Report on the AIAA DEIC Digital Thread Position Paper:

Generic Reference Model Section Summary

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V1.1.3

Purpose and scope

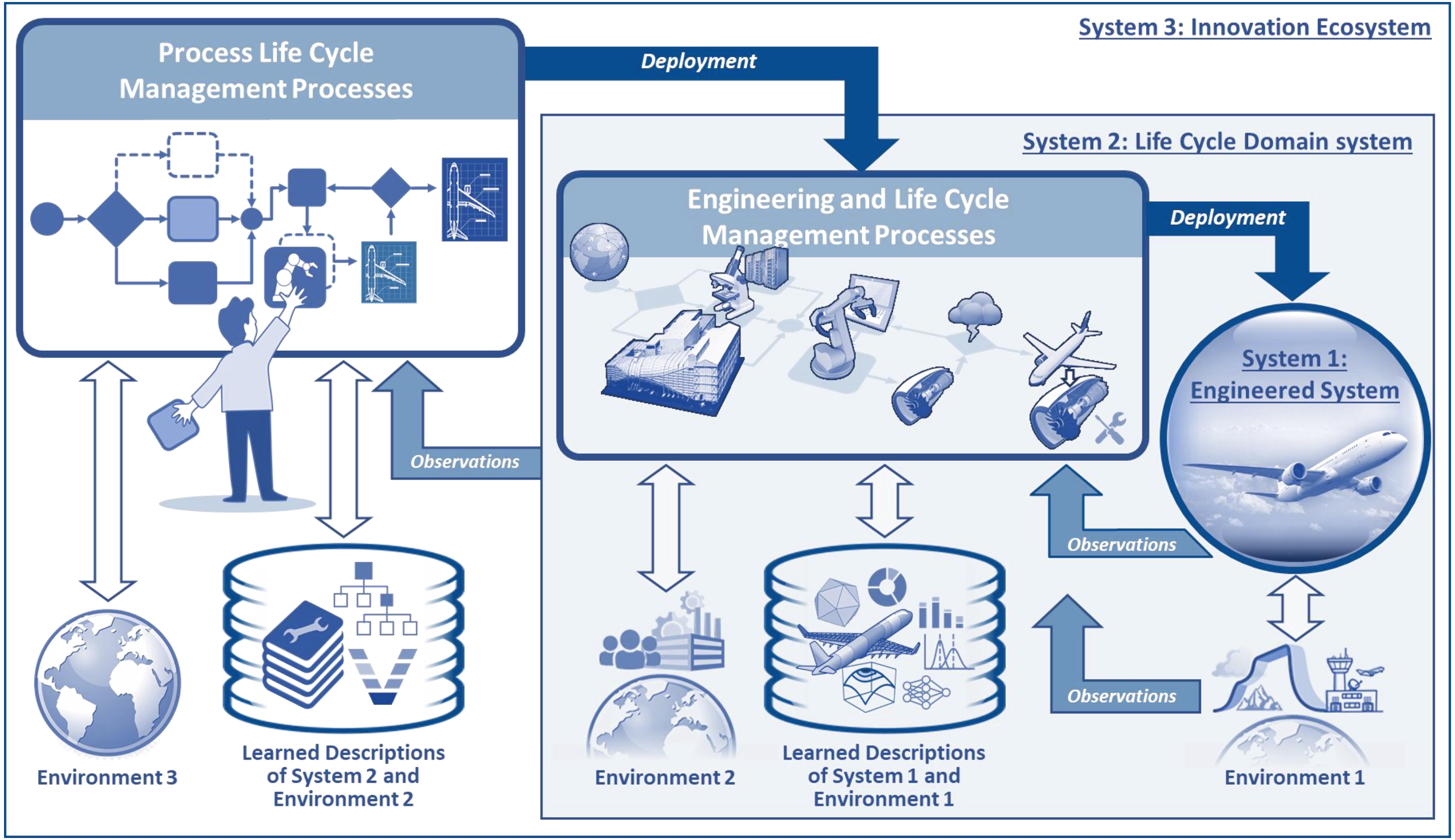
- Purpose and scope of this presentation:
  - Summarize leading aspects of the neutral reference model in use within the AIAA Digital Thread Position Paper.
  - Paper has been submitted to wide-ranging Red Team Review.
  - Your questions and additional feedback in today's session.

- Purpose and scope of generic reference model:
  - Provide an implementation-agnostic, generic reference model for describing, analyzing, planning, understanding aerospace digital threads in general.
  - Descriptive, not prescriptive.
  - Configurable to different cases, situations.

Origins of the Reference Model

- Originated as International Council on Systems Engineering (INCOSE) reference model for the analysis of systems of innovation in general, and their agility in particular:
  - INCOSE Agile Systems Engineering Life Cycle Management (ASELCM) Pattern.
  - Used for a series of published INCOSE case studies of Lockheed Martin, Rockwell Collins, Northrup Grumman, and US Navy SPAWAR, during 2016-2018.
- Also in use by the AIAA Digital Twin Implementation Case Studies Team to analyze numerous case studies in the related AIAA Digital Twin publication in preparation.
- More recently, central to:
  - INCOSE INSIGHT Digital Engineering Issue, March 2022
  - INCOSE 2022 International Symposium Digital Engineering Session, June 29, 2022
- (See the References.)

Figure 2. INCOSE ASELCM Level 0 Reference Model—Systems 1, 2, and 3.



System 3: Process definition, observation, advancement

System 2: Science, engineering, production, marketing, distribution, sustainment, retirement

System 1: Engineered Product

Table 1. Examples of Reference Model Level 0 Entities

Reference Model Boundary	Reference Model Level 0 Entity (See Figure 2)	Aerospace Examples
System 1: Engineered System	Engineered System	Aircraft, Landing Gear Subsystem, Landing Gear Component
System 2: Life Cycle Domain System	Environment 1	Airport, Weather System, Runway, Manufacturing Floor, Maintenance System
	Engineering and Life Cycle Management Processes	Mission Engineering, Design Review, Simulation Process, Manufacturing Process, Service Delivery
	Learned Descriptions of System 1 and Environment 1	Landing Gear Subsystem Requirements, Electrical Schematics, Weather Models, Landing Gear System Model, CFD Simulation, Production Recipes, Physics, Design Patterns, Personal and Tribal Knowledge, Digital Thread Describing System 1 Product
	Environment 2	Industry Funding, Job Market, Pandemic, Workplace
System 3: Process Life Cycle Management Processes	Process Life Cycle Management Processes	Program Definition Process, Engineering Methods Definition, Production Standards Process, Engineering Education, Tooling Specification, Program Analysis, AIAA, INCOSE, IEEE
	Learned Descriptions of System 2 and Environment 2	Enterprise Procedures, Production Job Descriptions, Organization Charts, Handbooks, Courseware, Personal & Tribal Knowledge, Digital Thread Describing System 2 Process
	Environment 3	Methods Research, Competition, Professional & Technical Societies, Engineering Educational Institutions

Figure 3. INCOSE ASELCM Level 1 Reference Model--Explicit **Learning** and **Application of Learning**

Learning: Acquiring and validating new knowledge about System 1 and its environment.

Execution: Applying what we already know about System 1 and its environment

Learning: Acquiring and validating new knowledge about System 2 and its environment.

Execution: Applying what we already know about System 2 and its environment

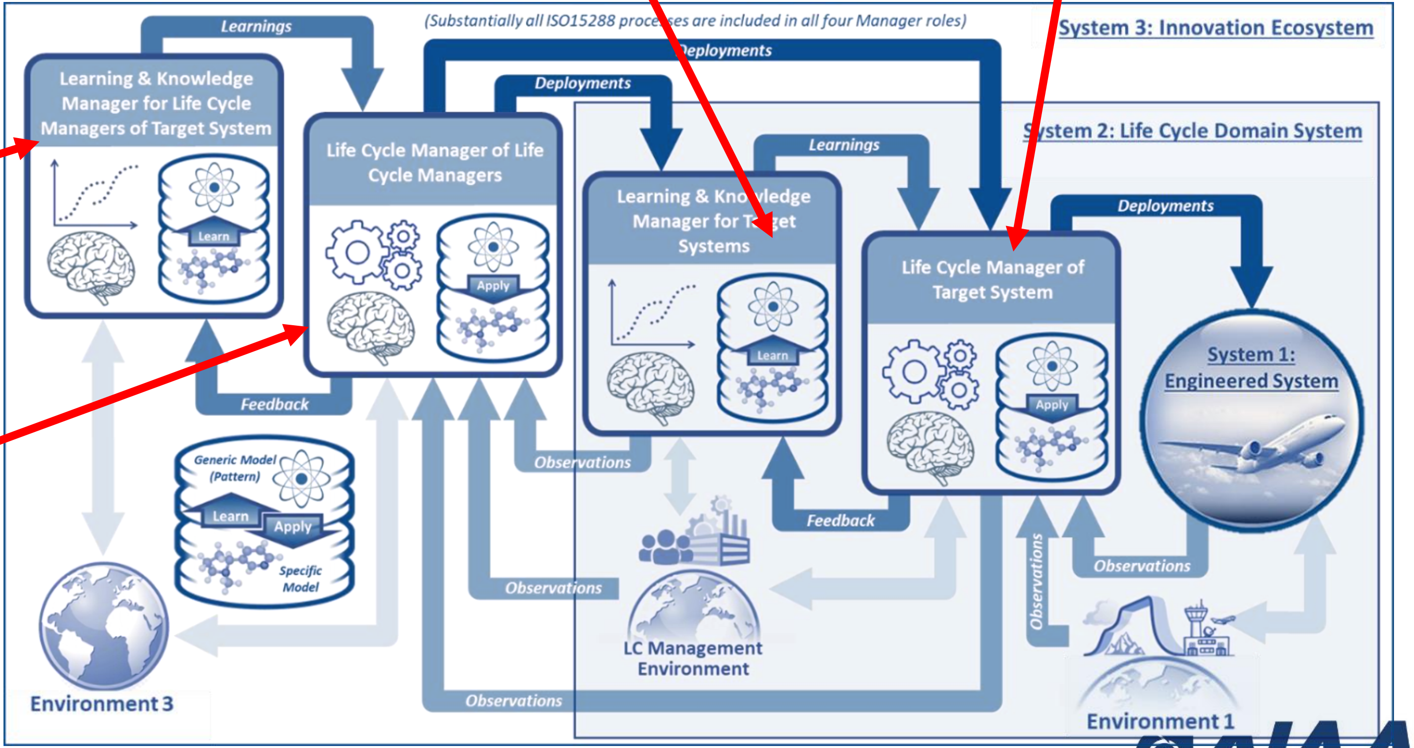


Figure 4. INCOSE ASELCM Level 2 Reference Model— Generic Process & Information Classes

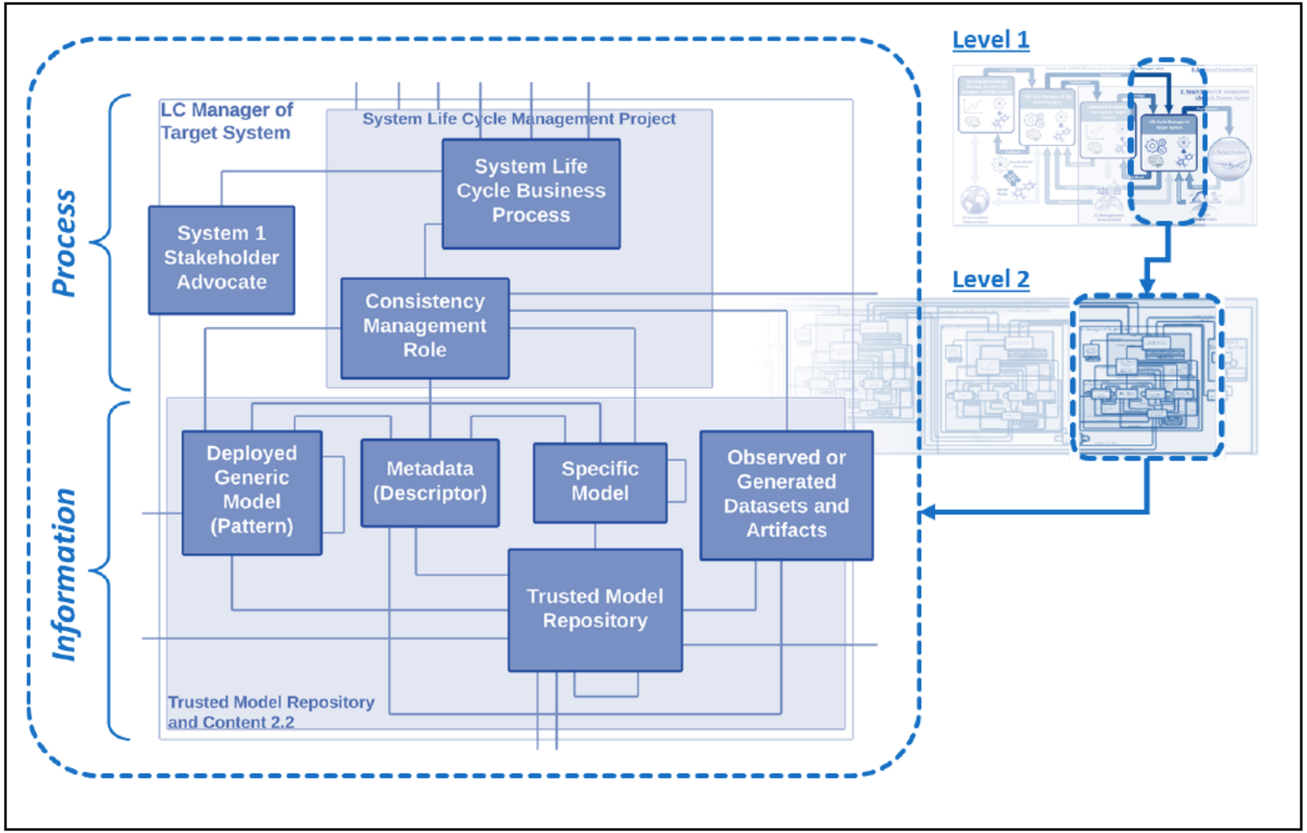
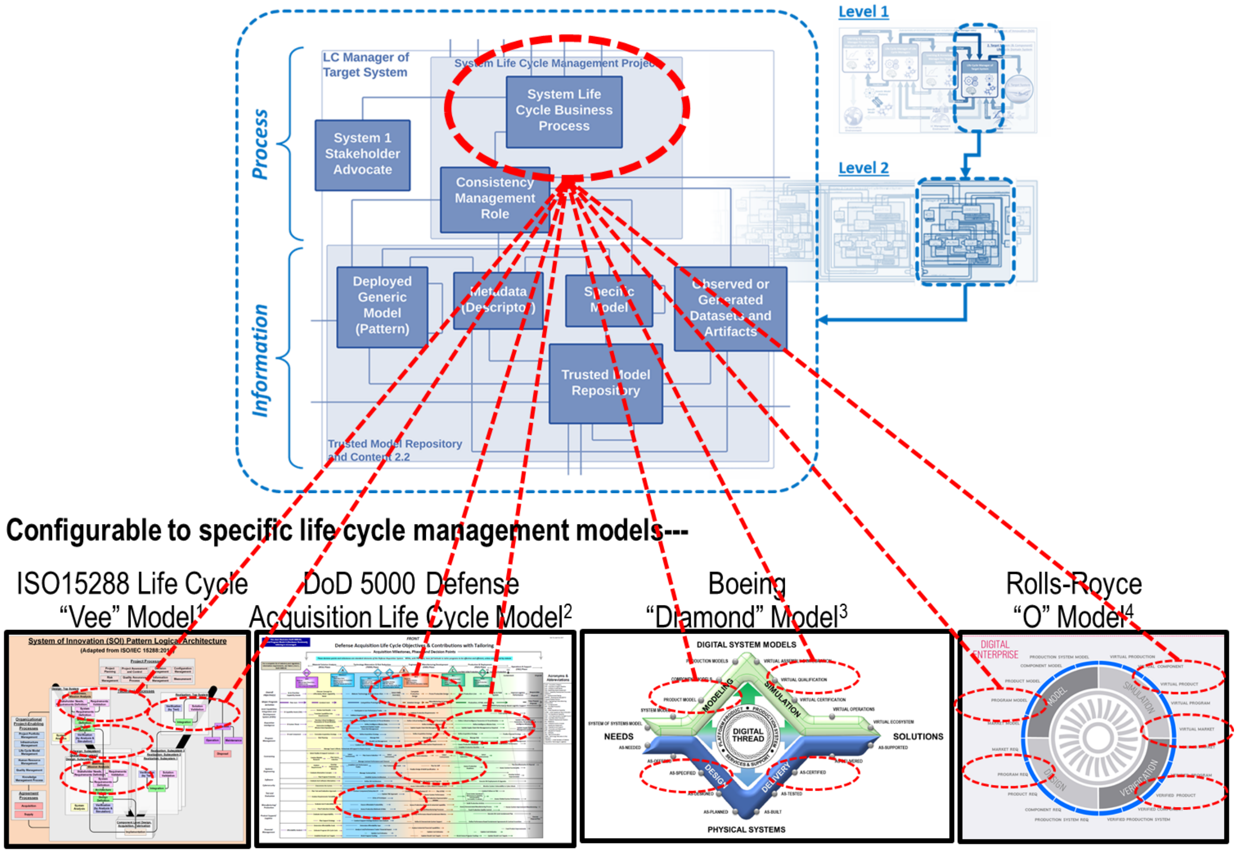
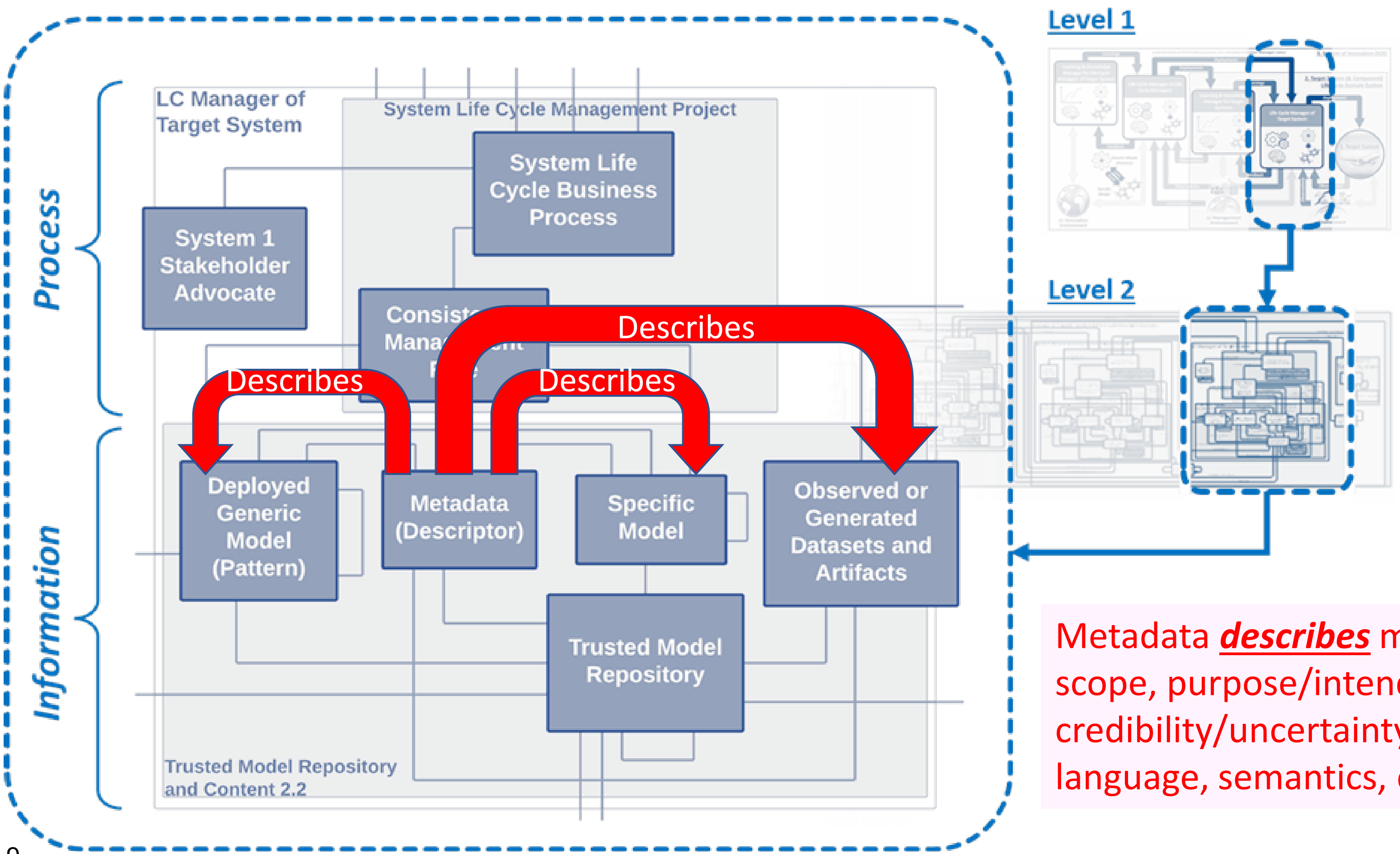


Figure 5: Configuring Reference Model Business Processes Supported by Digital Thread to the Business Processes at Hand



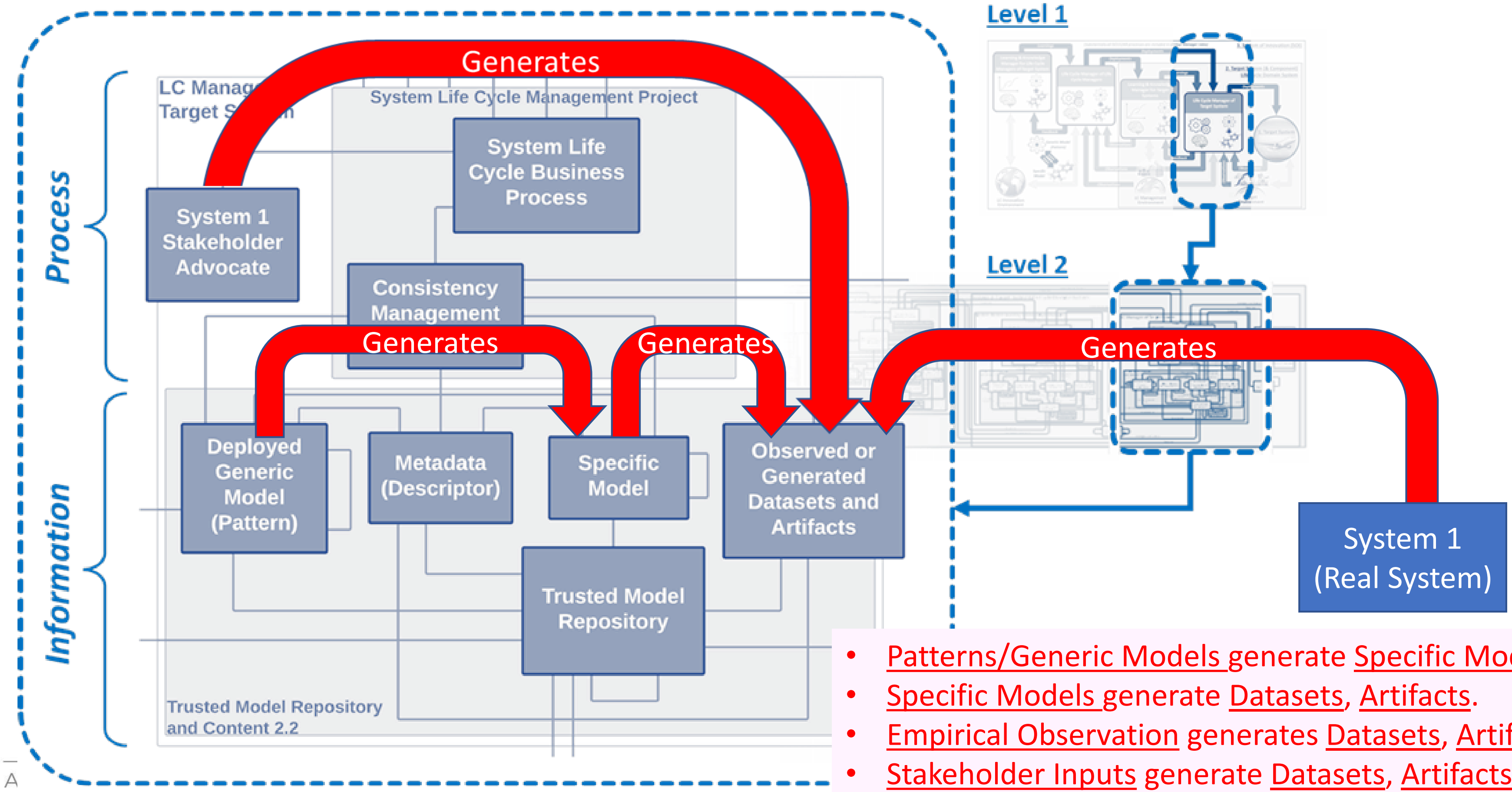
Excerpted or adapted from: (1) ISO15288 and INCOSE SE Handbook; (2) DoD5000 Wall Chart; (3) AIAA Sci Tech, 01.2020, J. Matakeyama; (4) AIAA DEIC Digital Twin Subcommittee, 04.08.19 Donaldson, Flay, French, Matlik, Myer, Pond, Randjelovic

Figure 6. Metadata Is the Guide to Diverse Information Across the Ecosystem



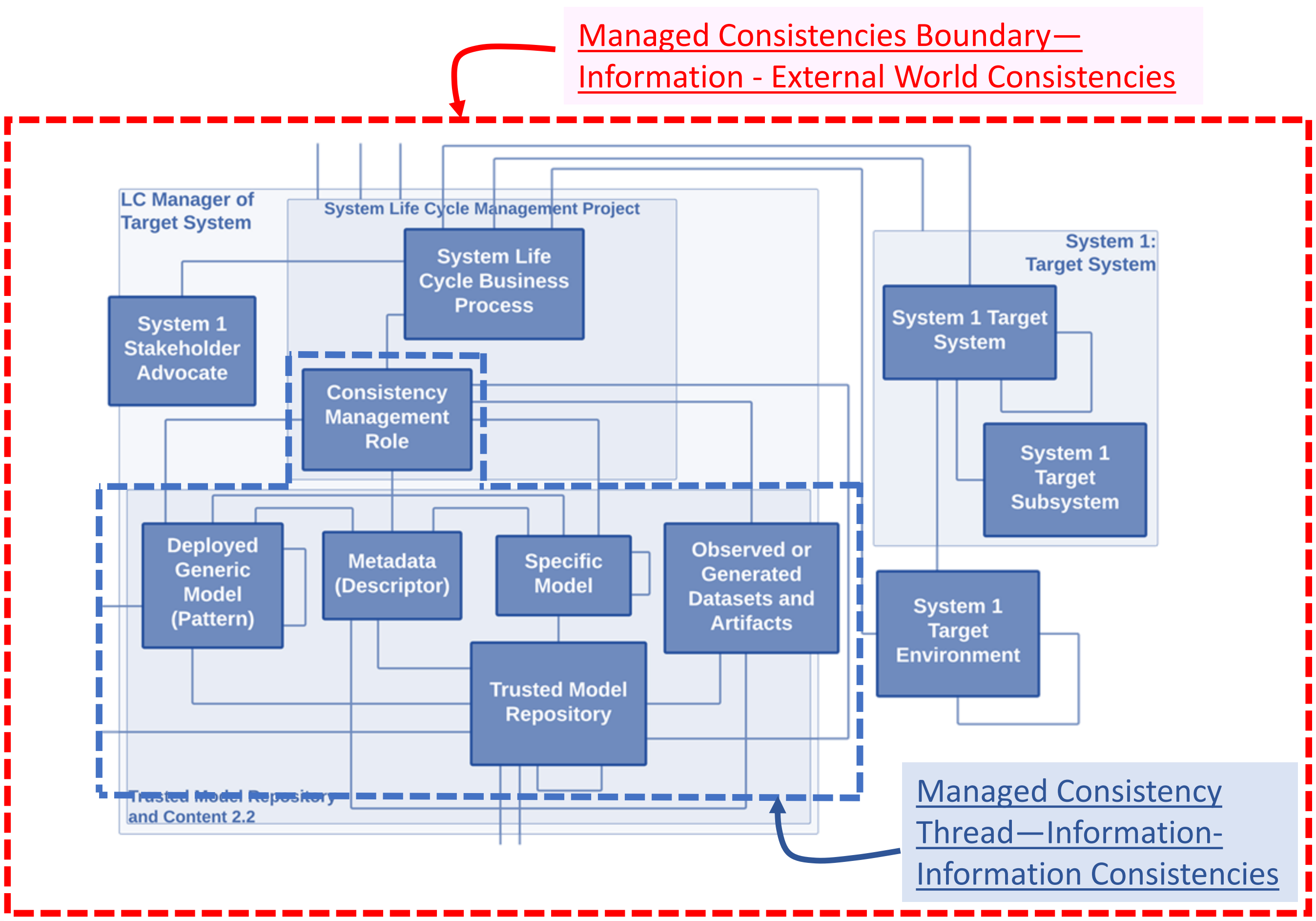
Metadata ***describes*** model and data scope, purpose/intended use, credibility/uncertainty, provenance, language, semantics, consistencies, etc.

Figure 7. Information Propagates from External and Internal Sources



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

Figure 8. Managed External-Internal and Internal-Internal Consistency.



Managed Consistency Thread System Boundaries

- Managed consistencies: A basic idea fundamental to historical engineering & life cycle management:
  - Not just a new “digital thread” idea—but fundamental to the digital thread.
  - Numerous examples, including Aerospace (SAE AS9145) and Automotive (APQP, PPAP).

- Examples of traditional managed consistencies:
  - Is the product design consistent with the product requirements? (Notice the answer can change over life cycle time.)
  - Are those requirements consistent with the mission and stakeholder needs and priorities?
  - Are the emergent behaviors (both required and to be avoided) in the engineered system consistent with the learned experience about the underlying phenomena from which they emerge?
  - Are instances of the manufactured product consistent with the design specifications? Are the customers’ uses of the product consistent with the original product mission and requirements?
  - Is the performance of the deployed product in the field consistent with the specified requirements?
  - Is the environment of use of the product consistent with its representation in the product mission and requirements?
  - Many others . . .

Figure 9. Three Sources of Authority--Often in Inconsistent Conflict.

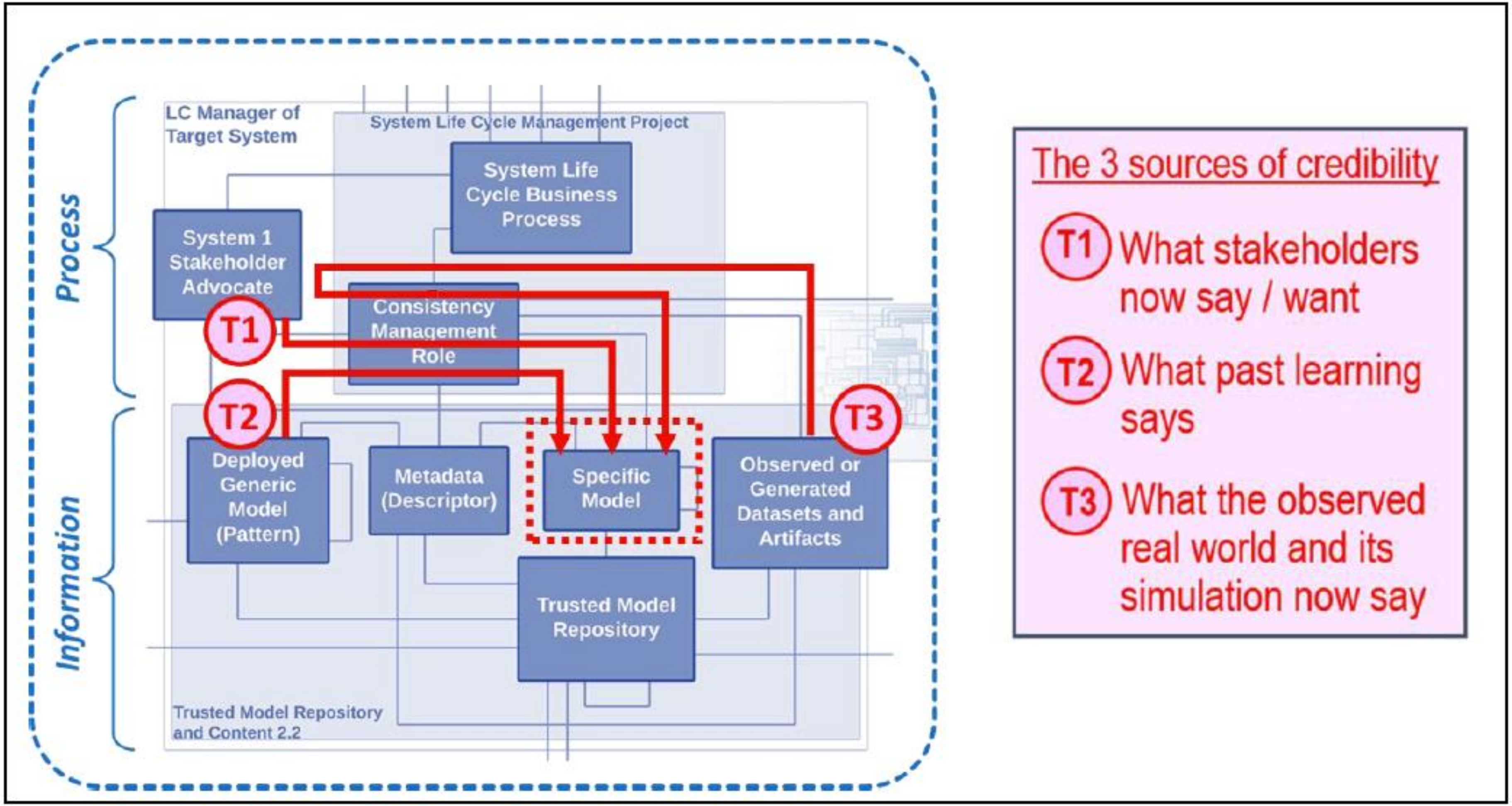
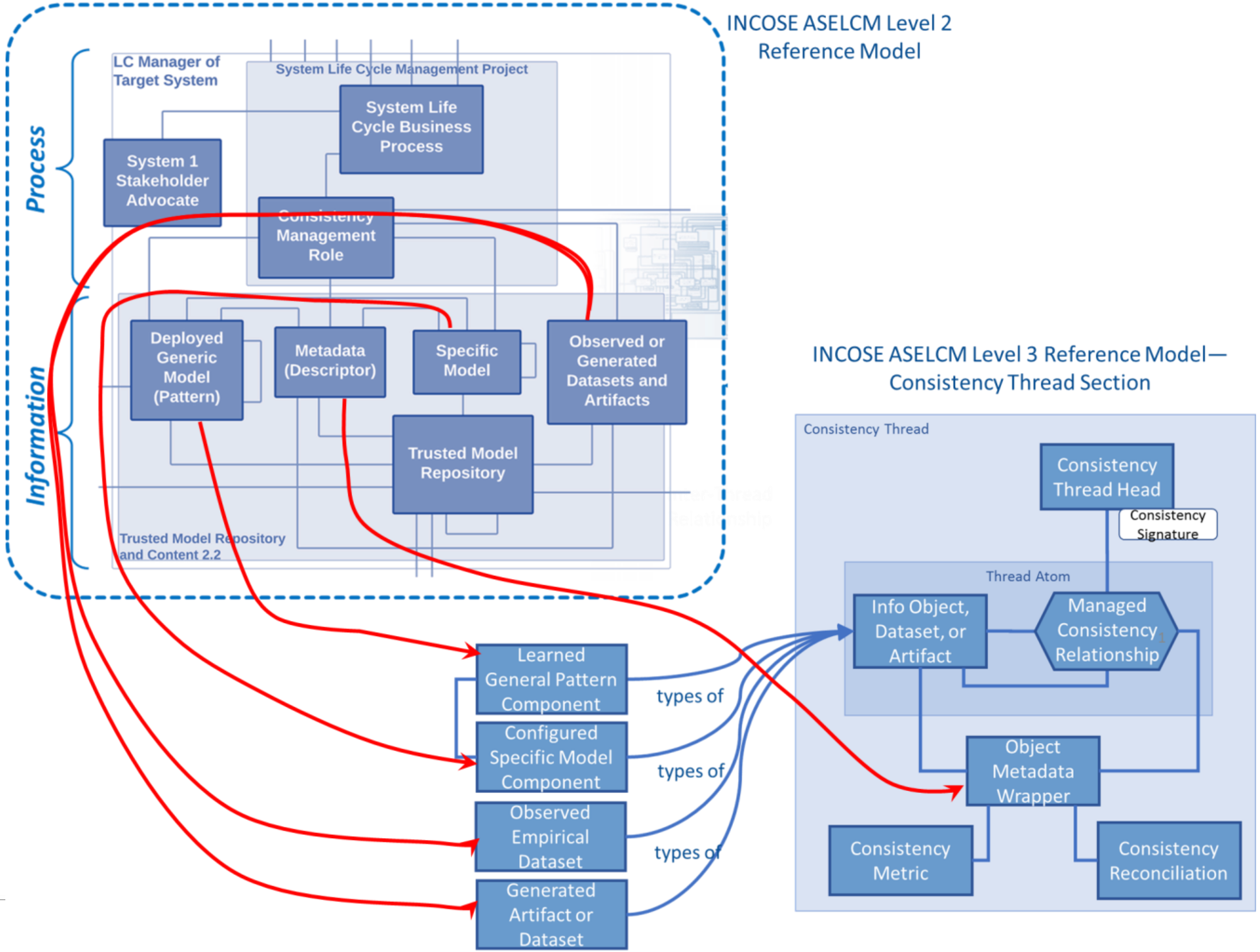


Figure 10. Consistency Threads Span Models, Patterns, Datasets, Artifacts



References

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