

SWISSED24
Building Bridges, Methodology to Process

The Schrödinger's VandV paradox

alias

*The **continuous evolution** of the Verification and Validation processes **implementation** at the light of steeply innovation in terms of methodologies, tools, procedural best practices.*

By

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Carlo Leardi, graduated in electronic engineering in Genova Italy.



His professional background starts with quality assurance responsibility evolving in the last years to full verification, validation and testing commitment within complex systems development deployment projects in the following areas: automotive, freight railways and packaging industry. As a passion before and today as a full job, he is dealing with Quantitative Systems Engineering on a day-to-day application and coaching of a full range of statistical and simulation methodologies supporting the decisional process. He published several articles in Engineering and Systems Engineering journals. He is certified CSEP, TLI member, one of the founders and past President of the INCOSE Italian Chapter and founder of AISE, the Italian association of Systems Engineering. 4

He taught at the Systems Engineering Master, ForteMare and Strategos.

He is serving the Incose Italian Chapter as director of events and coordinator of the Verification, Validation and Operation working group.

VandV yesterday, today and tomorrow

Agenda

Verification and Validation best practices are well established!

Methodological, technological and procedural opportunities impacting Verification and Validation processes: Digital transformation, MBSE, Digital Twins, AI, AGILE and Engineering Statistics.

*Is Verification and Validation processes **implementation** STILL well established?*

*Aren't the Verification and Validation objectives “**Shadowed**” under the wave and the enthusiasm of their implementation advancements?*

Do Incose Verification and Validation processes description require updates and their implementation further exemplification?

Wrap-up

State of the art?

Well established!

Can we SERIOUSLY challenge the rationales and the need for changing any of the below reported elements? What about the temporal, but not only, relationships with the other processes and their implementation.

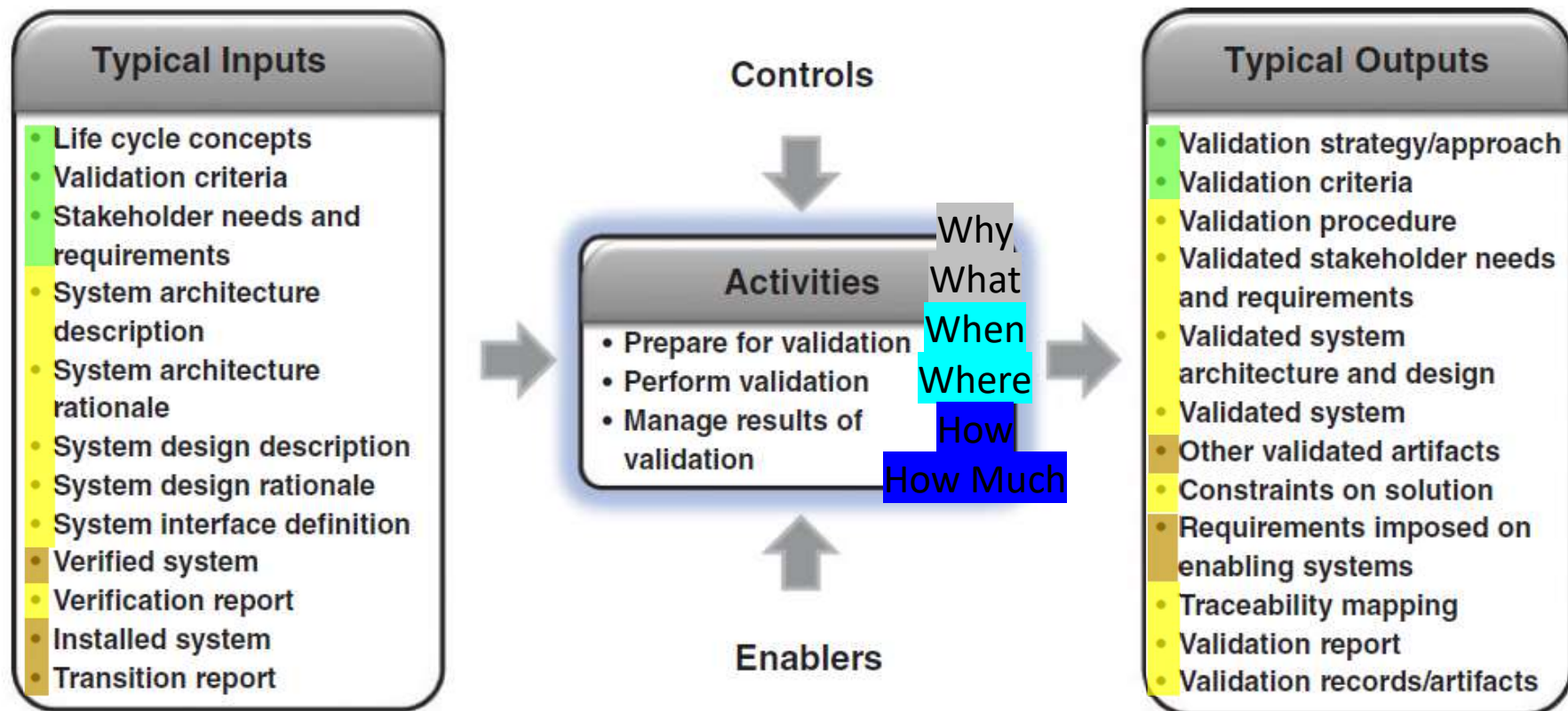


FIGURE 2.52 IPO diagram for Validation process. INCOSE SEH original figure created by Shortell, Walden, and Yip. Usage per the INCOSE Notices page. All other rights reserved.



Step Transition Challenges?

Procedures, methods, skills, tools and **organizations/persons, well known and documented, are continuously** although slowly evolving.

Transition to new/updated **approaches** and sometimes **mindsets**.

Each update requires specific validation.

Change implementation practices typically happens under pressure.

Improvement potential together with direct and un-direct costs, time and business scenario impacts.

Digital transformation impact on VandV

Industry 4.0 introduced a bunch of sensors of any nature which generates huge data-sets and make available **ancillary measures** which can be transformed into **information** and eventually **knowledge**.

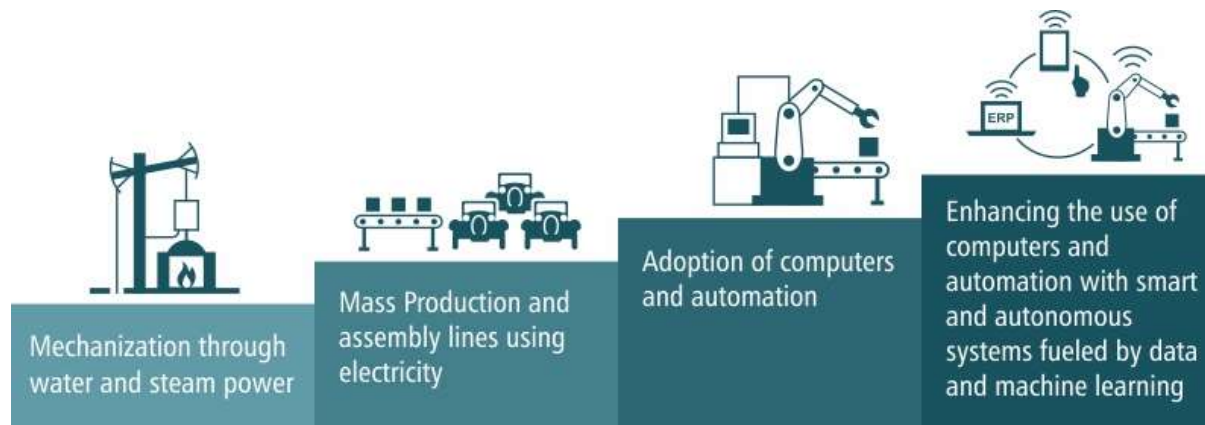
Are we ready to manage and make profit from this overwhelming, continuously evolving, **highly and diversely uncertain**, highly correlated flow of info?

What is the **delta between opportunities and jeopardized application scenario**?

How are visible into the **Verification and Validation processes descriptions/support**?

Measure systems are often “**self-referential**”. How to R&R them?

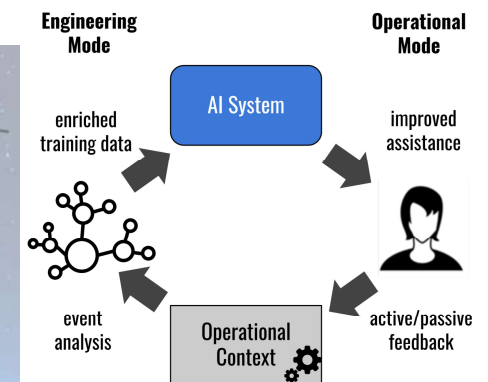
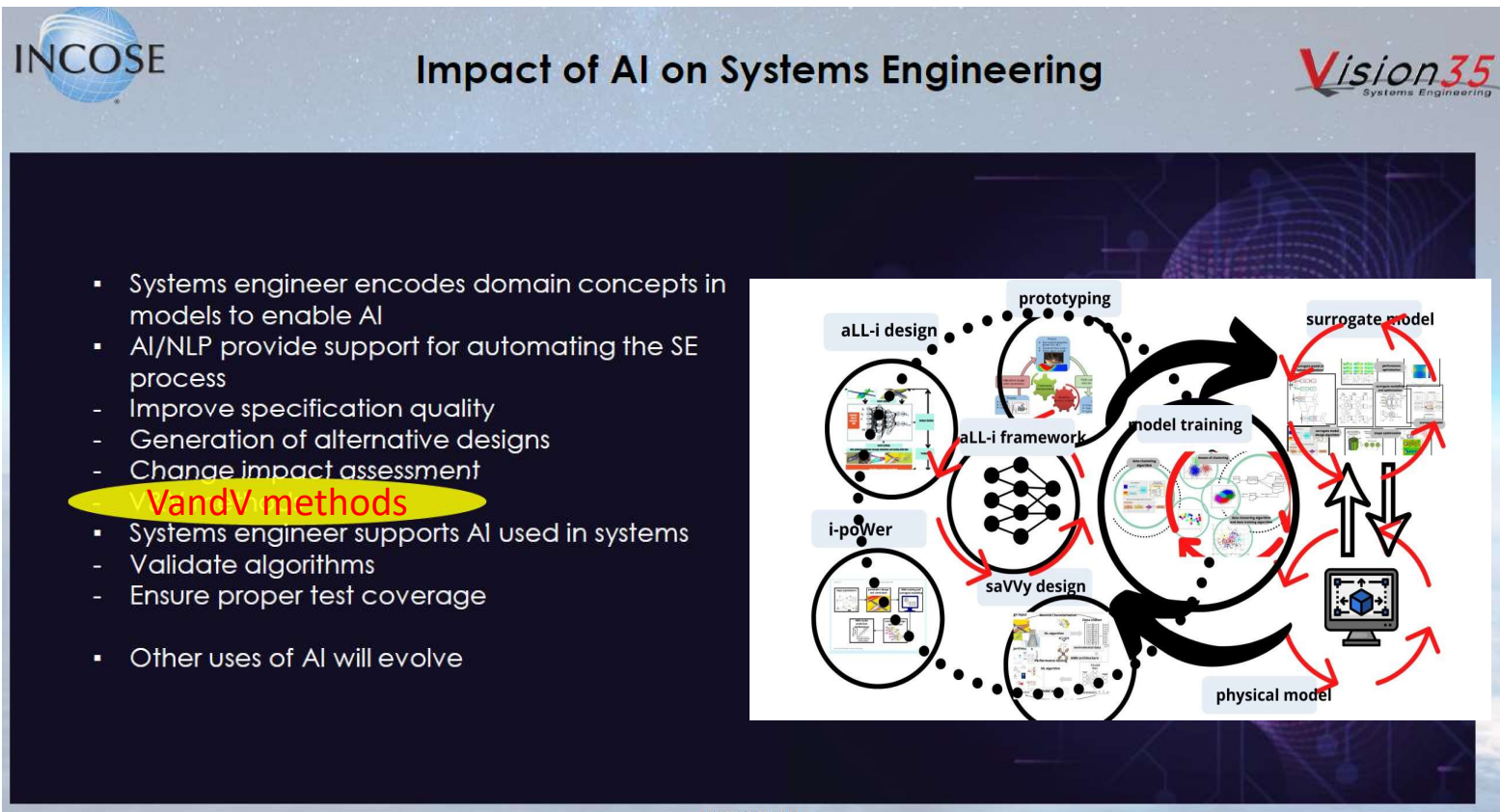
Do these opportunities, at least in part, already exist “**in nuce**” also in the past?



Artificial Intelligence impact on VandV

AI allows on-line analysis, trends, feedbacks, suggestions for correction and autonomous behaviour.
What are the roots and the past implementation of AI?
How to build-up "trust"?

SE4AI and AI4SE



Étienne Maurice Falconet,
Hermitage
Pygmalion et Galatée (1763)

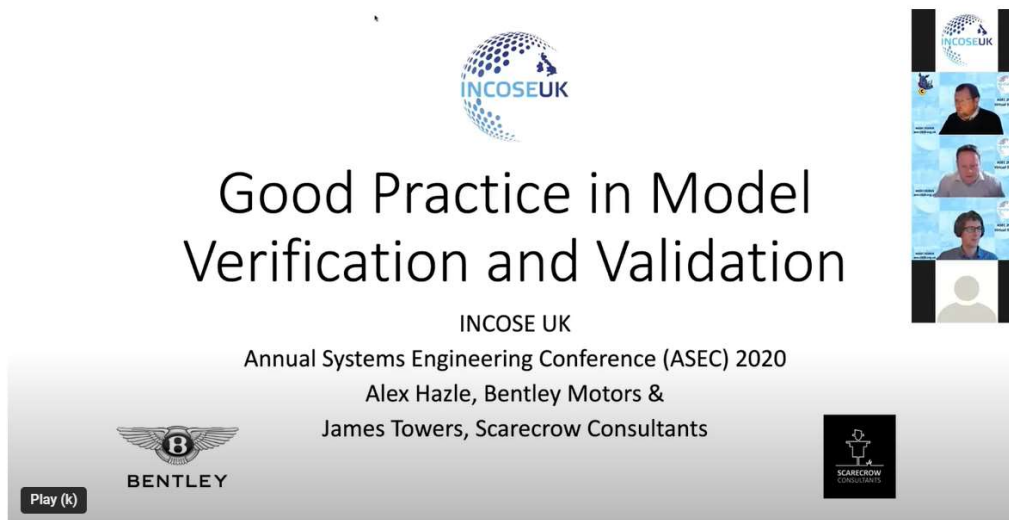
Impact of MBSE on VandV

Model verification and validation is seen as one of the obstacles to the adoption of MBSE.

Fewer books discuss the aspects of model verification and validation.

MBSE verification papers relate to semantic review, testing and formal methods.

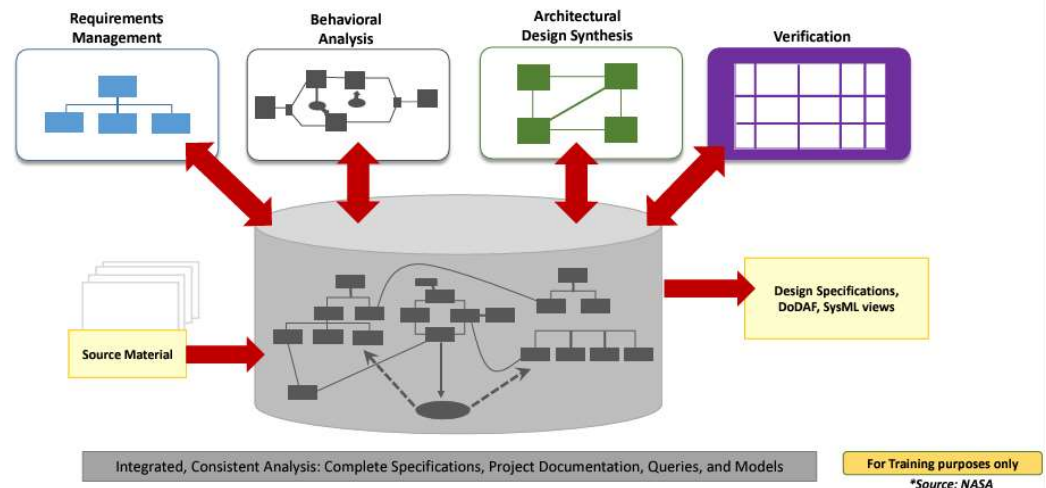
Learn from Model-based Software Engineering!



The screenshot shows a video player interface. The main content is a presentation slide with the following text:

- INCISEUK logo (a globe with dots)
- Good Practice in Model Verification and Validation**
- INCISE UK
- Annual Systems Engineering Conference (ASEC) 2020
- Alex Hazle, Bentley Motors & James Towers, Scarecrow Consultants
- Bentley logo (a winged 'B')
- Scarecrow Consultants logo (a stylized figure)
- A 'Play (k)' button in the bottom left corner.

Example: MBSE



ASEC 2020 Good Practice in MBSE Model Verification and Validation by Alex Hazle and James Towers

<https://www.youtube.com/watch?v=R5o-u3k07l0>

Impact of Digital Twins on VandV

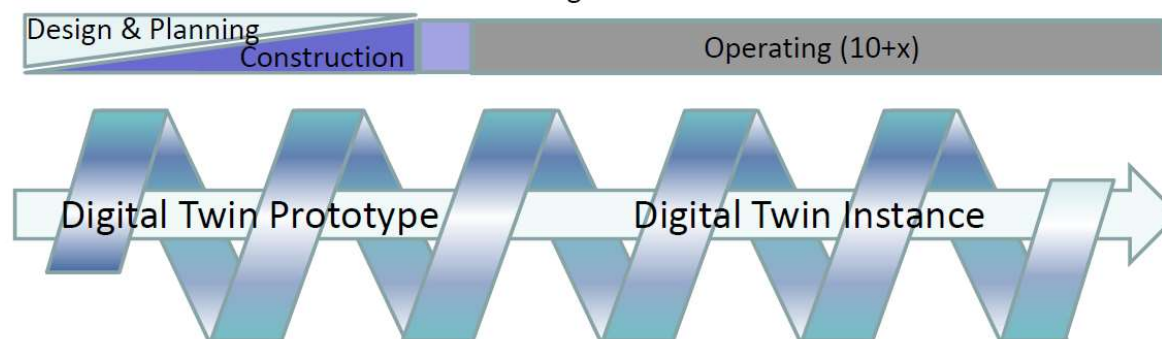


The Digital Twin application areas

"a realistic digital representation of something physical. What distinguishes a digital twin from any other digital model is its connection to the physical twin."

- Gemini Principles, 2018 Centre for Digital Built Britain

The digital twin is as much part of the Operation phase as it is part of the Design, Development and Planning
The digital twin is the DNA of the asset, it not only helps design and construct the asset but it is also part of monitoring its operation and describes how it behaves over time



Digital Twin Aggregate sitting in Digital Twin Environment

Project planning and construction phase utilizes a connected but consistent set of information (based upon the Building Information Model (BIM)) across the project lifecycle that extends into the Operation phase that allows project teams to collaborate seamlessly.

Agile impact on VandV

Agile principles and frameworks implementation involve an evolutionary mindset and cross-relational team work to afford enormously increasing systems complexity and shorter development times.

Do you notice any implicit concept?

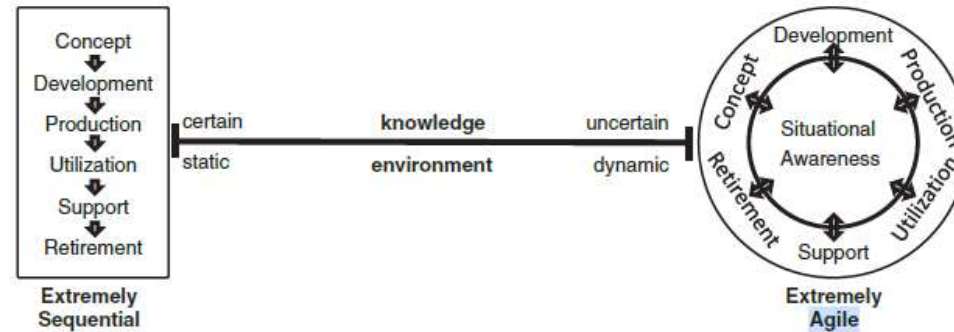
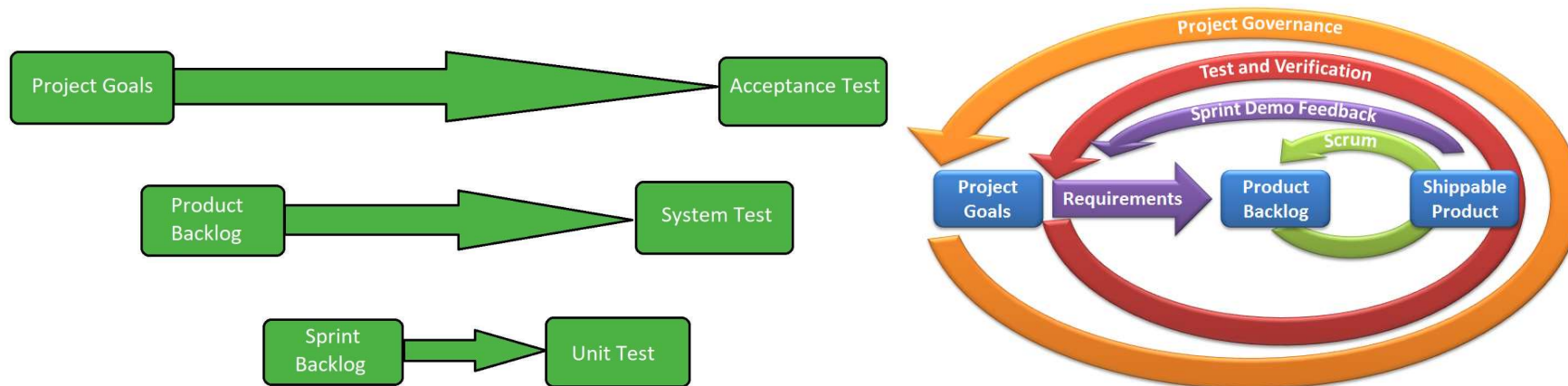


FIGURE 4.3 SE life cycle spectrum. From Dove (2022). Used with permission. All other rights reserved.



Agile Systems & Systems Engineering Working Group

Industrial Statistics impact on VandV

Jumping back into the future:

Shewhart vs. current academic industrial statistical approach by Geoff Vining

- Equation (2), Economic Control of Quality of Manufactured Product:

$$dy=f(X,\lambda_1,\lambda_2,\cdots,\lambda_m,)dX$$

- Deterministic Relationship

Shewhart versus Current Academic Approach

Current Academic

Shewhart

Sequence of Hypothesis Tests

Definitely Not Hypothesis Tests!

Assumes Process in Control

Assumes Process Not in Control

Decision: Statistical Test Result

Decision: Engineering Judgement

Focus: Testing Parameters

Focus: Prediction

Control Limits

Action Limits/Tolerance Limits

No Concern: Economic Costs

Complete Focus: Economic Costs

Enumerative Study

Analytic Study

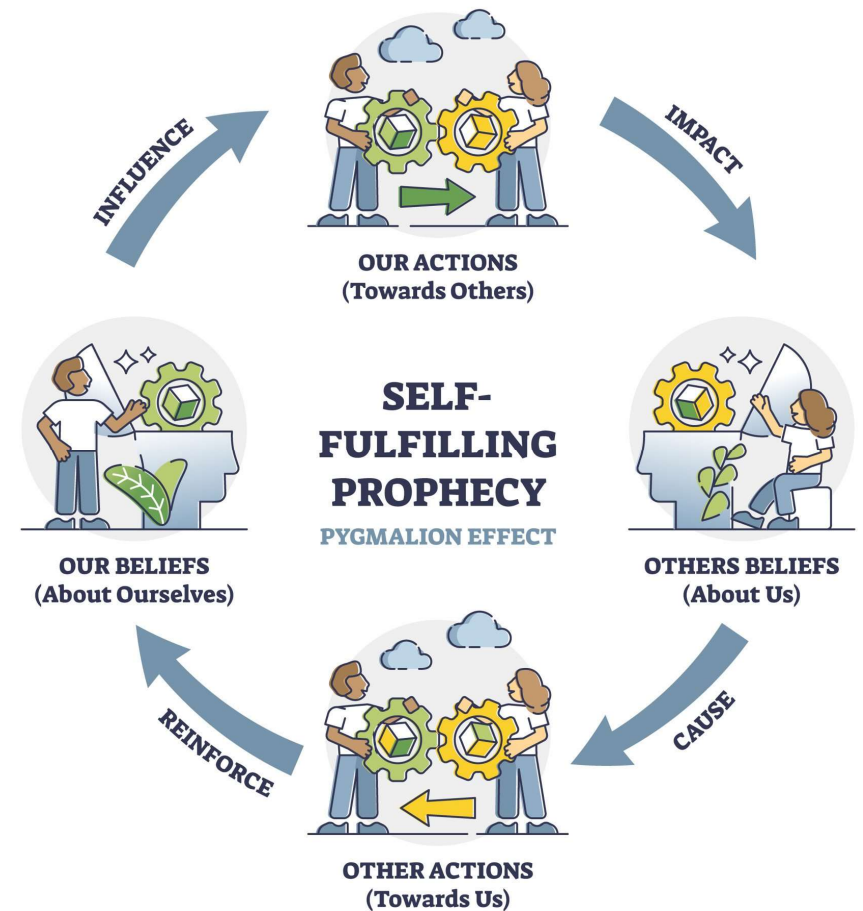
- Problem: How to Translate Shewhart to Current Modeling Practices

Confidence = Engineering + Statistical + psychological

are Verification and Validation processes implementations “shadowed?”

While we are:

- Integrating a new sensor/measure
- Instantiating a model update
- Defining a new behaviour
- Defining a new iteration
- Assessing a new algorithm



Do we keep focusing, through the overall system life-cycle, on the VandV processes?

Verification and Validation by INCOSE

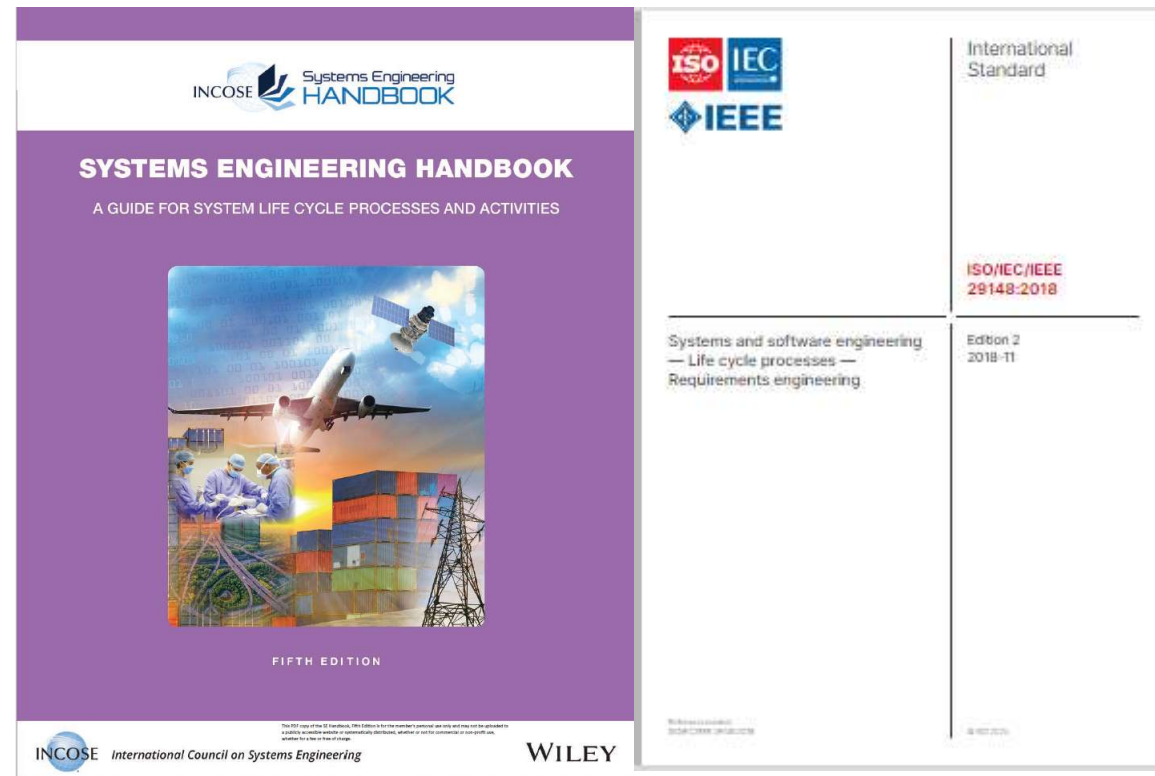
e.g. Verification Methods

Use of **analytical data or simulations** under defined conditions to show theoretical compliance.

Test: An action by which the operability, supportability or performance capability of an item is quantitatively verified when subjected to controlled conditions that are **real or simulated**.

“similarity”

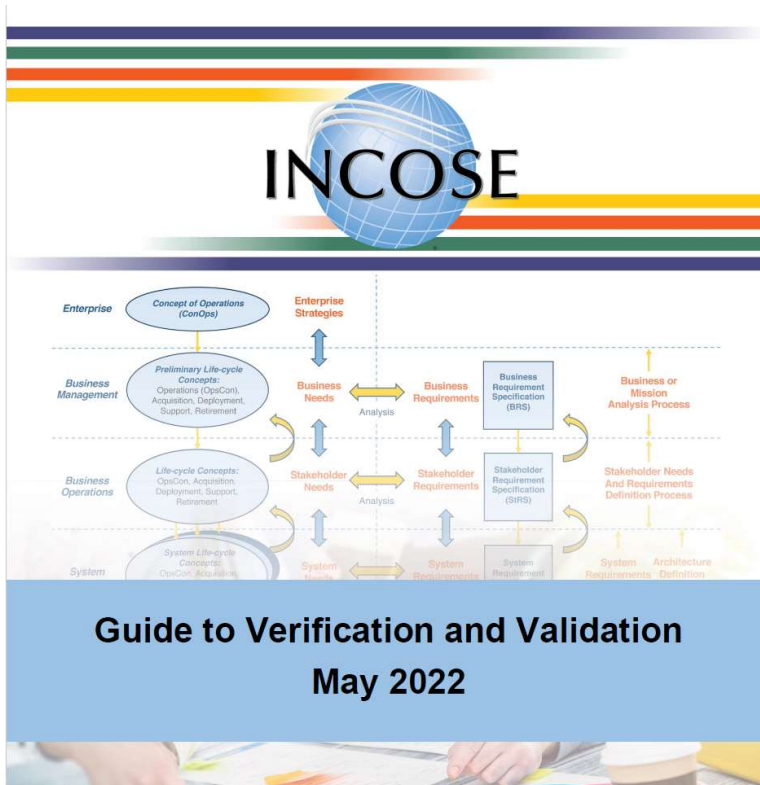
It is further more impossible to test **100% of the operational scenario**



Systems Engineering Handbook Fifth Edition
and
ISO/IEC/IEEE 29148,, 2018 validity confirmed 2024:

Verification and Validation by INCOSE

Early System Verification and System Validation



Models of the design <..> opportunity for risk buy-down in early and progressive system activities before “metal is cut” or full-scale programming begins. **Note this is not system verification and system validation that occurs on the right side of the SE Vee.**

Modeling and early verification and validation activities can be used extensively.

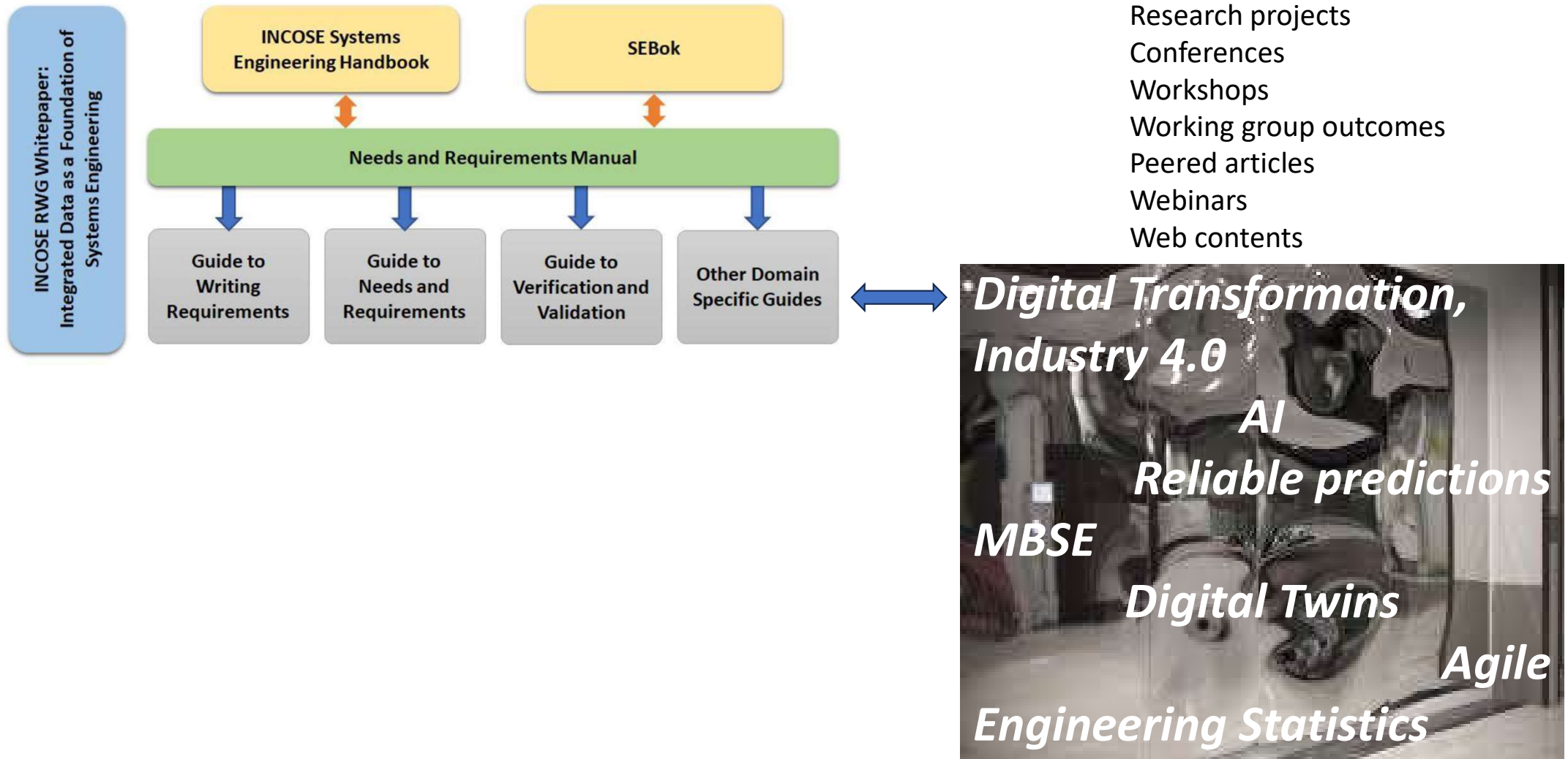
Determining early in the program what will be verified or validated using a model or simulation, or what must be physically verified and validated

A model or simulation is a system in its own right, driven by needs and requirements for its specific user, by its intended users, in its operational environment.

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Verification and Validation

Opportunities for a potential process documental ~~expansion~~ integration



Wrap-up

Verification and Validation processes implementation are severely impacted by new methodological, technological, procedural opportunities.

The positive impacts require, as usual, a minimum mass and maturity, to gather the expected value.

The Incose references COULD require, at the proper level, updates, in special way in the exemplification and supportive to day-to-day practice.

The interaction among the different Incose working groups and practitioners is fundamental to achieve the best from one specific approach while not sacrificing the uniqueness of the approach.

Bye Bye

