

Consistency Management—The Expanding Rosetta Stone

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ASME VVUQ 2026 Symposium
May 18-22, 2022
Vanderbilt School of Engineering
Nashville, Tennessee, USA

V1.2.3

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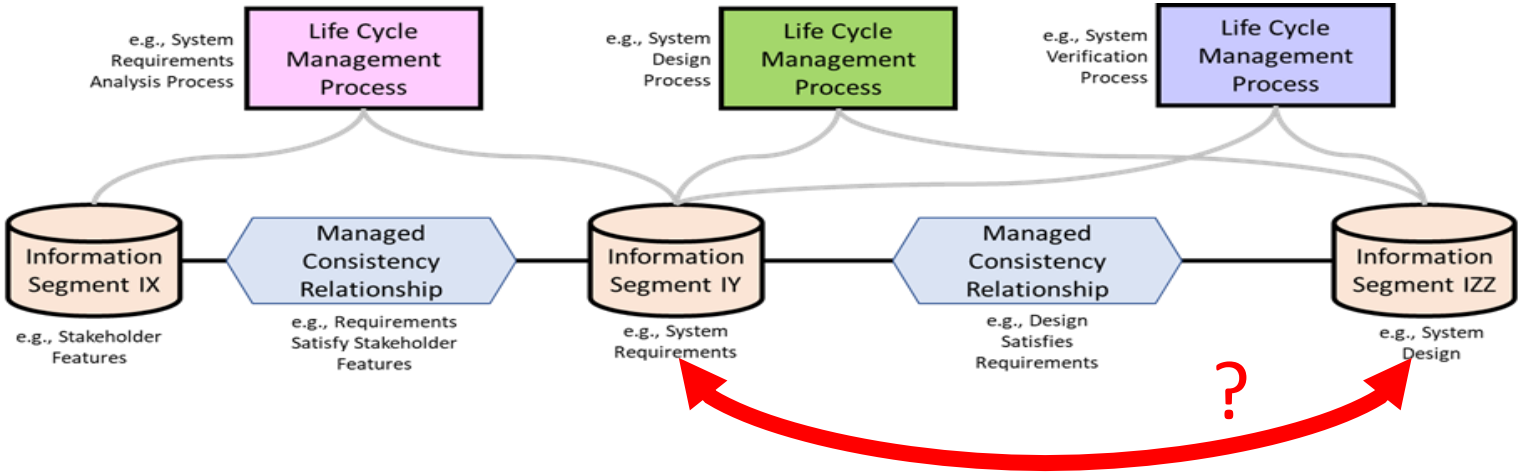
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Introduction to Consistency Management

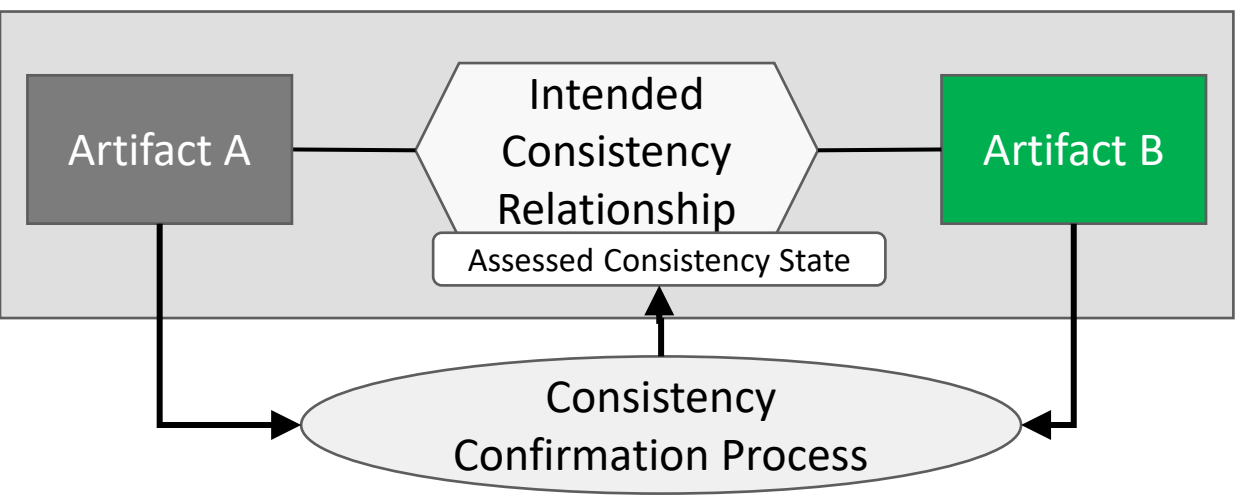
With thanks to:

- Rosetta Stone Project Team
- ASME VVUQ 50.1 Authoring Team
- ASME VVUQ Standards Committee

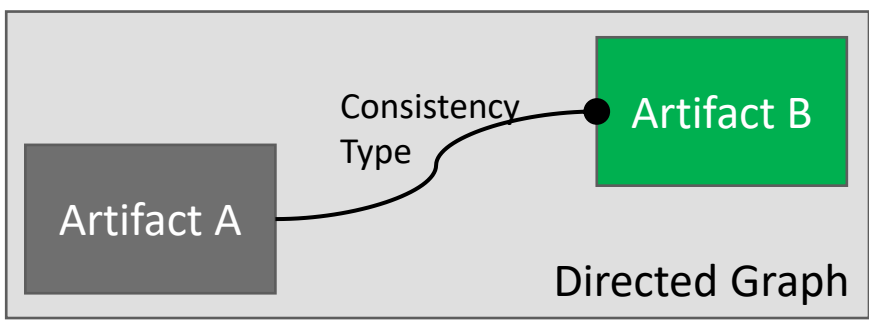
Examples of managed consistencies, as “questions” [7, 8]



1. Will this system conforming to the [System Design] mean it will satisfy the [System Requirements]?
2. Does this system satisfaction of the [System Requirements] mean it will satisfy the [Stakeholder Needs]?
3. If we build this system according to the [Manufacturing Process Specification], will the result conform to the [System Design]?
4. Does this [Simulation Data] agree with the [Empirical Measurement Data]?
5. How closely?
6. How certain are we?

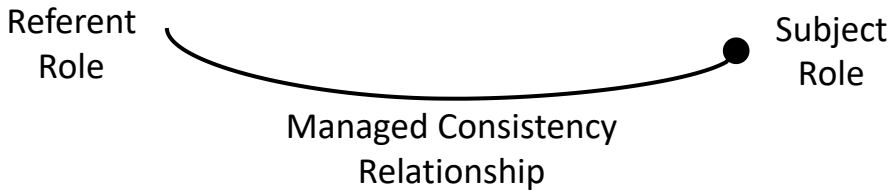


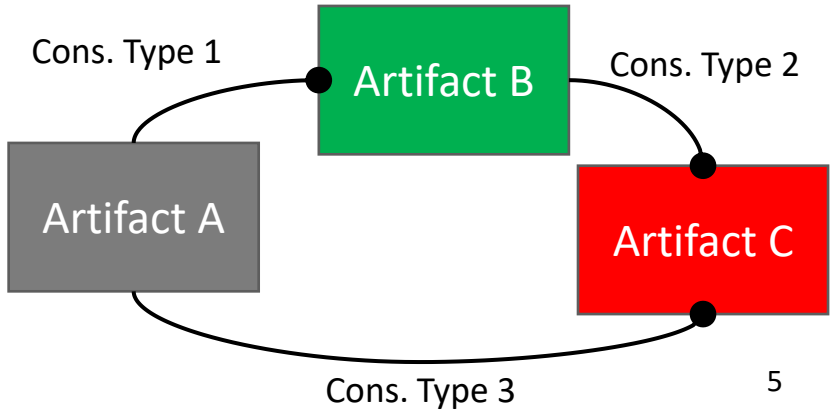
Shorthand Representation



- For any single discipline, the set of all its consistency relationship types (described by the discipline's standard practices) is a "directed graph" of pairwise *intended* consistencies:
  - The graph nodes are the compared information artifacts.
  - The graph edges (the linking lines) are the types of consistency sought (the consistency relationship, to be assessed).
  - This is not a process diagram—it is a model of desired information relationships.

- The graph links are "directed" to differentiate artifacts we are checking (the subjects) from what we are checking them against (the referents):

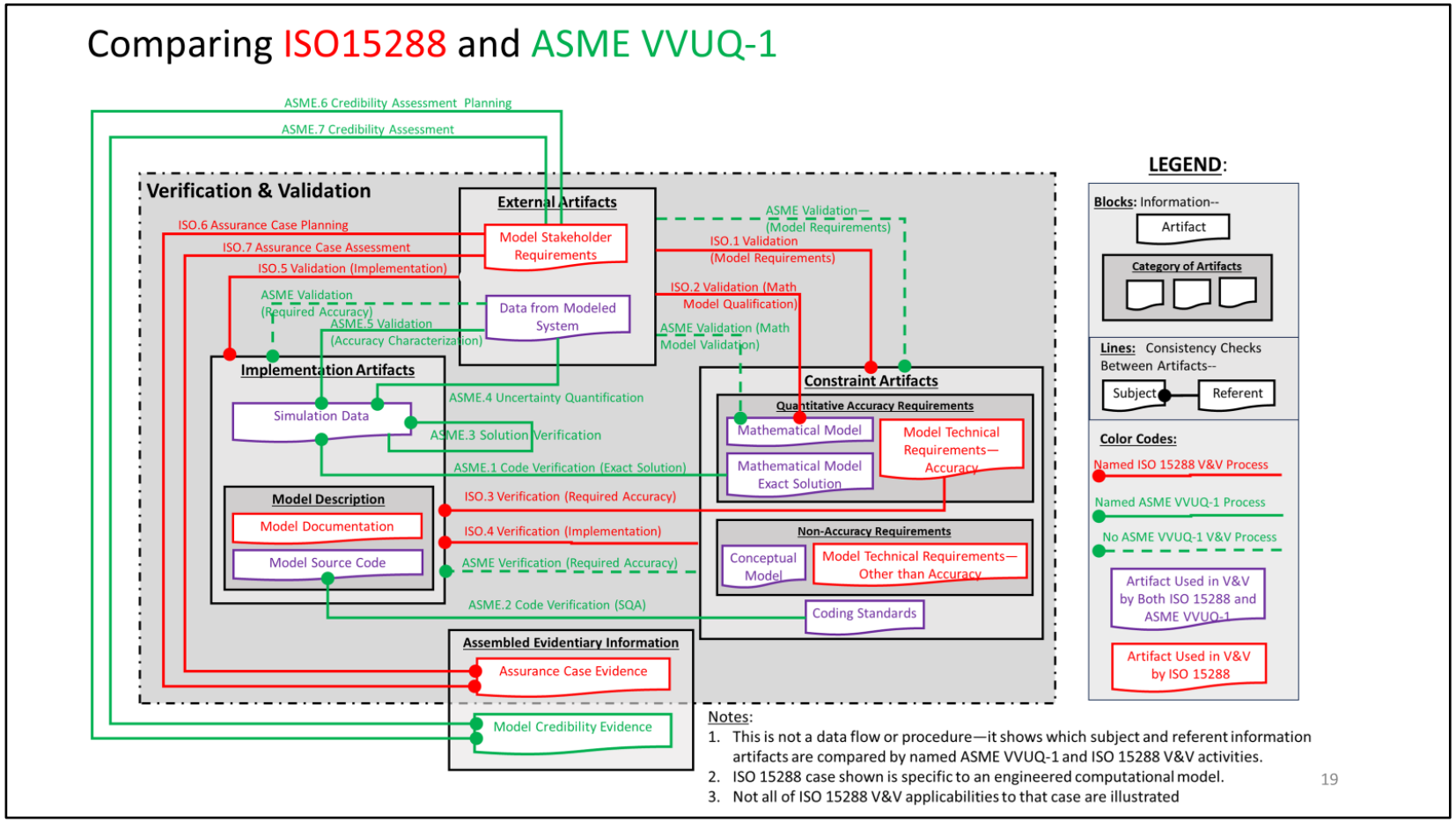




Consistency Management: What is it?

1. **Initially**: While authoring ASME VVUQ 50.1, a way to understand four different societies' diverse VVUQ standards in a common way—as comparisons for consistency of information items, *terminology aside*:

From 2024 Rosetta Stone Report [1, 2] and ASME VVUQ 50.1 [6]:



ASME VVUQ 50.1-2025

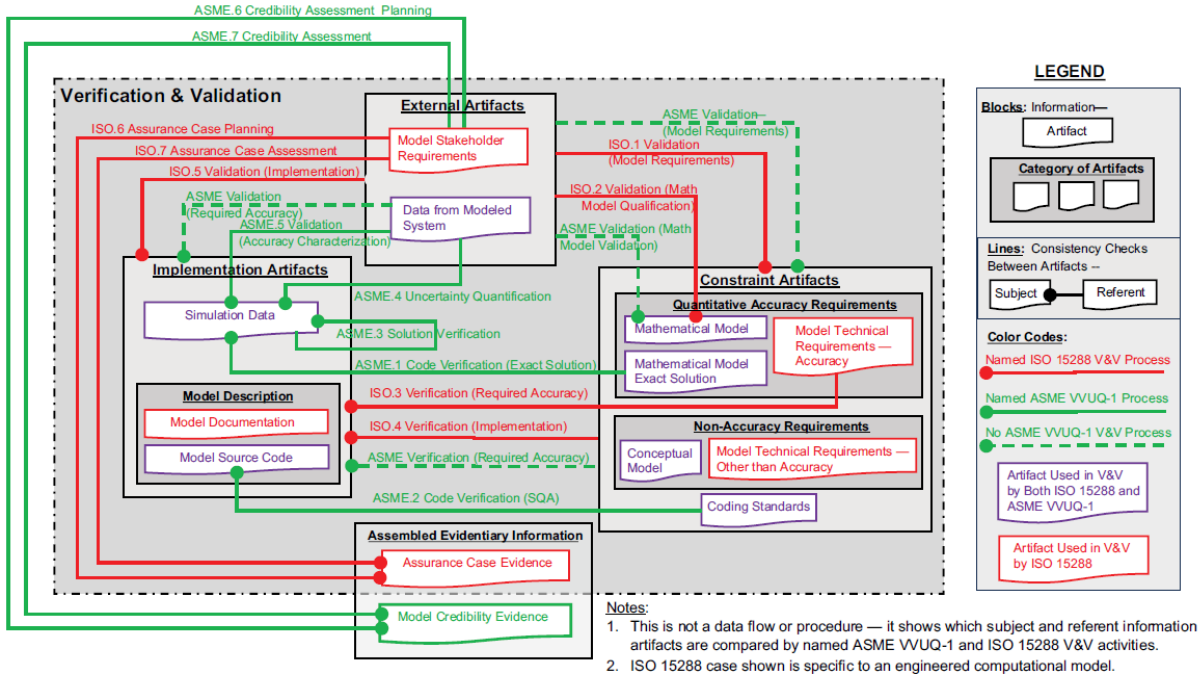
Guide to a Model Life Cycle Approach That Incorporates Verification, Validation, and Uncertainty Quantification

Entire Life Cycle of Model, Applications Included **[6]**

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Figure 3.1-2
ASME VVUQ 1 and ISO/IEC 15288 Terminology: Verification and Validation Consistency Checks and the Information Types They Compare



Notes:
1. This is not a data flow or procedure — it shows which subject and referent information artifacts are compared by named ASME VVUQ-1 and ISO 15288 V&V activities.
2. ISO 15288 case shown is specific to an engineered computational model.
3. Not all of ISO 15288 V&V applicabilities to that case are illustrated

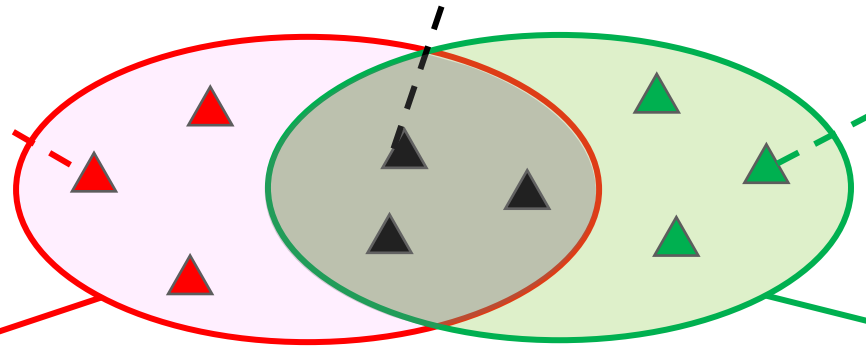
GENERAL NOTE: This figure is from Fischer et al. (2025). Used with permission.

ASME VVUQ 50.1-2025

Experiment, Accuracy, Evidence

Required Accuracy, Required User Interface, Required Execution Speed, MBSE Non-Quantitative Models

ISO 15288 *Explicit Conceptual Scope* (Not *Terminology*)

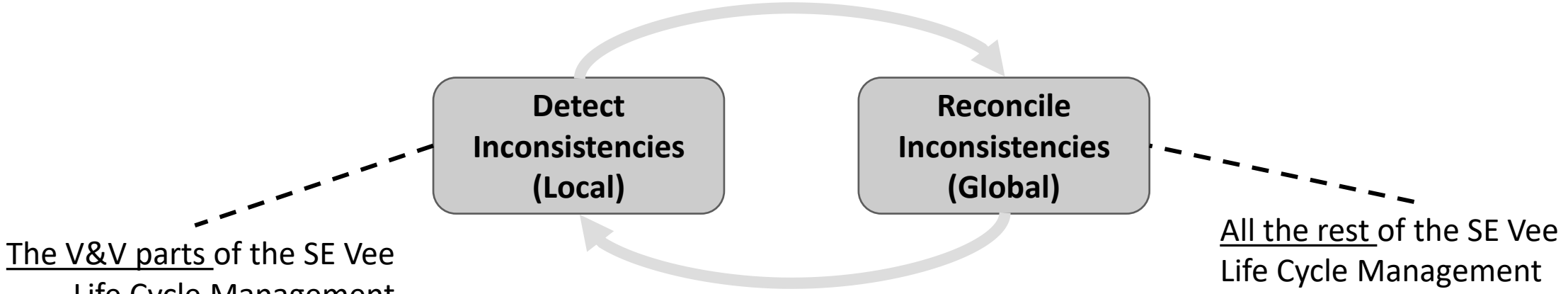


Inter-Model Distance, Convergence, UQ Methods

ASME VVUQ-1 *Explicit Conceptual Scope* (Not *Terminology*)

Consistency Management: What is it? [7, 8]

2. **Subsequently**: How to understand the whole of an engineering project as a "two cycle learning engine", not limited to V&V:
   - Detect Inconsistencies (local to subject-referent artifact pairs)
   - Reconcile Inconsistencies (global across web of project's artifacts)



Inspired by: Machine learning algorithms such as Back Propagation, generating trajectory strategy in configuration space.



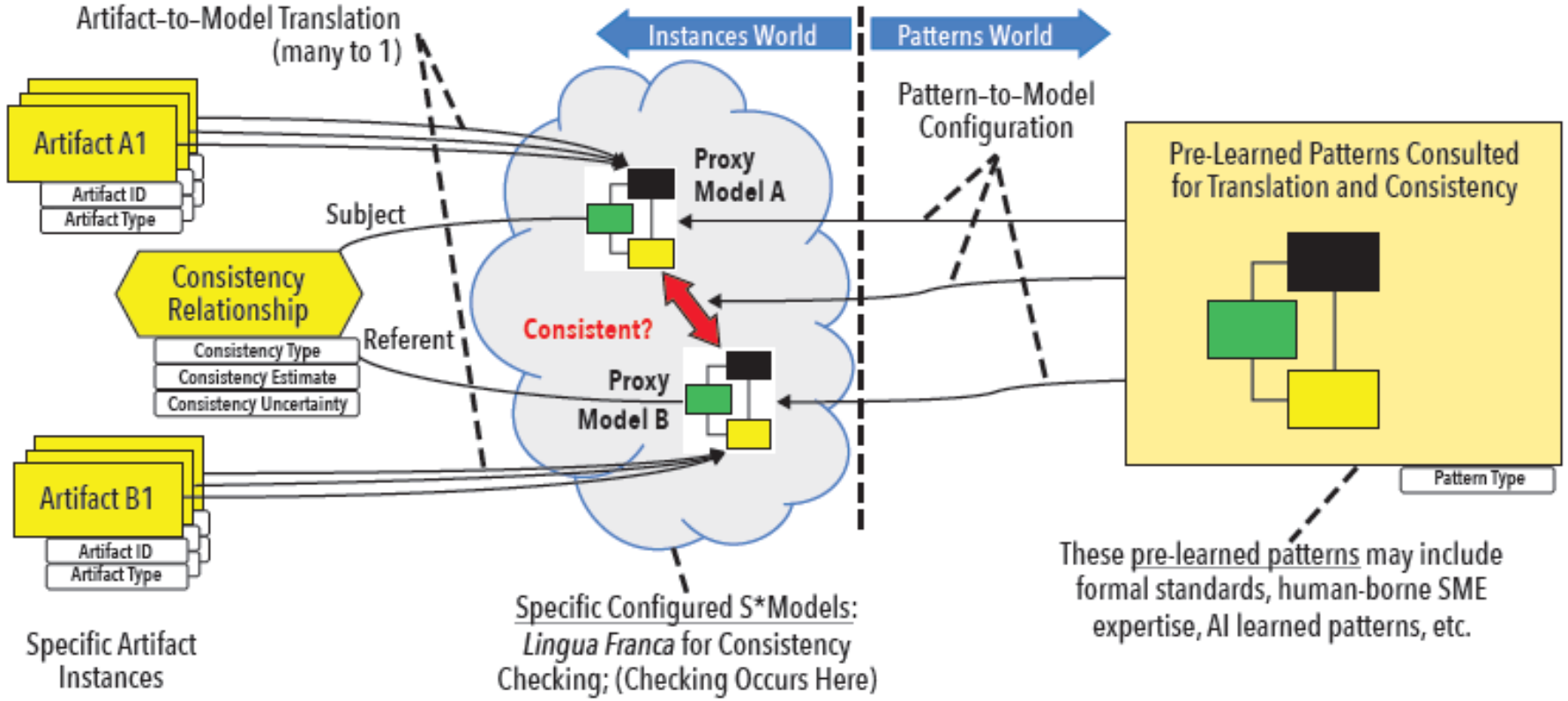
Additional Promising Applications

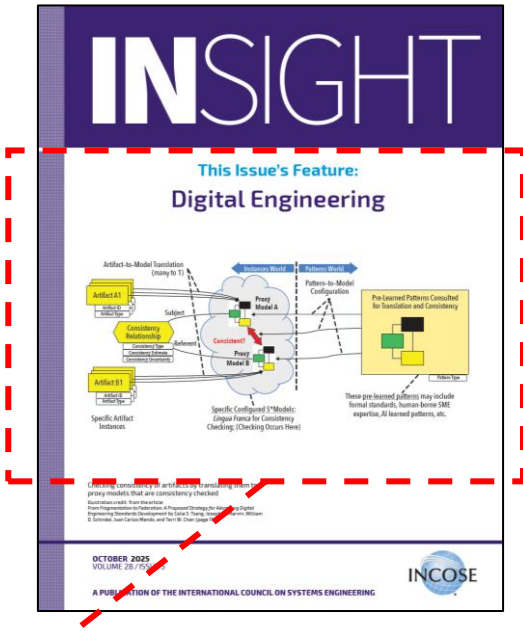
Systems Engineering (Bill)

with thanks to:

- MBSE–DE Integration Forum Team
- INCOSE Fellows

Artifacts are translated to MBSE models, which are then compared for consistency





From *INCOSE INSIGHT* Special Issue on Digital Engineering, Oct, 2025 [3]

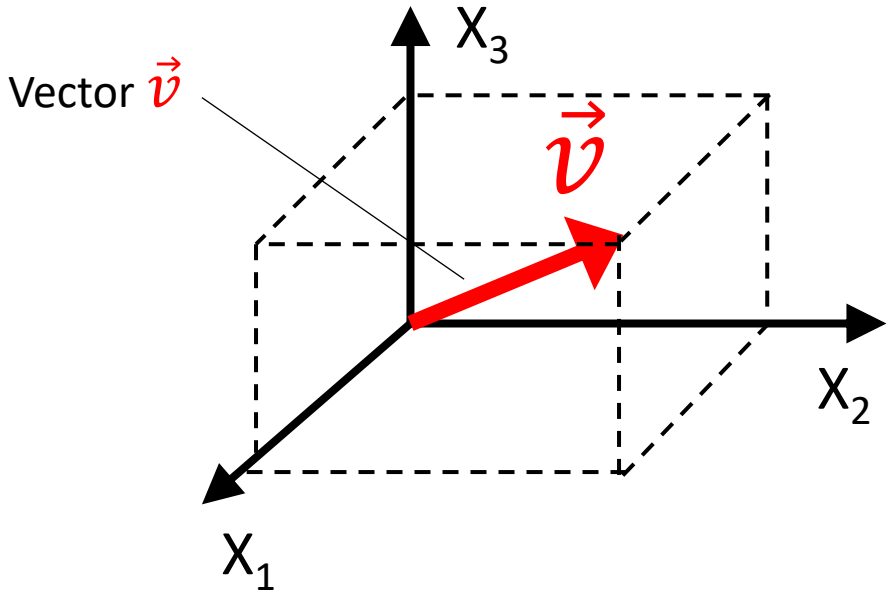
(Note that some artifacts and learned patterns may reside in human SMEs.)

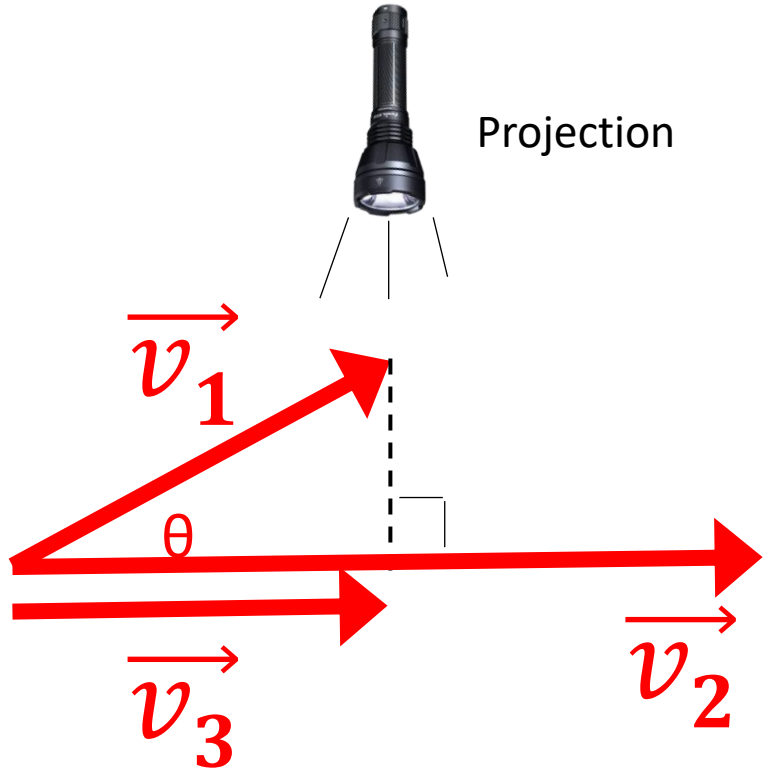
Vector Spaces in STEM: The Geometrization of System Models

- As mathematical models described continuous and non-linear behavior, David Hilbert provided a geometrical view of multi-dimensional Hilbert Space [4]:
  - Including not just finite dimensional spaces;
  - Also, infinite dimensional spaces of mathematical functions as embedded vectors

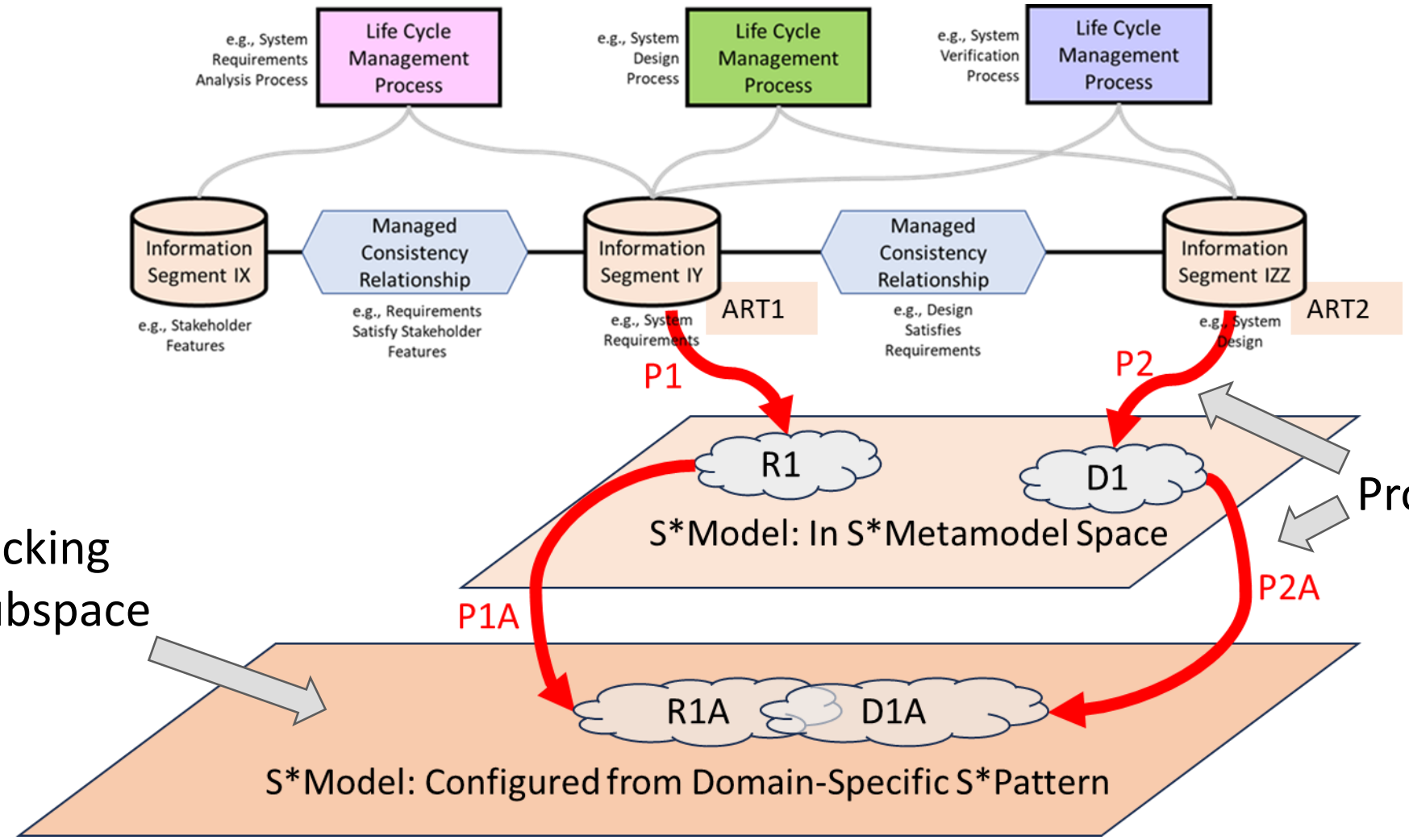


David Hilbert
1862 – 1943



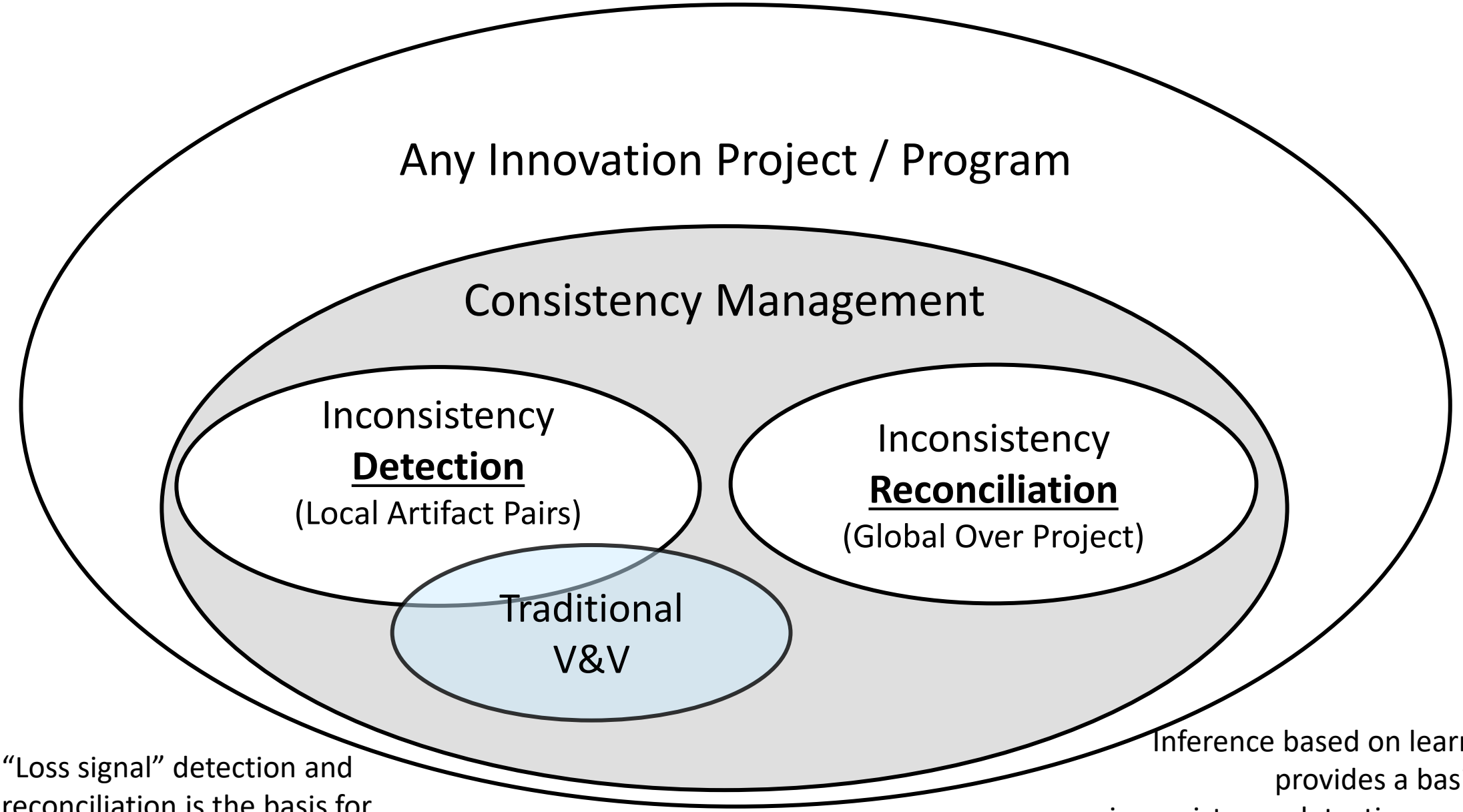


Translation and consistency checking as projections in a vector (metric) space [4]



Consistency Checking Occurs in this Subspace

Scope Implications and Opportunities



"Loss signal" detection and reconciliation is the basis for machine learning and inference.

Inference based on learned patterns also provides a basis for subsequent inconsistency detection and reconciliation—by both humans and machines.

Additional Promising Applications

Computational Modeling (Nigel)

with thanks to: AIAA ICE TAG-1,
NATO STO RTG-390,
Smart Aerodynamic Testing (ARA, BAE Systems, MBDA UK)

Refer to Wednesday PM session at this VVUQ 2026 Symposium [5]:

"Expanding the V&V 20 Standard: A Structured Approach for Validating CFD in Engineering Applications", Dowding, K., Taylor, N.

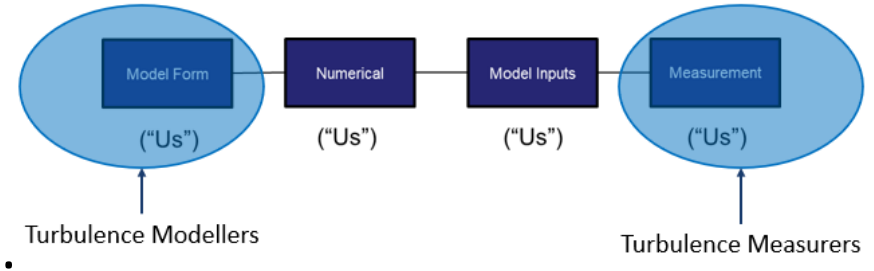
Establishing Mutual Accountability between Disparate Stakeholders – Identifying Synergy

The AIAA is keen to encourage improved interactions between its computational and physical testing communities (Applied Aero, Fluid Dynamics, Ground Test & Measurement Technologies Tech. Committees)

The Coleman-Stern equation (as per VV10, VV20) is being used to facilitate dialog between these communities, via sequences of "Special Sessions" at multiple AIAA Conferences:

"Meet the Turbulence Modelers"

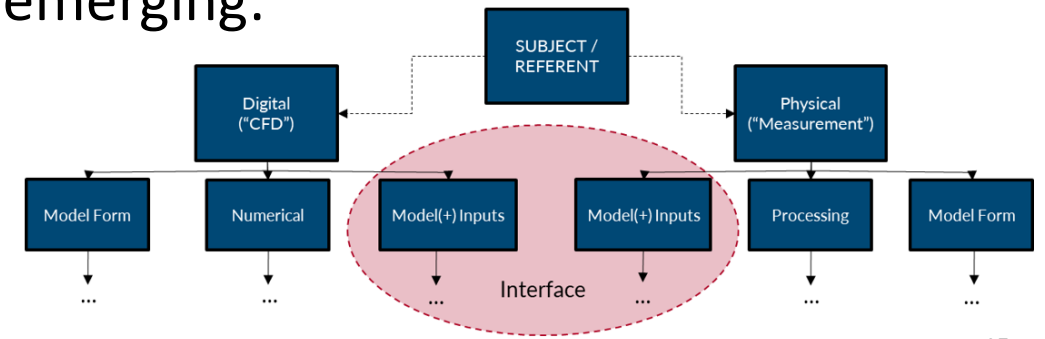
"Meet the Turbulence Measurers"



Aside from improving visibility of ASME VVUQ principles …

Similarities with principles established elsewhere are emerging:

As people better understand the challenges being faced by others, it is hoped that such interactions will be pre-cursors to more insightful, effective and rewarding integration – <u>with benefits accruing to all</u>



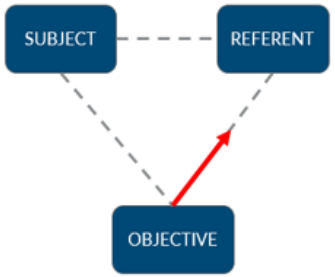
Simplified Elaboration of Subject & Referent (First Tier only)

Interactive Consistency Checking

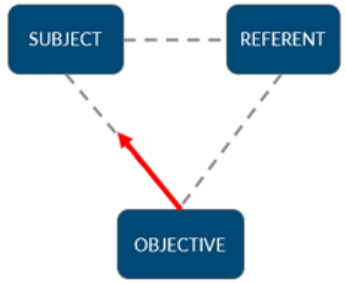
Dialog between stakeholders aimed at improving mutual understanding (e.g. as described on previous slide) may be considered a further example of consistency checking:

The consistency being checked here being (mutual) understanding rather than any specific engineering artifact

This is a different (but complimentary) type of consistency check to that considered by the Rosetta Stone project:

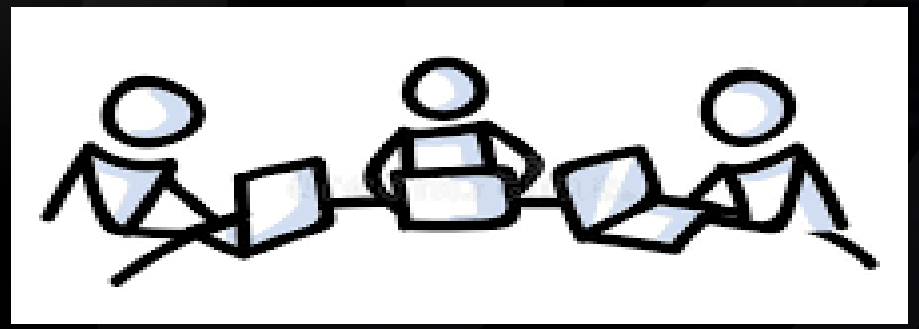


Checks identified in Rosetta Stone project (V & V)



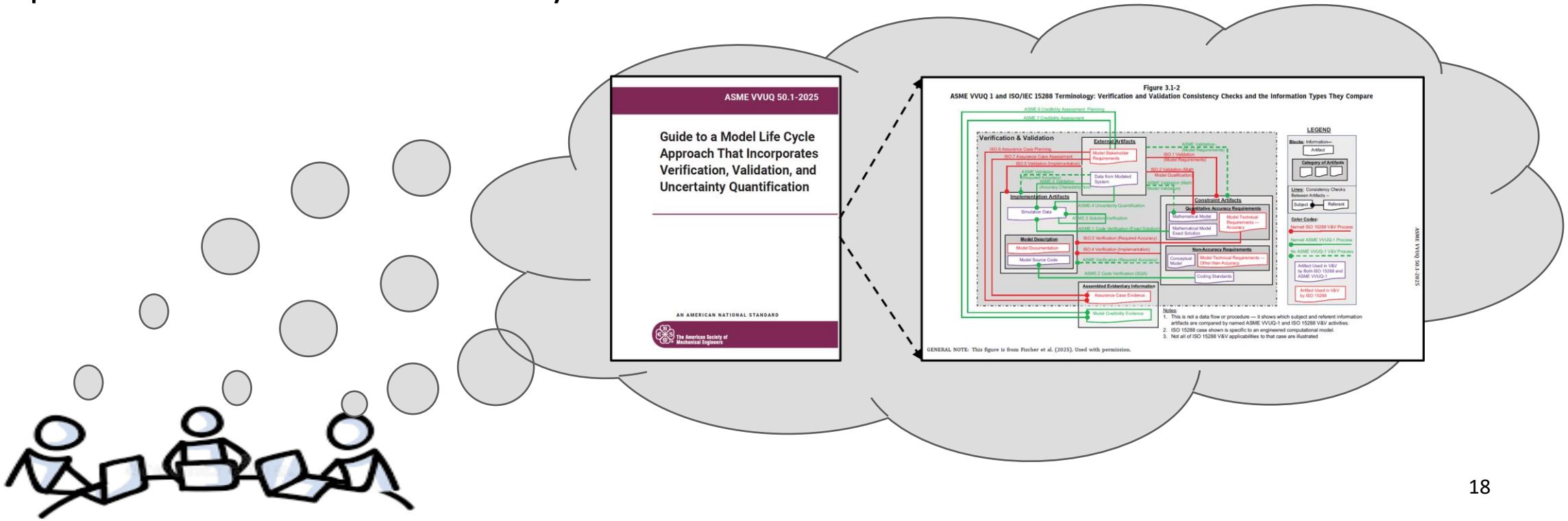
Checks designed to consolidate understanding

Rosetta Stone Mapping enables collaboration across discipline communities



Rosetta Stone enables collaboration across discipline communities

- ASME VV50.1 shows that it is not necessary to change terminologies in order to understand and integrate practice of the whole set of discipline-specific VVUQ methods in a single project:
  - Understanding of different concepts as well as terminologies is both feasible and constructive.
- Collaboration (vs denigration) of communities and their practices contributes to better outcomes:
  - The ASME Standards Committee has taken a leadership role in publishing VVUQ50.1 as a first step in the related cross-community collaborations to follow.



What's Next?

ASME participation in expanded collaboration across the discipline communities

Questions, discussion

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References

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8. Schindel, W., "Realizing the Promise of Digital Engineering: Planning, Implementing, and Evolving the Ecosystem", INCOSE 2022 International Symposium, July 2022. Download from – https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:realizing_the_vision_of_digital_engineering_is2022_v1.3.4.pdf