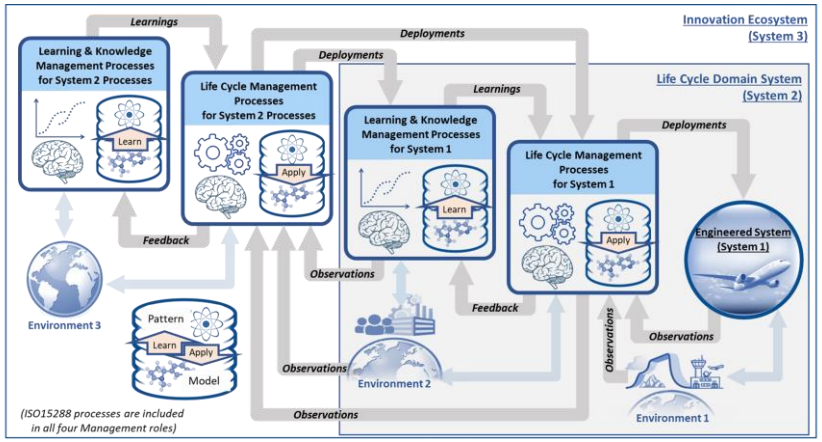
2023 Annual INCOSE international workshop

HYBRID EVENT

Torrance, CA, USA

January 28 - 31, 2023




ASELCM Level 1 Reference Model

# Discussion and References -- Decision Analysis Patterns

From: INCOSE MBSE Patterns Working Group

For: INCOSE Decision Analysis Working Group

Meeting of Jan 30, 2023

# Contents



**Attachments**:

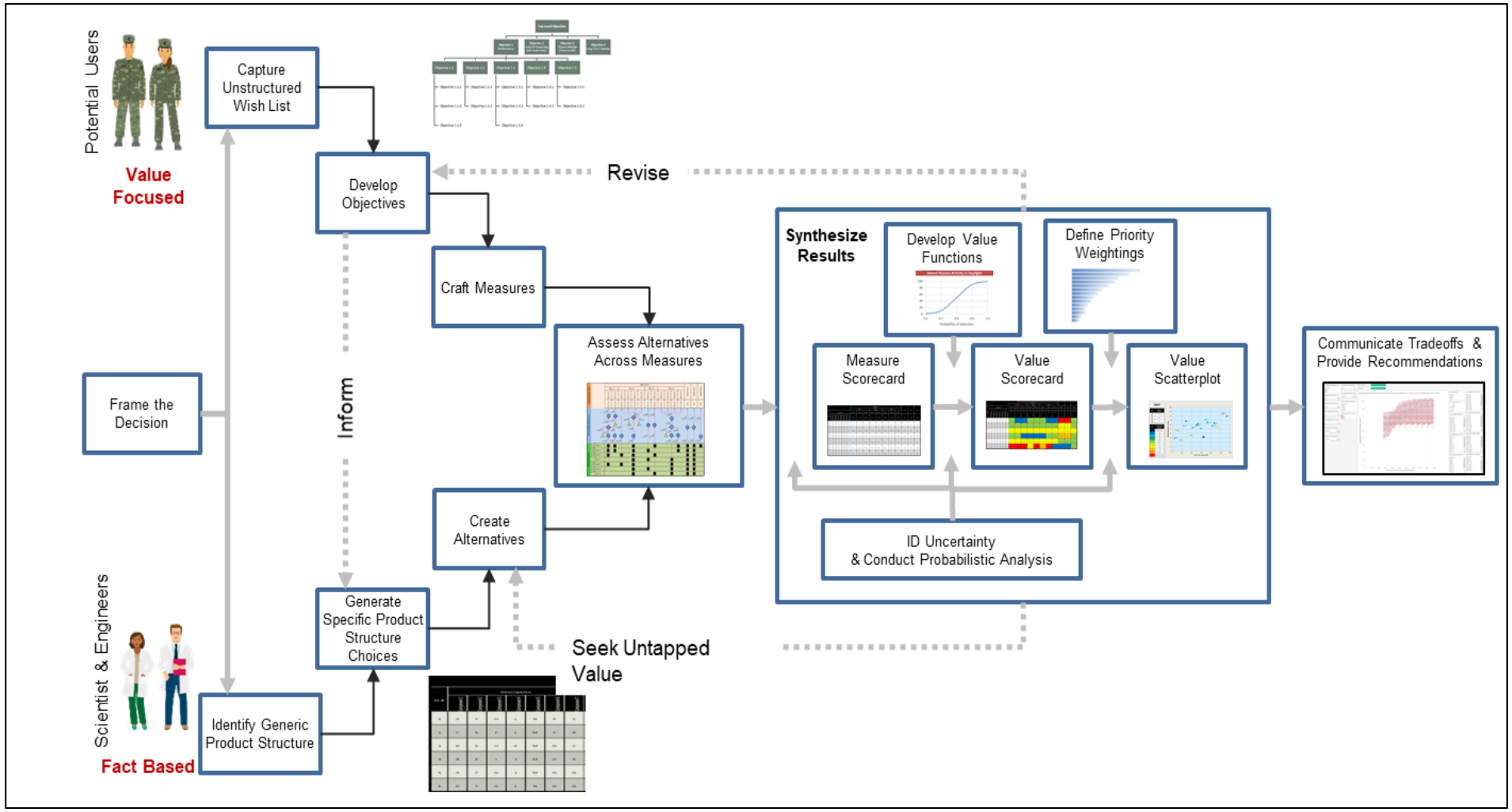
# Purpose and scope

- This material discusses the perceived relationship between the INCOSE Decision Analysis Working Group project on Decision Analysis templating, and the related formal pattern content of the INCOSE ASELCM  Innovation Ecosystem Pattern.
- This material is to support discussion of  possible collaboration between the MBSE Patterns  Working Group and the Decision Analysis Working Group.
- Expanded detailed discussion and examples are provided as Attachments.

# Decision Analysis Pattern: Potential Connection to DA WG Project

- The INCOSE Decision Analysis Working Group project is off to a good start to deliver initial practical value to SE practitioners:
  - By focusing on a “trade study” case of Decision Analysis, which is of wide interest in the System Design portion of Life Cycle Management.
  - For background, see Attachment 3.
- Without slowing that progress, the following describes a potential parallel activity using the general INCOSE Innovation Ecosystem Pattern:
  - Concerned with the whole Life Cycle Management range of many Decisions.
  - Therefore concerned with a more general (configurable) Decision Analysis Pattern.
- By initially showing how the more specialized “trade study” pattern is a configured specialization of the more abstract Innovation Ecosystem Decision Analysis Pattern.

# An example Trade Study Approach




From 2022 INCOSE Decision Analysis Working Group Project

# Innovation Ecosystem Pattern

Consistency Management Sub-Pattern

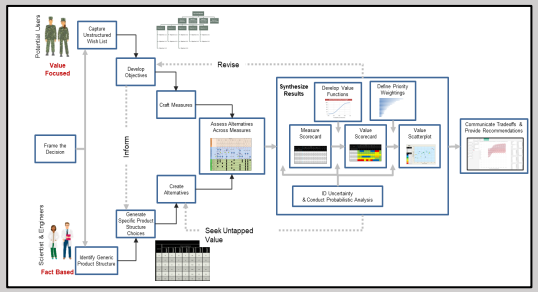
Decision Analysis Pattern Sub-Pattern

(INCOSE Patterns Working Group 2016-2022 ASELCM Project)

is a configuration of

This document explains this abstraction/specialization connection.

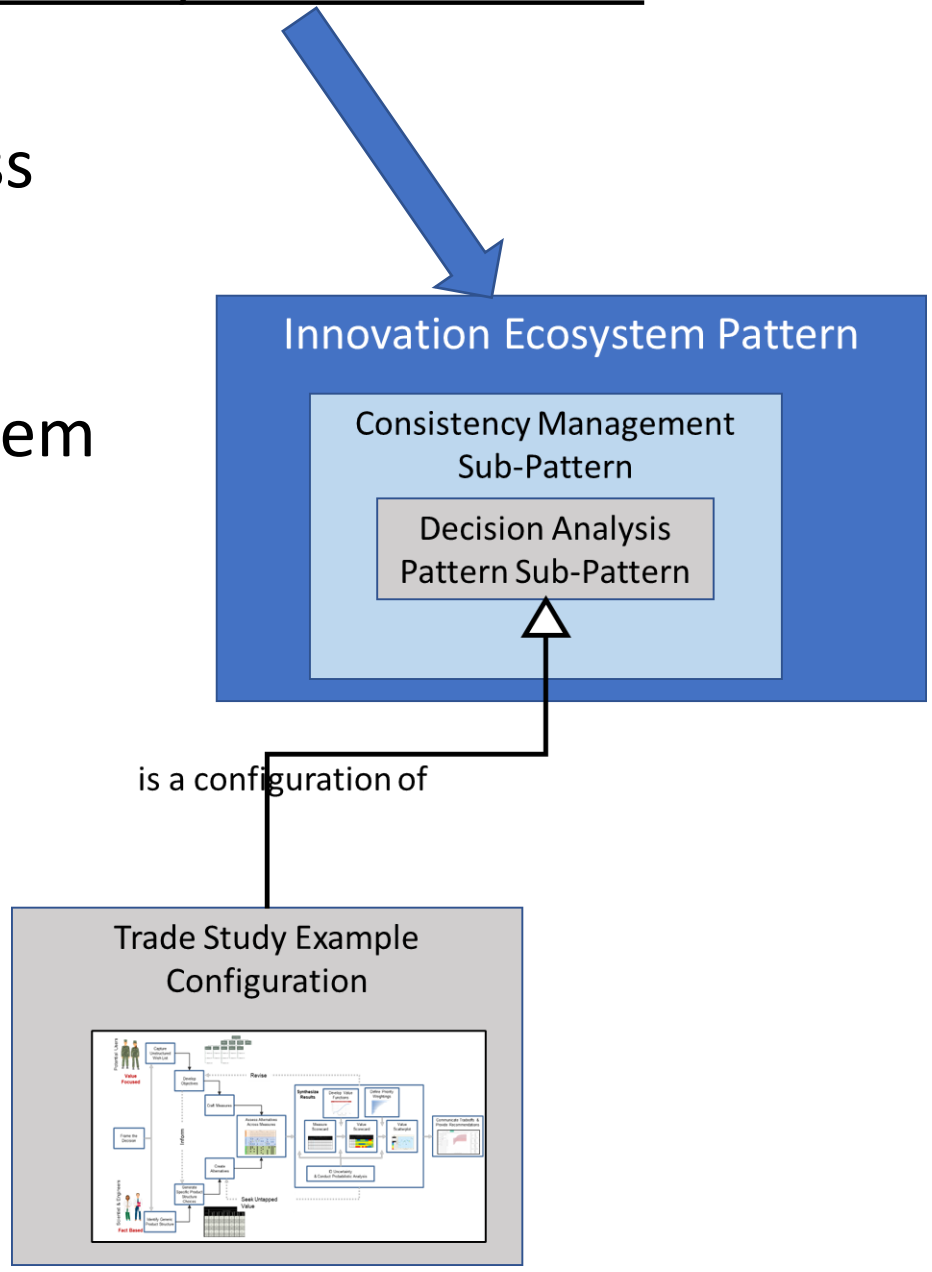
Trade Study Example Configuration



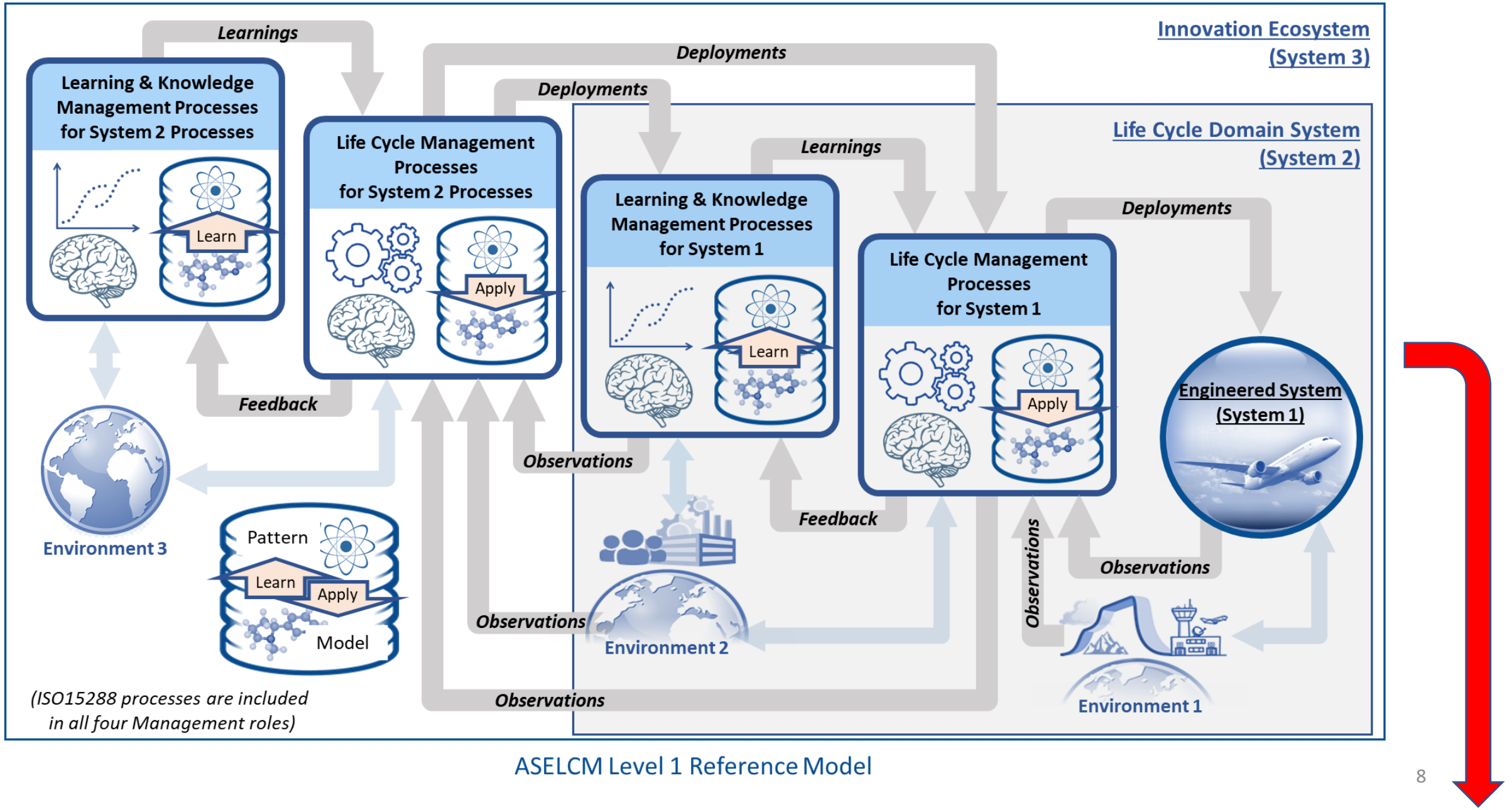
(2022 INCOSE Decision Analysis Working Group Project)

# Decision Analysis Aspects of the INCOSE ASELCM Innovation Ecosystem Pattern

A. The Innovation Ecosystem Level 2 Process and Information Pattern.
B. Beyond trade studies: Other types of consistencies & decisions across the System Life Cycle, subject to Selection Reconciliations.
C. Reconciliation Decision Interactions and Views.

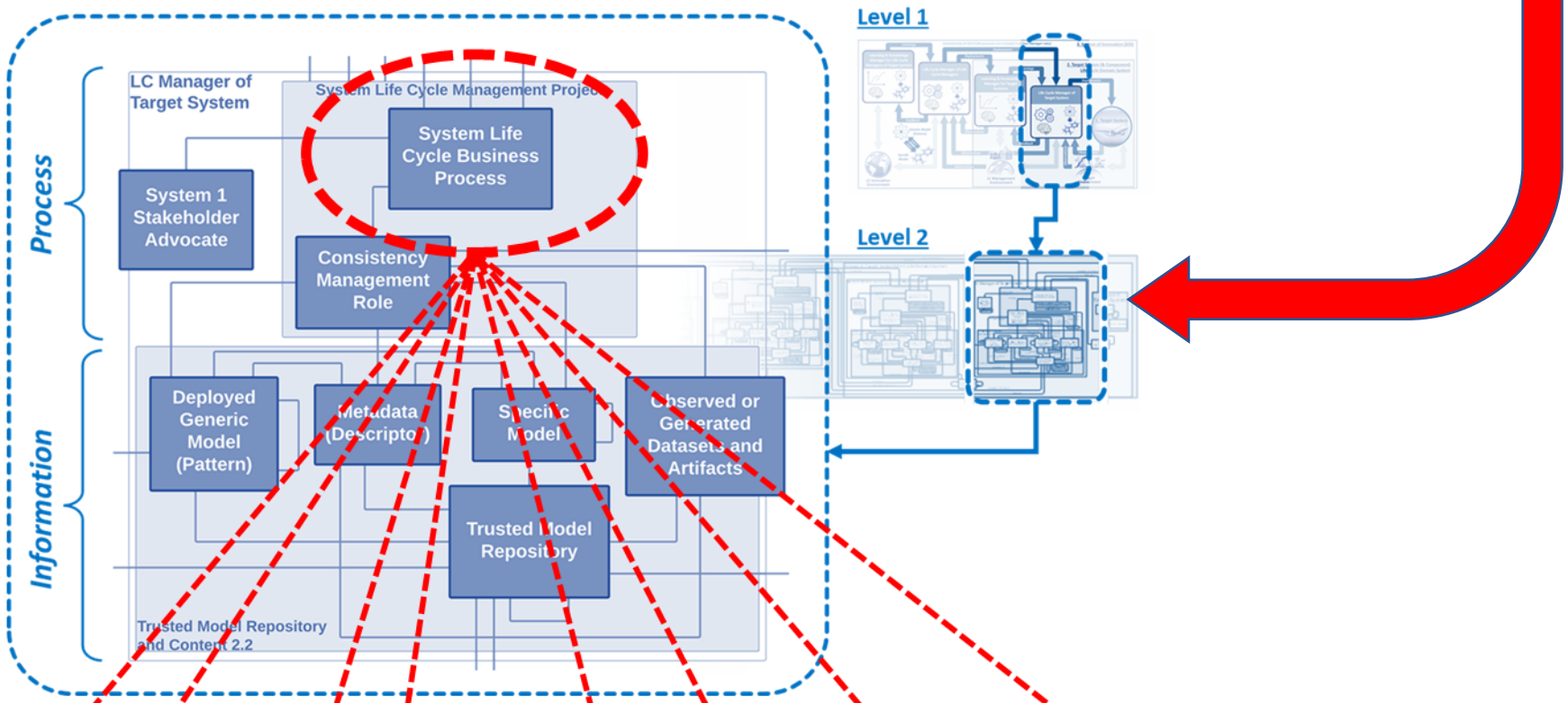


# A. The Innovation Ecosystem Level 2 Process and Information Pattern



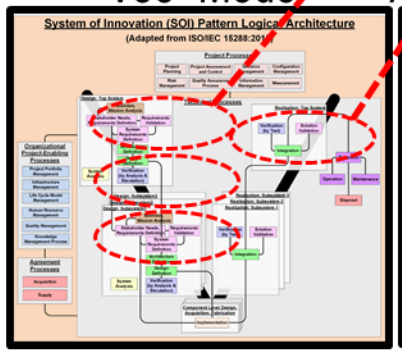

ASELCM Level 1 Reference Model

Drilling down: Level 2 configures to the business processes and information segments of the local organization.



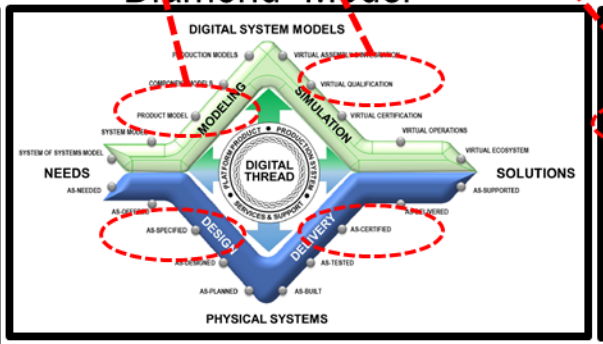

**Configurable to specific life cycle management models---**

ISO15288 Life Cycle "Vee" Model[1]

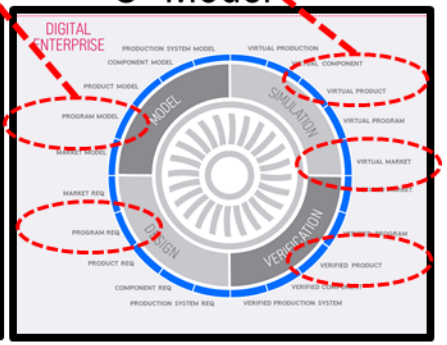



DoD 5000 Defense Acquisition Life Cycle Model[2]

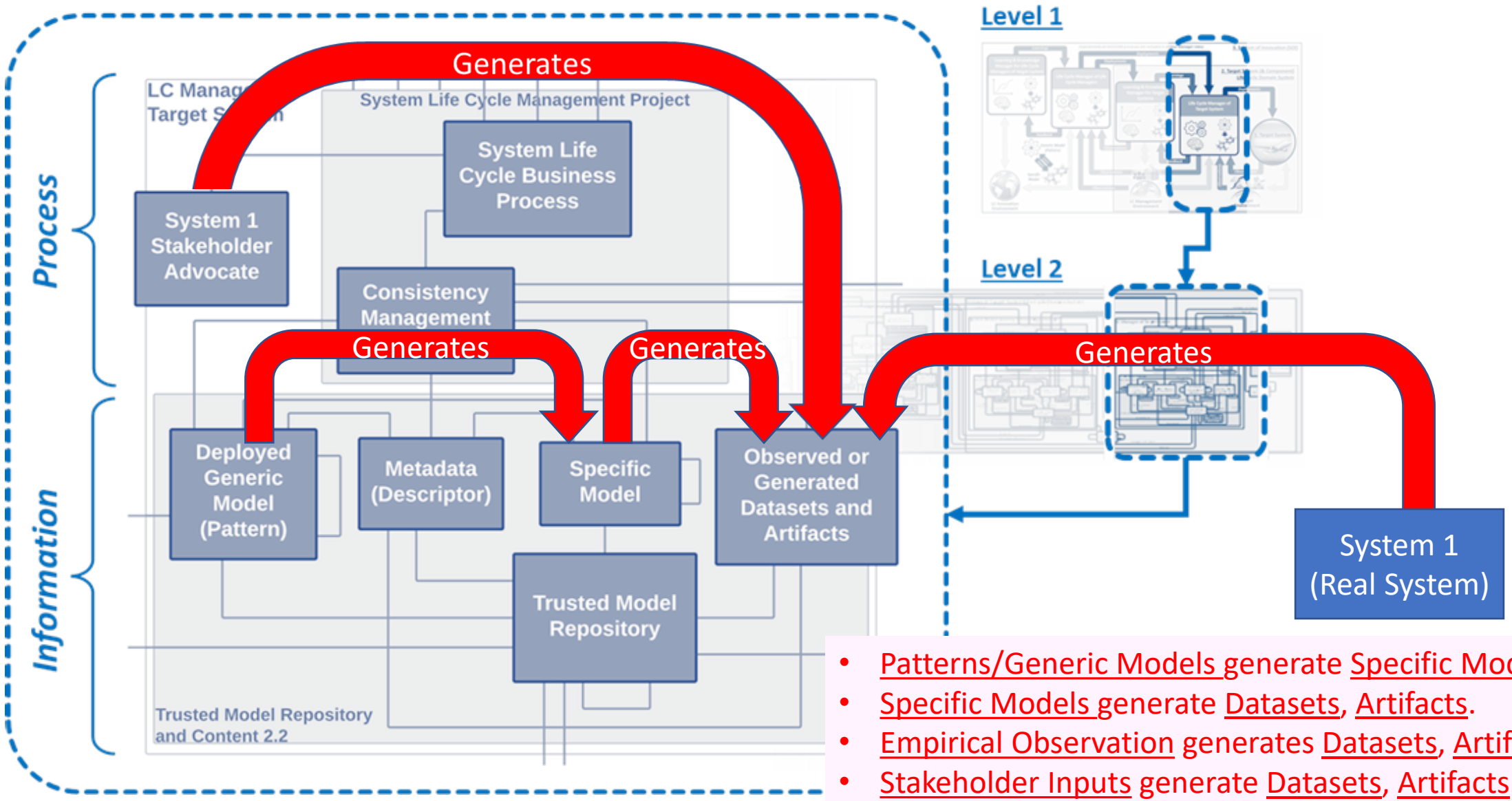

Boeing "Diamond" Model[3]



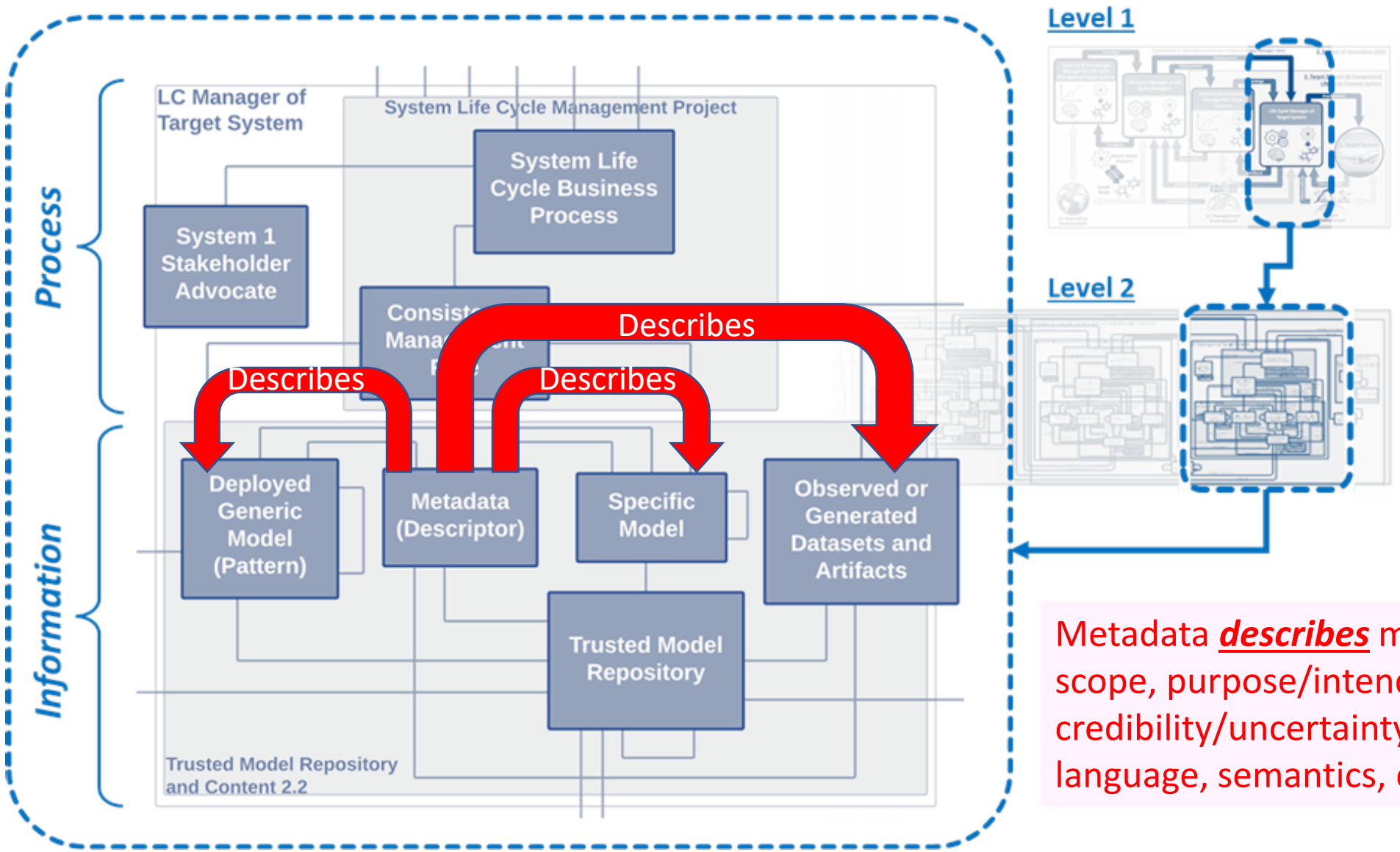

Rolls-Royce "O" Model[4]




Excerpted or adapted from: (1) ISO15288 and INCOSE SE Handbook; (2) DoD5000 Wall Chart; (3) AIAA Sci Tech, 01.2020, J. Matakeyama; (4) AIAA DEIC Digital Twin Subcommittee, 04.08.19 Donaldson, Flay, French, Matlik, Myer, Pond, Randjelovic

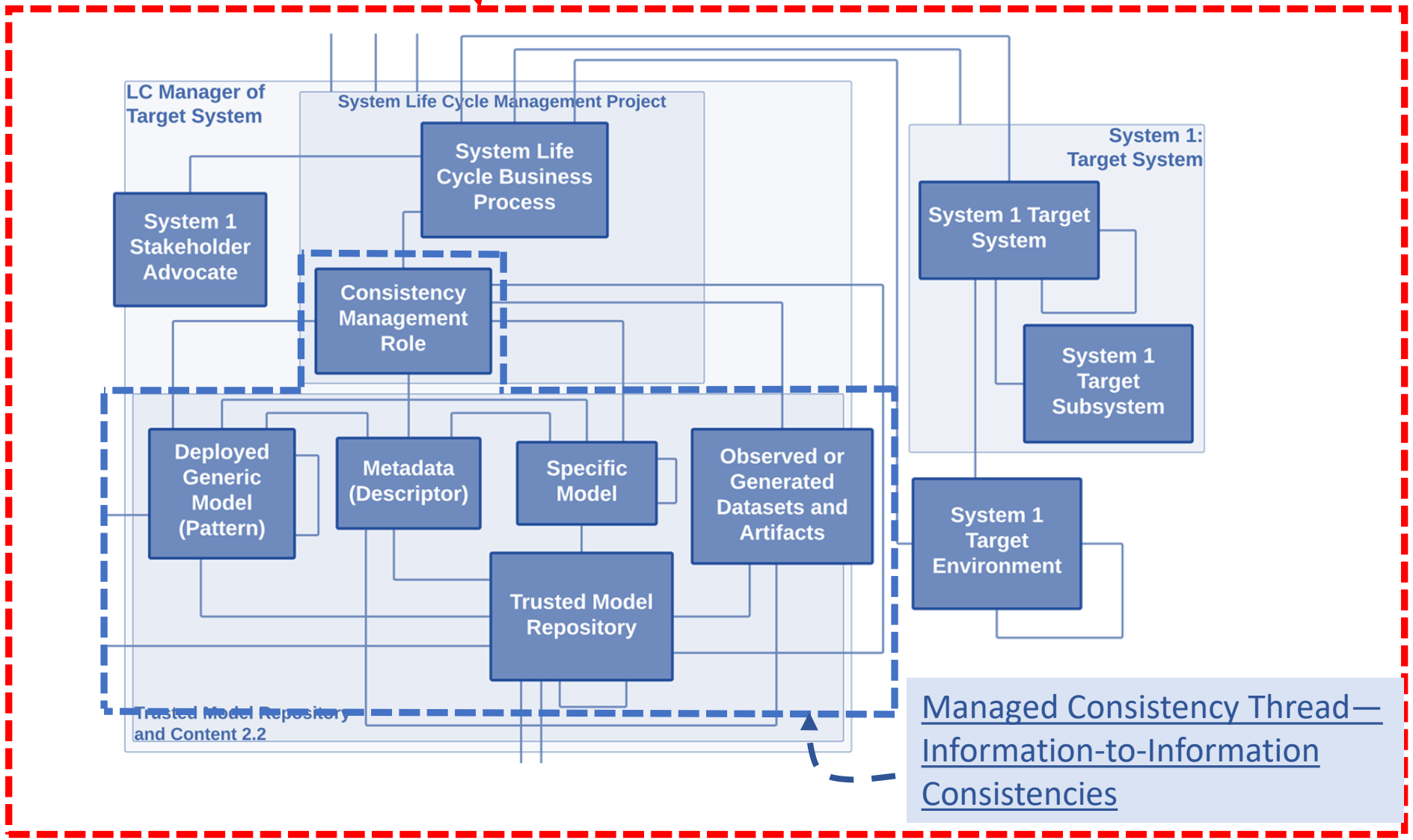



- Patterns/Generic Models generate Specific Models.
- Specific Models generate Datasets, Artifacts.
- Empirical Observation generates Datasets, Artifacts.
- Stakeholder Inputs generate Datasets, Artifacts.



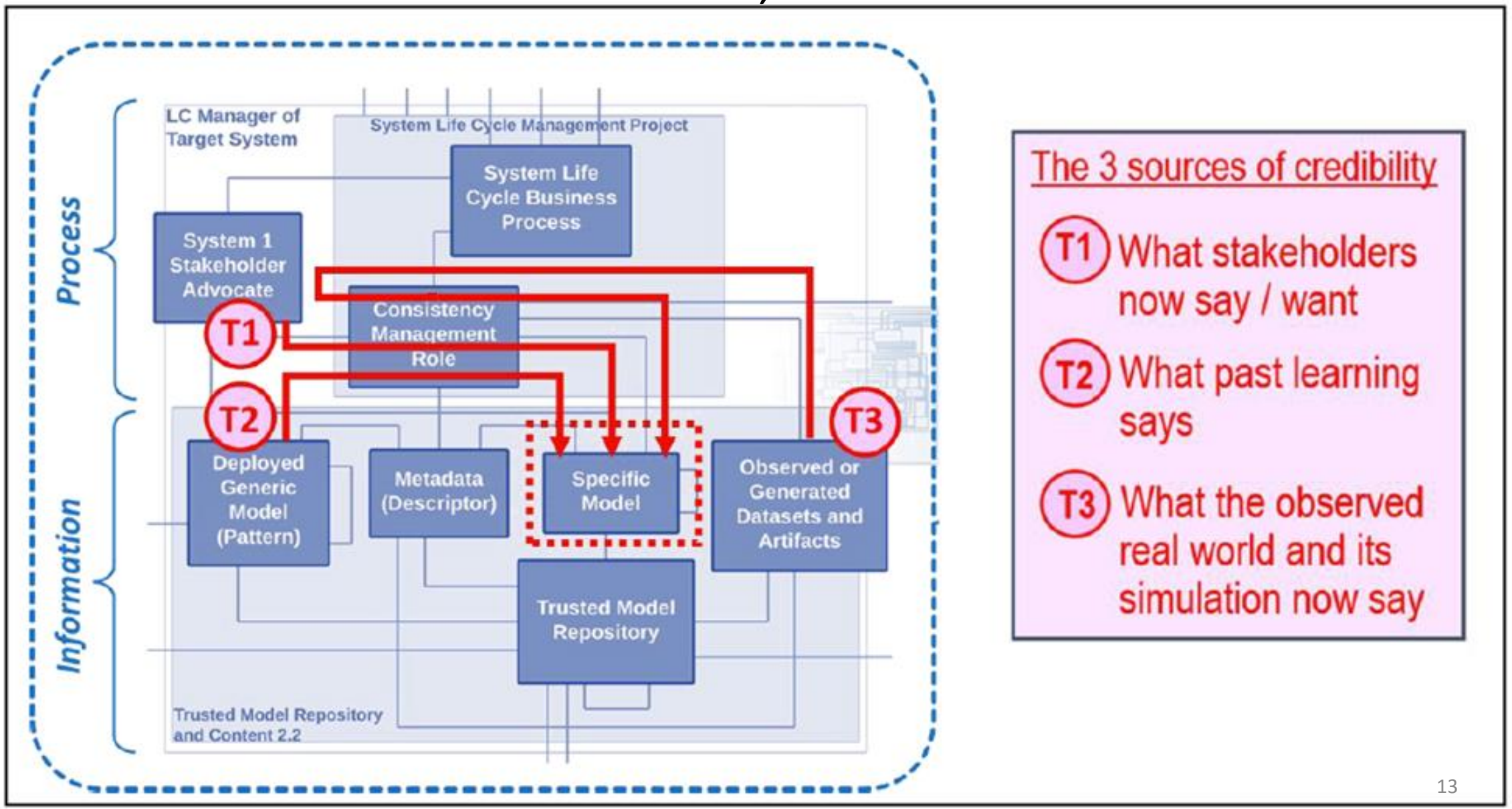

Metadata ***describes*** model and data scope, purpose/intended use, credibility/uncertainty, provenance, language, semantics, consistencies, etc.

Managed Consistencies Boundary—
Information - to - External World Consistencies

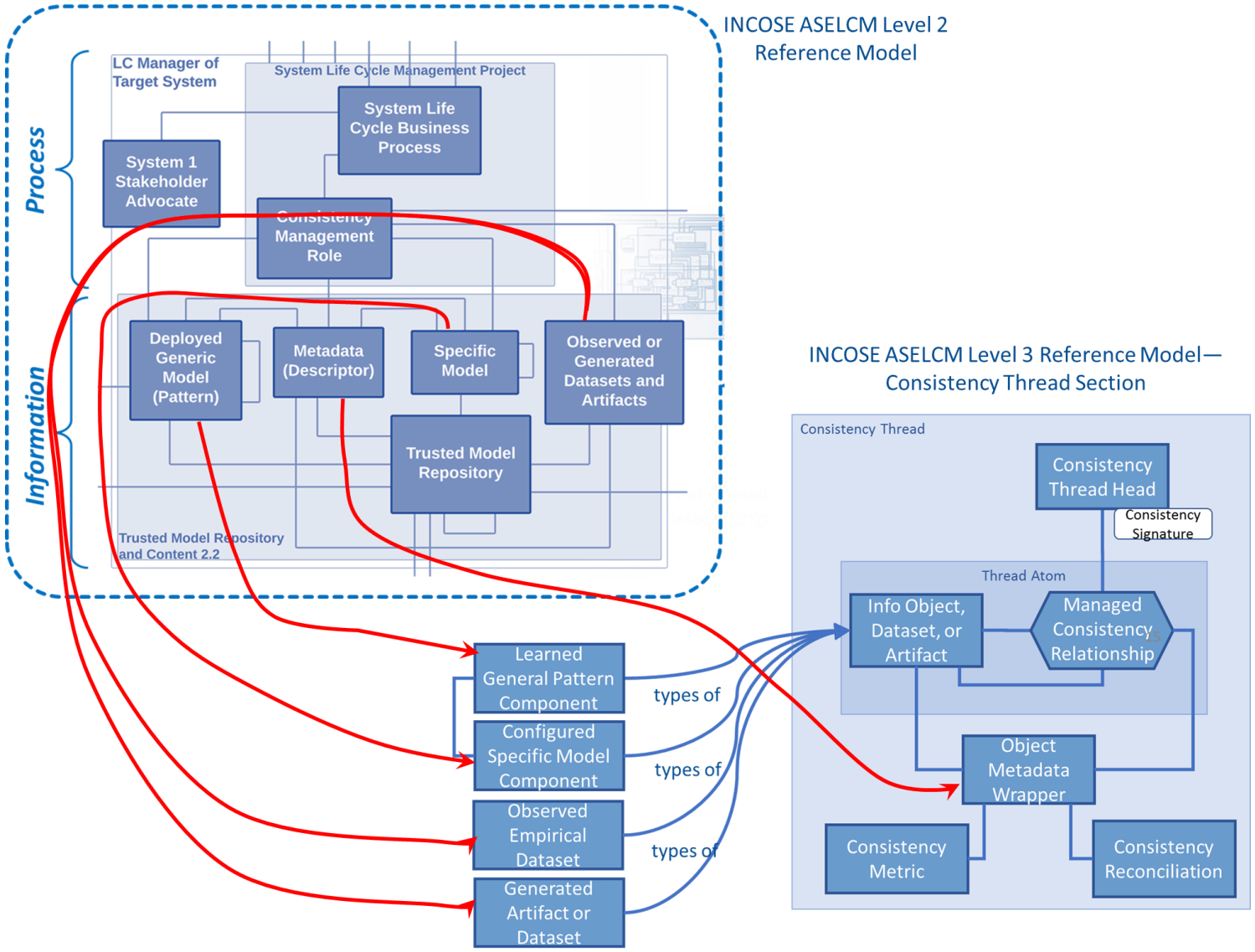



Managed Consistency Thread System Boundaries

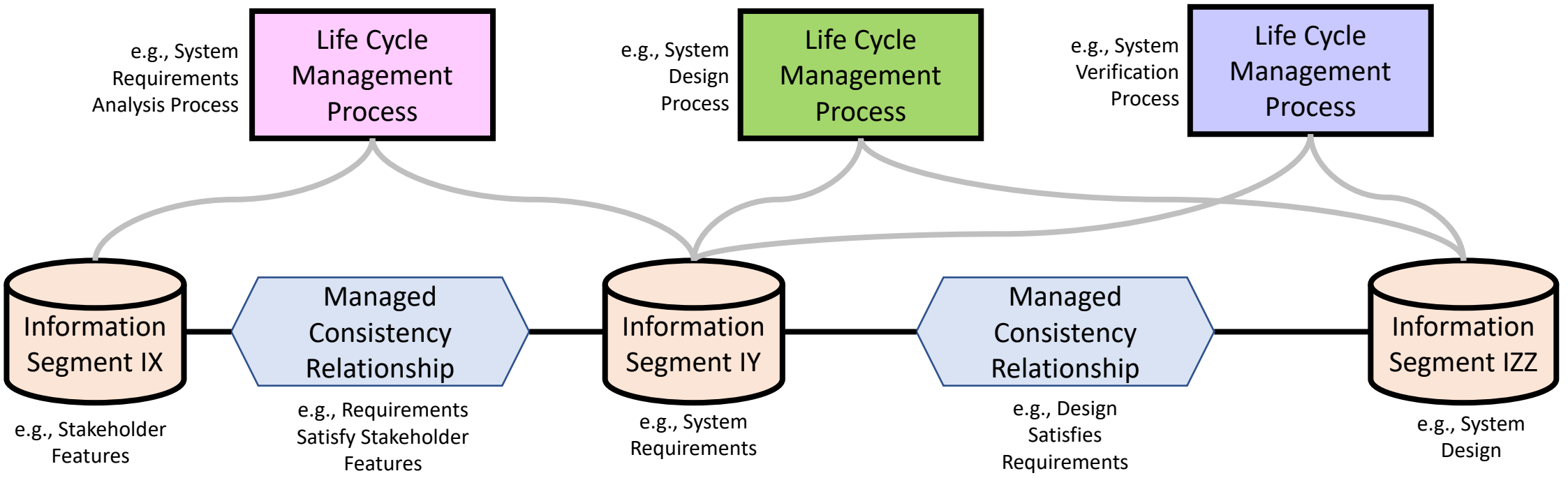
# These three key sources of credibility or authority nevertheless are often in conflict with each other, and must be reconciled

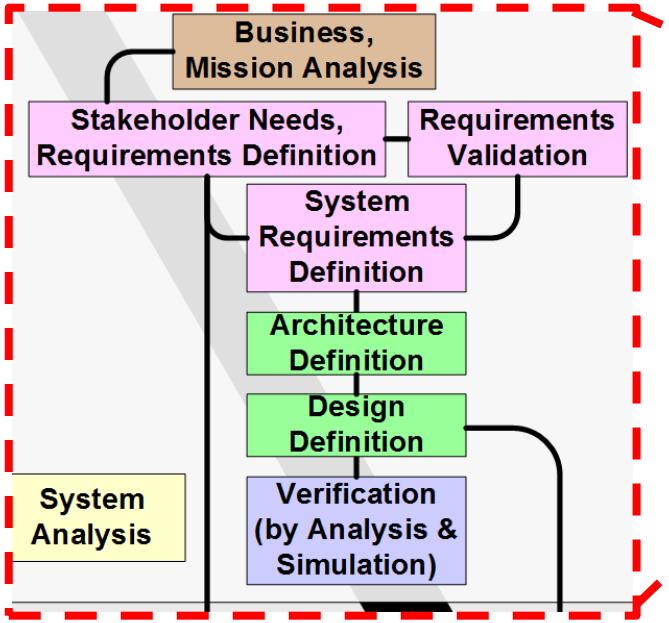


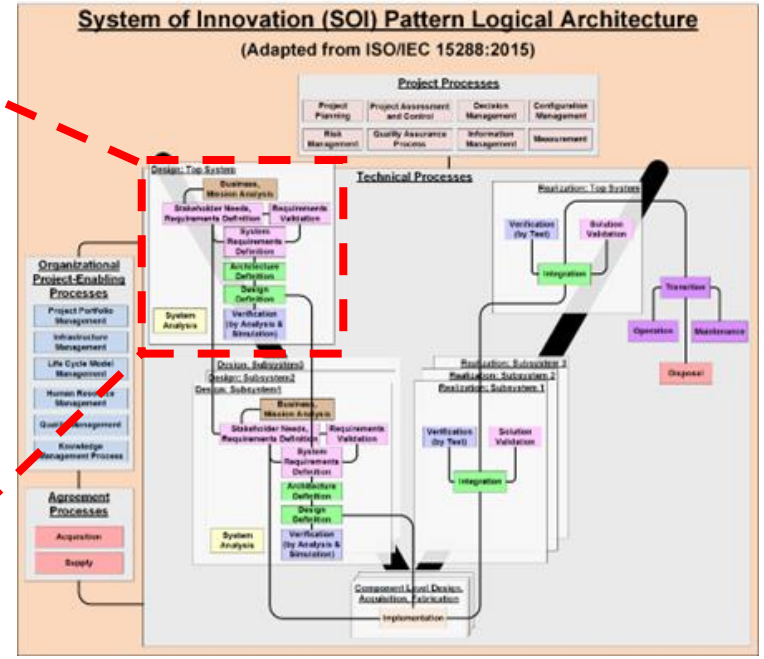
# Consistency Threads: Predecessors to the Digital Thread




- The general ecosystem reference pattern for Consistency Threads includes the use of learned experience patterns in the resulting Digital Threads.
- For Digital Threads within System 2, this describes learned patterns about System 1, the Engineered System, and its environment.
- For Digital Threads within System 3, this describes learned patterns about System 2, *including its decision-making processes.*

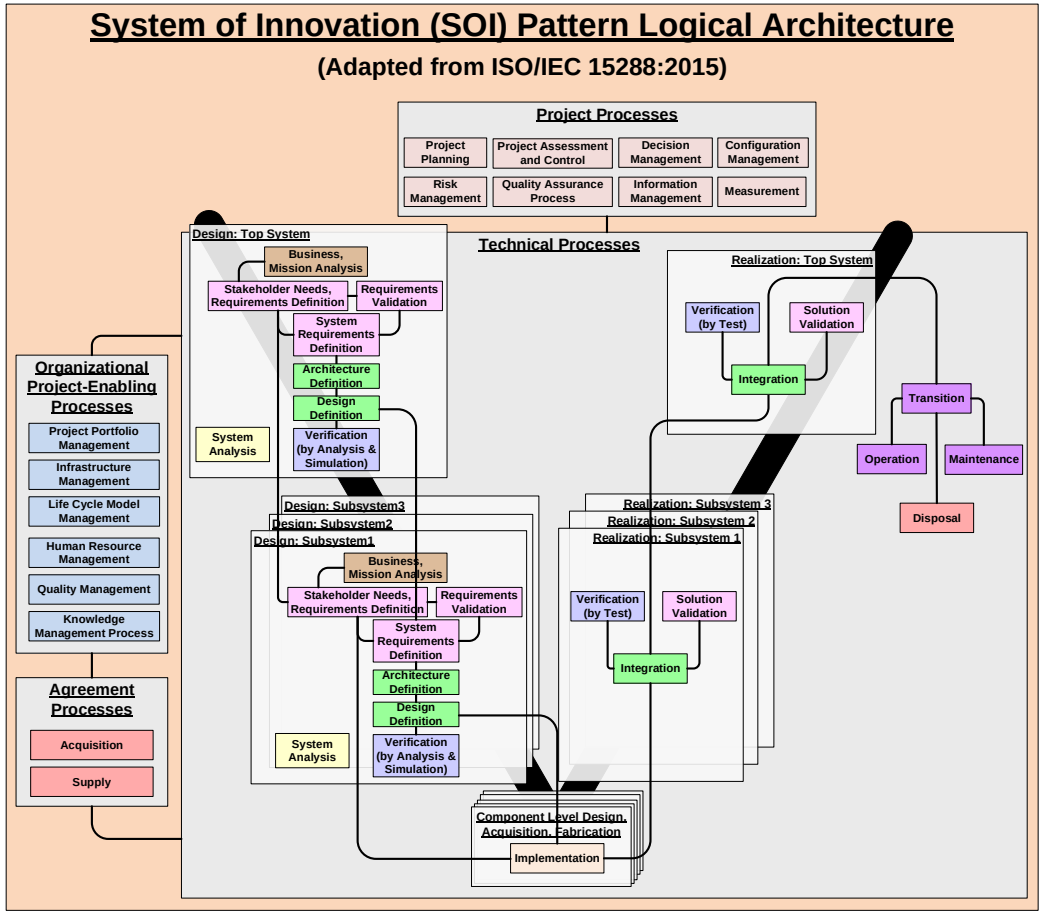

e.g., System Requirements Analysis Process
Life Cycle Management Process
e.g., System Design Process
Life Cycle Management Process
e.g., System Verification Process
Life Cycle Management Process
Information Segment IX
Managed Consistency Relationship
Information Segment IY
Managed Consistency Relationship
Information Segment IZZ
e.g., Stakeholder Features
e.g., Requirements Satisfy Stakeholder Features
e.g., System Requirements
e.g., Design Satisfies Requirements
e.g., System Design


Business, Mission Analysis
Stakeholder Needs, Requirements Definition
Requirements Validation
System Requirements Definition
Architecture Definition
Design Definition
System Analysis
Verification (by Analysis & Simulation)


System of Innovation (SOI) Pattern Logical Architecture
(Adapted from ISO/IEC 15288:2015)
Project Processes
Technical Processes
Organizational Project-Enabling Processes
Agreement Processes

# B. Beyond trade studies: Other types of consistencies & decisions cross the System Life Cycle, subject to Selection Reconciliations

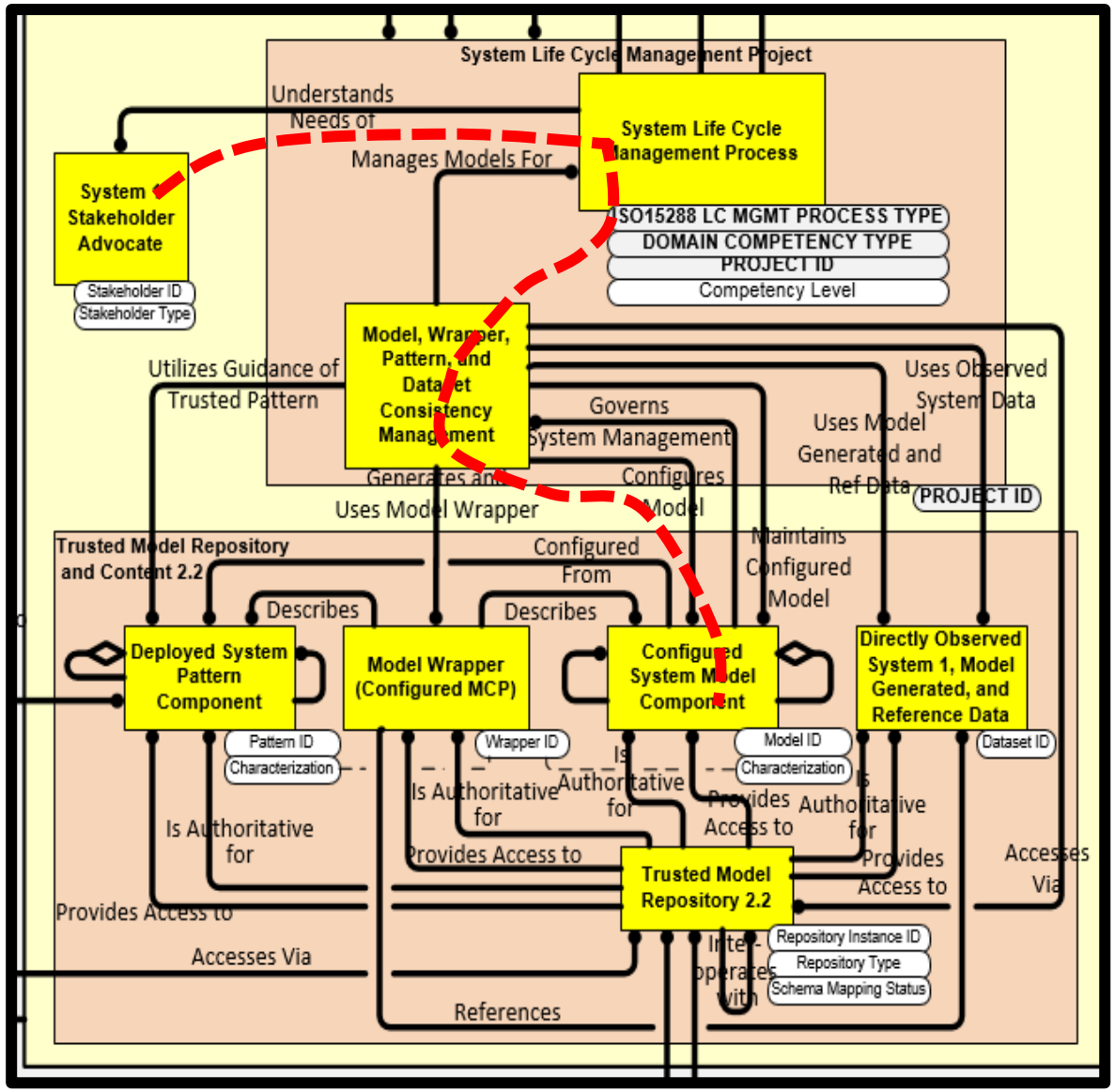
- The ISO/IEC 15288 (or INCOSE SE Handbook) provides a community credible list of life cycle management processes for systems.
- From these, we can infer a list of consistencies that these processes effectively seek to manage.
- For example: The consistency of a Design with Requirements. (Note that such a relationship can include the "optimality" constraint that there is no alternate consistent Design that is superior in its Requirements satisfaction.)
- So, what does this "consistency" look like?



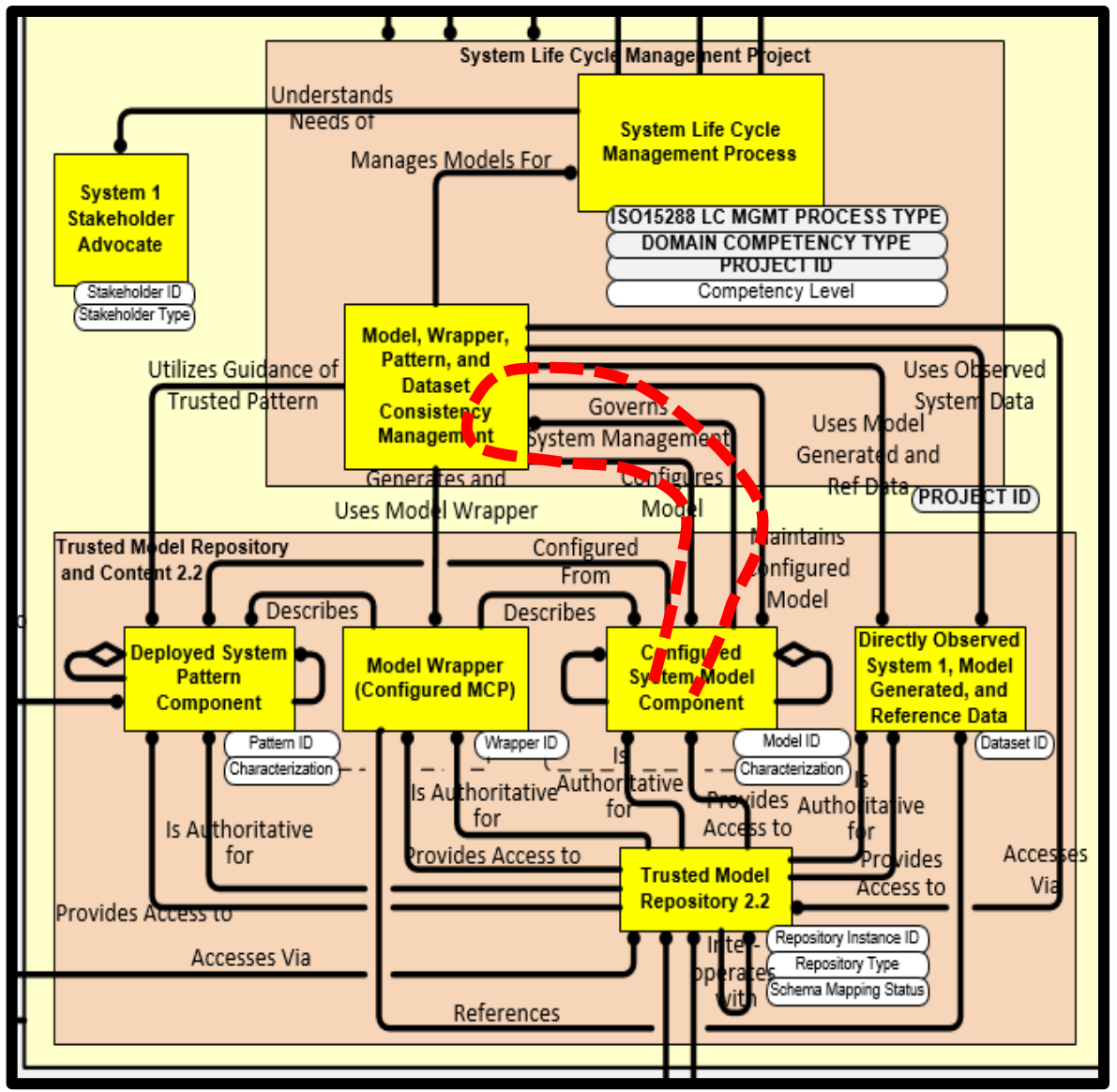
# Consistency Management as a Central Paradigm for Digital Engineering

- All the following cases of Consistency Management (and more) are *already historically performed* (well or not so well) by human labor and/or automated aids, even when the information involved is in human brains or prose specs.
- The recognition of Consistency Management is not new with the arrival of models, but . . .
- Current interest in Digital Engineering presents the opportunity to plan better solutions to the following cases of consistency management, as well as others . . .

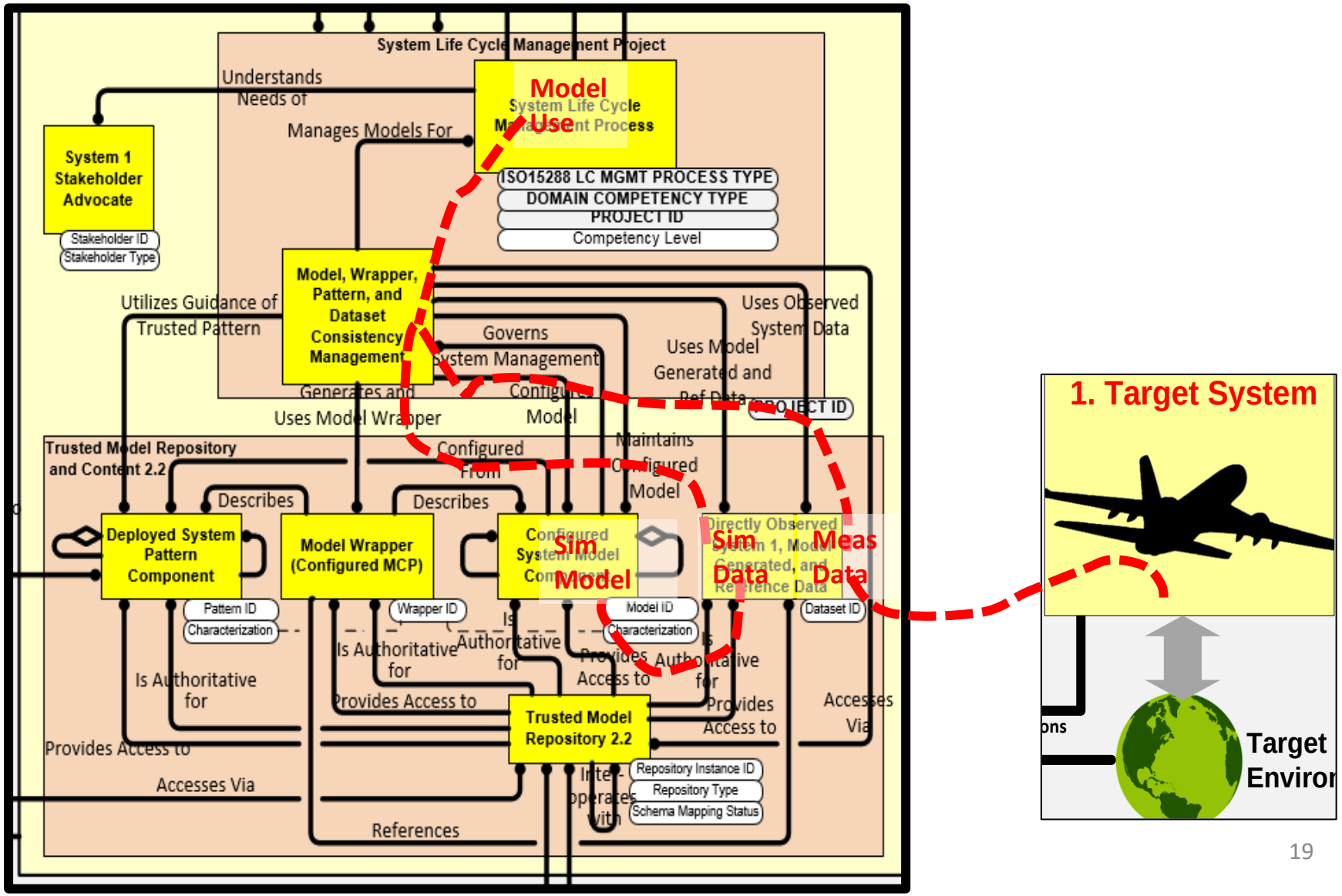
# Are the customer's expectations represented (well enough) by the modeled requirements?




# Are the product requirements consistent with the product design?

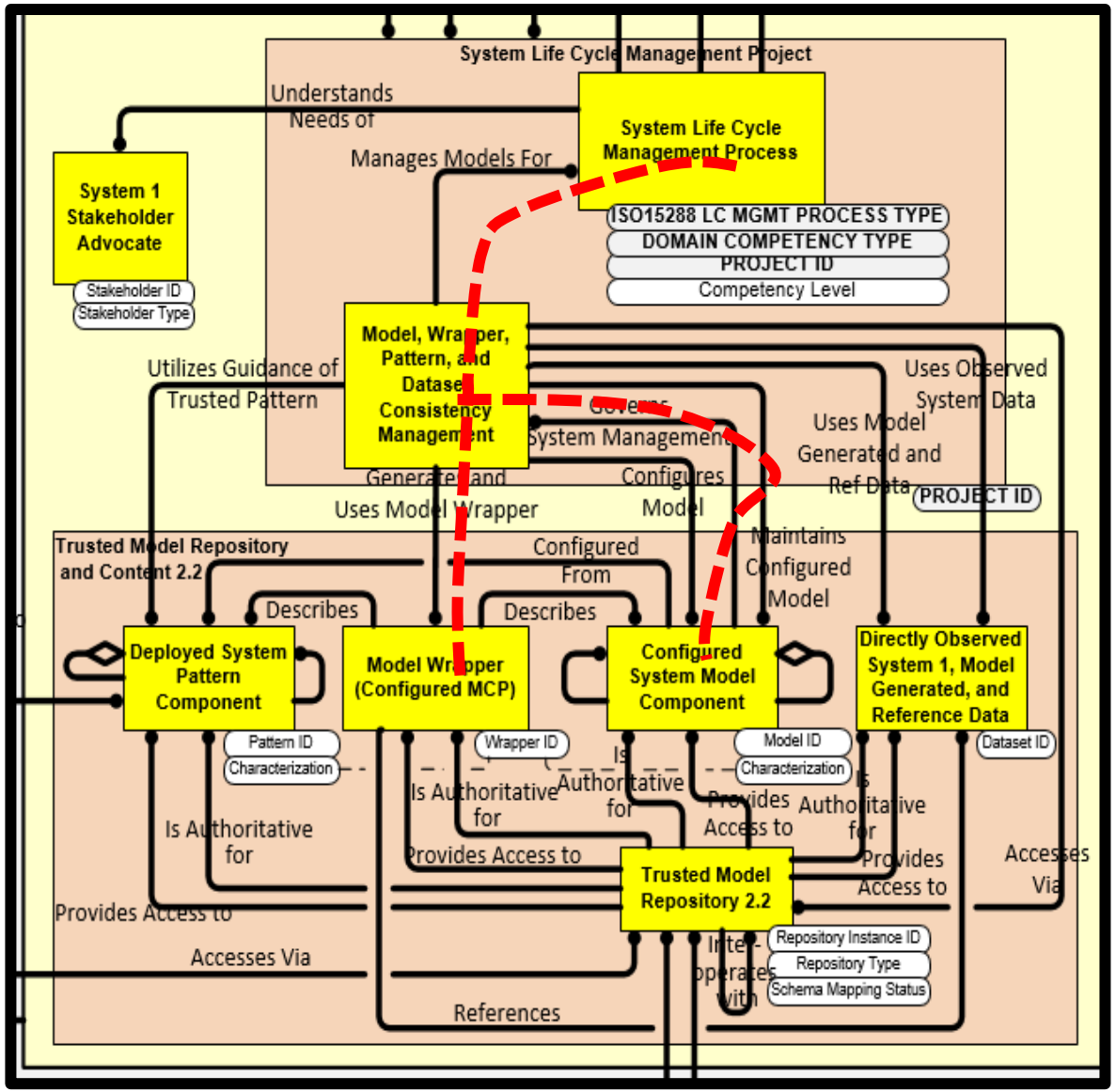


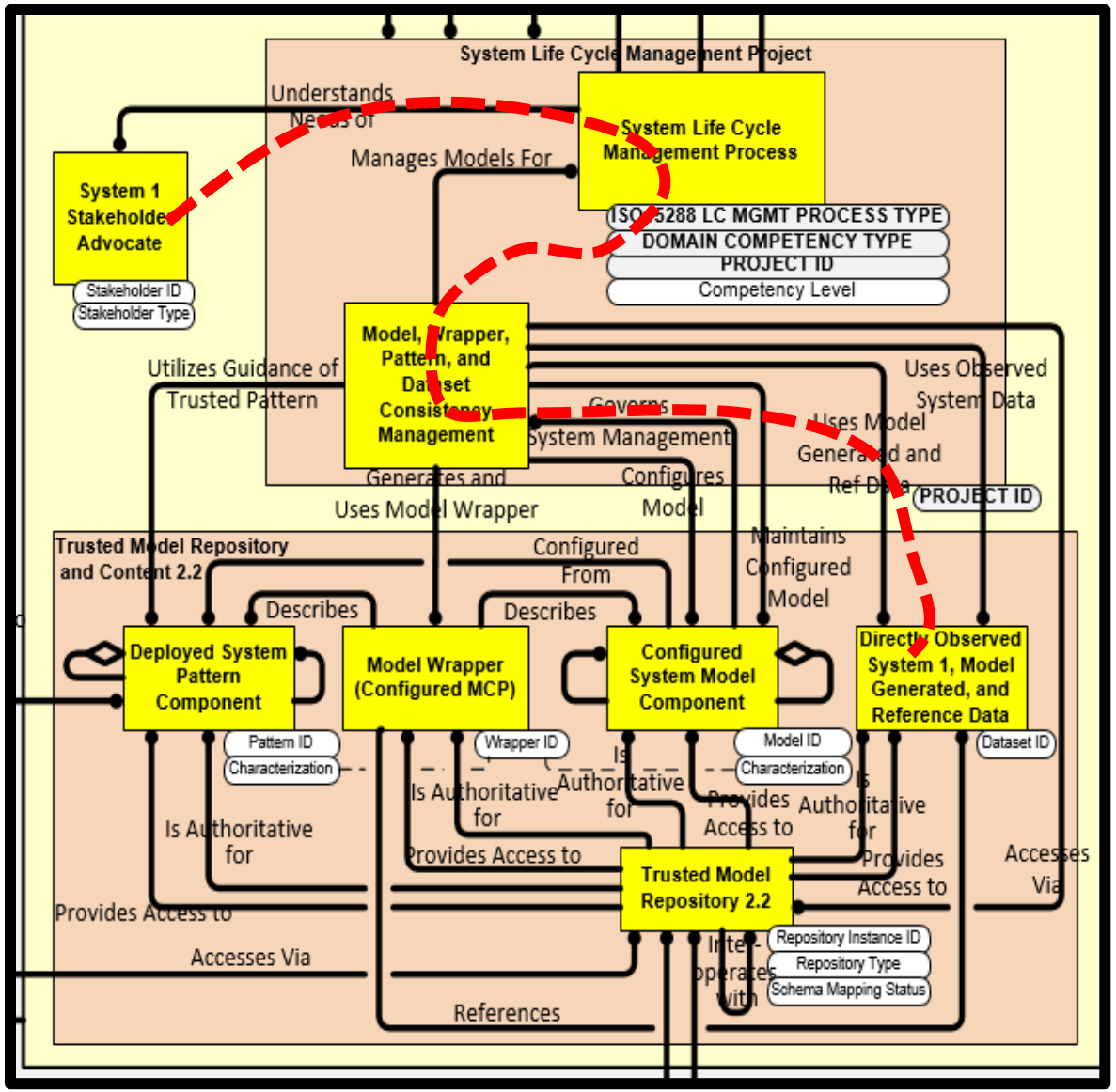
# Is the simulation model consistent (enough) with the physical system? (i.e., Model VVUQ)



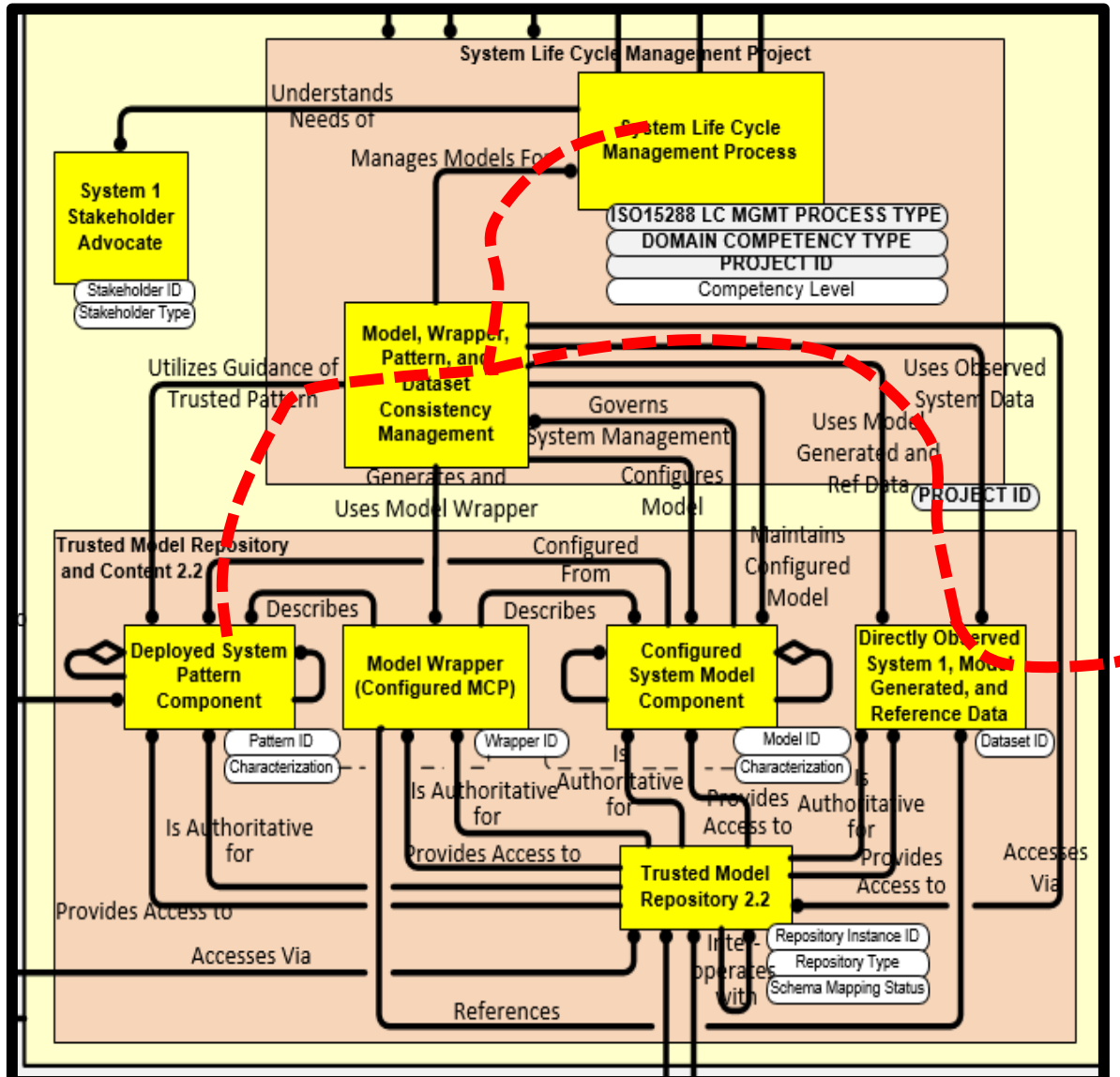
Is there already a credible simulation model available for the business purpose at hand?

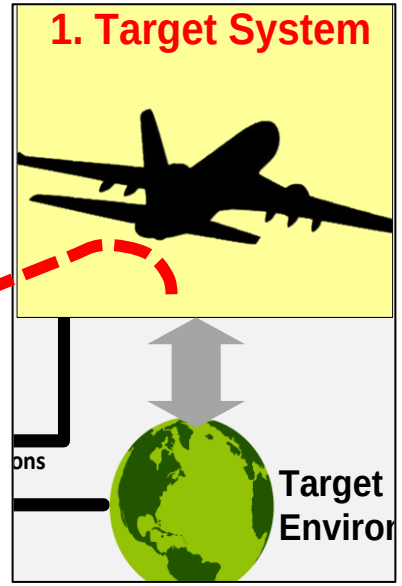
Is the simulation consistent with system performance that  the customer expects?



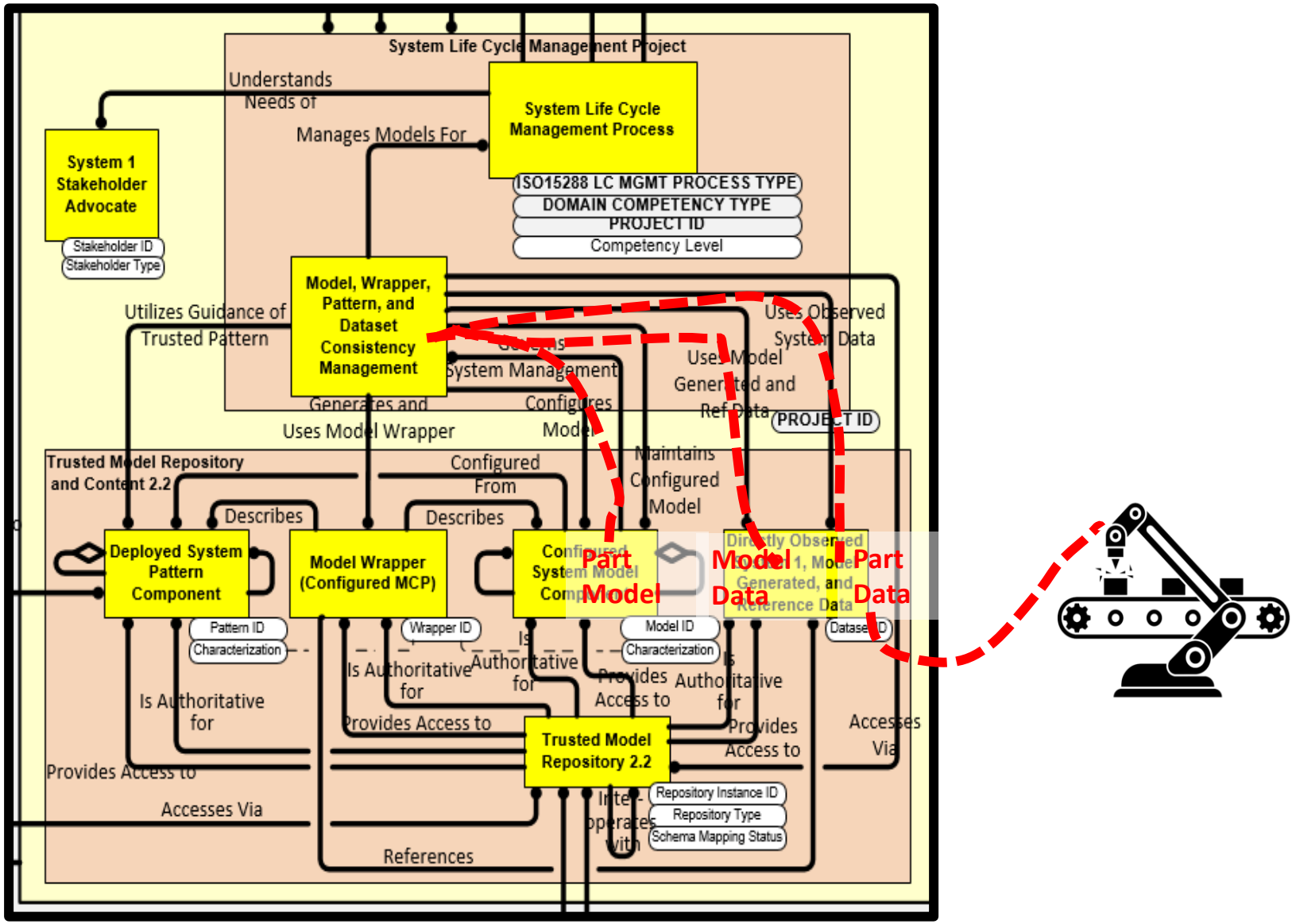



# Is the customer sustainment service based on information consistent with learned product operating characteristics?

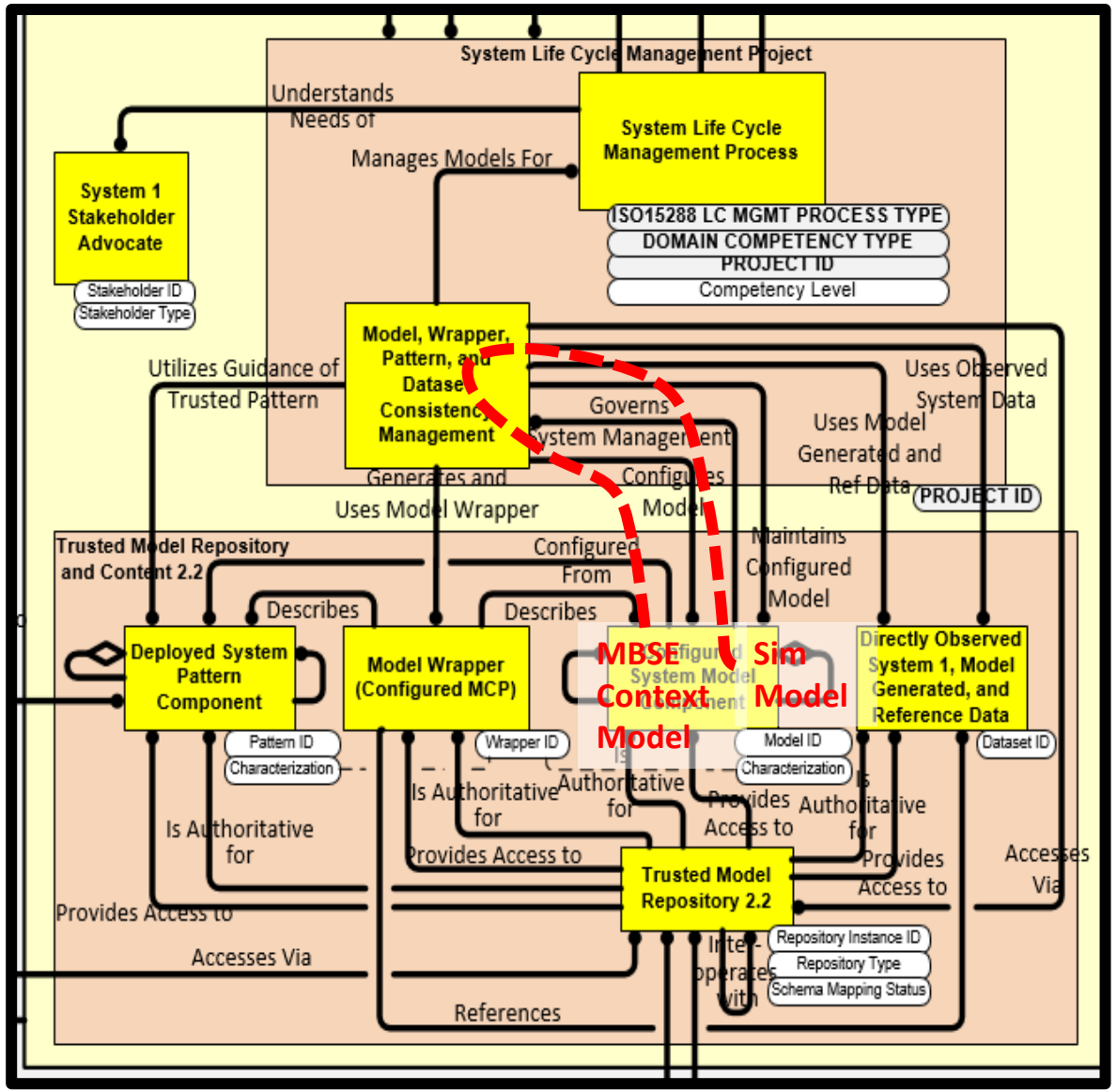


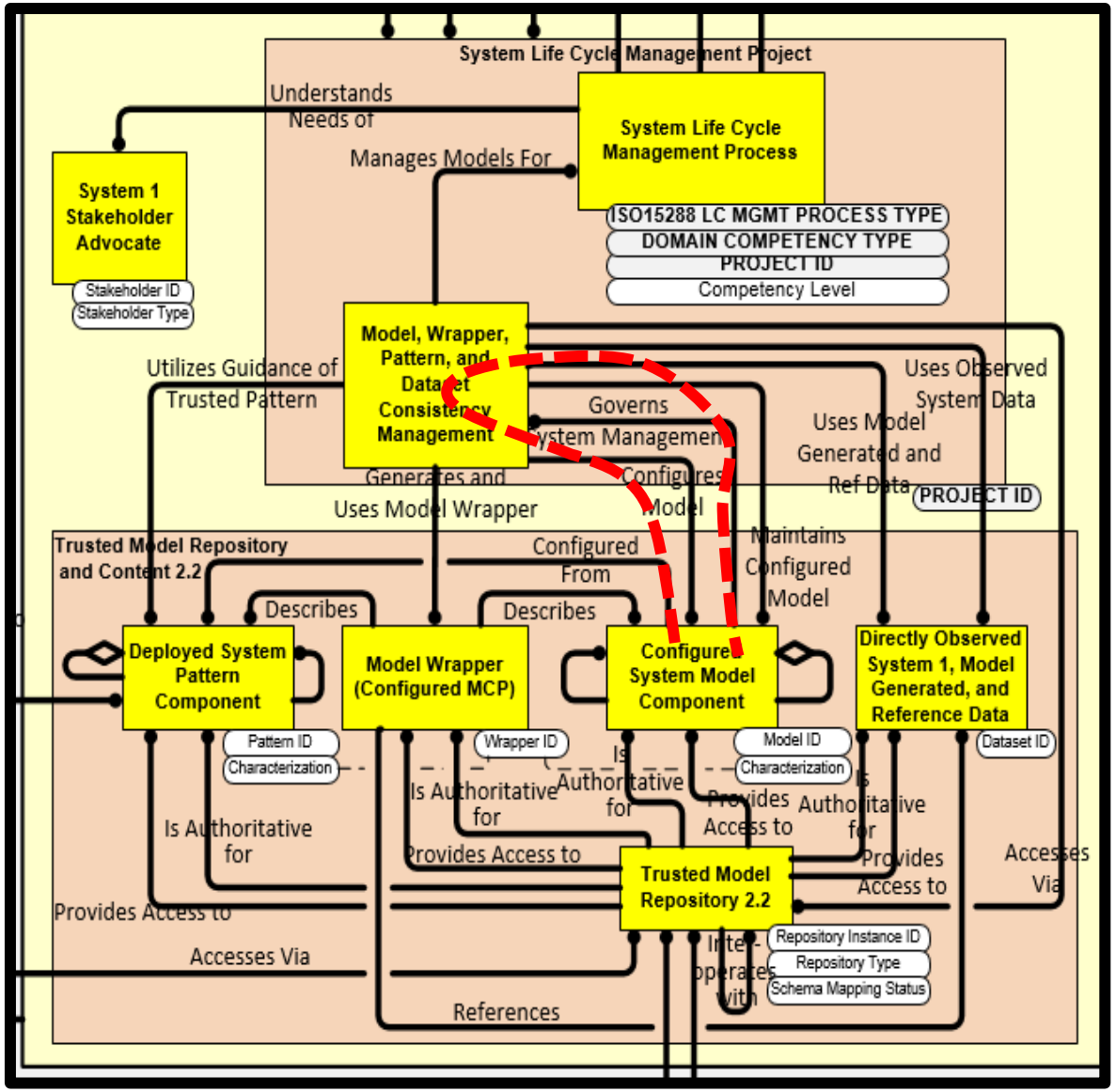
# Are the incoming supply chain parts consistent with modeled inspection criteria?



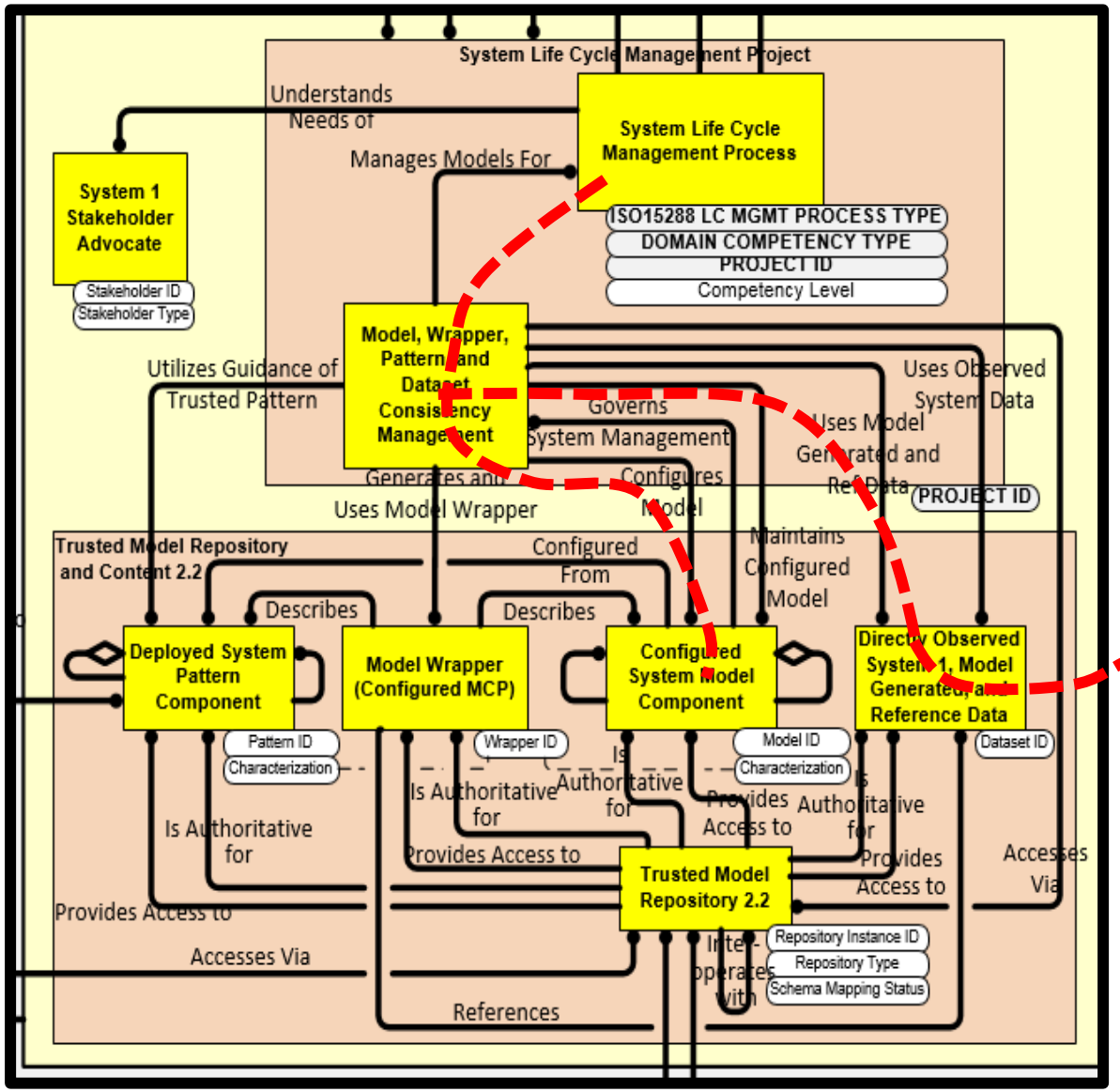
# Is the component simulation model consistent with the overall MBSE model?

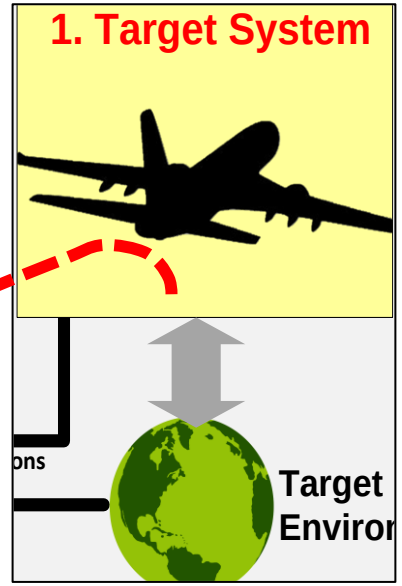



# Is the Tier 1 Airframe Customer model consistent (enough) with the As Designed Subsystem Supplier Model?

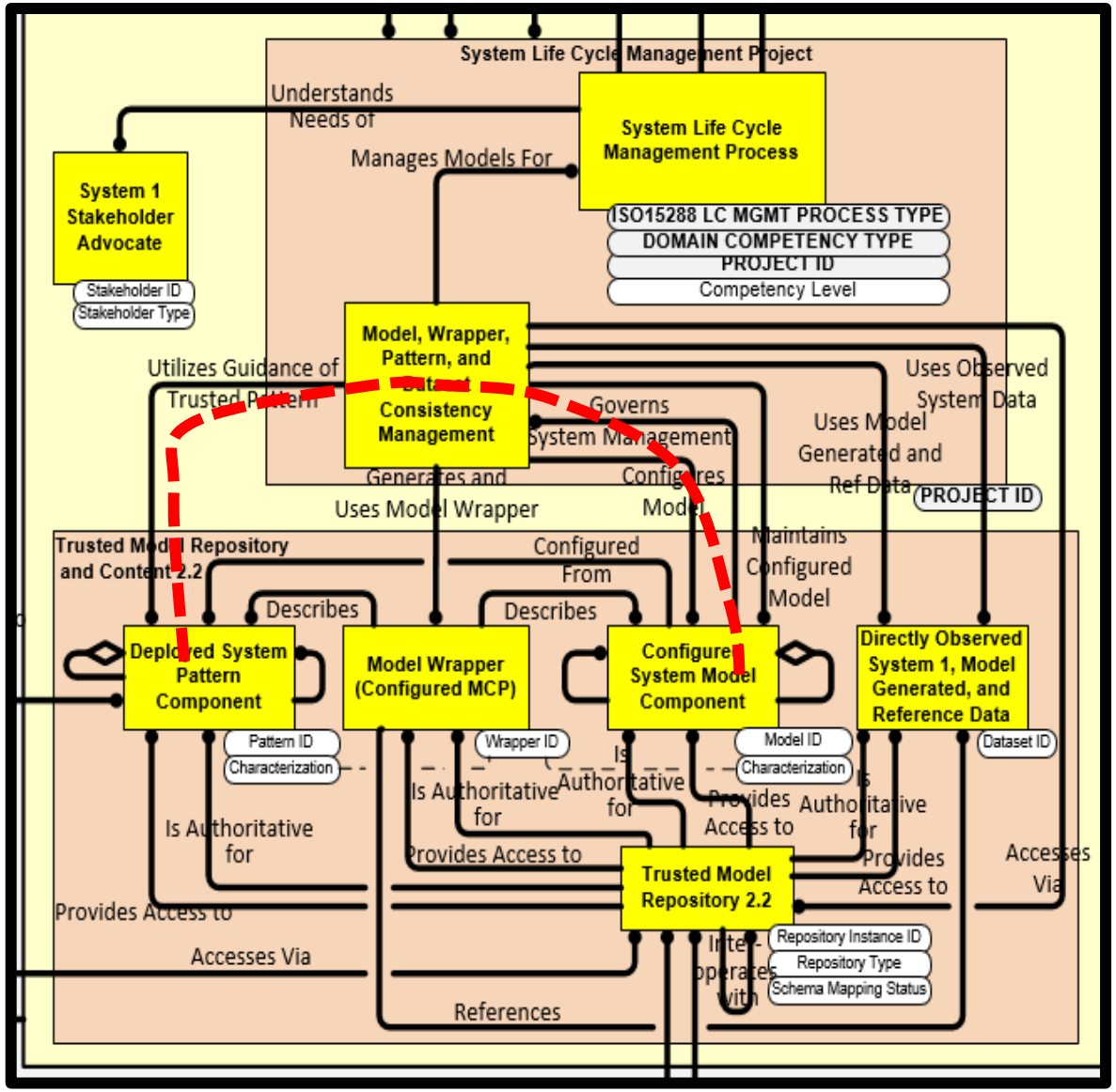


# Is the “As Designed” Model consistent (enough) with the “As Used” Observations?

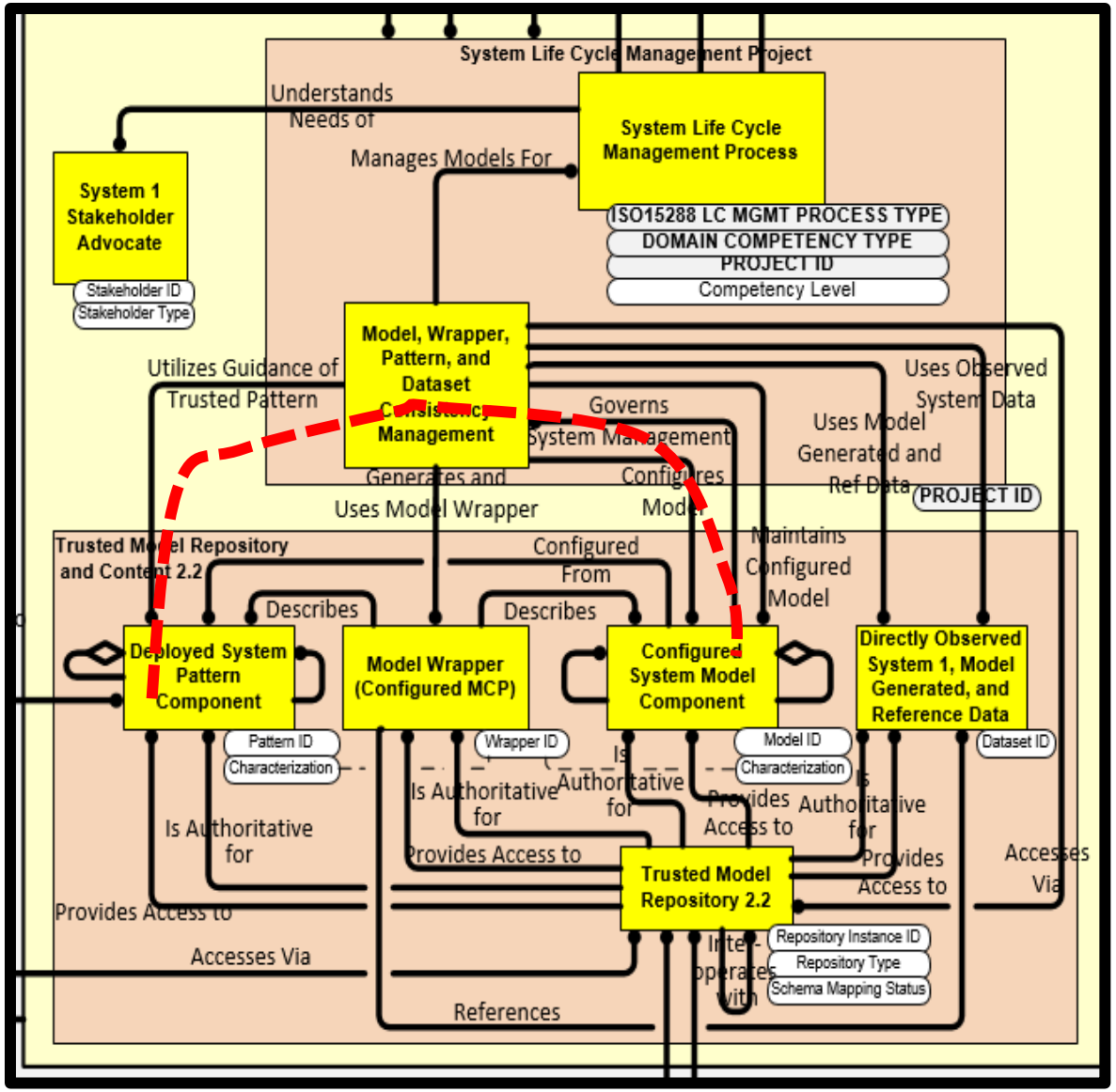


Does the System Model reflect what we have learned from past projects' results?

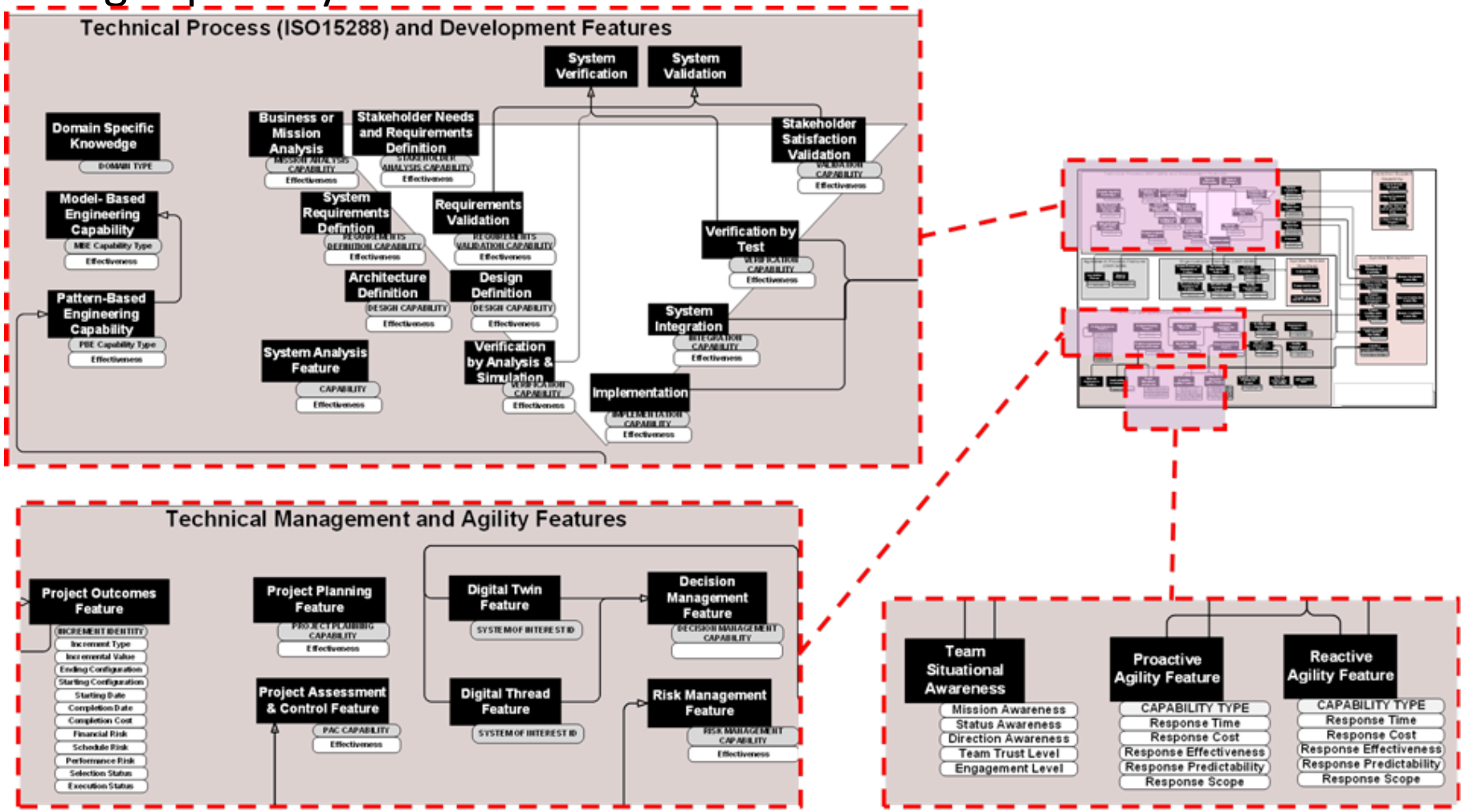



Is the current project's system Model consistent with customer/industry standard ontologies/frameworks?



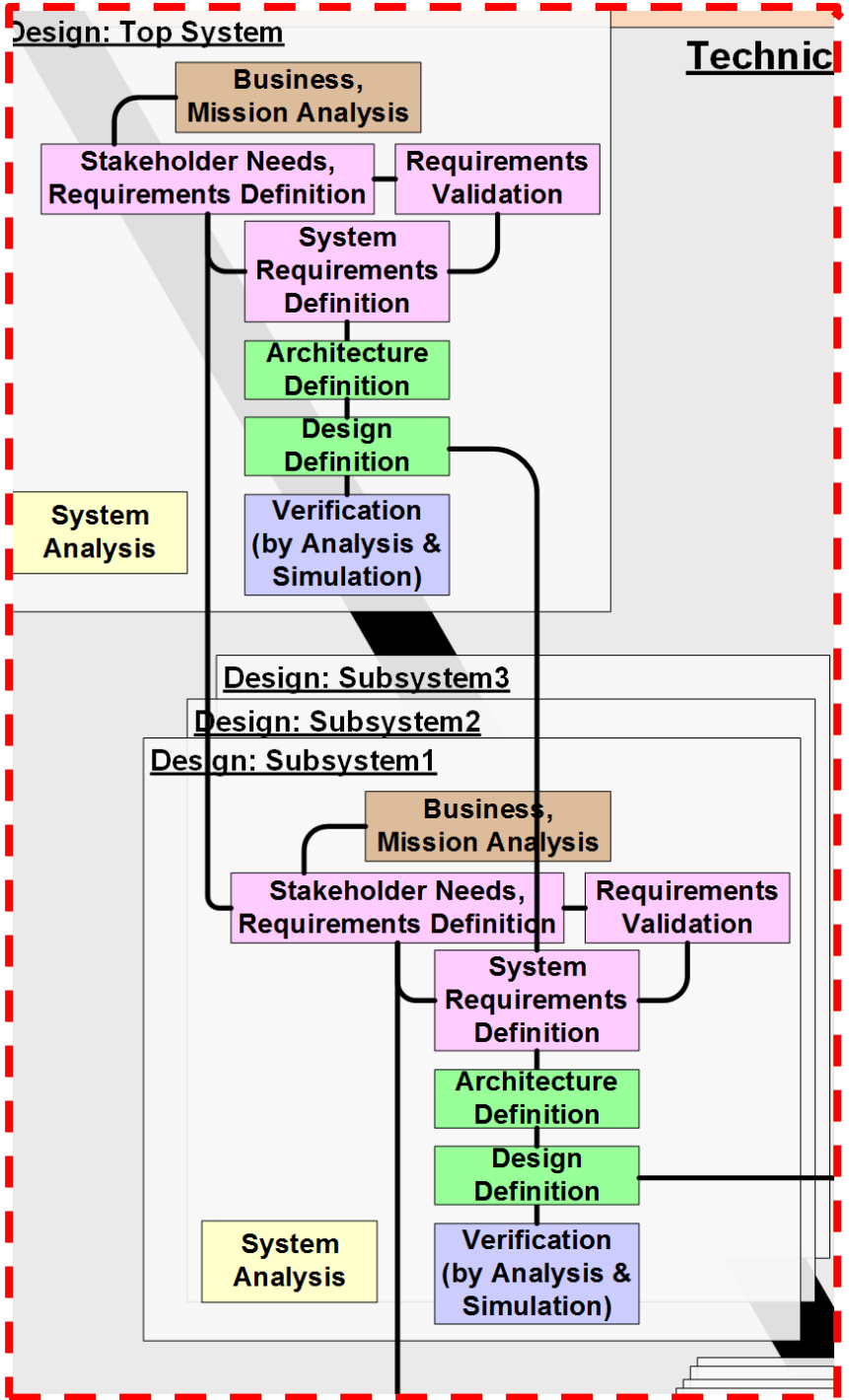
# C. Decision Reconciliation and Related Interactions and Information Views

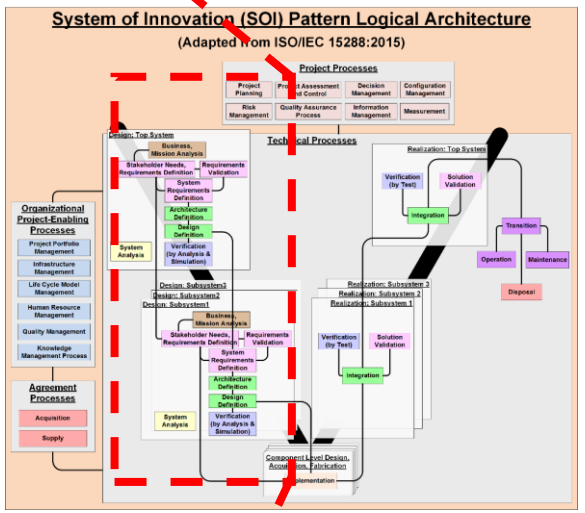
- The Innovation Ecosystem provides a set of ISO15288-like System 2 Stakeholder Features, each offering a set of configurable (populated or depopulated) Capabilities:
  - That list of options is usually a list of sources of information, plus a “reconciliation” and results reporting capability--



- The ASELCM Innovation Ecosystem Pattern offers configurable ISO 15288 and other Features for each of ISO15288 or similar business process.
- Their configurable capability options provide that most of these processes may be informed/driven by (depending on options):

1. **Predecessor**: Certain information predecessor sources (e.g., Design informed by Requirements; Flow-down Reqs etc.)
2. **Successor Feedback**: Feedback from an immediate successor source (e.g., Requirements informed by Feedback from Design, etc.)
3. **Experience**: Past experience source (e.g., formal patterns, standards, frameworks; informal human expertise, etc.)
4. **Empirical**: Observations, measurements of real systems (e.g., prototypes, test cells, in-service systems, labs, competitive systems)
5. **Simulation**: Computational or other trusted simulation models.
6. **Stakeholder**: Inputs or feedback from stakeholder representatives.

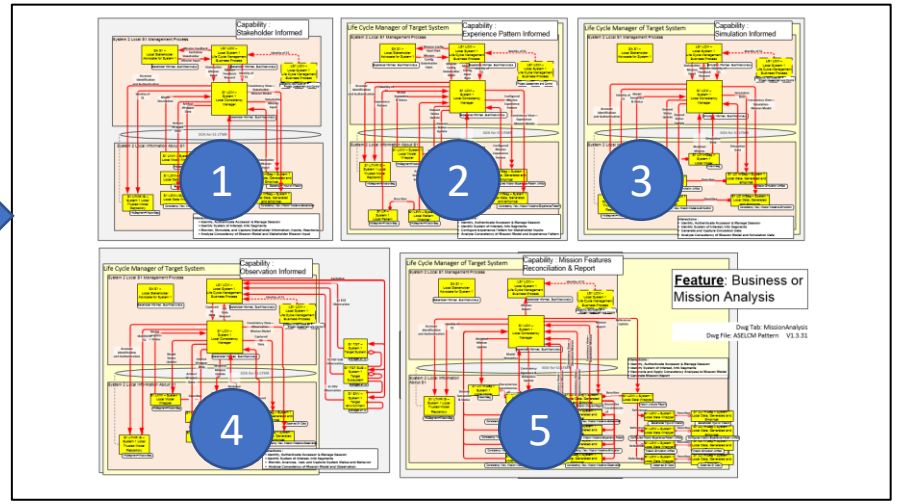



**ISO 15288 Processes**

- The “Reconciliation” capability offered by many of those Features reflects the Consistency Manager’s decision-oriented role of reconciling the multiple, often-conflicting sources of information, resulting in an overall reconciled output result.
- To the extent that the reconciled inputs to a process cannot be satisfied (e.g., if Design cannot be made to acceptably meet Requirements), then the Reconciliation process also generates Feedback to the information predecessor process.
- For example, the ASELCM Pattern’s configurable **Business or Mission Analysis Feature** provides the following Capabilities options in order to specify Mission, with multiple sources allowed:
  1. Stakeholder Informed
  2. Experience Informed
  3. Simulation Informed
  4. Observation Informed
  5. Mission Features Reconciliation & Report
- Illustrated in more detail by Attachment 3

5 Configurable Capabilities



# Discussion

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# References


1. Daniel Kahneman, Olivier Sibony, Cass R. Sunstein. *Noise: A Flaw in Human Judgment*. Little, Brown, Spark. 2021.
2. Herbert A. Simon. *Administrative Behavior*, 4th Edition. Free Press. 1997.
3. ISO/IEC/IEEE 15288:2015. "Systems and software engineering — System life cycle processes." International Standards Organization. 2015.
4. David Walden, et al, eds. *INCOSE Systems Engineering Handbook.* Fourth Edition. International Council on Systems Engineering. 2015.
5. John von Neumann, Oskar Morgenstern, Harold William Kuhn, Ariel Rubinstein. *Theory of Games and Economic Behavior*: *60th Anniversary Commemorative Edition*. Princeton Classic Editions. 2007.
6. W. Schindel. "Innovation, Risk, and Agility, Viewed as Optimal Control & Estimation." In Proc. of INCOSE 2017 International Symposium on Systems Engineering, Adelaide, AU. https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:risk_and_agility_as_optimal_control_and_estimation_v1.7.2.pdf