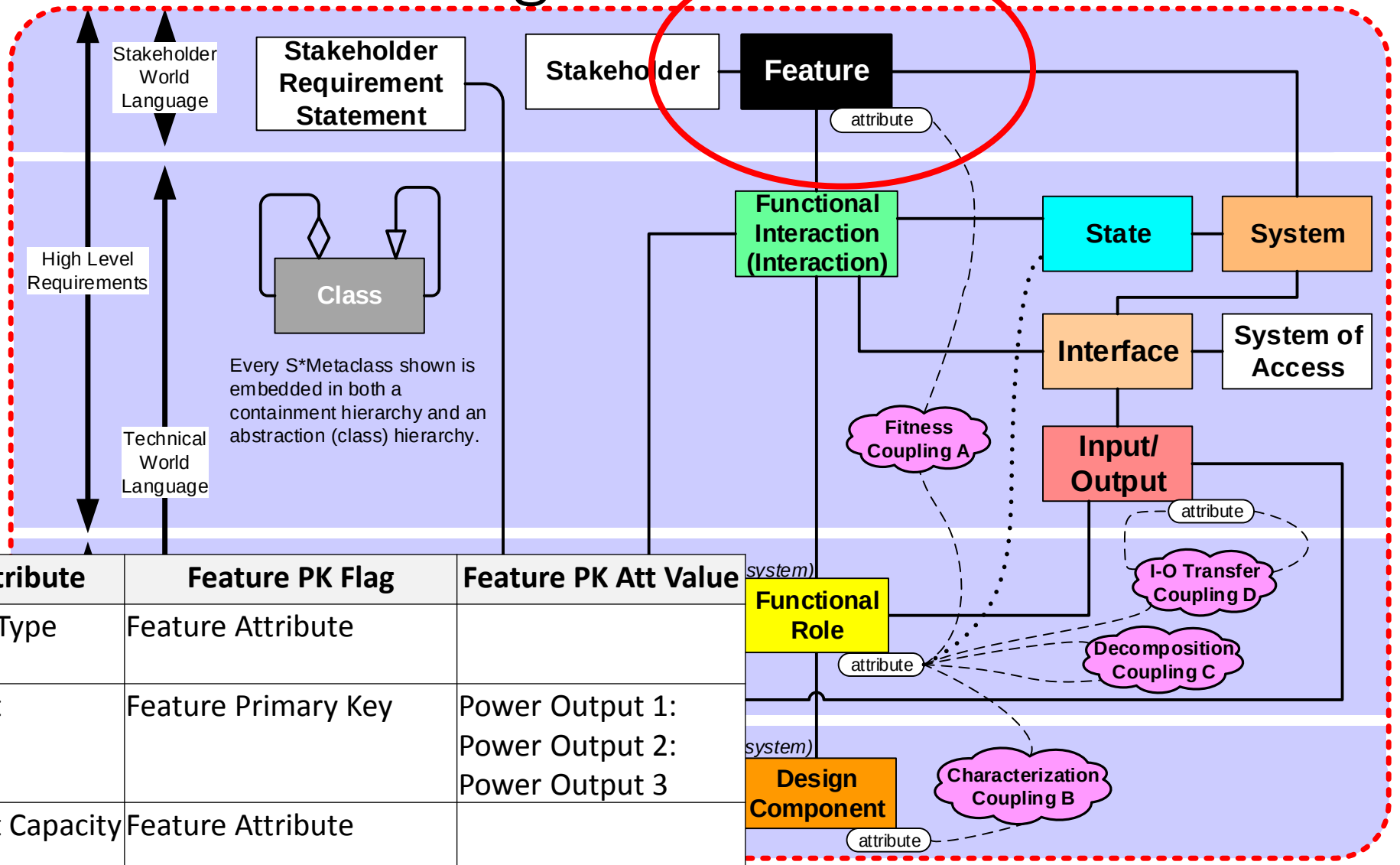
Simple example using configurable interfaces:
International Traveler Power Converter Family



Configuration of pattern changes number of Power Output Interfaces, for multiple powered devices.

Power Converter Pattern: Configurable Features

Feature Name
Power Mains Compatibility
Powered Devices Compatibility
Ease of Use
Safety
Portability
Reliability and Durability

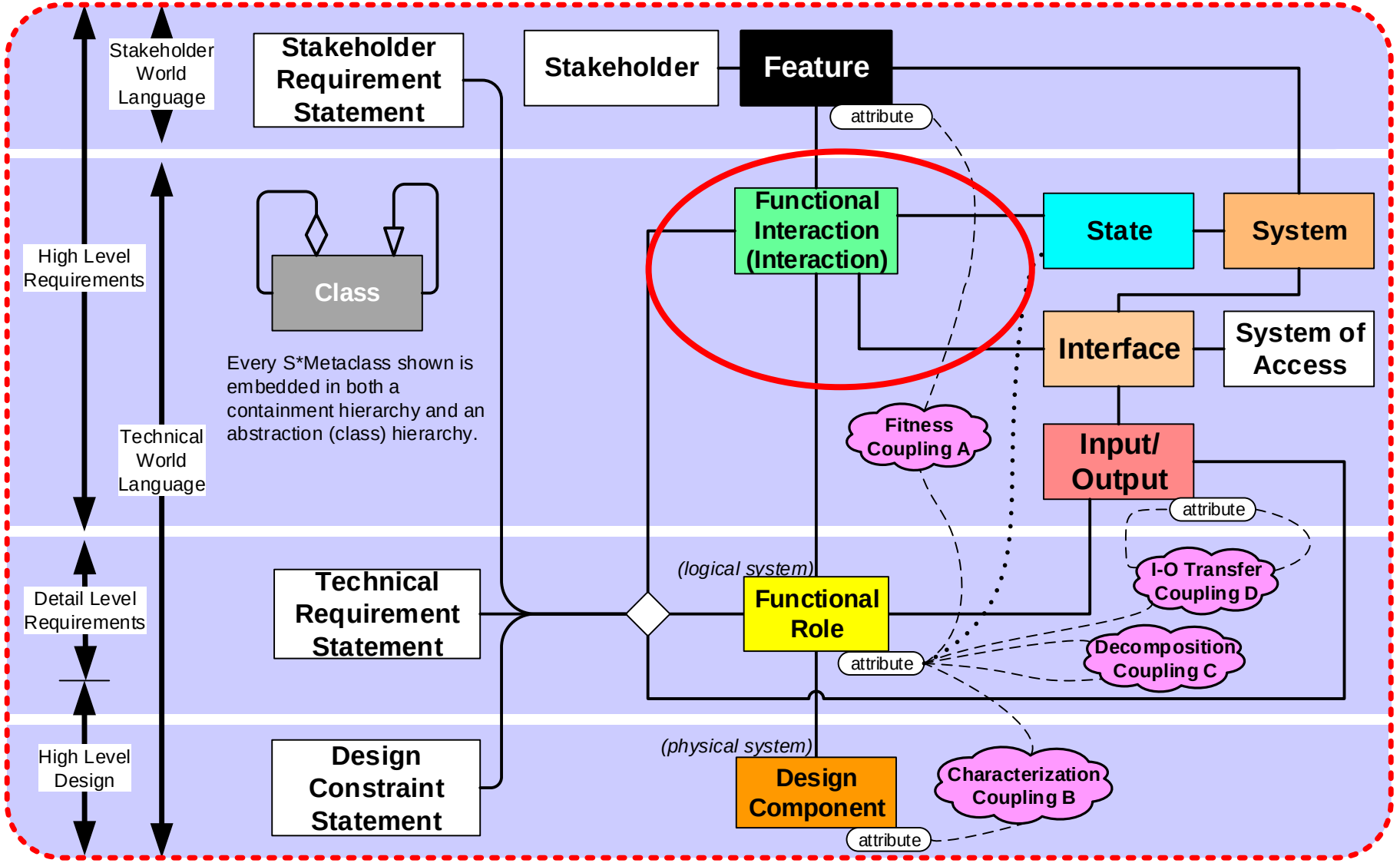


Feature Name	Feature Attribute	Feature PK Flag	Feature PK Att Value
Power Mains Compatibility	Power Mains Type	Feature Attribute	
Powered Devices Compatibility	Power Output Interface ID	Feature Primary Key	Power Output 1: Power Output 2: Power Output 3
Powered Devices Compatibility	Power Output Capacity	Feature Attribute	
Reliability and Durability	Design Life	Feature Attribute	

mary pedagogical diagram
udes additional details.)

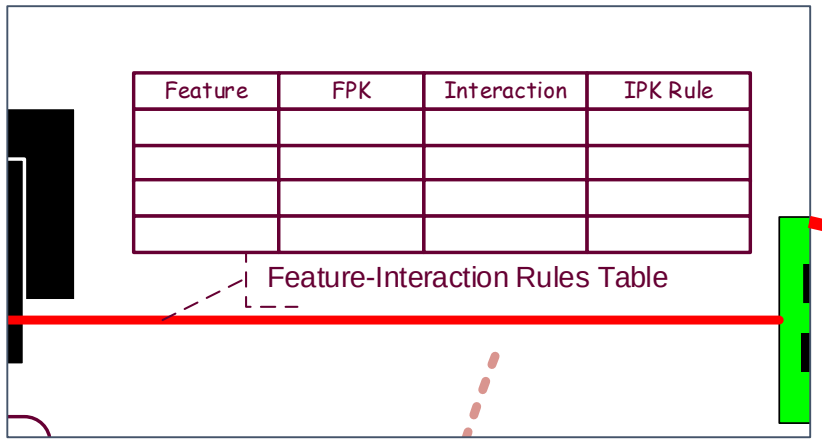
Power Converter Pattern: Configurable Interactions

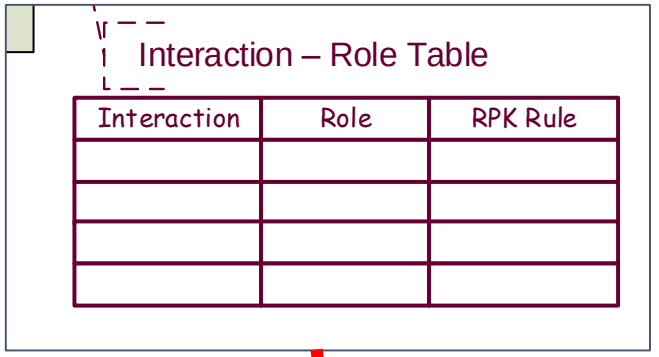
Interaction Name
Convert Electrical Power
Display Status and Information
Handle Device
Resist Contamination
Set Configuration
Tolerate Moisture

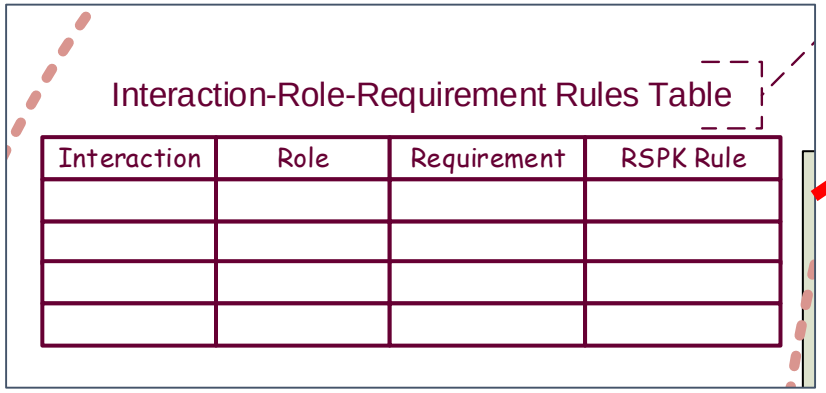


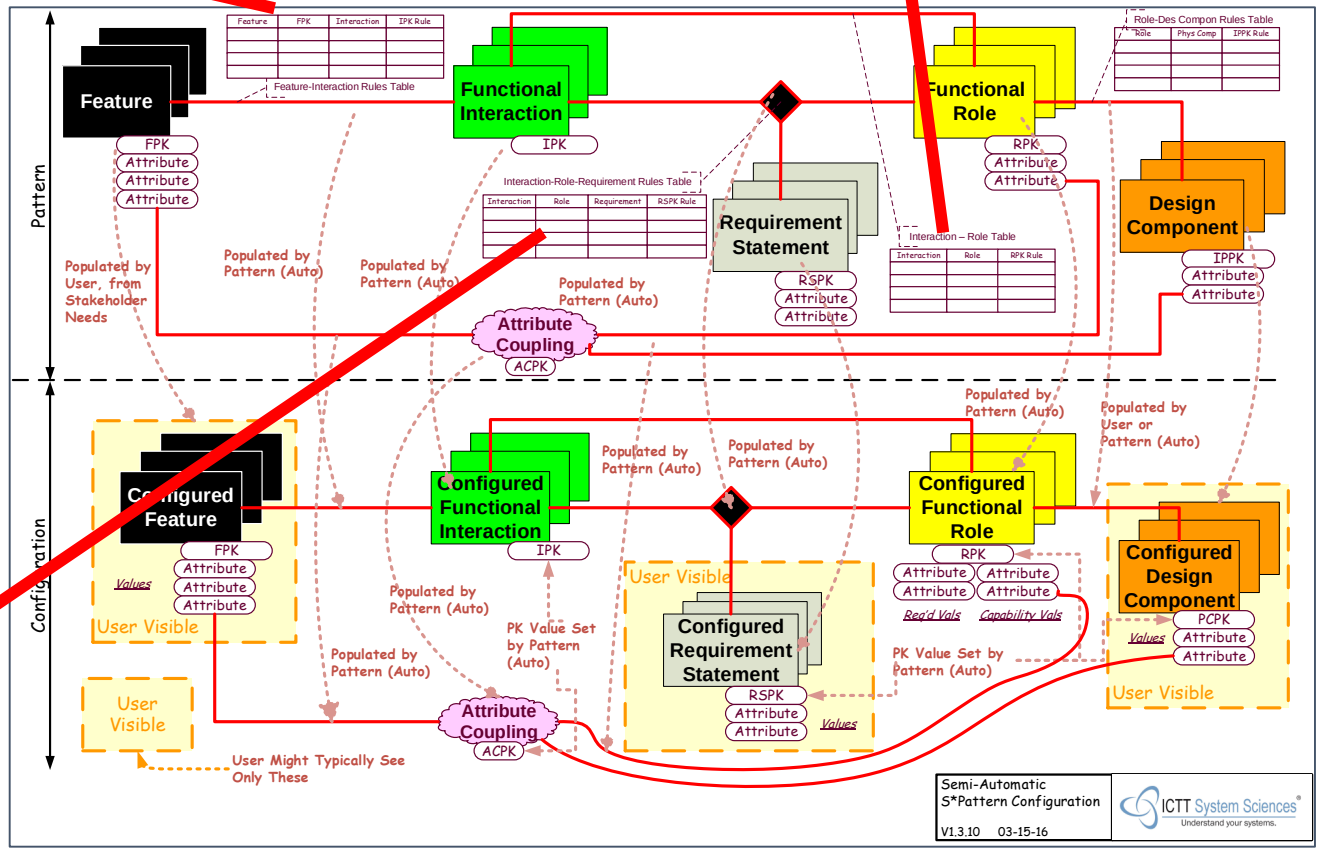
S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

Configuration rules at key population points:





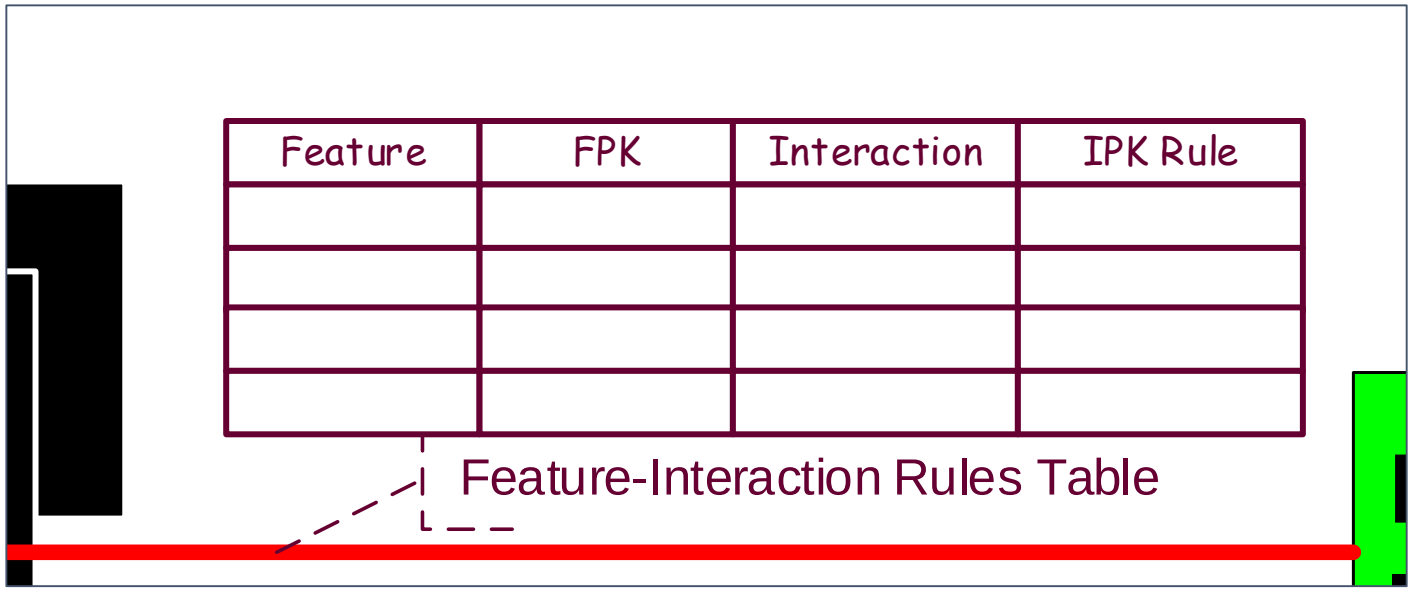




Form of configuration rules for populating Interactions from population of Features

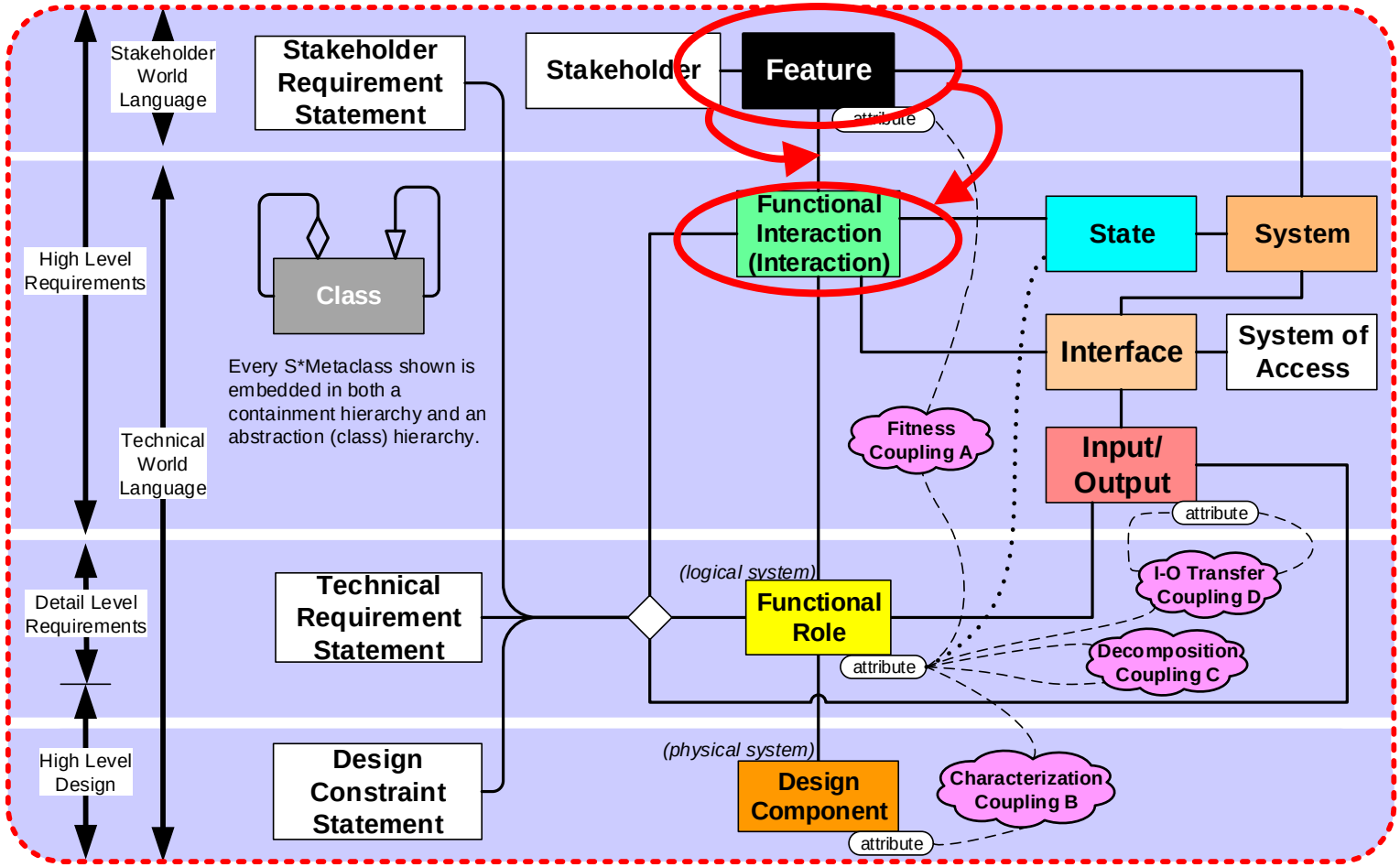
Each row of this configuration rules table is filled in with an “IF” part (First two columns) and a “THEN” part (last two columns:

1. IF a feature shown in first column is found to have already been populated in the model, with a Feature Primary Key (FPK) value in the second column of the table, . . .
2. THEN an Interaction shown in the third column is populated , with an Interaction Primary Key (IPK) value set by the rule in the fourth column;
3. AND a relationship instance is populated between the Feature and Interaction.



Feature-Interaction Configuration Rules

Feature Name	FPK Value	Interaction Name	Interaction PK Rule
Power Mains Compatibility		Convert Electrical Power	/*ANY*/
Powered Devices Compatibility	*ANY*	Convert Electrical Power	FPK
Safety		Handle Device	
Portability		Handle Device	
Reliability and Durability		Resist Contamination	
Reliability and Durability		Tolerate Moisture	
Ease of Use		Set Configuration	
Ease of Use		Display Status and Information	
Ease of Use		Handle Device	

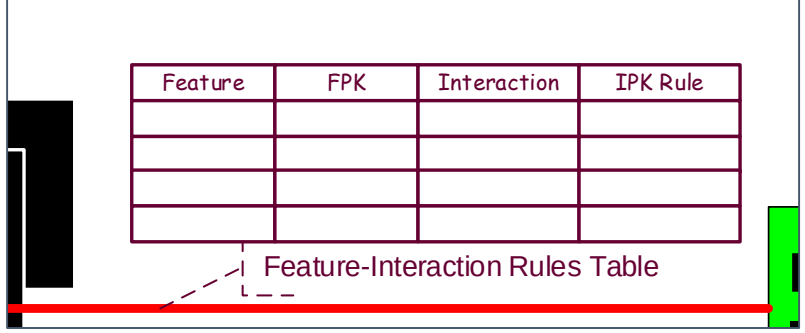


S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

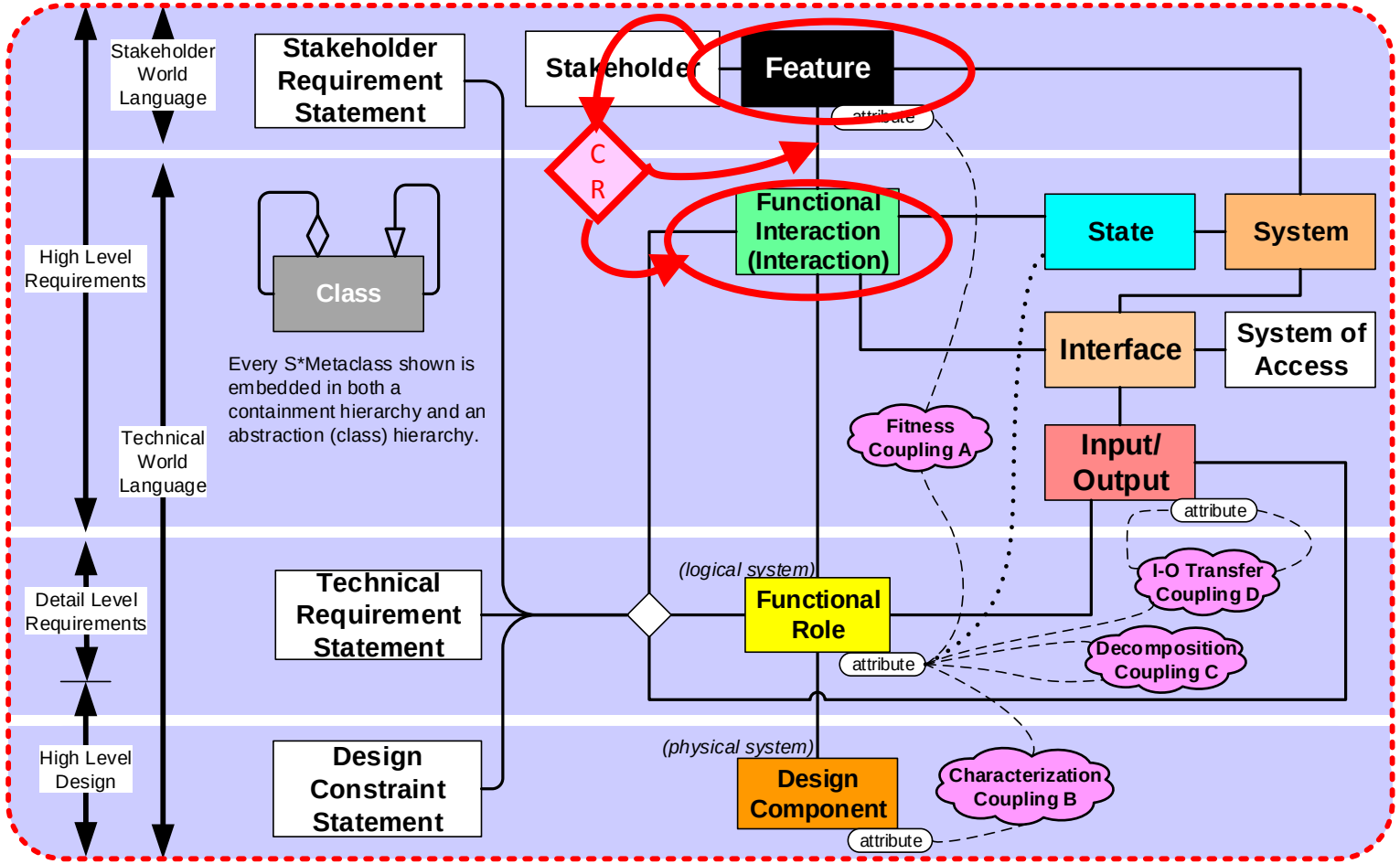
Governs population of Interactions and Feature-Interaction relationships.

Possible Interaction PK Rule column entries:

A. Nothing (means no IPK value is set).
B. /text string/ (means populate IPK with value of the text string.
C. FPK (means populate IPK with same value as FPK value.
D. FPK + /text string/ (means populate IPK with concatenation of both.
E. *ANY* as Interaction PK Rule means don't populate an additional Interaction, but populate Feature-Interaction relationship links from the populated Feature to any other populated Interactions.



Feature-Interaction Configuration Rules (CRs)

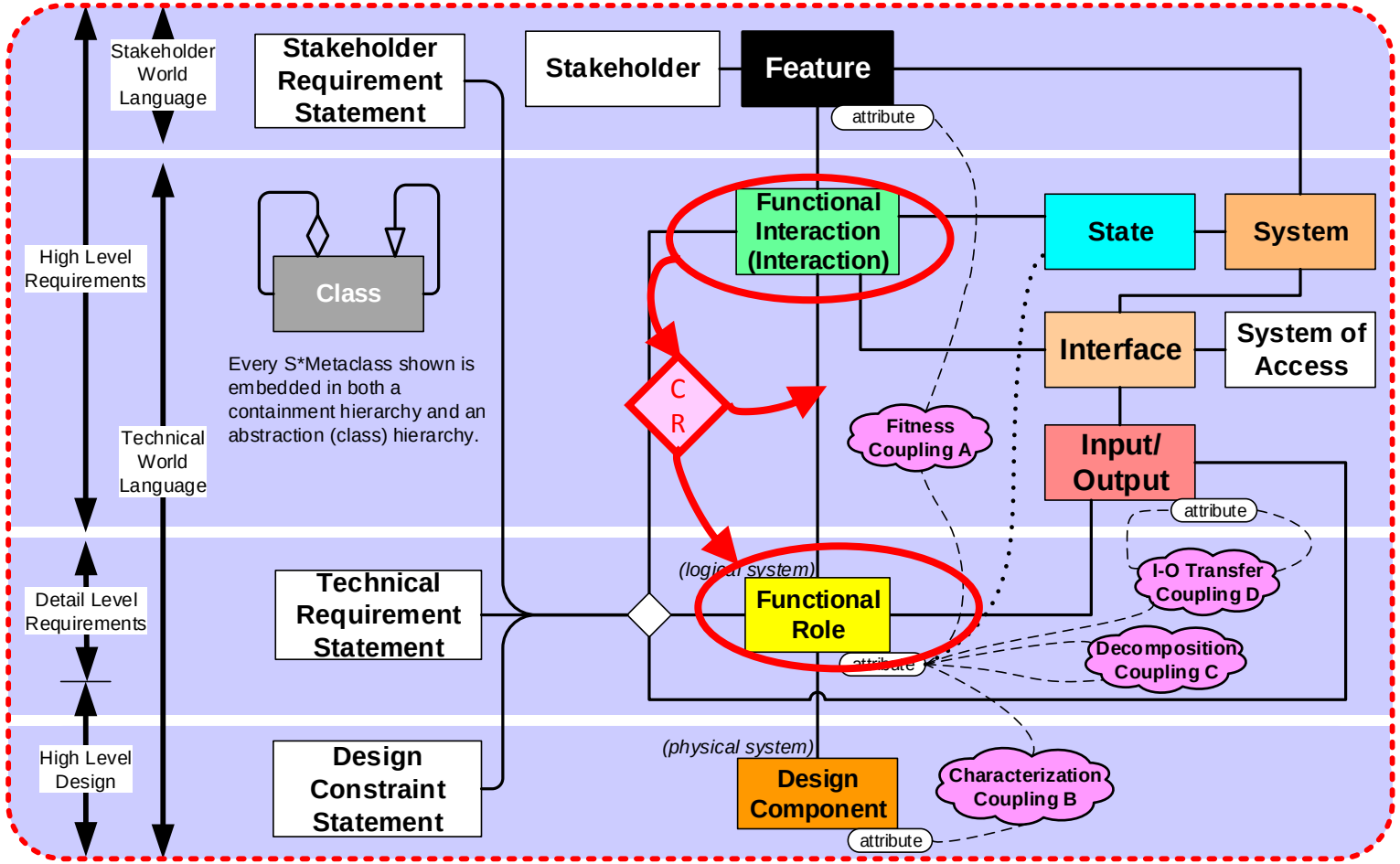


S*Metamodel informal summary pedagogical diagram
(formal S*Metamodel includes additional details.)

Interaction – Role Table

Interaction	Role	RPK Rule

Interaction-Role Configuration Rules (CRs)



S*Metamodel informal summary pedagogical diagram
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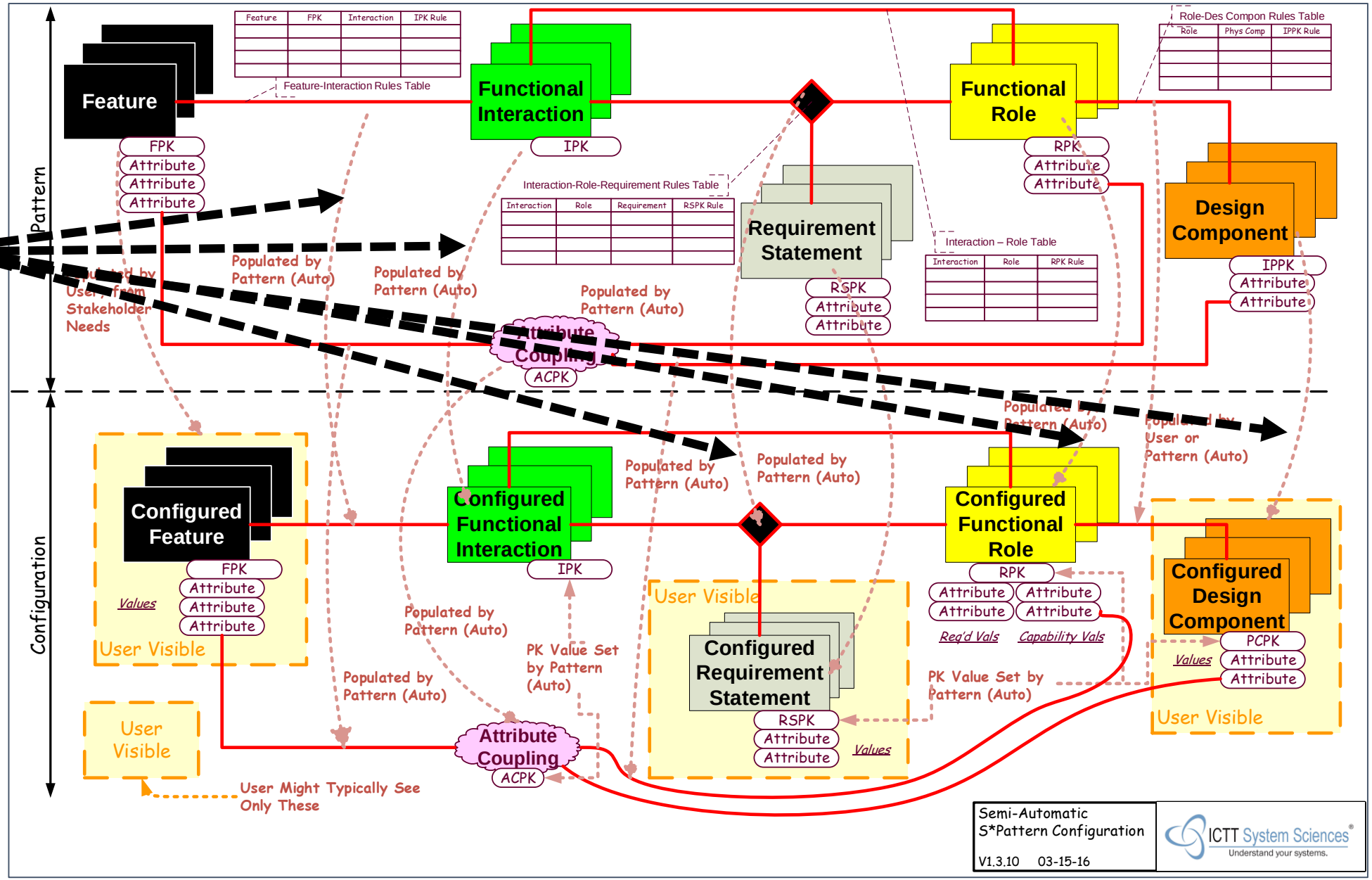
What configuring S*Pattern means

Inherently "Inner JOIN"-oriented steps

JOIN of upstream populated items with pattern configuration rules, resulting in downstream populated items.

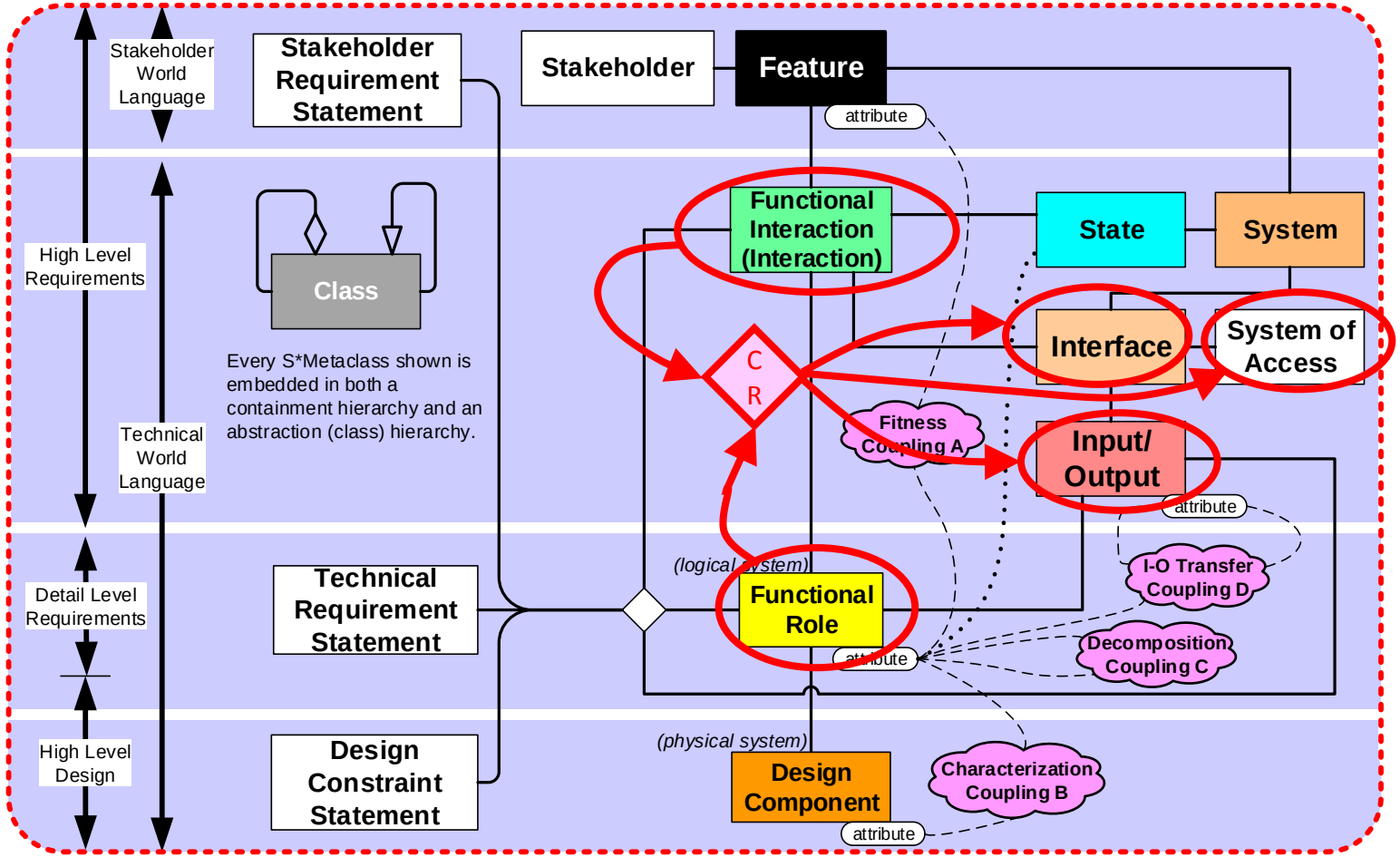
Investigation of JOIN technology for bulk synthesis cases, and semantic technologies for checking cases.



Interaction	IPK	Role	RPK	Port	Port PK	Interface	Interface PK Rule	Arch Relat	Arch Relat PK Rule	Arch Relat Role	Input Output	IO Direction	Input Output PK Rule	SOA	SOA PK Rule

Interface Context Configuration Rules (CRs)

(Note that these are part of the recent extension of the pattern configuration process to include the Interface sub-pattern.)



S*Metamodel informal summary pedagogical diagram

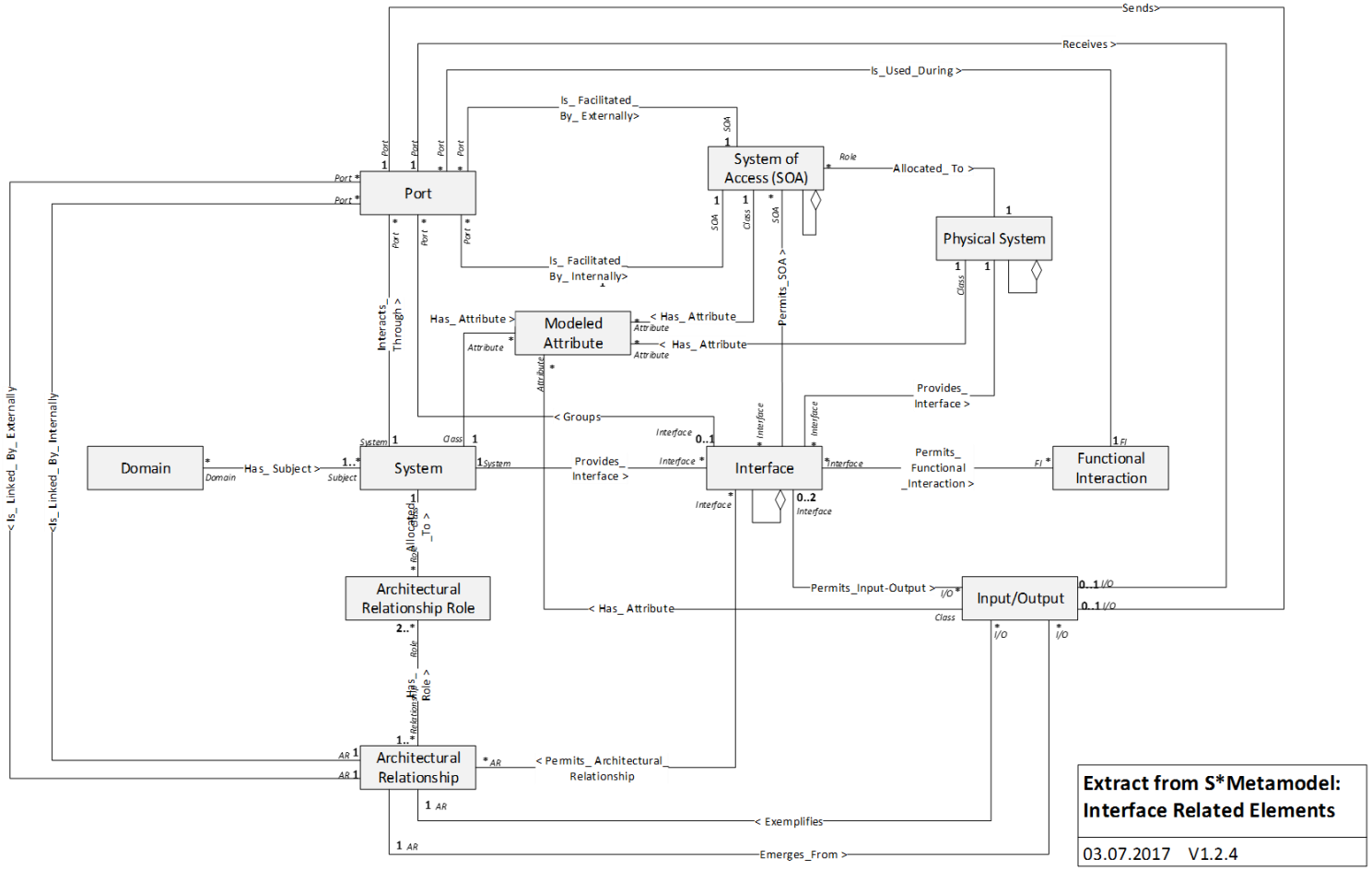
(formal S*Metamodel includes additional details.)

Port (visible in formal model)

Arch Relat (visible in formal model)

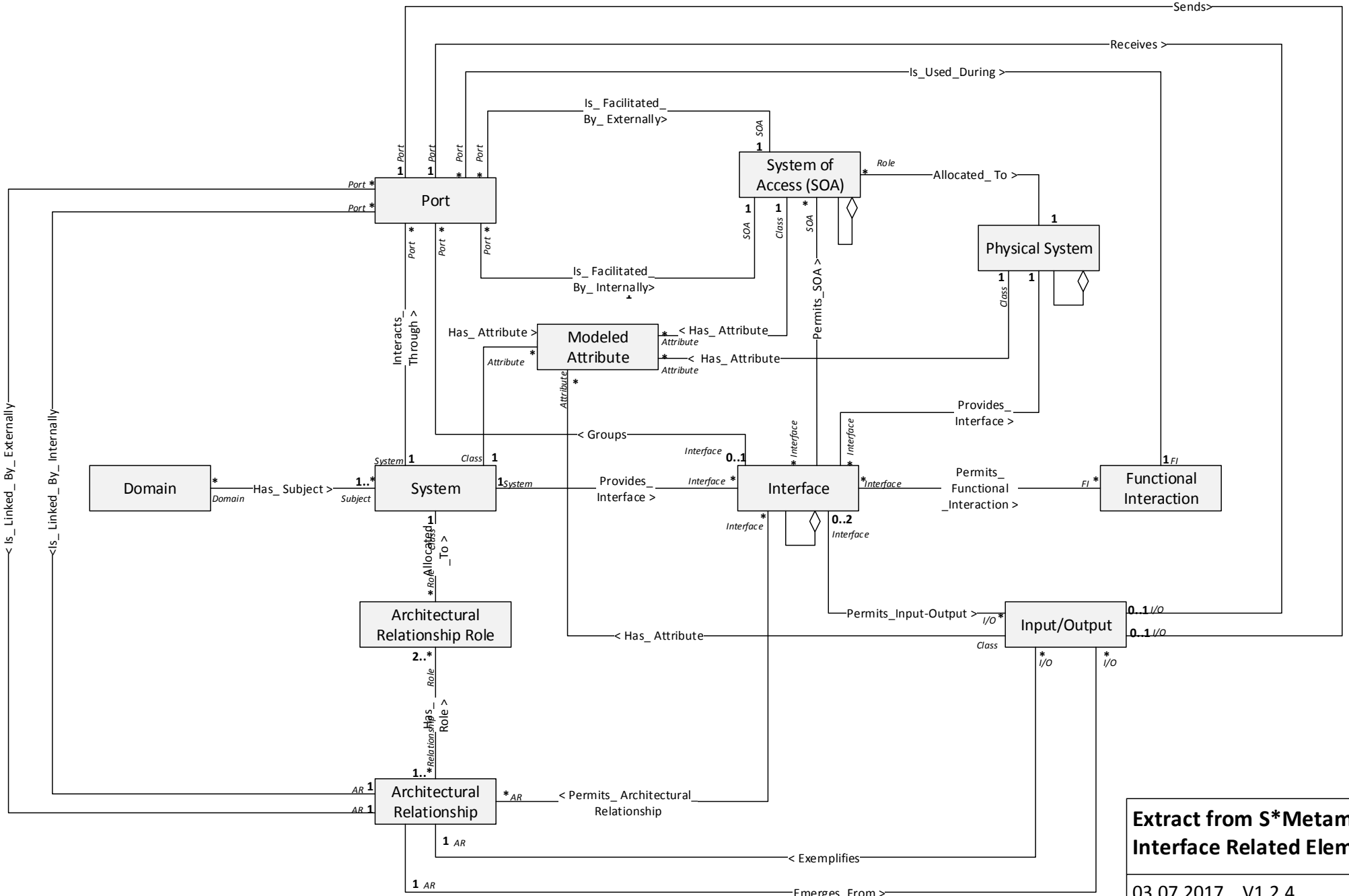
Interface Pattern configuration rules—

- Leading us to review minimum set of Interface-related relationships needed for variations in both subject systems and engineering processes



Extract from S*Metamodel: Interface Related Elements

03.07.2017 V1.2.4



Extract from S*Metamodel: Interface Related Elements

03.07.2017 V1.2.4

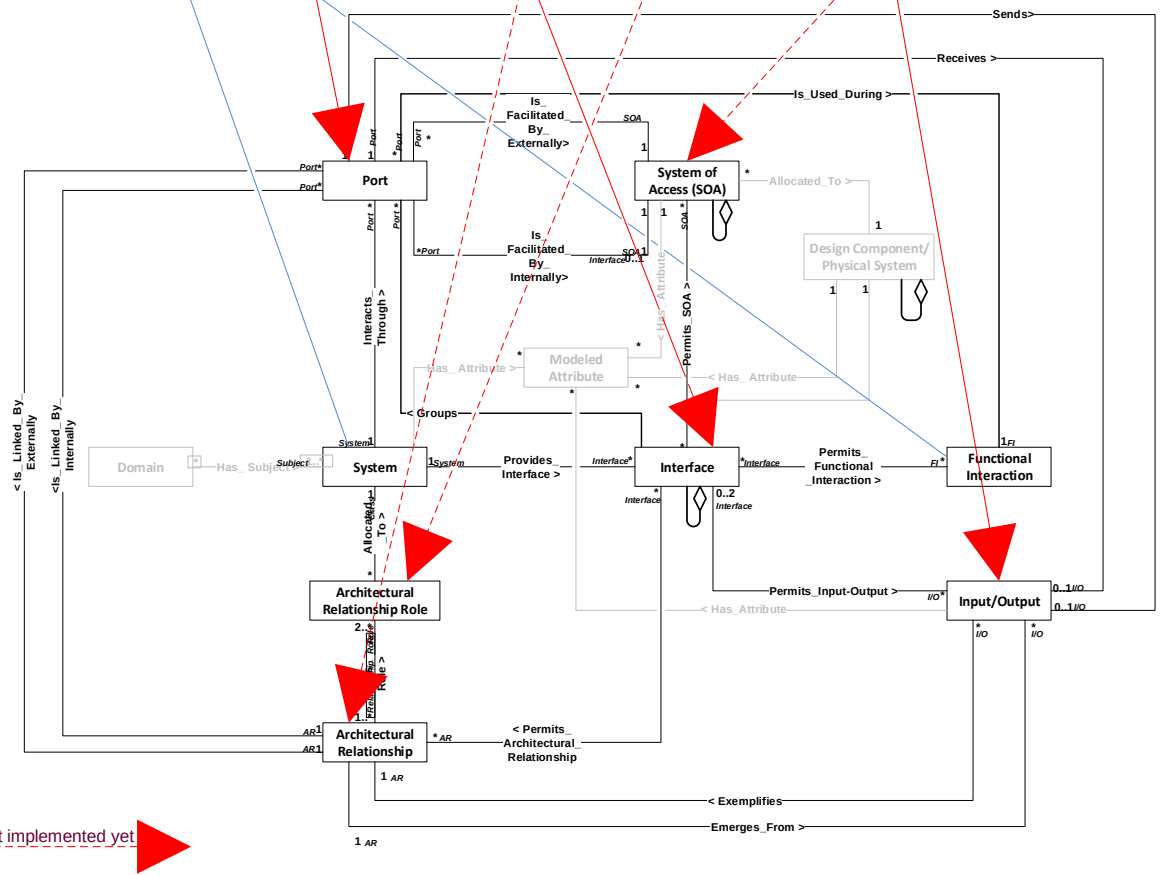
“IF” PART

“THEN” PART

Interface Context Configuration Rules Table

Interaction	IPK	Role	RPK	Port	Port PK	Interface	Interface PK Rule	Arch Relat	Arch Relat PK Rule	Arch Relat Role	Input Output	IO Direction	Input Output PK Rule	SOA	SOA PK Rule

POPULATE CLASSES AND PK VALUES

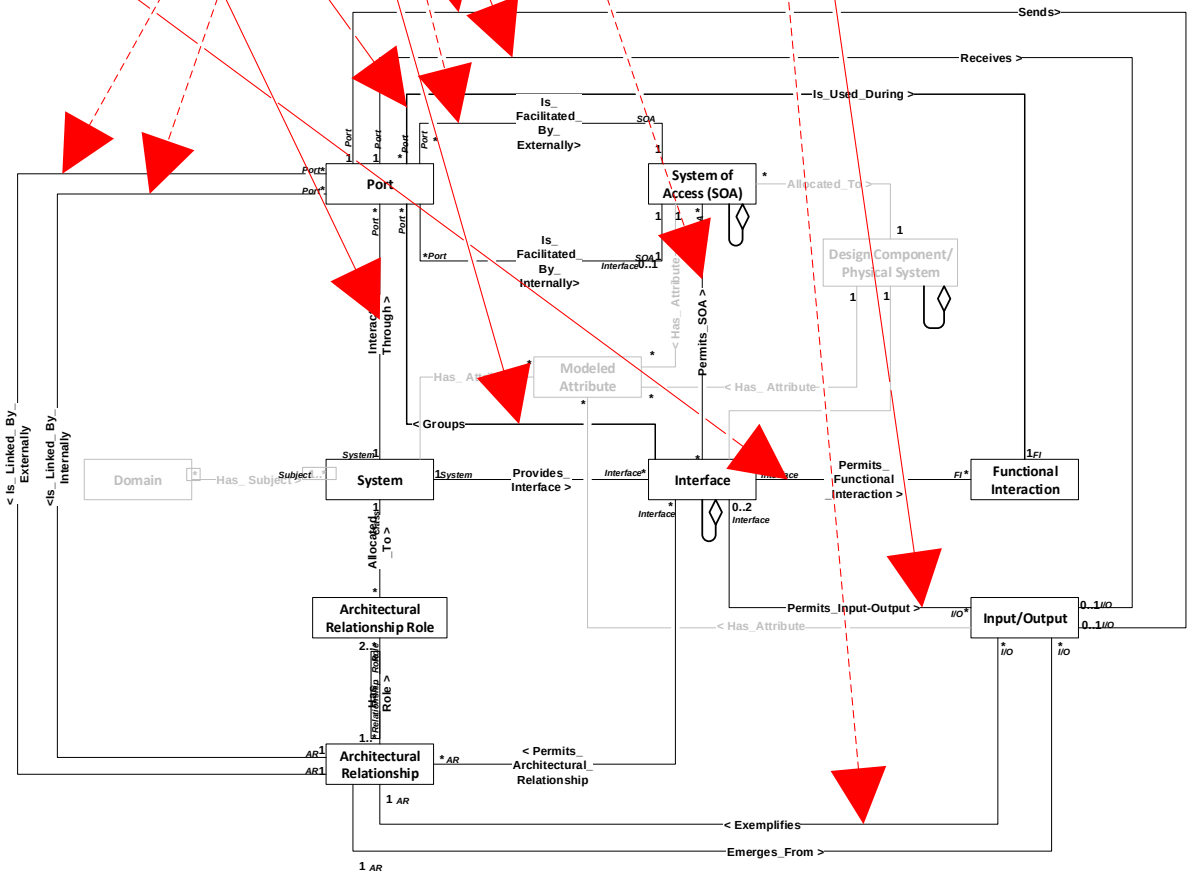


(SAME TABLE)

Interface Context Configuration Rules Table

Interaction	IPK	Role	RPK	Port	Port PK	Interface	Interface PK Rule	Arch Relat	Arch Relat PK Rule	Arch Relat Role	Input Output	IO Direction	Input Output PK Rule	SOA	SOA PK Rule

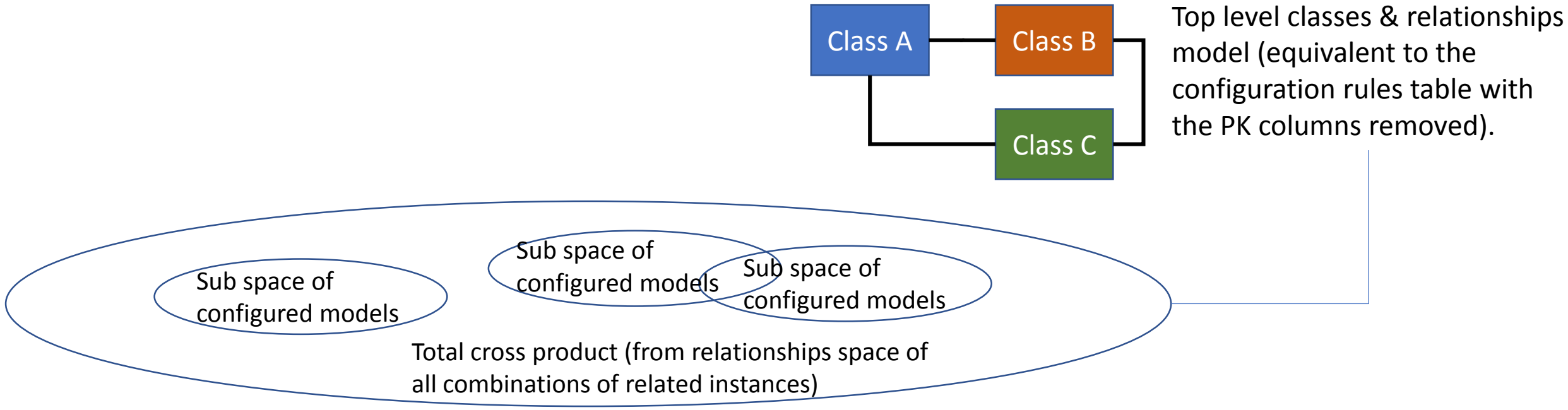
(PAIRS) POPULATE RELATIONSHIPS



Interface Context Rules Table for IPC Pattern

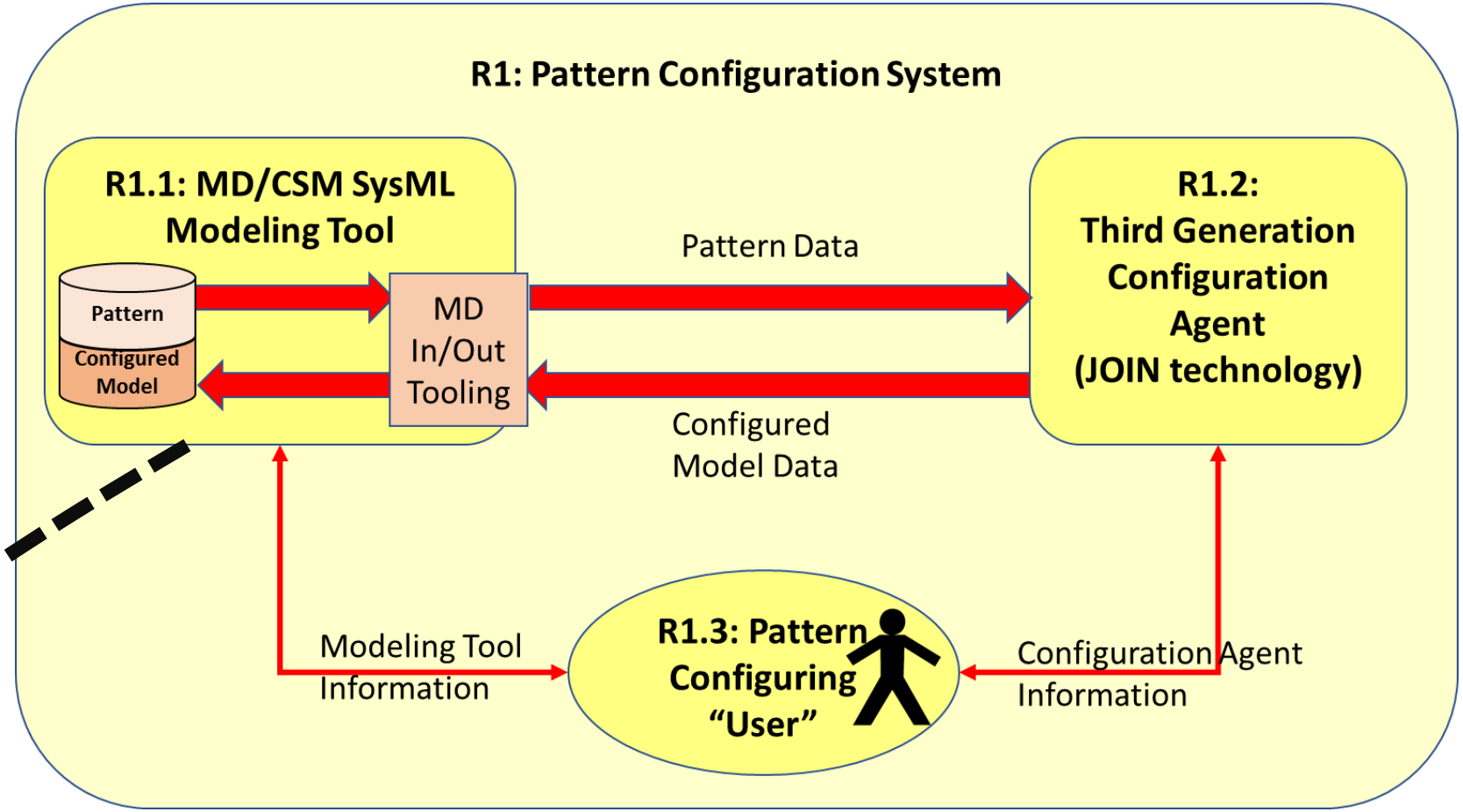
System Name	Interaction Name	Interface Name	Interface PK Rule	IO Name	IO PK Rule	Port Direction	Port Name	Port PK Rule	SOA Name	SOA PK Rule	SOA Internal or External	Arch Relat	Arch Relat PK Rule	Arch Relat Role	Arch Relat Role PK Rule	Arch Relat Internal or External	Arch Relat IO Assoc
International Power Converter	Convert Electrical Power	Power Input Interface		Input Power		In	PI.1	IFPK	Local Power Connector			Converts Electrical Power		Converter			
International Power Converter	Convert Electrical Power	Power Output Interface	IPK	Output Power	IPK	Out	PO.1	IFPK	Device Power Connector	IPK		Converts Electrical Power		Converter			
International Power Converter	Convert Electrical Power	Environmental Interface		Heat		In	EN.1	IFPK	Airspace Convection System								
International Power Converter	Convert Electrical Power	Environmental Interface		EMI		Out	EN.2	IFPK	EMI Radiation								
International Power Converter	Resist Contamination	Environmental Interface		Contaminants		In	EN.3	IFPK	Airspace Transport System								
International Power Converter	Tolerate Moisture	Environmental Interface		Moisture		In	EN.4	IFPK	Airspace Transport System								
International Power Converter	Set Configuration	Configuration and Information Interface		Configuration Setting		In	CI.1	IFPK	HMI Buttons								
International Power Converter	Display Status and Information	Configuration and Information Interface		Device Status and Information		Out	CO.2	IFPK	HMI Display								
International Power Converter	Handle Device	Handling Interface		Handling Force		InOut	HI.1	IFPK	Handle								
Local Power Distribution System	Convert Electrical Power	Power Mains Interface		Input Power		Out	LPO.1	IFPK	Local Power Connector			Converts Electrical Power		Source			
Electrically Powered Device	Convert Electrical Power	Device Power Interface		Output Power	IPK	In	DPI.1	IFPK	Device Power Connector	IPK		Converts Electrical Power		Sink	IPK		
Device and Converter User	Handle Device	Hand Interface		Handling Force		InOut	UHO.1	IFPK	Handle								
Device and Converter User	Set Configuration	Finger Interface		Configuration Setting		Out	UCO.1	IFPK	HMI Buttons								
Device and Converter User	Display Status and Information	Vision Interface		Device Status and Information		In	UC1.1	IFPK	HMI Display								
Local Environment	Resist Contamination	Contaminant Source Interface		Contaminants		Out	ENV.1	IFPK	Airspace Transport System								
Local Environment	Tolerate Moisture	Moisture Source Interface		Moisture		Out	ENV.2	IFPK	Airspace Transport System								
Local Environment	Convert Electrical Power	EMI Receiver Interface		EMI		In	ENV.3	IFPK	EMI Radiation								
Local Environment	Convert Electrical Power	Environment Thermal Sink Interface		Heat		In	ENV.4	IFPK	Airspace Convection System								

- This exercise has made it clearer that we need to understand that configuration rules, even when they are considered part of a pattern, are a “different” part of the pattern.
- What part are they?
- They describe the structure of the connected relational cross product sub-space(s) that configuration (specialization) permits.
- Not same as (quantitative) cardinality constraints.



Can similar projections onto subspaces tell us anything about model checking?

Third generation configuration agent: S*Pattern Wizard



CSM = Cameo Systems Modeler (Magic Draw), for SysML

- MD "In" tooling: CSV Import Tool (bulk import plug in to CSM)
- MD "Out" tooling: "Excel Synch" Feature of MD
- Exchange media in both directions: .csv files
- Chosen for speed of exchange

R1.1: MD/CSM SysML Modeling Tool

Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\WSc ... Worksheets\Workbook\2020-21 Wkbk Experiments\Updates from SAL\Updat...

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Create Diagram

Containment | Diagrams | Structure

Containment

- Systematica Project
  - Relations
  - 01 Local Pattern
    - 01 Feature Framework
    - 02 Logical System Analysis
    - 03 Interaction Framework
    - 04 Physical Architecture
  - 02 Configured Model
    - 01 Feature Framework
    - 02 Logical System Analysis
    - 03 Interaction Framework
    - 04 Physical Architecture
  - CSV Imports
  - Systematica Profile [Systematica Profile.mdzip]

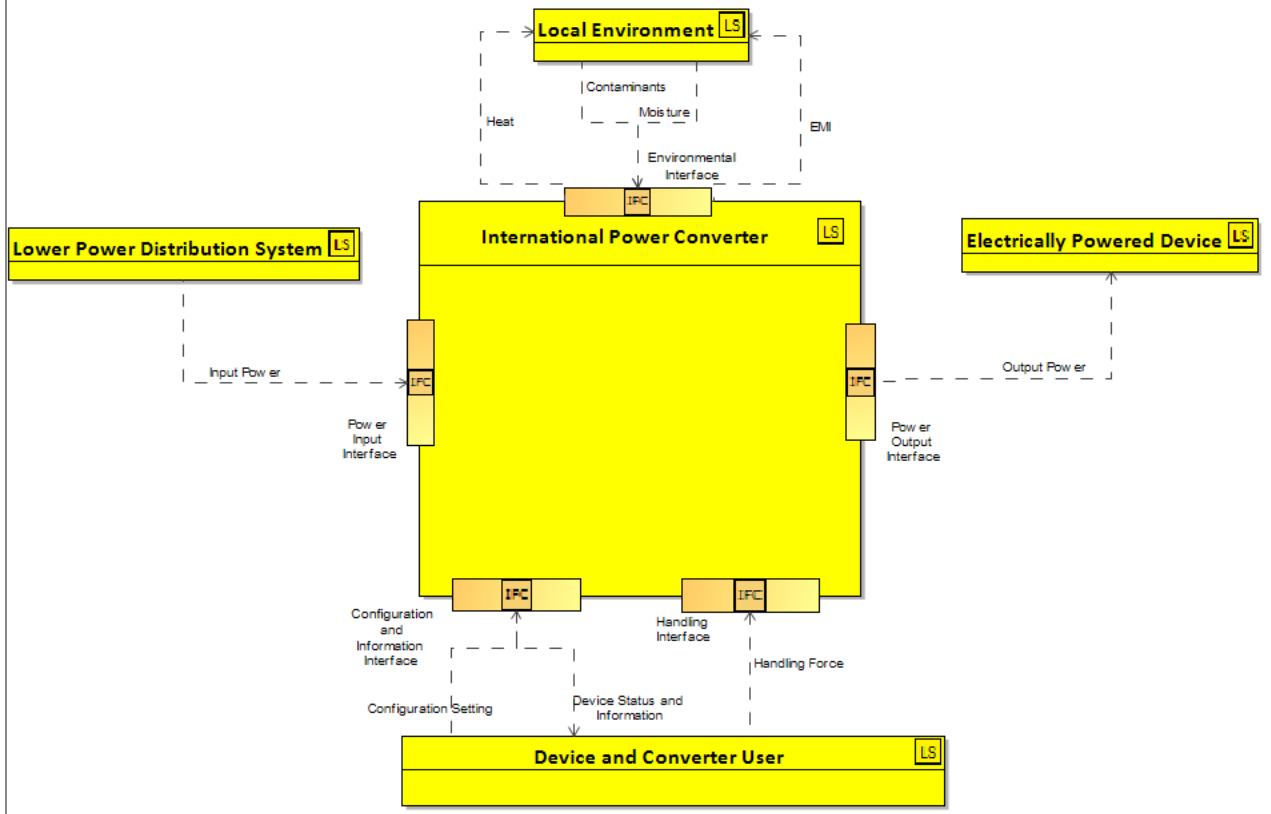
IPC Pattern is here

Configured Model here

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

Selection | Tools | Common | Block D... | Package | Block | Interf... | Const... | Value ... | Enum... | Signal | Instance | Port | Proxy ... | Full Port | Link | Associ... | Dir... | Dir... | Dir... | Gener... | Item ...

bdd [Domain] International Pow er Converter Domain [International Pow er Converter Domain]



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Create Diagram

Containment | Diagrams | Structure

Containment

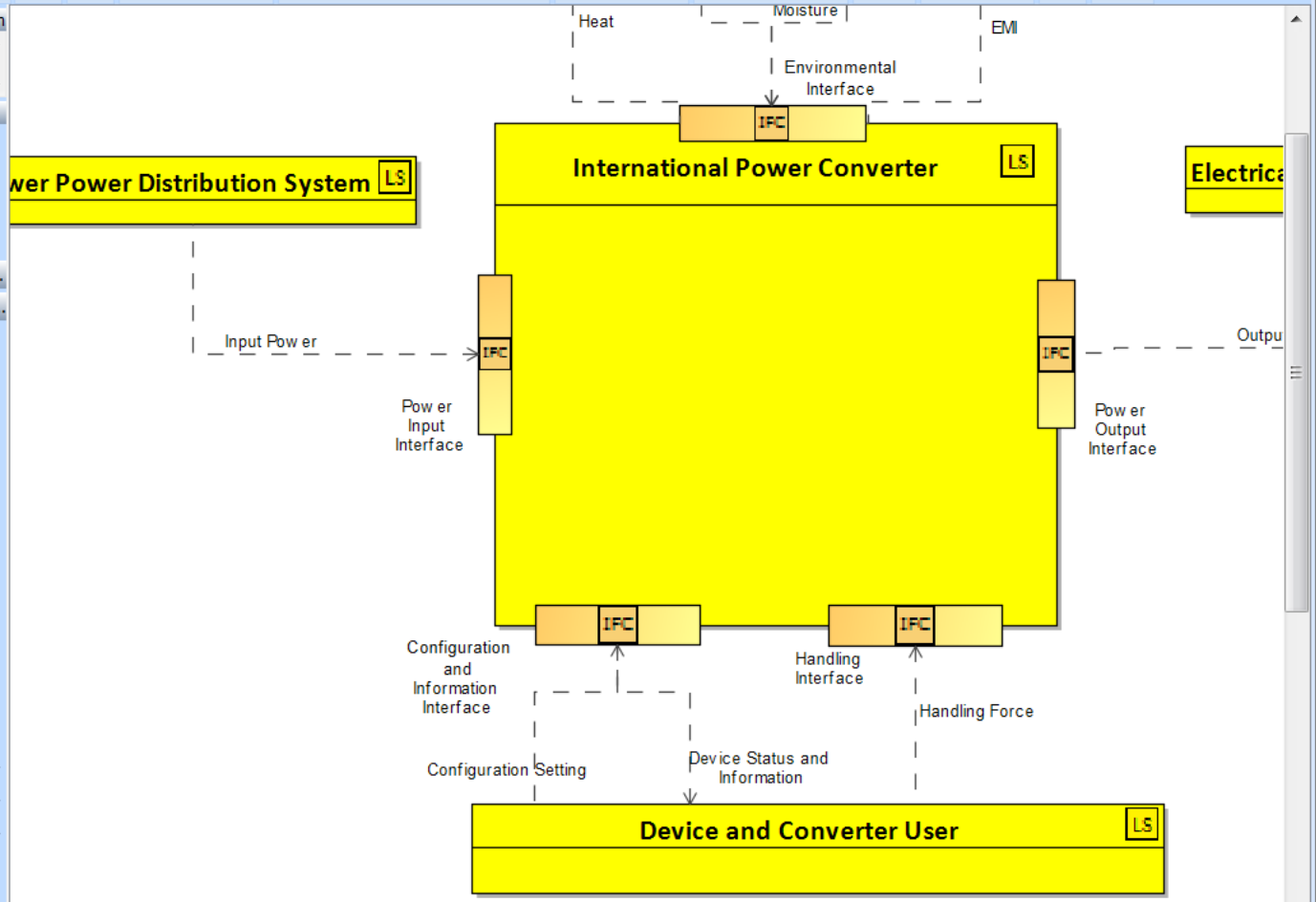
- Systematica Project
  - Relations
  - 01 Local Pattern
    - 01 Feature Framework
      - 01 Stakeholders
      - 02 Advocates
      - 03 Needs
      - 04 Features
        - Containment Population Rules
        - Pattern Feature Attributes File
        - Pattern Features and Feature Attributes
        - Pattern Features File
        - Pattern Fitness Couplings
        - Ease of Use
        - Portability
        - Power Mains Compatibility
        - Powered Devices Compatibility
        - Reliability and Durability
        - Safety
      - 05 Project Contacts
      - Pattern Feature Needs
      - Pattern Feature Overview Diagram
      - Pattern Feature Stakeholders
      - Pattern Stakeholder Advocates
    - 02 Logical System Analysis
    - 03 Interaction Framework
      - Relations
      - Pattern Feature-Interactions File
      - Pattern Functional Interactions
      - Pattern Input-Outputs
      - Pattern Interaction Overview Diagram
      - Pattern Interaction Roles
      - Pattern Interaction States
      - Pattern Requirements
      - Convert Electrical Power
      - Display Status and Information
      - Handle Device
      - Resist Contamination
      - Set Configuration
      - Tolerate Moisture
    - 04 Physical Architecture
  - 02 Configured Model

Pattern Features

Pattern Interactions

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

Selection | Tools



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Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\salewis\Documents\ICTT\CSM\IPC Pattern\]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Create Diagram

Containment Diagrams Structure

Containment

- Systematica Project
  - Relations
  - 01 Local Pattern
    - 01 Feature Framework
    - 02 Logical System Analysis
      - Relations
      - Interaction-Interface Table
      - Pattern Architectural Relationships
      - Pattern Decomposition Couplings
      - Pattern Events
      - Pattern Input Output Couplings
      - Pattern Interfaces
      - Pattern Logical Systems
      - Pattern Role Attributes File
      - Pattern States
      - Airspace Convection System
      - Airspace Transport System
      - Converts Electrical Power
      - Device and Converter User
      - Device Power Connector
      - Electrically Powered Device
      - EMI Radiation
      - Handle
      - HMI Buttons
      - HMI Display
      - International Power Converter
      - International Power Converter Domain
      - Local Environment
      - Local Power Connector
      - Lower Power Distribution System
    - 03 Interaction Framework
    - 04 Physical Architecture
  - 02 Configured Model
  - CSV Imports
  - Derived Properties
  - ISO-80000 [ISO-80000.mdzip]
  - MD Customization for Requirements [MD Customization for Requirements.mdzip]
  - MD Customization for SysML [MD_customization_for_SysML.mdzip]
  - MD Customization for ViewsViewpoints [MD_customization_for_ViewsViewpoints.mdzip]
  - UML Standard Profile [UML_Standard_Profile.mdzip]
  - Excel Import Profile [Excel Import Profile.mdzip]
  - SysML [SysML Profile.mdzip]
  - Systematica Profile [Systematica Profile.mdzip]

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

Selection

Tools

Common

Block Definition Di...
Package
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Interface Block
Flow Specific...
Constraint Bl...
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Interface
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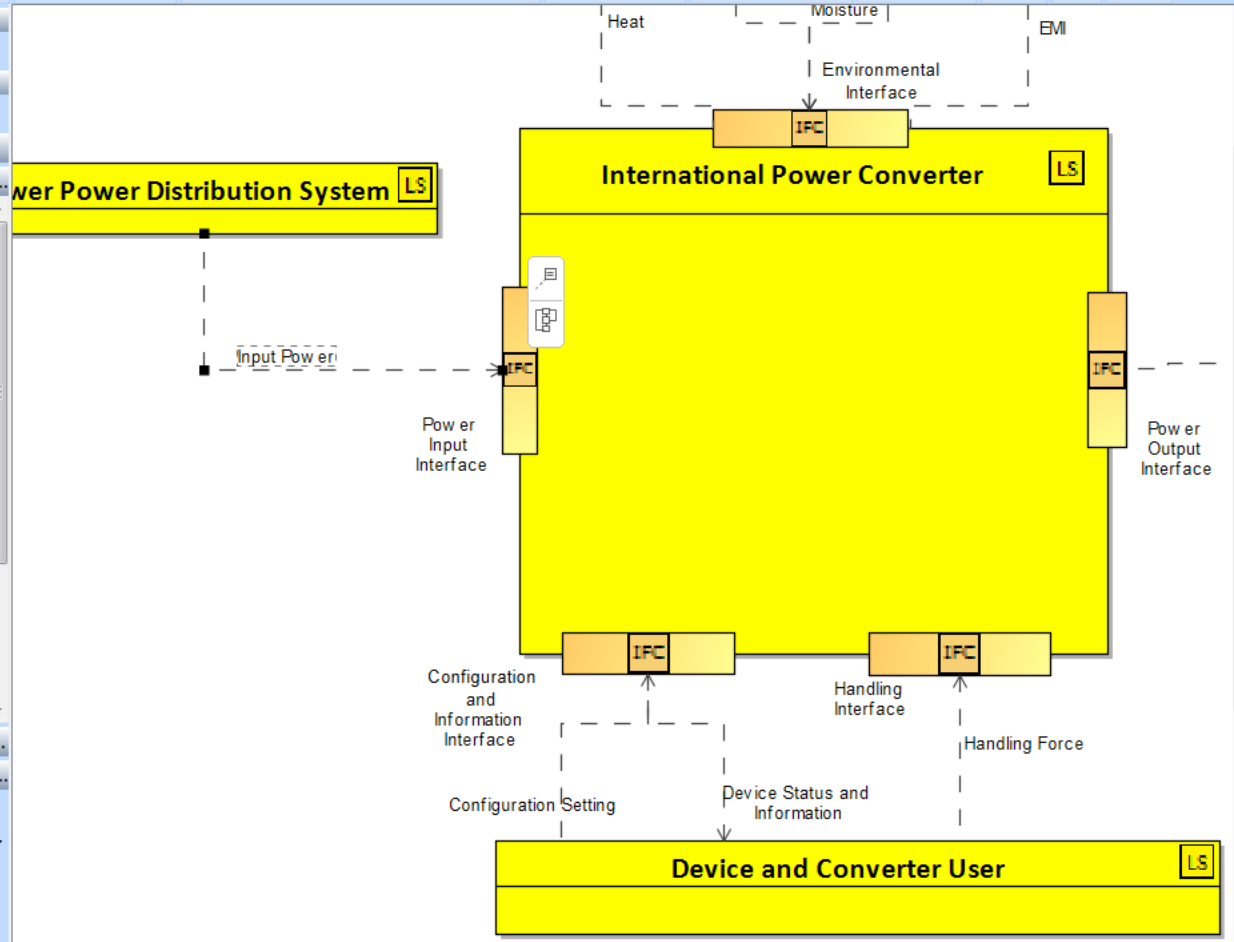
Verify
Refine
Test Case Ac...

Use Case Diagram

Profiling Mechani...



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Create Diagram

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- Airspace Transport System
- Converts Electrical Power
- Device and Converter User
- Device Power Connector
- Electrically Powered Device
- EMI Radiation
- Handle
- HMI Buttons
- HMI Display
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  - Environmental Interface
  - Handling Interface
  - Power Input Interface
  - Power Output Interface
    - : Display Status and Information
    - : Handle Device
    - : Resist Contamination
    - : Set Configuration
    - : Tolerate Moisture
    - power Converter Assembly : Power Converter Assembly
    - : Convert Electrical Power
    - out Power Output Interface : Power Output Interface
    - in Power Input Interface : Power Input Interface
    - inout Configuration and Information Interface : Configuration and Information Interface
    - inout Environmental Interface : Environmental Interface
    - inout Handling Interface : Handling Interface
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Pattern Interfaces

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

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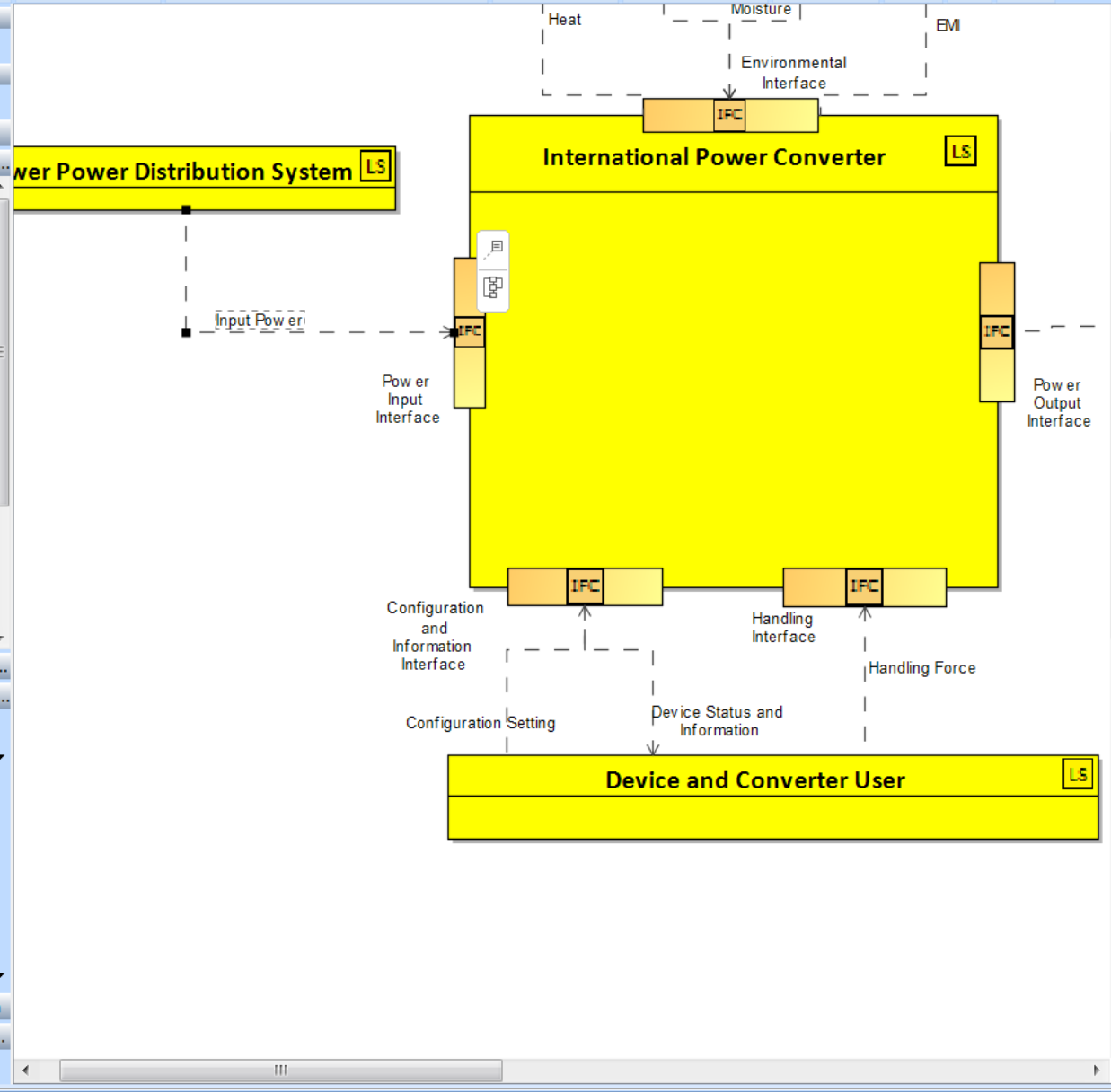

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Create Diagram

Containment | Diagrams | Structure

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  - Power Input Interface
  - Power Output Interface
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    - out Converts Electrical Power : Converts Electrical Power
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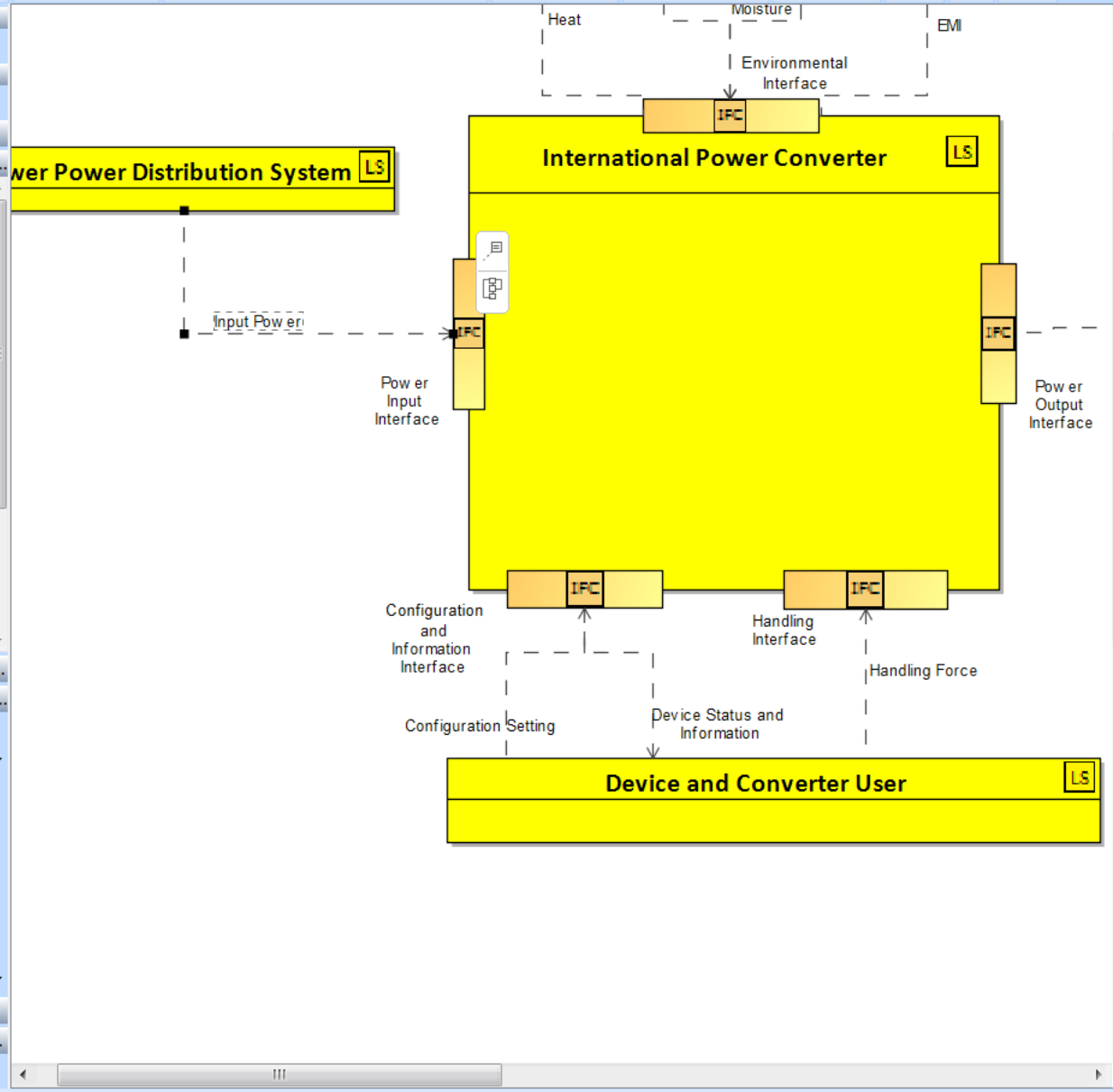

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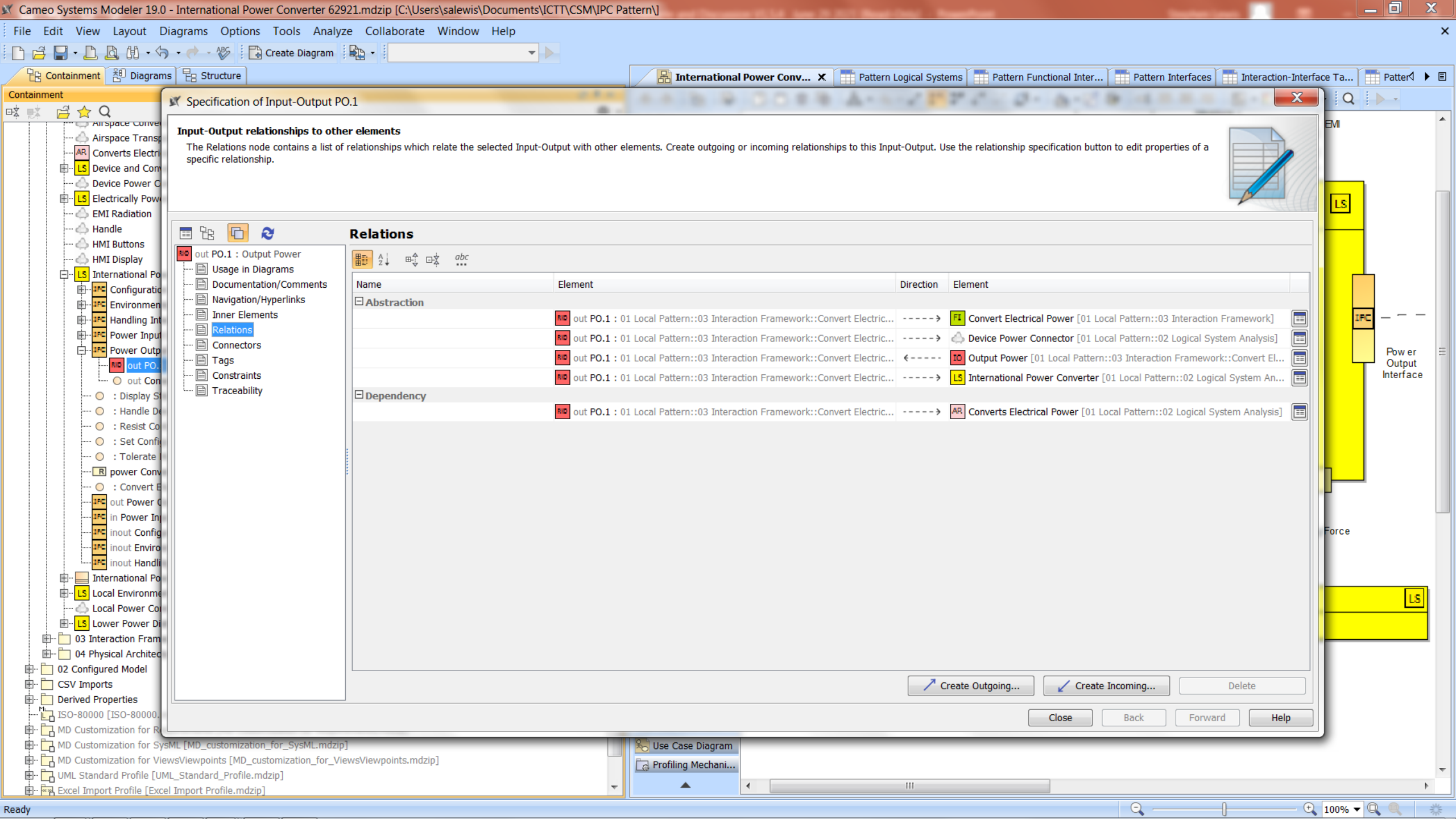
Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\salewis\Documents\ICTT\CSM\IPC Pattern\]
File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help
Create Diagram
Containment Diagrams Structure
International Power Conv... Pattern Logical Systems Pattern Functional Inter... Pattern Interfaces Interaction-Interface Ta... Patter
Containment
Specification of Input-Output PO.1
Input-Output relationships to other elements
The Relations node contains a list of relationships which relate the selected Input-Output with other elements. Create outgoing or incoming relationships to this Input-Output. Use the relationship specification button to edit properties of a specific relationship.
Relations
out PO.1 : Output Power
Usage in Diagrams
Documentation/Comments
Navigation/Hyperlinks
Inner Elements
Relations
Connectors
Tags
Constraints
Traceability
Name
Element
Direction
Element
Abstraction
out PO.1 : 01 Local Pattern::03 Interaction Framework::Convert Electric...
Convert Electrical Power [01 Local Pattern::03 Interaction Framework]
Device Power Connector [01 Local Pattern::02 Logical System Analysis]
Output Power [01 Local Pattern::03 Interaction Framework::Convert El...
International Power Converter [01 Local Pattern::02 Logical System An...
Dependency
Converts Electrical Power [01 Local Pattern::02 Logical System Analysis]
Create Outgoing...
Create Incoming...
Delete
Close
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Forward
Help
Use Case Diagram
Profiling Mechani...
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Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\salewis\Documents\ICTT\CSM\IPC Pattern\]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Create Diagram

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    - 03 Interaction Framework
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      - Electrically Powered Device [Power Output 2]
      - Electrically Powered Device [Power Output 3]
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Configured Model

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

Selection
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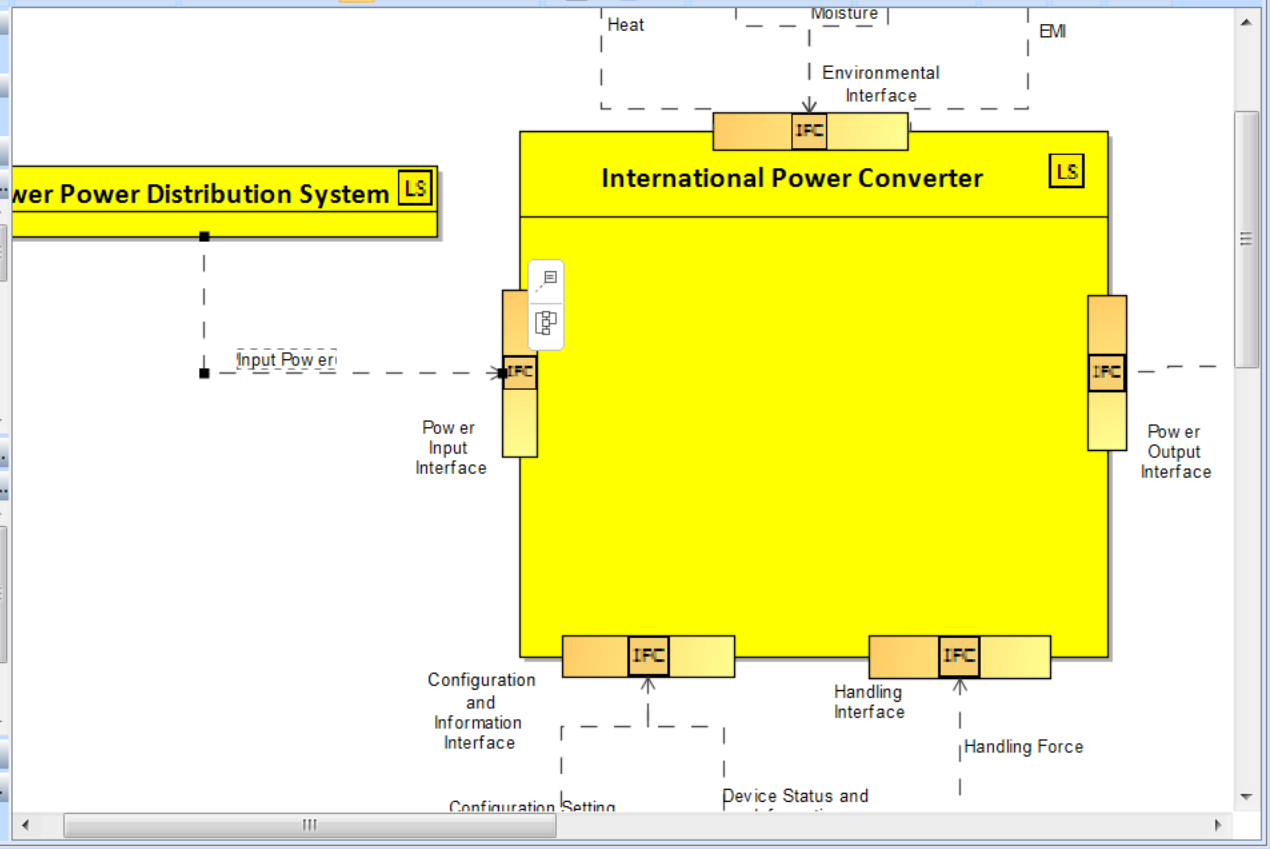

Notification Window

Notification Window

Project
Environment

[2021.06.29::08:36:50] Import Complete - 0 records processed from total 34 records.
[2021.06.29::11:00:18] Import Wizard Started
[2021.06.29::11:00:57] Import Started
[2021.06.29::11:00:57] Import Complete - 17 records processed from total 17 records.
[2021.06.29::11:01:26] Import Wizard Started
[2021.06.29::11:02:52] Import Started
[2021.06.29::11:02:52] Import Complete - 34 records processed from total 34 records.
[2021.06.29::11:08:41] Import Wizard Started
[2021.06.29::11:08:59] Import Started
[2021.06.29::11:08:59] Import Complete - 1 records processed from total 1 records.

Import Log of Incoming Configured Model, from Config Wizard

Ready

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Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\salewis\Documents\ICTT\CSM\IPC Pattern\]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Create Diagram

Containment Diagrams Structure

Containment

- 02 Logical System Analysis
- 03 Interaction Framework
- 04 Physical Architecture
- 02 Configured Model
  - 01 Feature Framework
  - 02 Logical System Analysis
    - Configured Logical Systems
    - Configured Role Attribute Values
    - AR Converts Electrical Power
    - LS Device and Converter User
    - LS Electrically Powered Device [Power Output 1]
    - LS Electrically Powered Device [Power Output 2]
    - LS Electrically Powered Device [Power Output 3]
    - LS International Power Converter
      - IFC Configuration and Information Interface
      - IFC Environmental Interface
      - IFC Handling Interface
      - IFC Power Input Interface
      - IFC Power Output Interface [Power Output 1]
      - IFC Power Output Interface [Power Output 2]
      - IFC Power Output Interface [Power Output 3]
        - : Convert Electrical Power [Power Output 1]
        - : Convert Electrical Power [Power Output 2]
        - : Convert Electrical Power [Power Output 3]
        - : Display Status and Information
        - : Handle Device
        - : Resist Contamination
        - : Set Configuration
        - : Tolerate Moisture
      - R power Converter Assembly1 : Power Converter Assembly
      - R power Converter Assembly6 : Power Converter Assembly
      - R power Converter Assembly5 : Power Converter Assembly
      - R power Converter Assembly4 : Power Converter Assembly
      - R power Converter Assembly3 : Power Converter Assembly
      - R power Converter Assembly7 : Power Converter Assembly
      - R power Converter Assembly : Power Converter Assembly
      - R power Converter Assembly2 : Power Converter Assembly
      - IFC Configuration and Information Interface : Configuration and Information Interface
      - IFC Environmental Interface : Environmental Interface
      - IFC Handling Interface : Handling Interface
      - IFC Power Input Interface : Power Input Interface
      - IFC Power Output Interface [Power Output 1] : Power Output Interface [Power Output 1]
      - IFC Power Output Interface [Power Output 2] : Power Output Interface [Power Output 2]
      - IFC Power Output Interface [Power Output 3] : Power Output Interface [Power Output 3]

Configured Model

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

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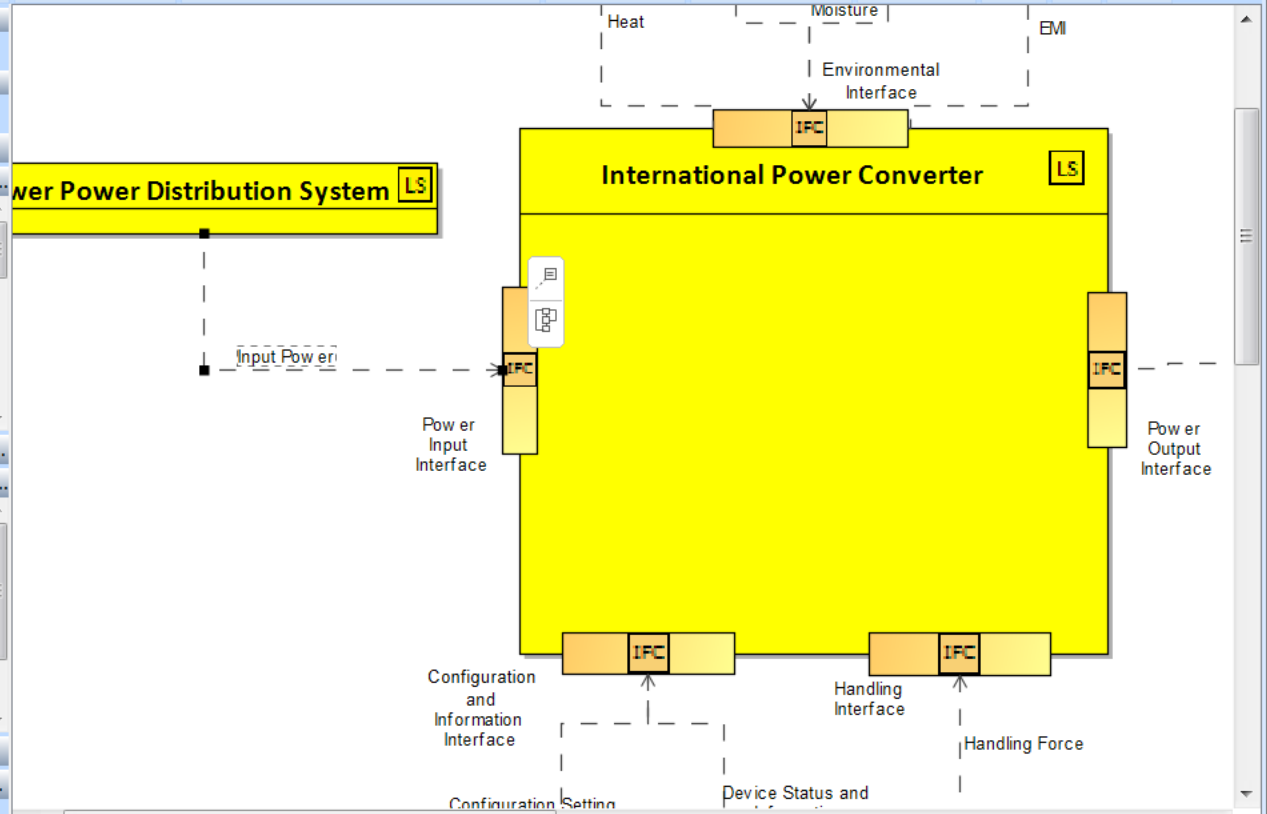

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Import Log of Incoming Configured Model, from Config Wizard

Project Environment

Ready

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Cameo Systems Modeler 19.0 - International Power Converter 62921.mdzip [C:\Users\salewis\Documents\ICTT\CSM\IPC Pattern\]

File Edit View Layout Diagrams Options Tools Analyze Collaborate Window Help

Create Diagram

Containment Diagrams Structure

Containment

- 02 Logical System Analysis
- 03 Interaction Framework
- 04 Physical Architecture
- 02 Configured Model
  - 01 Feature Framework
  - 02 Logical System Analysis
    - Configured Logical Systems
    - Configured Role Attribute Values
    - Converts Electrical Power
    - Device and Converter User
    - Electrically Powered Device [Power Output 1]
    - Electrically Powered Device [Power Output 2]
    - Electrically Powered Device [Power Output 3]
    - International Power Converter
      - Configuration and Information Interface
      - Environmental Interface
      - Handling Interface
      - Power Input Interface
      - Power Output Interface [Power Output 1]
        - out PO.1 [Power Output 1]
      - Power Output Interface [Power Output 2]
        - out PO.1 [Power Output 2]
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        - out PO.1 [Power Output 3]
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      - power Converter Assembly : Power Converter Assembly
      - power Converter Assembly2 : Power Converter Assembly
      - Configuration and Information Interface : Configuration and Information Interface
      - Environmental Interface : Environmental Interface
      - Handling Interface : Handling Interface
      - Power Input Interface : Power Input Interface

Configured Model

International Power Conv... | Pattern Logical Systems | Pattern Functional Inter... | Pattern Interfaces | Interaction-Interface Ta... | Patter

Selection

Tools

Common

Block Definition Di...
Package
Block
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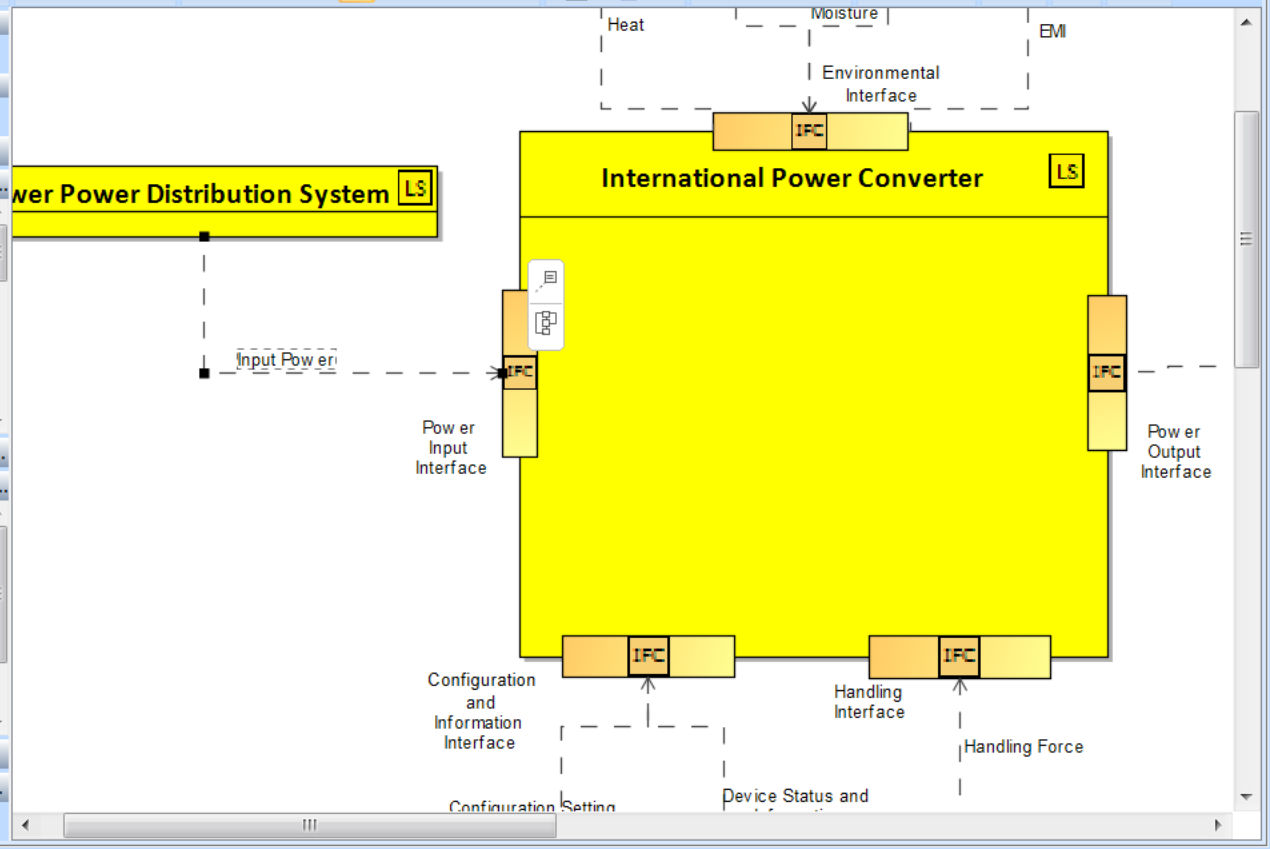

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Import Log of Incoming Configured Model, from Config Wizard

Project Environment

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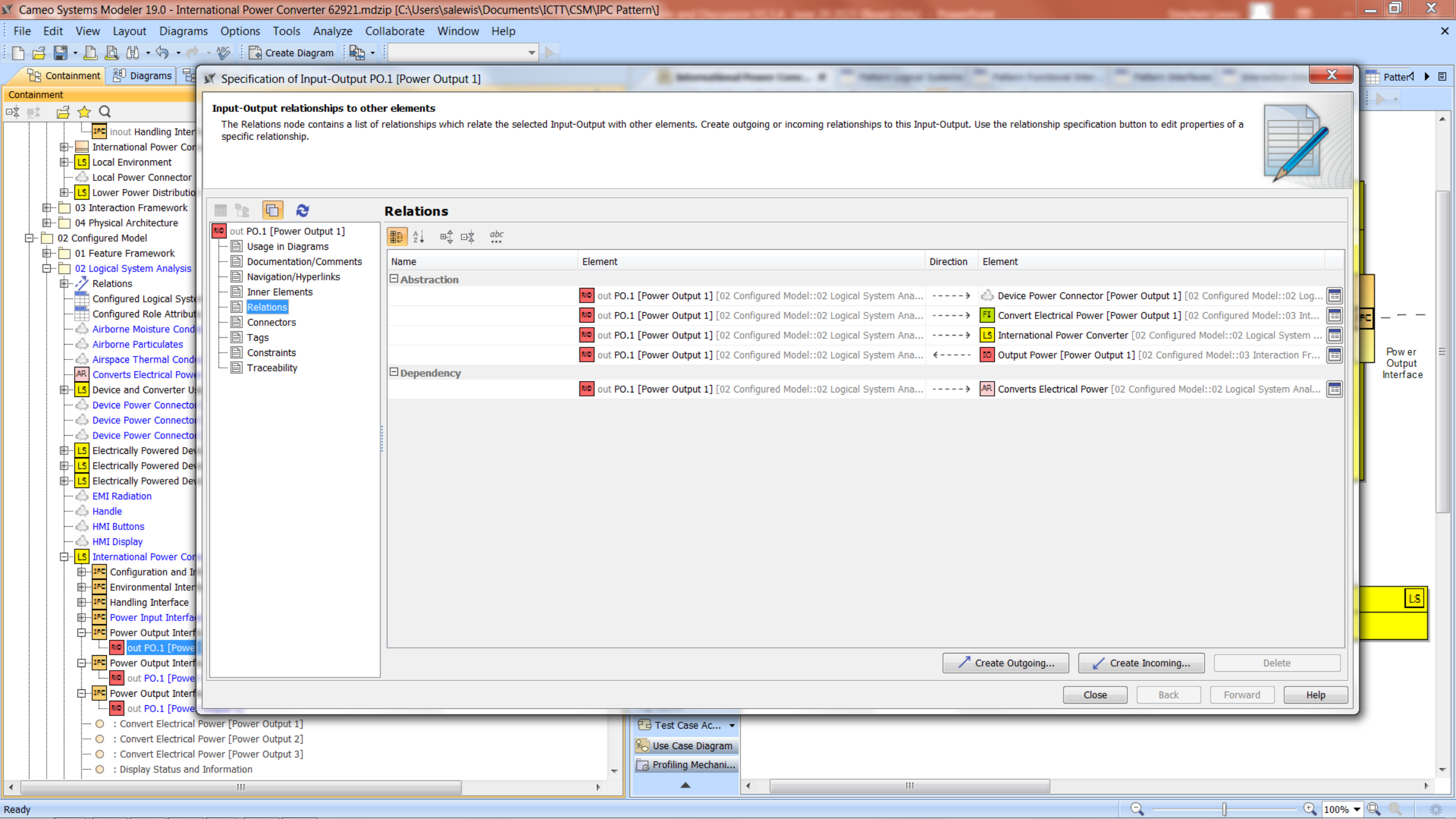
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03 Interaction Framework
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01 Feature Framework
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Specification of Input-Output PO.1 [Power Output 1]
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Direction
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Abstraction
out PO.1 [Power Output 1] [02 Configured Model::02 Logical System Ana... -----> Device Power Connector [Power Output 1] [02 Configured Model::02 Log...
out PO.1 [Power Output 1] [02 Configured Model::02 Logical System Ana... -----> Convert Electrical Power [Power Output 1] [02 Configured Model::03 Int...
out PO.1 [Power Output 1] [02 Configured Model::02 Logical System Ana... -----> International Power Converter [02 Configured Model::02 Logical System ...
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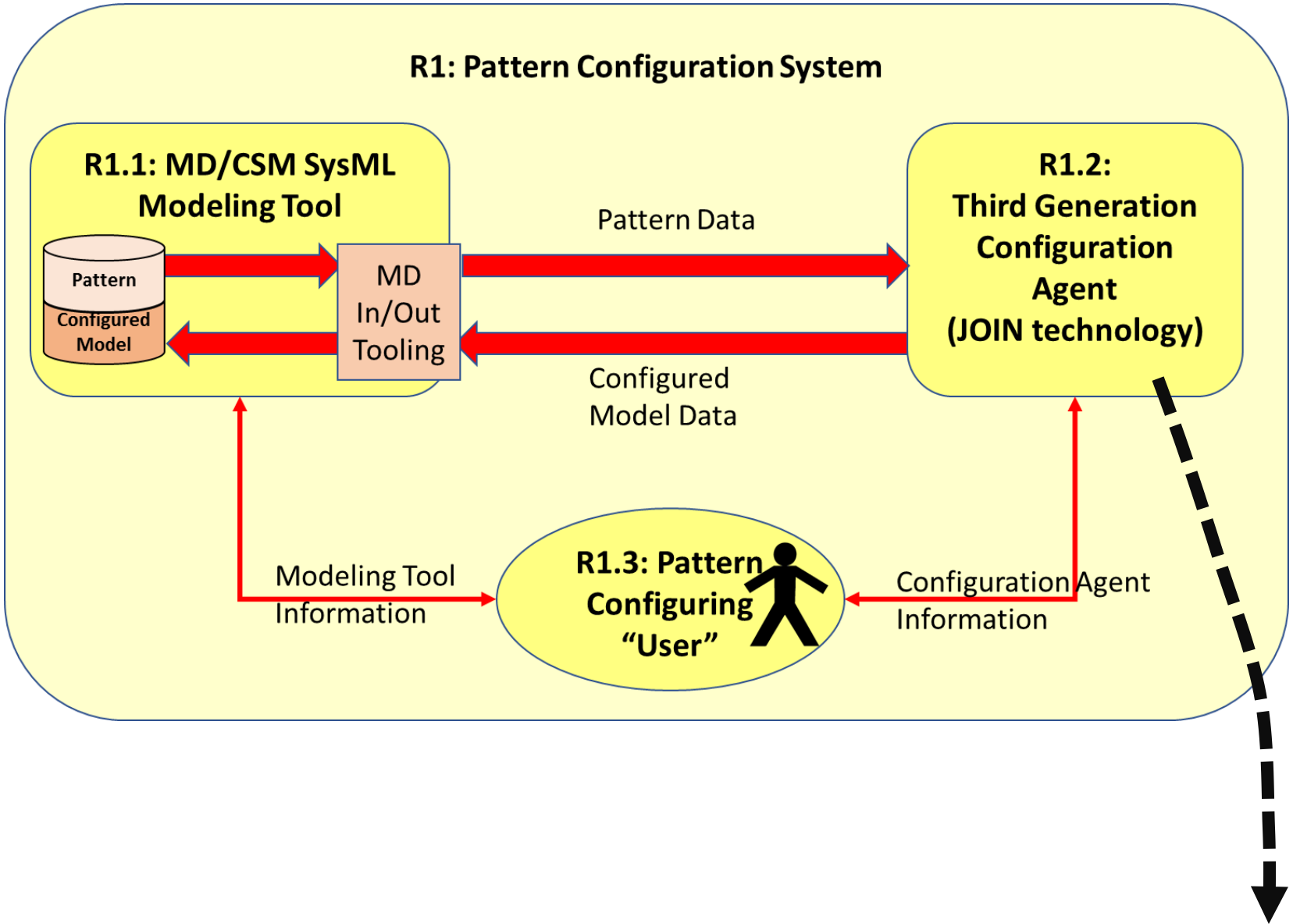
Dependency
out PO.1 [Power Output 1] [02 Configured Model::02 Logical System Ana... -----> Converts Electrical Power [02 Configured Model::02 Logical System Anal...
Create Outgoing...
Create Incoming...
Delete
Close
Back
Forward
Help
Test Case Ac...
Use Case Diagram
Profiling Mechani...
Pow er Output Interface
Ready
100%

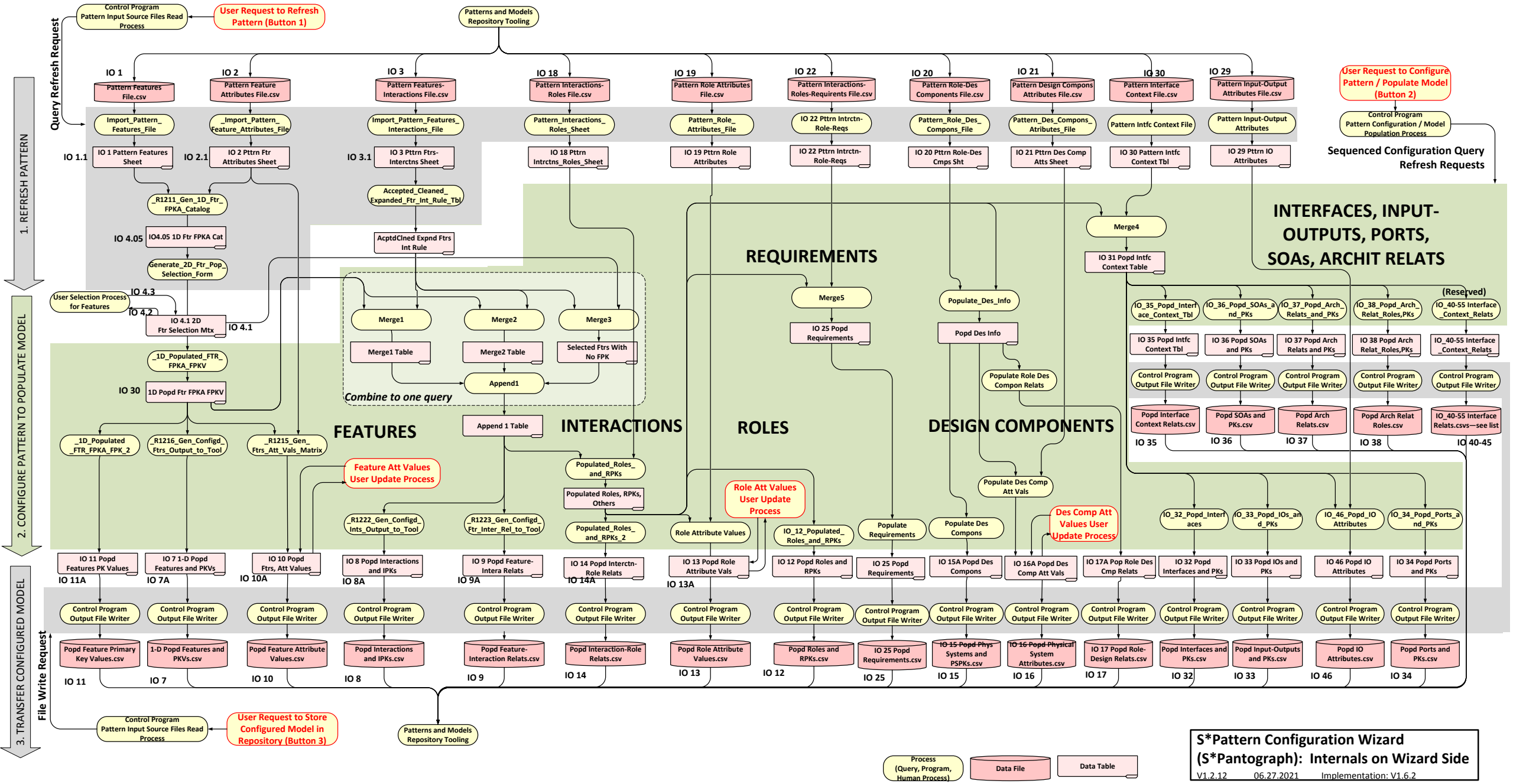
R1.2: Third Generation Configuration Agent (JOIN technology)

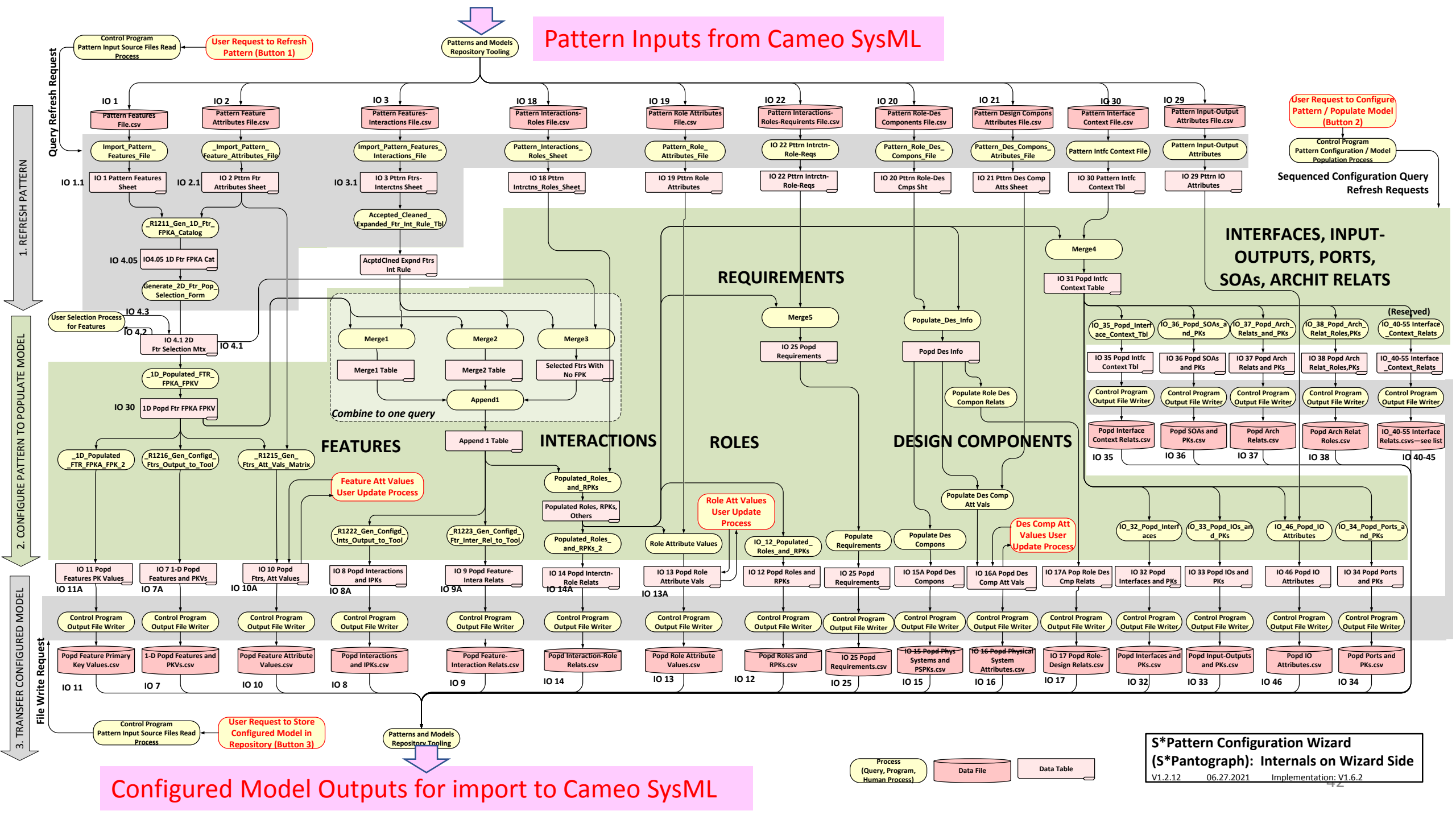


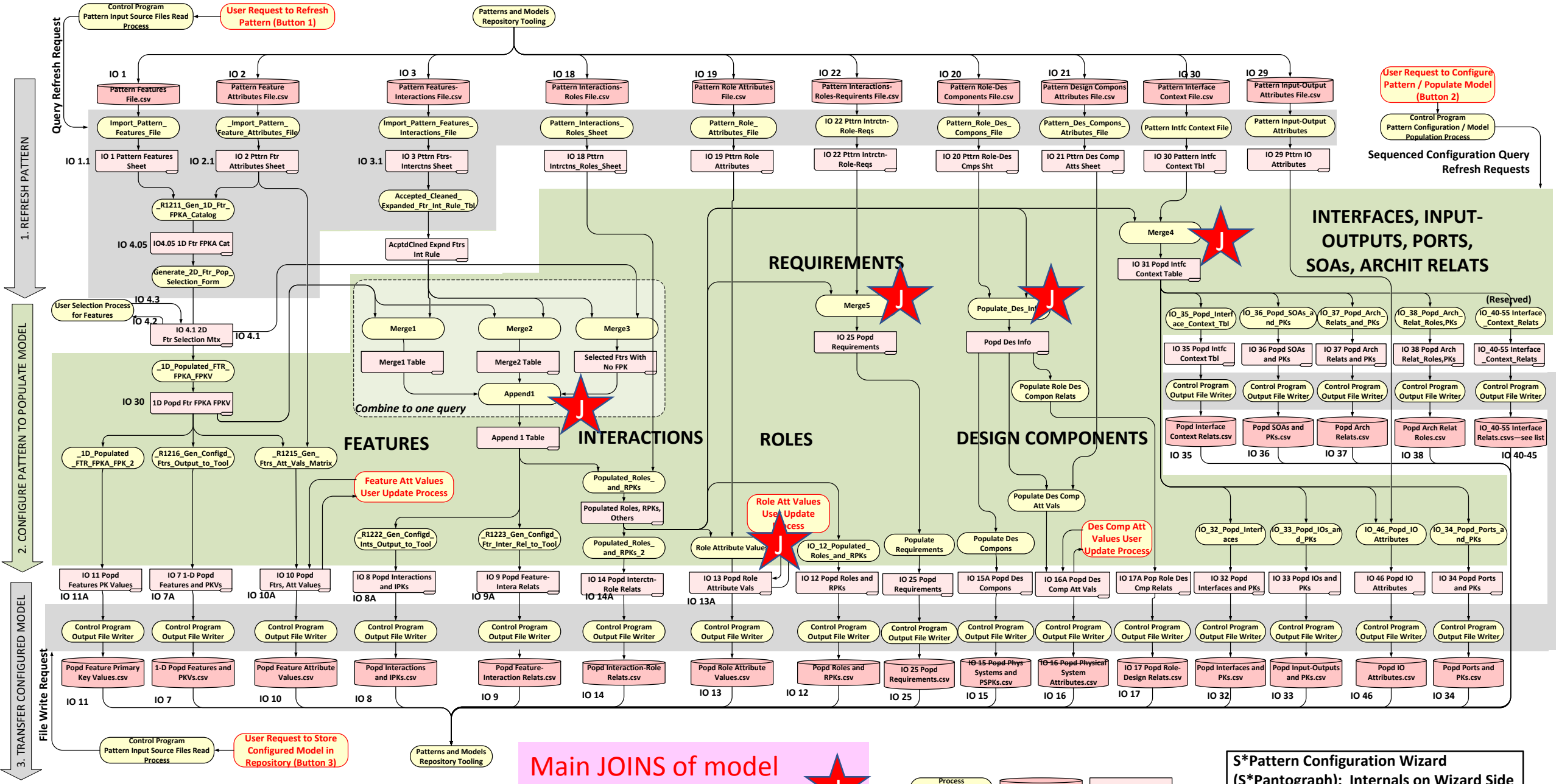
Three Generations of Configuration Agents

- All used same underlying S*Metamodel, maintaining data portability over years
- First Generation: (circa 2003-2010)
  - Pattern and model in large (~40 MB) desktop workbook, built-in pattern configuration algorithms
  - Allowed build-up of (portable) patterns and early validation of configuration process
  - Applied from small products up through medium sized manufacturing facilities, as configurable patterns
  - Limited scale and not integrated with system modeling environments, repositories
- Second Generation: (circa 2010-2020)
  - Separated pattern configuration algorithm into portable configuration agent with interface to multiple 3rd party COTS tools/repositories that author, contain, and manage the patterns and configured models.
  - Integrated with numerous modeling tools, repositories (EA, NM/CSM, Team Center PLM SE, Dassault Enovia, IBM Rhapsody, IBM/Telelogic DOORS, others)
  - Proof of concept for mappings to SysML and other languages, schema
  - Used for somewhat larger models of enterprises and supply chain ecosystem, but . . .
  - Configuration performance (speed) limited, as we get to really large models (enterprises, supply chains, etc.)
- Third Generation: (2021 prototype now in test)
  - Focused on higher performance for large scale configured models
  - Use of widely available relational JOIN technology for bulk configuration processes
  - Reduced configuration times
  - Extended to include Interfaces and other parts of S*Metamodel scope
  - Still integrated with third party COTS model authoring tools, repositories.
  - Basis of current activities—being used as an early test in this project.

Configuration Agent: Flow of JOINS and other queries




Pattern Inputs from Cameo SysML
Patterns and Models Repository Tooling
Control Program Pattern Input Source Files Read Process
User Request to Refresh Pattern (Button 1)
Query Refresh Request
1. REFRESH PATTERN
2. CONFIGURE PATTERN TO POPULATE MODEL
3. TRANSFER CONFIGURED MODEL
IO 1
Pattern Features File.csv
IO 2
Pattern Feature Attributes File.csv
IO 3
Pattern Features-Interactions File.csv
IO 18
Pattern Interactions-Roles File.csv
IO 19
Pattern Role Attributes File.csv
IO 22
Pattern Interactions-Roles-Requirents File.csv
IO 20
Pattern Role-Des Components File.csv
IO 21
Pattern Design Compons Attributes File.csv
IO 30
Pattern Interface Context File.csv
IO 29
Pattern Input-Output Attributes File.csv
User Request to Configure Pattern / Populate Model (Button 2)
Control Program Pattern Configuration / Model Population Process
Sequenced Configuration Query Refresh Requests
Import_Pattern_Features_File
_Import_Pattern_Feature_Attributes_File
Import_Pattern_Features_Interactions_File
Pattern_Interactions_Roles_Sheet
Pattern_Role_Attributes_File
IO 22 Pttrn Intrctn-Role-Reqs
Pattern_Role_Des_Compons_File
Pattern_Des_Compons_Atributes_File
Pattern Intfc Context File
Pattern Input-Output Attributes
IO 1.1
IO 1 Pattern Features Sheet
IO 2.1
IO 2 Pttrn Ftr Attributes Sheet
IO 3.1
IO 3 Pttrn Ftrs-Interctns Sheet
IO 18 Pttrn Intrctns_Roles_Sheet
IO 19 Pttrn Role Attributes
IO 22 Pttrn Intrctn-Role-Reqs
IO 20 Pttrn Role-Des Cmps Sht
IO 21 Pttrn Des Comp Atts Sheet
IO 30 Pattern Intfc Context Tbl
IO 29 Pttrn IO Attributes
_R1211_Gen_1D_Ftr_FPKA_Catalog
IO 4.05
IO4.05 1D Ftr FPKA Cat
Generate_2D_Ftr_Pop_Selection_Form
Accepted_Cleaned_Expanded_Ftr_Int_Rule_Tbl
AcptdCln ed Expnd Ftrs Int Rule
Merge4
IO 31 Popd Intfc Context Table
INTERFACES, INPUT-OUTPUTS, PORTS, SOAs, ARCHIT RELATS
(Reserved)
IO_35_Popd_Interface_Context_Tbl
IO_36_Popd_SOAs_and_PKs
IO_37_Popd_Arch_Relats_and_PKs
IO_38_Popd_Arch_Relat_Roles,PKs
IO_40-55 Interface_Context_Relats
IO 35 Popd Intfc Context Tbl
IO 36 Popd SOAs and PKs
IO 37 Popd Arch Relats and PKs
IO 38 Popd Arch Relat_Roles,PKs
IO_40-55 Interface_Context_Relats
Control Program Output File Writer
Popd Interface Context Relats.csv
Popd SOAs and PKs.csv
Popd Arch Relats.csv
Popd Arch Relat Roles.csv
IO_40-55 Interface Relats.csvs—see list
IO 35
IO 36
IO 37
IO 38
IO 40-45
User Selection Process for Features
IO 4.3
IO 4.2
IO 4.1 2D Ftr Selection Mtx
IO 4.1
_1D_Populated_FTR_FPKA_FPKV
IO 30
1D Popd Ftr FPKA FPKV
Merge1
Merge2
Merge3
Merge1 Table
Merge2 Table
Selected Ftrs With No FPK
Append1
Combine to one query
Append 1 Table
Merge5
IO 25 Popd Requirements
Populate_Des_Info
Popd Des Info
Populate Role Des Compon Relats
REQUIREMENTS
FEATURES
INTERACTIONS
ROLES
DESIGN COMPONENTS
_1D_Populated_FTR_FPKA_FPK_2
_R1216_Gen_Configd_Ftrs_Output_to_Tool
_R1215_Gen_Ftrs_Att_Vals_Matrix
Feature Att Values User Update Process
Populated_Roles_and_RPKs
Populated Roles, RPKs, Others
Populated_Roles_and_RPKs_2
Role Att Values User Update Process
Populate Des Comp Att Vals
Des Comp Att Values User Update Process
_R1222_Gen_Configd_Ints_Output_to_Tool
_R1223_Gen_Configd_Ftr_Inter_Rel_to_Tool
Role Attribute Values
IO_12_Populated_Roles_and_RPKs
Populate Requirements
Populate Des Compons
IO_32_Popd_Interfaces
IO_33_Popd_IOs_and_PKs
IO_46_Popd_IO Attributes
IO_34_Popd_Ports_and_PKs
IO 11 Popd Features PK Values
IO 7 1-D Popd Features and PKVs
IO 10 Popd Ftrs, Att Values
IO 8 Popd Interactions and IPKs
IO 9 Popd Feature-Intera Relats
IO 14 Popd Interctn-Role Relats
IO 13 Popd Role Attribute Vals
IO 12 Popd Roles and RPKs
IO 25 Popd Requirements
IO 15A Popd Des Compons
IO 16A Popd Des Comp Att Vals
IO 17A Pop Role Des Cmp Relats
IO 32 Popd Interfaces and PKs
IO 33 Popd IOs and PKs
IO 46 Popd IO Attributes
IO 34 Popd Ports and PKs
IO 11A
IO 7A
IO 10A
IO 8A
IO 9A
IO 14A
IO 13A
Control Program Output File Writer
Popd Feature Primary Key Values.csv
1-D Popd Features and PKVs.csv
Popd Feature Attribute Values.csv
Popd Interactions and IPKs.csv
Popd Feature-Interaction Relats.csv
Popd Interaction-Role Relats.csv
Popd Role Attribute Values.csv
Popd Roles and RPKs.csv
IO 25 Popd Requirements.csv
IO 15 Popd Phys Systems and PSPKs.csv
IO 16 Popd Physical System Attributes.csv
IO 17 Popd Role-Design Relats.csv
Popd Interfaces and PKs.csv
Popd Input-Outputs and PKs.csv
Popd IO Attributes.csv
Popd Ports and PKs.csv
IO 11
IO 7
IO 10
IO 8
IO 9
IO 14
IO 13
IO 12
IO 25
IO 15
IO 16
IO 17
IO 32
IO 33
IO 46
IO 34
File Write Request
Control Program Pattern Input Source Files Read Process
User Request to Store Configured Model in Repository (Button 3)
Patterns and Models Repository Tooling
Configured Model Outputs for import to Cameo SysML
Process (Query, Program, Human Process)
Data File
Data Table
S*Pattern Configuration Wizard (S*Pantograph): Internals on Wizard Side
V1.2.12 06.27.2021 Implementation: V1.6.2


1. REFRESH PATTERN
2. CONFIGURE PATTERN TO POPULATE MODEL
3. TRANSFER CONFIGURED MODEL
Query Refresh Request
File Write Request
Control Program Pattern Input Source Files Read Process
User Request to Refresh Pattern (Button 1)
Patterns and Models Repository Tooling
IO 1
Pattern Features File.csv
IO 2
Pattern Feature Attributes File.csv
IO 3
Pattern Features-Interactions File.csv
IO 18
Pattern Interactions-Roles File.csv
IO 19
Pattern Role Attributes File.csv
IO 22
Pattern Interactions-Roles-Requirents File.csv
IO 20
Pattern Role-Des Components File.csv
IO 21
Pattern Design Compons Attributes File.csv
IO 30
Pattern Interface Context File.csv
IO 29
Pattern Input-Output Attributes File.csv
User Request to Configure Pattern / Populate Model (Button 2)
Control Program Pattern Configuration / Model Population Process
Sequenced Configuration Query Refresh Requests
Import_Pattern_Features_File
_Import_Pattern_Feature_Attributes_File
Import_Pattern_Features_Interactions_File
Pattern_Interactions_Roles_Sheet
Pattern_Role_Attributes_File
IO 22 Pttrn Intrctn-Role-Reqs
Pattern_Role_Des_Compons_File
Pattern_Des_Compons_Atributes_File
Pattern Intfc Context File
Pattern Input-Output Attributes
IO 1.1
IO 1 Pattern Features Sheet
IO 2.1
IO 2 Pttrn Ftr Attributes Sheet
IO 3.1
IO 3 Pttrn Ftrs-Interctns Sheet
IO 18 Pttrn Intrctns_Roles_Sheet
IO 19 Pttrn Role Attributes
IO 22 Pttrn Intrctn-Role-Reqs
IO 20 Pttrn Role-Des Cmps Sht
IO 21 Pttrn Des Comp Atts Sheet
IO 30 Pattern Intfc Context Tbl
IO 29 Pttrn IO Attributes
INTERFACES, INPUT-OUTPUTS, PORTS, SOAs, ARCHIT RELATS
REQUIREMENTS
FEATURES
INTERACTIONS
ROLES
DESIGN COMPONENTS
_R1211_Gen_1D_Ftr_FPKA_Catalog
IO 4.05
IO4.05 1D Ftr FPKA Cat
Generate_2D_Ftr_Pop_Selection_Form
IO 4.3
User Selection Process for Features
IO 4.2
IO 4.1 2D Ftr Selection Mtx
IO 4.1
_1D_Populated_FTR_FPKA_FPKV
IO 30
1D Popd Ftr FPKA FPKV
AcptdClned Expnd Ftrs Int Rule
Merge1
Merge2
Merge3
Merge1 Table
Merge2 Table
Selected Ftrs With No FPK
Append1
Combine to one query
Append 1 Table
Merge5
IO 25 Popd Requirements
Populate_Des_Int
Popd Des Info
Merge4
IO 31 Popd Intfc Context Table
Populate Role Des Compon Relats
Populate Des Comp Att Vals
(Reserved)
IO_35_Popd_Interface_Context_Tbl
IO_36_Popd_SOAs_and_PKs
IO_37_Popd_Arch_Relats_and_PKs
IO_38_Popd_Arch_Relat_Roles,PKs
IO_40-55 Interface_Context_Relats
IO 35 Popd Intfc Context Tbl
IO 36 Popd SOAs and PKs
IO 37 Popd Arch Relats and PKs
IO 38 Popd Arch Relat_Roles,PKs
IO_40-55 Interface_Context_Relats
Control Program Output File Writer
Popd Interface Context Relats.csv
Popd SOAs and PKs.csv
Popd Arch Relats.csv
Popd Arch Relat Roles.csv
IO_40-55 Interface Relats.csvs—see list
IO 35
IO 36
IO 37
IO 38
IO 40-45
_1D_Populated_FTR_FPKA_FPK_2
_R1216_Gen_Configd_Ftrs_Output_to_Tool
_R1215_Gen_Ftrs_Att_Vals_Matrix
Feature Att Values User Update Process
Populated_Roles_and_RPKs
Populated Roles, RPKs, Others
Populated_Roles_and_RPKs_2
Role Att Values User Update Process
IO_12_Populated_Roles_and_RPKs
Populate Requirements
Populate Des Compons
Des Comp Att Values User Update Process
IO_32_Popd_Interfaces
IO_33_Popd_IOs_and_PKs
IO_46_Popd_IO Attributes
IO_34_Popd_Ports_and_PKs
_R1222_Gen_Configd_Ints_Output_to_Tool
_R1223_Gen_Configd_Ftr_Inter_Rel_to_Tool
Role Attribute Values
IO 11 Popd Features PK Values
IO 7 1-D Popd Features and PKVs
IO 10 Popd Ftrs, Att Values
IO 8 Popd Interactions and IPKs
IO 9 Popd Feature-Intera Relats
IO 14 Popd Interctn-Role Relats
IO 13 Popd Role Attribute Vals
IO 12 Popd Roles and RPKs
IO 25 Popd Requirements
IO 15A Popd Des Compons
IO 16A Popd Des Comp Att Vals
IO 17A Pop Role Des Cmp Relats
IO 32 Popd Interfaces and PKs
IO 33 Popd IOs and PKs
IO 46 Popd IO Attributes
IO 34 Popd Ports and PKs
IO 11A
IO 7A
IO 10A
IO 8A
IO 9A
IO 14A
IO 13A
Popd Feature Primary Key Values.csv
1-D Popd Features and PKVs.csv
Popd Feature Attribute Values.csv
Popd Interactions and IPKs.csv
Popd Feature-Interaction Relats.csv
Popd Interaction-Role Relats.csv
Popd Role Attribute Values.csv
Popd Roles and RPKs.csv
IO 25 Popd Requirements.csv
IO 15 Popd Phys Systems and PSPKs.csv
IO 16 Popd Physical System Attributes.csv
IO 17 Popd Role-Design Relats.csv
Popd Interfaces and PKs.csv
Popd Input-Outputs and PKs.csv
Popd IO Attributes.csv
Popd Ports and PKs.csv
IO 11
IO 7
IO 10
IO 8
IO 9
IO 14
IO 13
IO 12
IO 25
IO 15
IO 16
IO 17
IO 32
IO 33
IO 46
IO 34
Control Program Pattern Input Source Files Read Process
User Request to Store Configured Model in Repository (Button 3)
Patterns and Models Repository Tooling
Main JOINS of model configuration algorithm
Process (Query, Program, Human Process)
Data File
Data Table
S*Pattern Configuration Wizard (S*Pantograph): Internals on Wizard Side
V1.2.12 06.27.2021 Implementation: V1.6.2

1

1: Refresh Configurable Pattern

Pattern Template Loading Started:
05.30.21 17:09:07 0 Items
Pattern Features Loaded:
05.30.21 17:09:08 6 Items
Pattern Feature Attributes Loaded:
05.30.21 17:09:09 4 Items
Pattern Ftr-Interctn Rules Loaded:
05.30.21 17:09:10 9 Items
Pattern Interctn-Role Rules Loaded:
05.30.21 17:09:11 15 Items
Pattern Role Attributes Loaded:
05.30.21 17:09:12 0 Items
Pattern Des Compon Atts Loaded:
05.30.21 17:09:13 1 Items
Pattern Role-Des Compons Loaded:
05.30.21 17:09:13 1 Items
Pattern 1D Options Catalog Gend:
05.30.21 17:09:15 6 Items
Pattern Ftr-Intercnt Rules Gend:
05.30.21 17:09:15 9 Items
Pattern 2-D Selection Matrix Gend:
05.30.21 17:09:16 6 Items
Pattern Interface Context Loaded:
05.30.21 17:09:17 18 Items

2

2: Populate Configured Model

Model Generation Started:
05.30.21 17:10:05 0 Items
1D Configured Feature Population Generated:
05.30.21 17:10:06 8 Items
Group 1 Interactions Populated:
05.30.21 17:10:07 0 Items
Group 2 Interactions Populated:
05.30.21 17:10:09 3 Items
Group 3 Interactions Populated:
05.30.21 17:10:10 8 Items
Combined Interactions Populated:
05.30.21 17:10:15 13 Items
Popd Ftrs Sheet Generated:
05.30.21 17:10:16 8 Items
Popd Intrcns Sheet Generated:
05.30.21 17:10:16 8 Items
Popd Ftr-Ints Sheet Generated:
05.30.21 17:10:17 13 Items
Popd Ftr Att Values Sheet Generated:
05.30.21 17:10:18 5 Items
Popd Ftr PK Values Sheet Generated:
05.30.21 17:10:19 3 Items
Popd Roles , RPKs, Others Generated:
05.30.21 17:10:27 22 Items
IO 12 Popd Roles Sheet Generated:
05.30.21 17:10:28 7 Items
IO 13 Popd Role Att Vals Form Gend:
05.30.21 17:10:38 0 Items
IO 14 Popd Interctn-Role Relats Gend:
05.30.21 17:10:39 22 Items
Popd Des Info Gend:
05.30.21 17:10:52 8 Items
IO 15 Popd Des Cmps and PKs Gend:
05.30.21 17:10:53 1 Items
IO 16 Popd Dec Cmp Atts Gend:
05.30.21 17:10:54 1 Items
IO 17 Popd Role-Des Relats Gend:
05.30.21 17:10:55 8 Items
IO 31 Popd Intfc Context Initial:
05.30.21 17:11:06 34 Items
IO 32 Popd Interfaces Gend:
05.30.21 17:11:07 7 Items
IO 33 Popd IOs and PKs Gend:
05.30.21 17:11:07 11 Items
IO 34 Popd Ports and PKs Gend:
05.30.21 17:11:08 20 Items
IO 35 Popd Intfc Context Tbl Gend:
05.30.21 17:11:09 34 Items
IO 36 Popd SOAs and PKs:
05.30.21 17:11:09 11 Items
IO 37 Popd Arch Relats and PKs:

Select Features
Set Ftr Att Vals
Set Role Att Vals
Set Des Att Vals

3

3: Return Configured Model to Repository

Start Configured Model Return:
05.30.21 17:19:37 0 Items
Popd Ftrs CSV File Saved:
05.30.21 17:19:38 8 Items
Popd Interactions and IPKs
05.30.21 17:19:39 8 Items
Popd Feature-Interaction Relats
05.30.21 17:19:40 13 Items
Popd Feature Attribute Values
05.30.21 17:19:41 5 Items
Popd Feature PK Values
05.30.21 17:19:42 3 Items
Popd Roles and RPKs
05.30.21 17:19:43 7 Items
Popd Roles Att Values
05.30.21 17:19:45 0 Items
Popd Interactn-Role Relats
05.30.21 17:19:46 22 Items
Popd Design Components
05.30.21 17:19:47 1 Items
Popd Des Compon Att Vals
05.30.21 17:19:48 1 Items
Popd Role-Des Compon Relats
05.30.21 17:19:49 8 Items
Popd Interfaces
05.30.21 17:19:50 7 Items
Popd Input-Outputs
05.30.21 17:19:51 11 Items
Popd Ports
05.30.21 17:19:54 20 Items
Popd Interface Context
05.30.21 17:19:55 34 Items
Popd SOAs
05.30.21 17:19:56 11 Items
Popd Arch Relats
05.30.21 17:19:57 1 Items
Popd Arch Relat Roles
05.30.21 17:19:58 5 Items

Select Configurable Pattern Repository Access Folder

C:\Users\WSchindel\Documents\Docs\System Sciences, LLC\Tech\Systematica\STM Methodology\STMTemplatesWorksheets\Workbook\2020-21 Wkbk Experiments\File Interchange Test Data--Pwr Cnvrter Pttrn

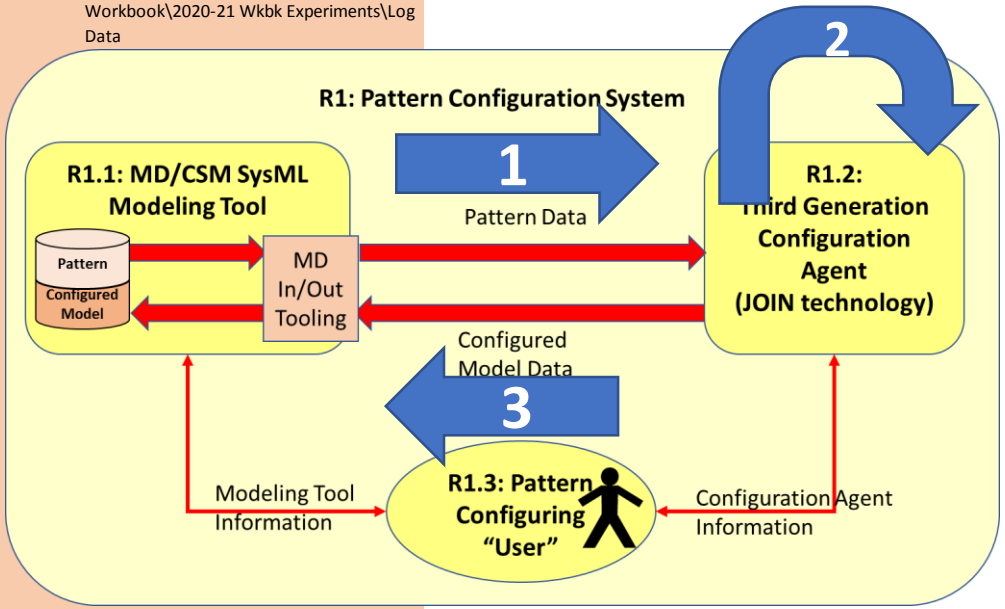
Select Configured Model Repository Insertion Folder

C:\Users\WSchindel\Documents\Docs\System Sciences, LLC\Tech\Systematica\STM Methodology\STMTemplatesWorksheets\Workbook\2020-21 Wkbk Experiments\File Interchange Test Data--Pwr Cnvrter Pttrn

Select Configurator Logging Folder ☐ Enable File Logging

C:\Users\WSchindel\Documents\Docs\System Sciences, LLC\Tech\Systematica\STM Methodology\STMTemplatesWorksheets\Workbook\2020-21 Wkbk Experiments\Log Data

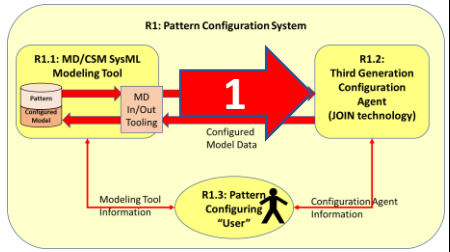
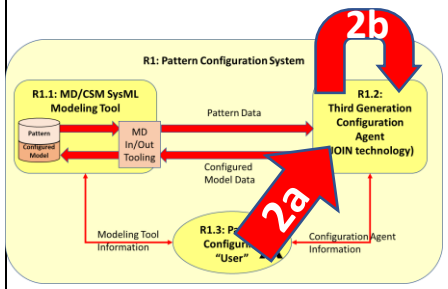
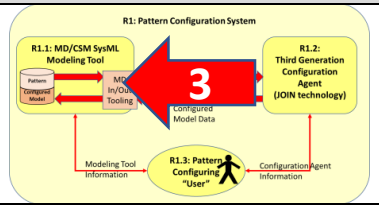
Prototype Test Jig Setup: Logging / Time Stamping of three main flows



Initial results from example

- Illustrates configuration of Interfaces from S*Pattern:
  - S*Interface part of S*Metamodel
  - S*Interfaces within the International Power Converter S*Pattern application
- Illustrates prototype of third-generation S*Pattern Configuration Wizard / S*Pantograph:
  - Including practical integration with Cameo System Modeler & SysML
- Resulting configured SysML model data (S*Model)
- Favorable initial timing data for this small pattern and a larger pattern
- Suggests a number of next steps . . .

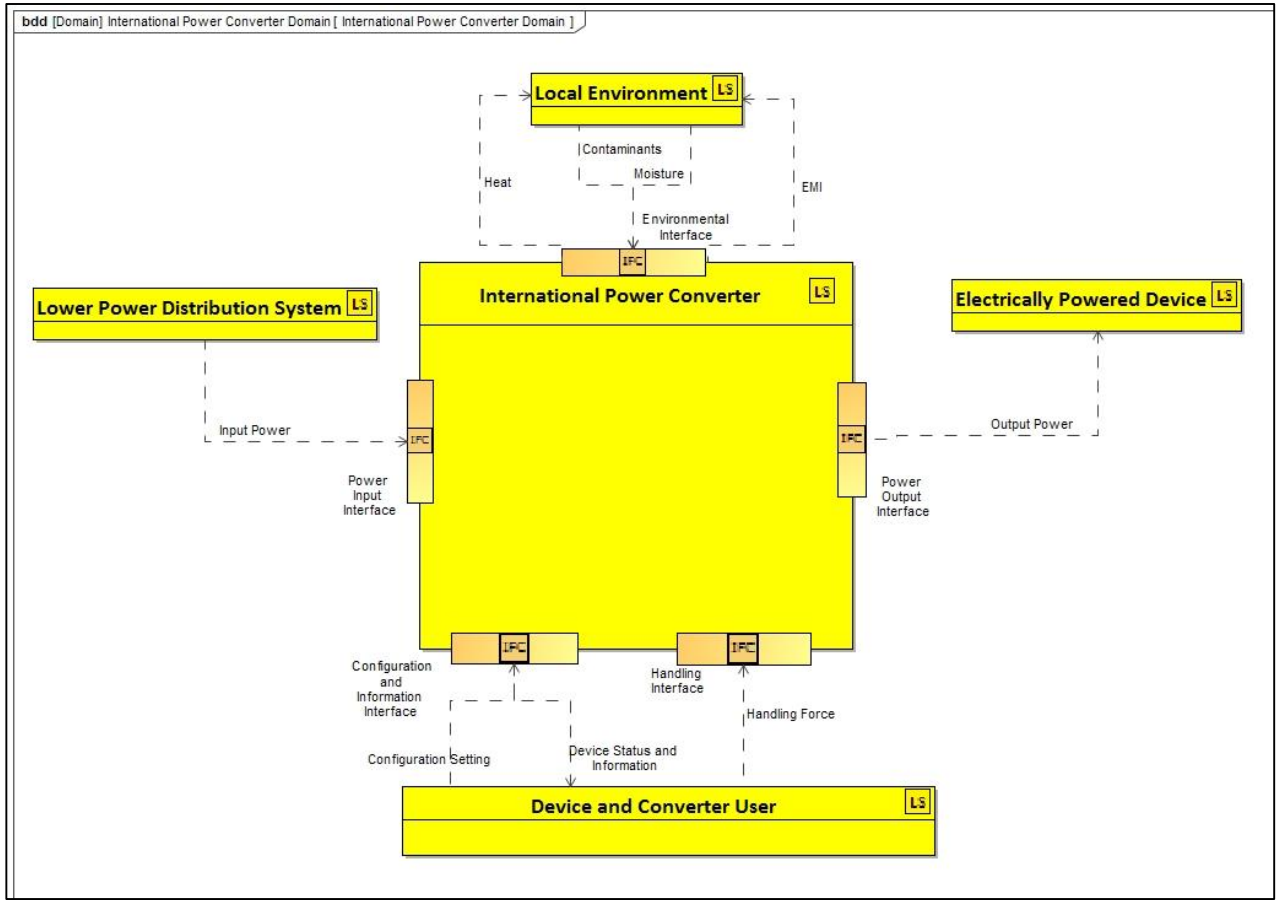
Summary of timing data

Measurements made in May-June, 2021, using a small desktop Power Query based configuration wizard and desktop Cameo Systems Modeler (CSM). Times shown would be reduced using cloud-based query engine. Times shown include generation of configured Features, Interactions, Roles, Design Components, Interfaces, IOs, etc, and could vary depending on what is needed.		**Tiny model (Power Converter Pattern)**	**Medium model (INCOSE ASELCM Ecosystem Pattern, hundreds to thousands of instances)**	**Comments**
1. Load SysML pattern data to configuration wizard (from Cameo SM). This is done only once before generating as many configurations as needed, or a work session:				
	CSM generate output files (these csv data structures are automatically kept up to date with the Cameo model of the pattern, by Cameo Synch feature). About 10 files.	~0	~0	
	Wizard loads the ~10 files into internal tables. This also includes some query and generation of 2-D user interface for pattern configuration choices, pull-downs, etc.	15 seconds (~102 pattern row items)	19 seconds (~1500 pattern row items)	
2. Generate configured model data in wizard:				
	User enters configuration choices, values	(User working time, thinking, entering configuration choices)		
	Upon user request, wizard generates configured model data from user configuration choices. Depending on pattern and user choices, number of instances at this stage can readily grow by 1-3 orders of magnitude. (~25 queries; ~6 are significant JOINS)	94 seconds (~ 529 configured model internal query output row items, down to interface, IO level, requirements detail)	45 seconds (~12,846 configured model internal query output row items, at upper level features, roles, interactions)	Dominating time is overhead not very senstive to data scale. Row counts here include internal queries for intermediate results, whereas item (3) below is process output rows only.
3. Generate outputs from Wizard and load into configured model in Cameo model repository. (This need only occur when user is satisfied with configuration in step 2.)				
	Export configured model data (~20 csv files) from wizard:	~28 seconds (~333 file output data rows)	~20 seconds (~8,142 file output data rows)	
	Import configured model data (~20 csv files) to Cameo, using CSM bulk CSV Import plug in technology:	Prelim data not recorded, but under a minute	Prelim data not recorded, but on the order of a minute.	

Next steps discussion, team suggestions, QA

- Generation of same power converter example model information in SysML 2.0 and other language (e.g., OWL, OML) equivalents
- Compare model configuration checking with model configuration generation—how do these inform each other?
  - Analyze how checker and configure each interpreted the same configuration rules from common pattern, noting any differences.
  - Analyze lessons about the approaches, technologies.
- Package information, at different levels of detail, for interested third parties.
-
- Other . . .
-

Appendix 1: Example pattern in SysML and extracted pattern data



Interface pattern configuration rules table

System Name	Interaction Name	Interface Name	Interface PK Rule	IO Name	IO PK Rule	Port Direction	Port Name	Port PK Rule	SOA Name	SOA PK Rule	SOA Internal or External	Arch Relat	Arch Relat PK Rule	Arch Relat Role	Arch Relat Role PK Rule	Arch Relat Internal or External	Arch Relat IO Assoc
International Power Converter	Convert Electrical Power	Power Input Interface		Input Power		In	PI.1	IFPK	Local Power Connector			Converts Electrical Power		Converter			
International Power Converter	Convert Electrical Power	Power Output Interface	IPK	Output Power	IPK	Out	PO.1	IFPK	Device Power Connector	IPK		Converts Electrical Power		Converter			
International Power Converter	Convert Electrical Power	Environmental Interface		Heat		In	EN.1	IFPK	Airspace Convection System								
International Power Converter	Convert Electrical Power	Environmental Interface		EMI		Out	EN.2	IFPK	EMI Radiation								
International Power Converter	Resist Contamination	Environmental Interface		Contaminants		In	EN.3	IFPK	Airspace Transport System								
International Power Converter	Tolerate Moisture	Environmental Interface		Moisture		In	EN.4	IFPK	Airspace Transport System								
International Power Converter	Set Configuration	Configuration and Information Interface		Configuration Setting		In	CI.1	IFPK	HMI Buttons								
International Power Converter	Display Status and Information	Configuration and Information Interface		Device Status and Information		Out	CO.2	IFPK	HMI Display								
International Power Converter	Handle Device	Handling Interface		Handling Force		InOut	HI.1	IFPK	Handle								
Local Power Distribution System	Convert Electrical Power	Power Mains Interface		Input Power		Out	LPO.1	IFPK	Local Power Connector			Converts Electrical Power		Source			
Electrically Powered Device	Convert Electrical Power	Device Power Interface		Output Power	IPK	In	DPI.1	IFPK	Device Power Connector	IPK		Converts Electrical Power		Sink	IPK		
Device and Converter User	Handle Device	Hand Interface		Handling Force		InOut	UHO.1	IFPK	Handle								
Device and Converter User	Set Configuration	Finger Interface		Configuration Setting		Out	UCO.1	IFPK	HMI Buttons								
Device and Converter User	Display Status and Information	Vision Interface		Device Status and Information		In	UC1.1	IFPK	HMI Display								
Local Environment	Resist Contamination	Contaminant Source Interface		Contaminants		Out	ENV.1	IFPK	Airspace Transport System								
Local Environment	Tolerate Moisture	Moisture Source Interface		Moisture		Out	ENV.2	IFPK	Airspace Transport System								
Local Environment	Convert Electrical Power	EMI Receiver Interface		EMI		In	ENV.3	IFPK	EMI Radiation								
Local Environment	Convert Electrical Power	Environment Thermal Sink Interface		Heat		In	ENV.4	IFPK	Airspace Convection System								

Appendix 2: Configured Pwr Converter S*Model data

Pattern user selecting Power Converter Features to populate, and Feature PK Values, by pull downs

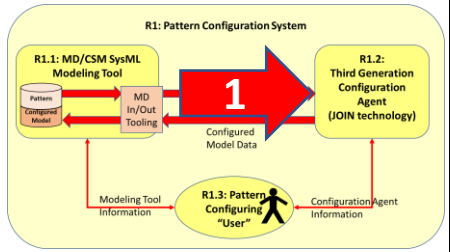
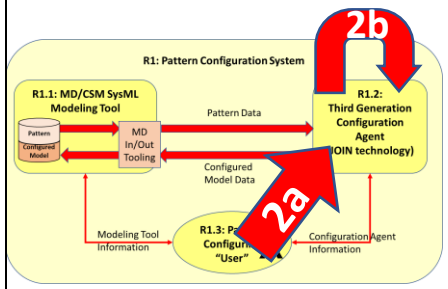
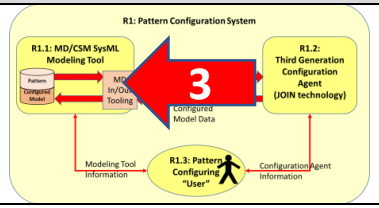
B	C	AI	AJ	AK	AL	AM	
Feature Name	Feature Attribute	Populate? Yes/No	Selection 1	Selection 2	Selection 3	Selection 4	Sele
Powered Devices Compatibility	Power Output Interface ID	Yes	Power Output 1	Power Output 2	Power Output 3		
Power Mains Compatibility		Yes					
Ease of Use		Yes					
Safety		Yes					
Portability		Yes					
Reliability and Durability		Yes					

Power Output 1
Power Output 2
Power Output 3

Populated Interfaces in Configured Model

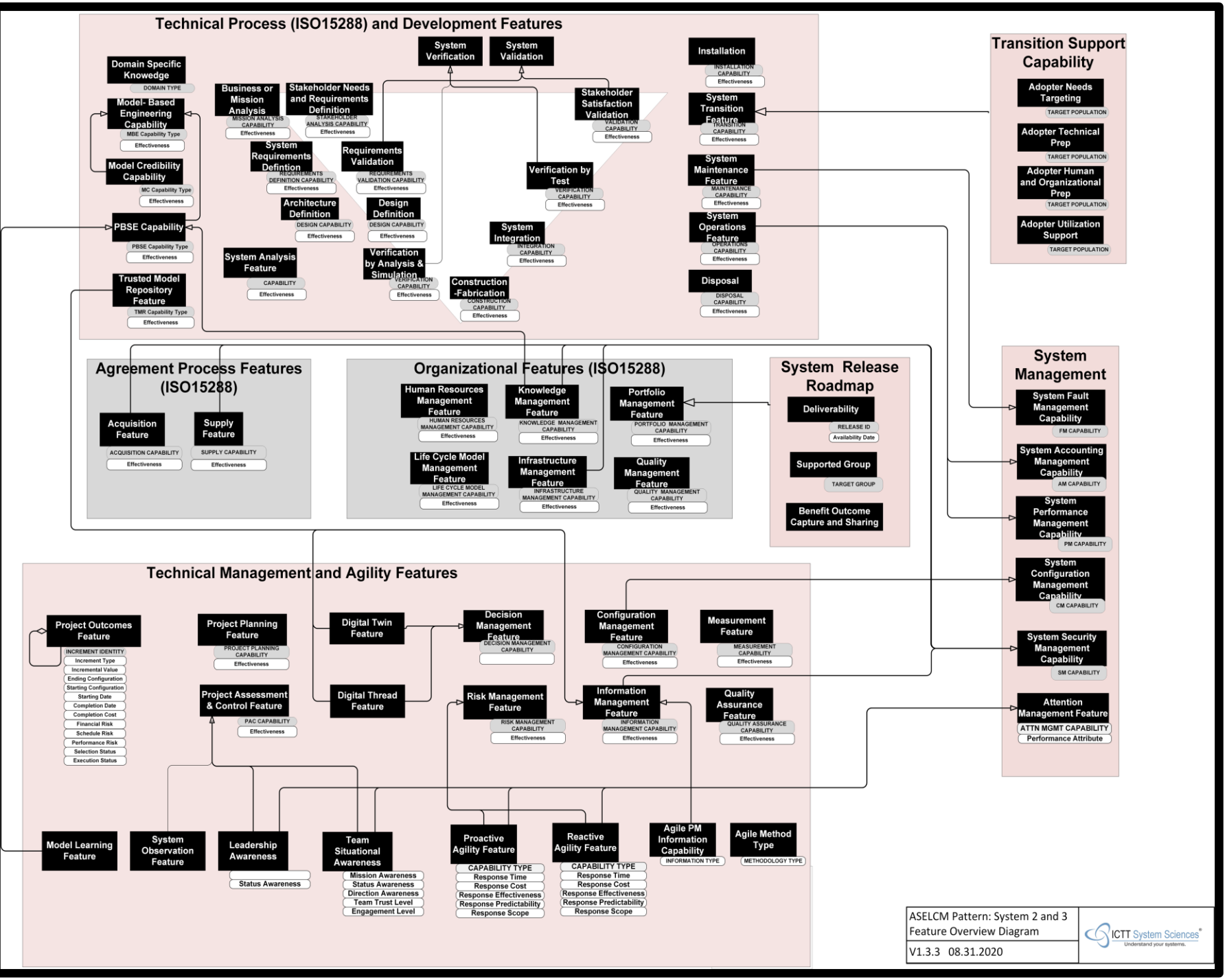
Configured Interface Name	Pattern Interface	Owner	Configured Interface
Configuration and Information Interface	01 Local Pattern::02 Logical System Analysis::International Power Converter::Configuration and Information Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Configuration and Information Interface
Contaminant Source Interface	01 Local Pattern::02 Logical System Analysis::Local Environment::Contaminant Source Interface	02 Configured Model::02 Logical System Analysis::Local Environment	02 Configured Model::02 Logical System Analysis::Local Environment::Contaminant Source Interface
Device Power Interface	01 Local Pattern::02 Logical System Analysis::Electrically Powered Device::Device Power Interface	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 1]	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 1]::Device Power Interface
Device Power Interface	01 Local Pattern::02 Logical System Analysis::Electrically Powered Device::Device Power Interface	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 2]	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 2]::Device Power Interface
Device Power Interface	01 Local Pattern::02 Logical System Analysis::Electrically Powered Device::Device Power Interface	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 3]	02 Configured Model::02 Logical System Analysis::Electrically Powered Device [Power Output 3]::Device Power Interface
EMI Receiver Interface	01 Local Pattern::02 Logical System Analysis::Local Environment::EMI Receiver Interface	02 Configured Model::02 Logical System Analysis::Local Environment	02 Configured Model::02 Logical System Analysis::Local Environment::EMI Receiver Interface
Environment Thermal Sink Interface	01 Local Pattern::02 Logical System Analysis::Local Environment::Environment Thermal Sink Interface	02 Configured Model::02 Logical System Analysis::Local Environment	02 Configured Model::02 Logical System Analysis::Local Environment::Environment Thermal Sink Interface
Environmental Interface	01 Local Pattern::02 Logical System Analysis::International Power Converter::Environmental Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Environmental Interface
Finger Interface	01 Local Pattern::02 Logical System Analysis::Device and Converter User::Finger Interface	02 Configured Model::02 Logical System Analysis::Device and Converter User	02 Configured Model::02 Logical System Analysis::Device and Converter User::Finger Interface
Hand Interface	01 Local Pattern::02 Logical System Analysis::Device and Converter User::Hand Interface	02 Configured Model::02 Logical System Analysis::Device and Converter User	02 Configured Model::02 Logical System Analysis::Device and Converter User::Hand Interface
Handling Interface	01 Local Pattern::02 Logical System Analysis::International Power Converter::Handling Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Handling Interface
Moisture Source Interface	01 Local Pattern::02 Logical System Analysis::Local Environment::Moisture Source Interface	02 Configured Model::02 Logical System Analysis::Local Environment	02 Configured Model::02 Logical System Analysis::Local Environment::Moisture Source Interface
Power Input Interface	01 Local Pattern::02 Logical System Analysis::International Power Converter::Power Input Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Power Input Interface
Power Mains Interface	01 Local Pattern::02 Logical System Analysis::Local Power Distribution System::Power Mains Interface	02 Configured Model::02 Logical System Analysis::Local Power Distribution System	02 Configured Model::02 Logical System Analysis::Local Power Distribution System::Power Mains Interface
Power Output Interface [Power Output 1]	01 Local Pattern::02 Logical System Analysis::International Power Converter::Power Output Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Power Output Interface [Power Output 1]
Power Output Interface [Power Output 2]	01 Local Pattern::02 Logical System Analysis::International Power Converter::Power Output Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Power Output Interface [Power Output 2]
Power Output Interface [Power Output 3]	01 Local Pattern::02 Logical System Analysis::International Power Converter::Power Output Interface	02 Configured Model::02 Logical System Analysis::International Power Converter	02 Configured Model::02 Logical System Analysis::International Power Converter::Power Output Interface [Power Output 3]
Vision Interface	01 Local Pattern::02 Logical System Analysis::Device and Converter User::Vision Interface	02 Configured Model::02 Logical System Analysis::Device and Converter User	02 Configured Model::02 Logical System Analysis::Device and Converter User::Vision Interface

Appendix 3: Preliminary timing data

Measurements made in May-June, 2021, using a small desktop Power Query based configuration wizard and desktop Cameo Systems Modeler (CSM). Times shown would be reduced using cloud-based query engine. Times shown include generation of configured Features, Interactions, Roles, Design Components, Interfaces, IOs, etc, and could vary depending on what is needed.		**Tiny model (Power Converter Pattern)**	**Medium model (INCOSE ASELCM Ecosystem Pattern, hundreds to thousands of instances)**	**Comments**
1. Load SysML pattern data to configuration wizard (from Cameo SM). This is done only once before generating as many configurations as needed, or a work session:				
	CSM generate output files (these csv data structures are automatically kept up to date with the Cameo model of the pattern, by Cameo Synch feature). About 10 files.	~0	~0	
	Wizard loads the ~10 files into internal tables. This also includes some query and generation of 2-D user interface for pattern configuration choices, pull-downs, etc.	15 seconds (~102 pattern row items)	19 seconds (~1500 pattern row items)	
2. Generate configured model data in wizard:				
	User enters configuration choices, values	(User working time, thinking, entering configuration choices)		
	Upon user request, wizard generates configured model data from user configuration choices. Depending on pattern and user choices, number of instances at this stage can readily grow by 1-3 orders of magnitude. (~25 queries; ~6 are significant JOINS)	94 seconds (~ 529 configured model internal query output row items, down to interface, IO level, requirements detail)	45 seconds (~12,846 configured model internal query output row items, at upper level features, roles, interactions)	Dominating time is overhead not very senstive to data scale. Row counts here include internal queries for intermediate results, whereas item (3) below is process output rows only.
3. Generate outputs from Wizard and load into configured model in Cameo model repository. (This need only occur when user is satisfied with configuration in step 2.)				
	Export configured model data (~20 csv files) from wizard:	~28 seconds (~333 file output data rows)	~20 seconds (~8,142 file output data rows)	
	Import configured model data (~20 csv files) to Cameo, using CSM bulk CSV Import plug in technology:	Prelim data not recorded, but under a minute	Prelim data not recorded, but on the order of a minute.	

Appendix 4: Sample aspects of INCOSE ASELCM Ecosystem Pattern

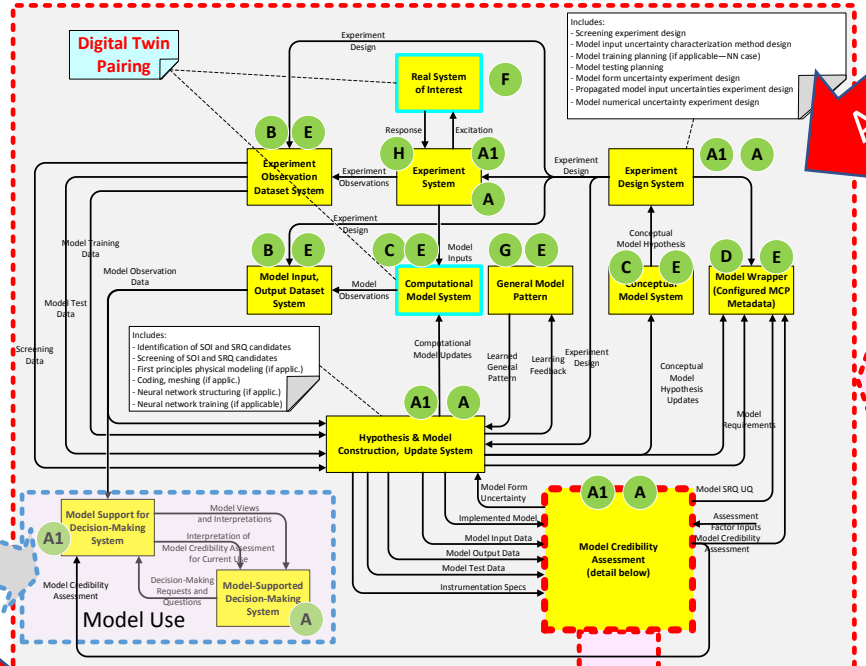
- The INCOSE ASELCM Ecosystem Pattern is being used for testing of newer configuration wizard as to its speed on larger patterns.
- Configured models of this pattern can easily reach thousands of tens of thousands of elements, representing a supply chain ecosystem.
- It is outside the scope of the Interface Patterns / ST4SE Project, but a little information is provided here since:
  - The Power Converter Pattern is too small for bulk performance testing—the timing data tables show both patterns
  - The much richer range of selectable Stakeholder Features shows that aspect of the Configuration Wizard better

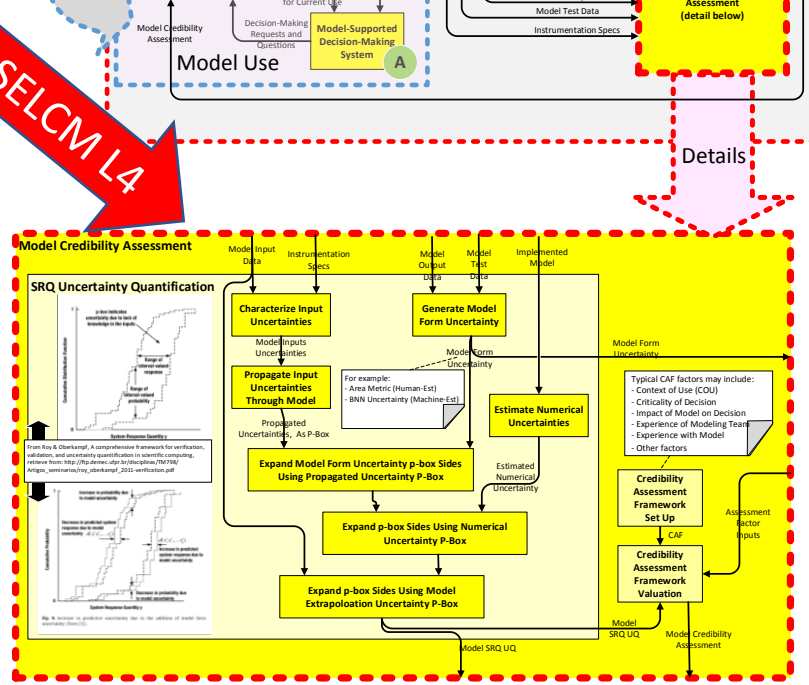


Ecosystem Pattern Selectable Features

Ecosystem Pattern Logical Architecture

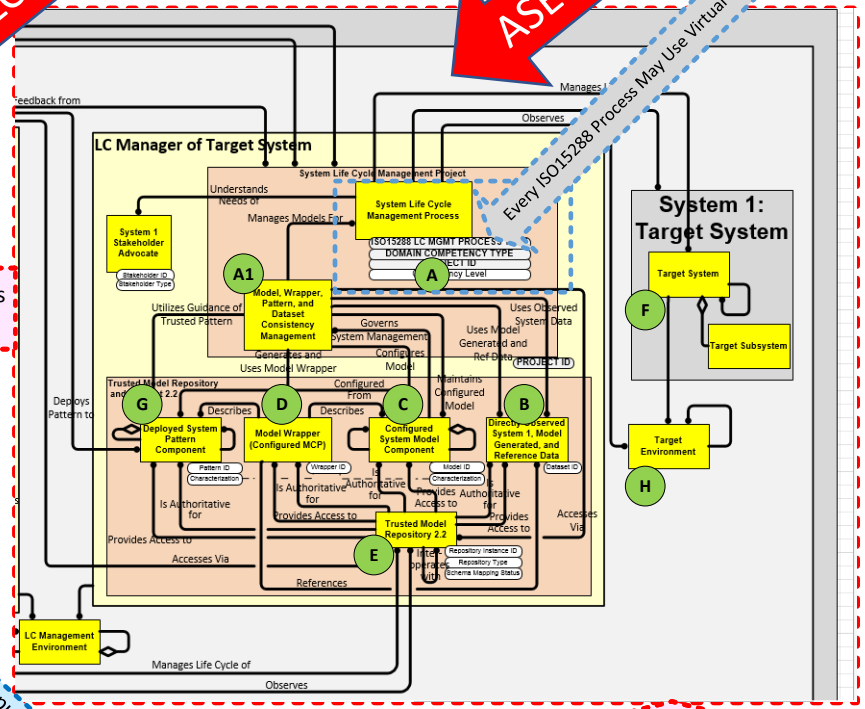
System 2: Overview of Virtual Model Creation, Validation, and Utilization

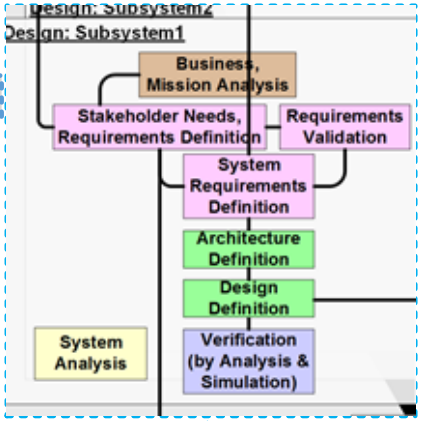


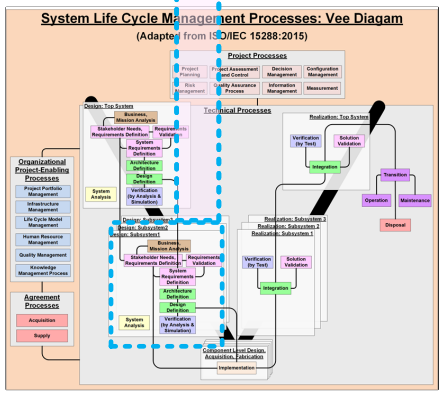


Virtual Model Credibility Assessment-- including Model Verification, Validation, Uncertainty Quantification (VVUQ)

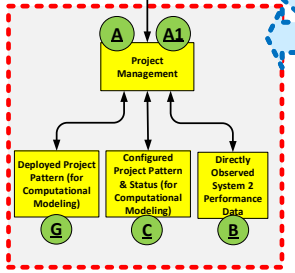
System 2: Each ISO15288 Process Can Interact with Virtual Model Data



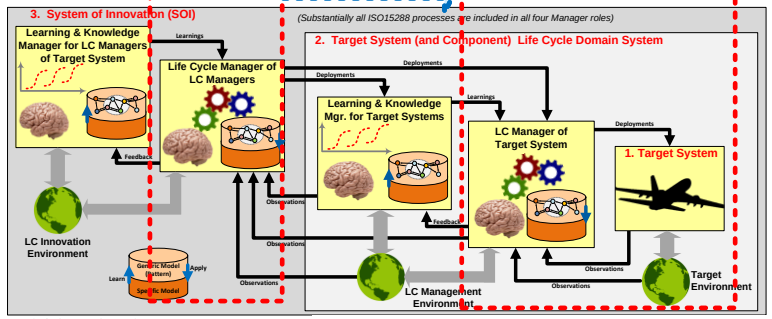




ISO15288 Processes ("Vee Diagram") – Basis of the INCOSE SE Handbook



System 3:
Configures Project from Learned Pattern, Tracks and Controls Project, "Scores" Project Performance, Learns More



INCOSE ASELCM Pattern – Virtual Learning Ecosystem Framework

From Schindel & Dove, Introduction to the ASELCM Pattern, INCOSE 2016 International Symposium, retrieve from https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:is2016_intro_to_the_aselcm_pattern_v1.4.8.pdf

ASELCM L3

ASELCM L2

ASELCM L4

ASELCM L1

Details

Details

Details

Details

Populates

Populates

Every ISO15288 Process May Use Virtual Models

Decision-Making of Every ISO15288 Process May Use Virtual Models

Modeling, Model VVUQ, and Model Use: ASELCM Ecosystem Overview Levels

V1.4.4 04.30.2020

Selecting Ecosystem Pattern Feature Options for a Configured Model

	Feature Configuratic	Feature Name	Feature Attribut	Populate? Yes/N	Selection 1	Selection 2	Selection 3	Selection 4	Selection 5	Selection 6	Selection 7	Selection 8	Selection 9	Selection 10	Selection 11	Selection 12
2	Optional	Acquisition	Acquisition Capability	Yes	Materials Acquisition Other Than for Target Systems and Component	Services Acquisition	Qualify Supplier	Incoming Acceptance Inspection	Observation Informed	Acquisition Report	Supply Agreement					
3	Optional	Architectural Definition	Architectural Definition Capability	Yes	Stakeholder Constrained	Experience Pattern Informed	Observation Informed	Logical Architecture & Alternatives	White Box Requirements, Logical Allocs	Black Box Reqs Consistent	Design Feedback to Reqs	Alternatives, Trades, Selection	Logical Architecture Report			
4	Optional	Business or Mission	Mission Analysis	Yes	Stakeholder Informed	Experience Pattern Informed	Observation Informed	Simulation Informed	Mission Features Report							
5	Optional	Design Definition	Design Capability	Yes	Observation Informed	Optimize MOEs, MOPs	Black Box Requirements Consistent	Design Feedback to Reqs	Alternatives, Trades, Selection	Physical Architecture & ign Report	Stakeholder Constrained	Experience Pattern Informed	Components and Alternatives			
6	Optional	Implementatio n	Implementati on Capability	Yes	Software Construction	Purchased Inclusion	Personnel Assignment	Facilities Construction		servation ormed	Implementation Report	Hardware Fabrication				
7	Optional	Feature With		Yes												
8	Optional	MBE Capability	MBE Capability	Yes	MBSE Models	FEA Models	CFD Models	SysDyn Models		chine rning Models	VirtReality Sim Models	AugReality Sim Models	Observation Informed	Experience Informed	Stakeholder Informed	Model Integrati Informed
9	Optional	Feature With Attributes But		Yes												
10	Optional	PBE Capability	PBE Capability Type	Yes	S* Patterns	Ontologies	Schema	Standards	PLE Variants	Math and Statistical Patterns	Human Expertise	Heuristics	Parent Pattern Experience Informed	Pattern Application Feedback	Observation Informed	Pattern Library
11	Optional	Project Assessment and Control	PAC Capability Type	Yes	Basic Project Assessment and Control	CAF Informed	Consistency Signature Informed	Drives Learning	S1 Environment Driven Agility	Market & Competitor Driven Agility	Stakeholder Driven Agility	Supply Chain Driven Agility				
12	Optional	Project	Increment													
13	Optional	Requirements Validation	Requirements Validation													

Observation Informed
Components and Altern
Optimize MOEs, MOPs
Black Box Requirement:
Design Feedback to Rec
Alternatives, Trades, Se
Physical Architecture & I

... | AcptdCln ed Expnd Ftrs Ints Rule | Merge 1 Table | Merge 2 Table | Selected Ftrs with No FPK | Append 1 Table | IO 4.1 2D Ftr Selection Mtx | 1D Popd Ftr FPKA FPKV ...