

Using Historical Measurement Data for the Validation of Engineering Simulations

Erwin Hack, Empa

K. Dvurecenska and E.A. Patterson, University of Liverpool

G. Lampeas, Athena Research and Innovation Centre

T. Siebert, Dantec Dynamics GmbH

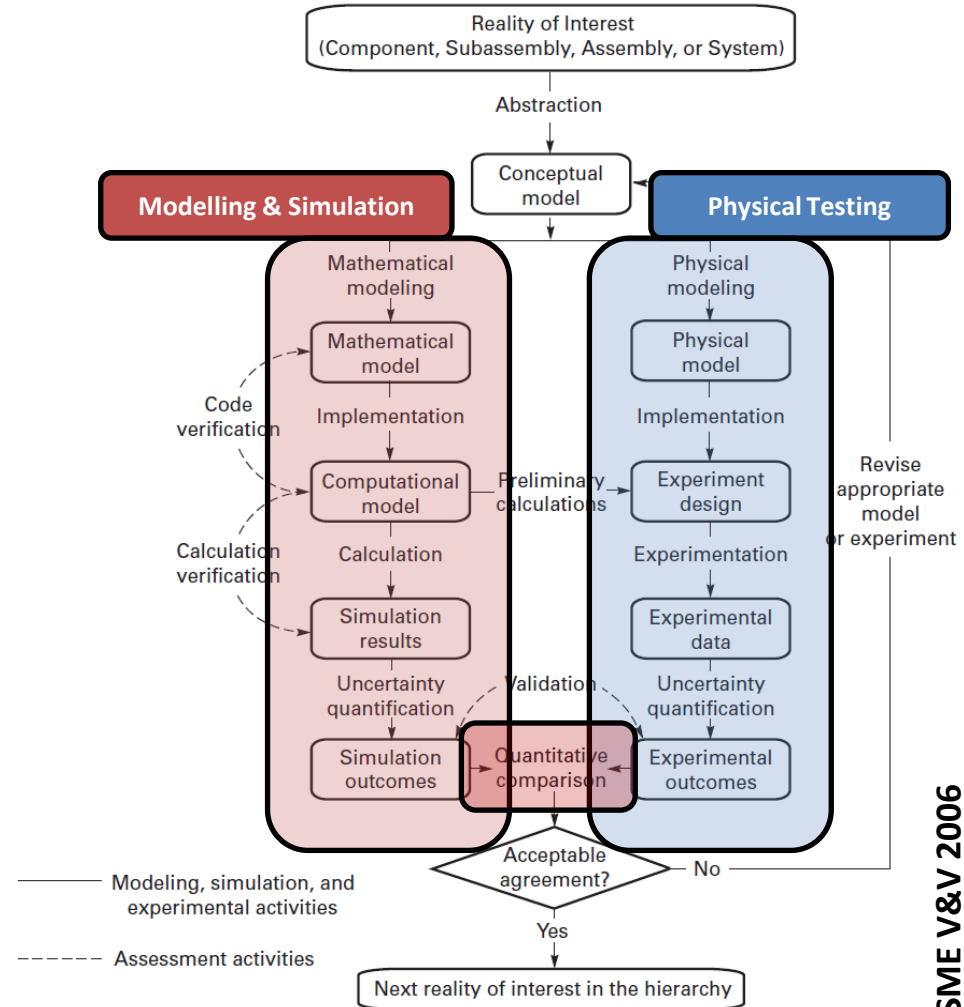
E. Szigeti, Airbus UK

erwin.hack@empa.ch



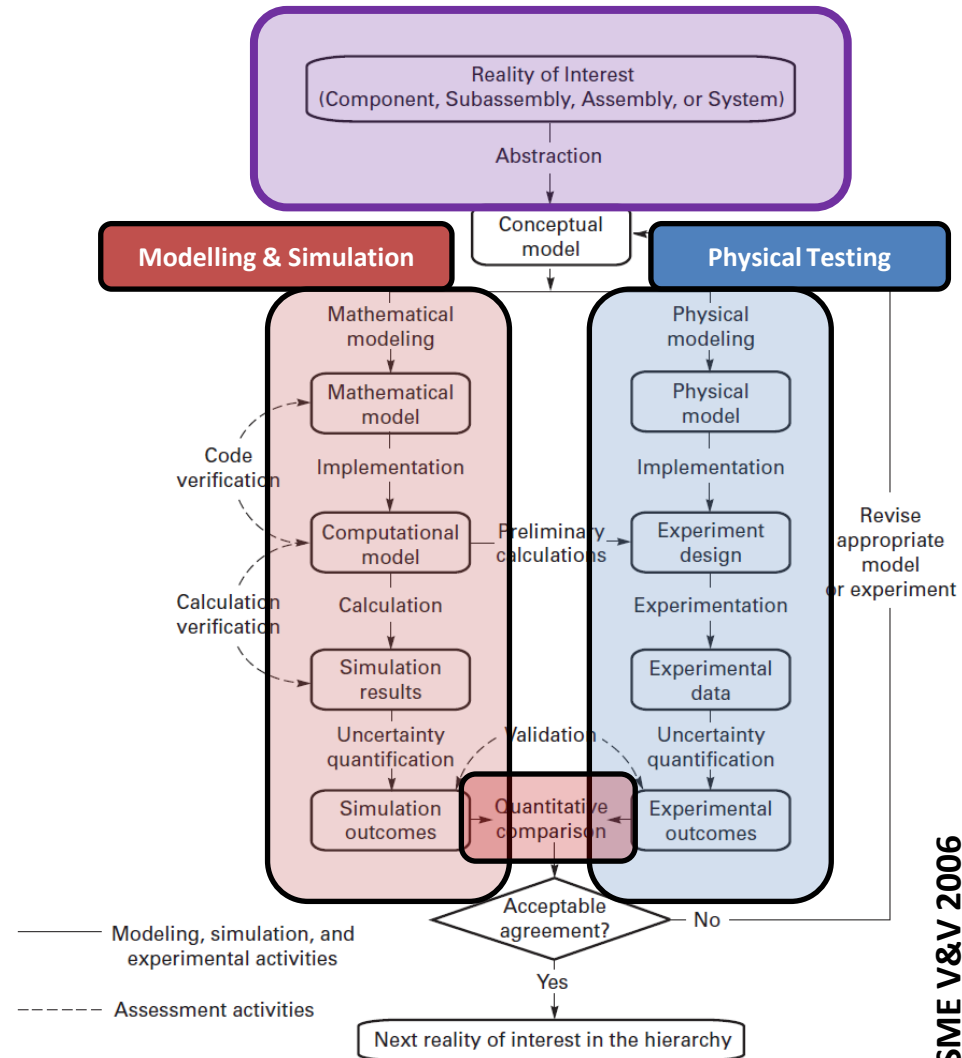
Motivation

- **ASME V&V**
 - Perform a dedicated validation experiment
 - Parallel strands for simulation and experimentation
 - Validation by comparison of resulting data
- **Feasible for all “Realities of Interest”?**
- **Breaking symmetry of strands?**



Modifications

- **Reflect different weight of simulation and experimentation**
 - **High cost** for sub-component and component tests on a higher level of the test pyramid
 - **Number of tests** to cover the entire range of the intended use far too high to be practical.
- **Increase body of evidence for the purpose of validation**
 - include «Historical Data»
 - introduce modelling credentials
 - obviate the need for dedicated validation experiments?

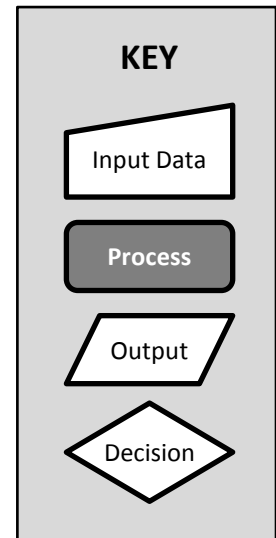
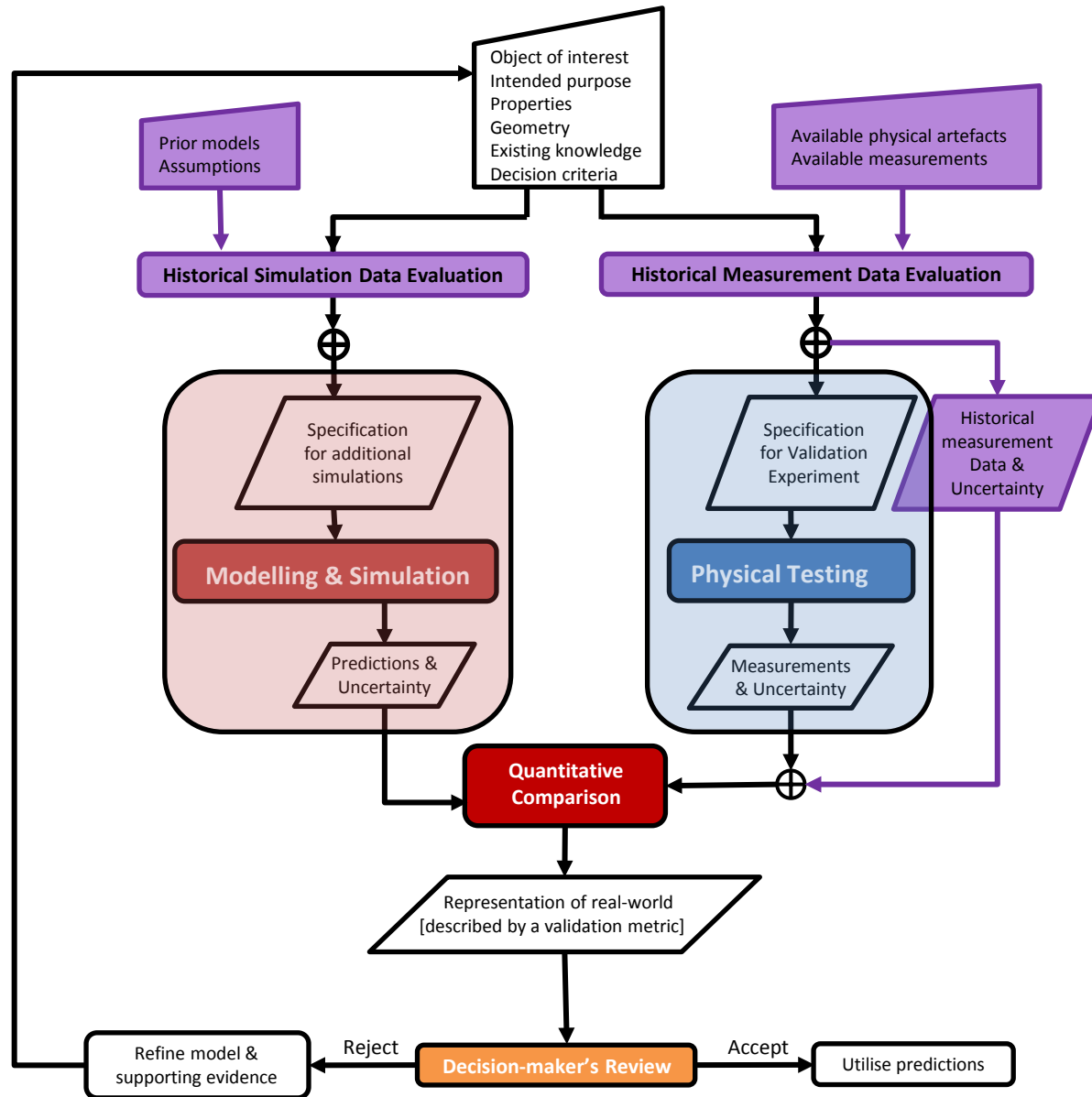


Historical Data

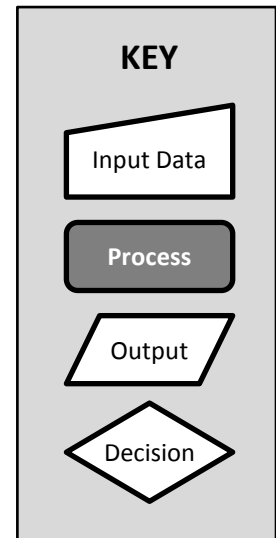
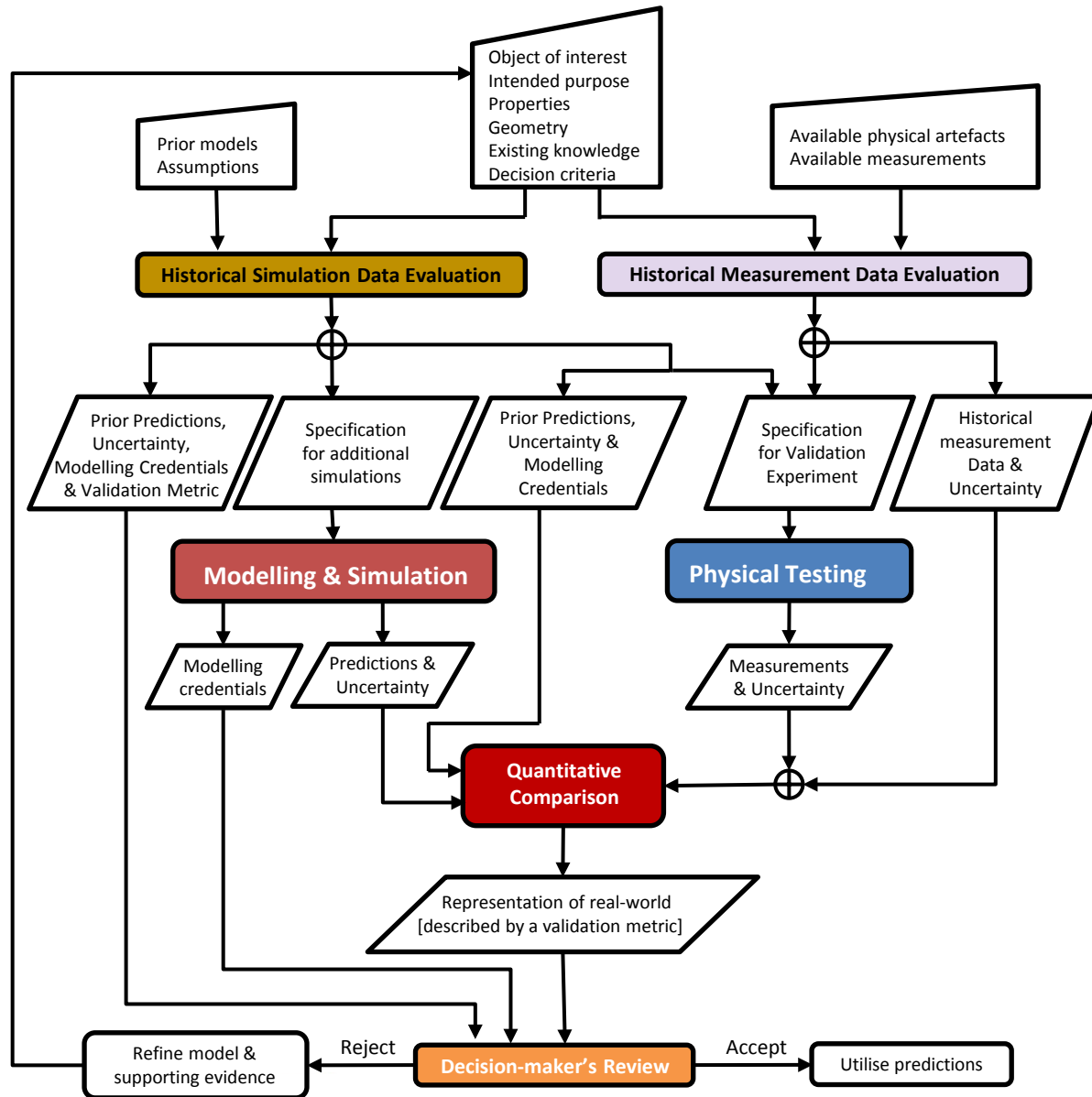
- «Historical Data»
 - Data on a **system in a previous state**
 - **Prior data** for a (similar) system
- «Data» in the validation context
 - Results from simulations
 - Results from experiments
- Metadata
 - **describe** the contents and context of Data, e.g. software tools, authors, project relation.
 - **organize** electronic resources, provide digital identification, and support the archiving and preservation of resources.
 - help **discover** relevant information by "allowing resources to be found by relevant criteria, identifying resources, bringing similar resources together, distinguishing dissimilar resources, and giving location information." ¹



Modified 'validation' flow-chart including Historical Data

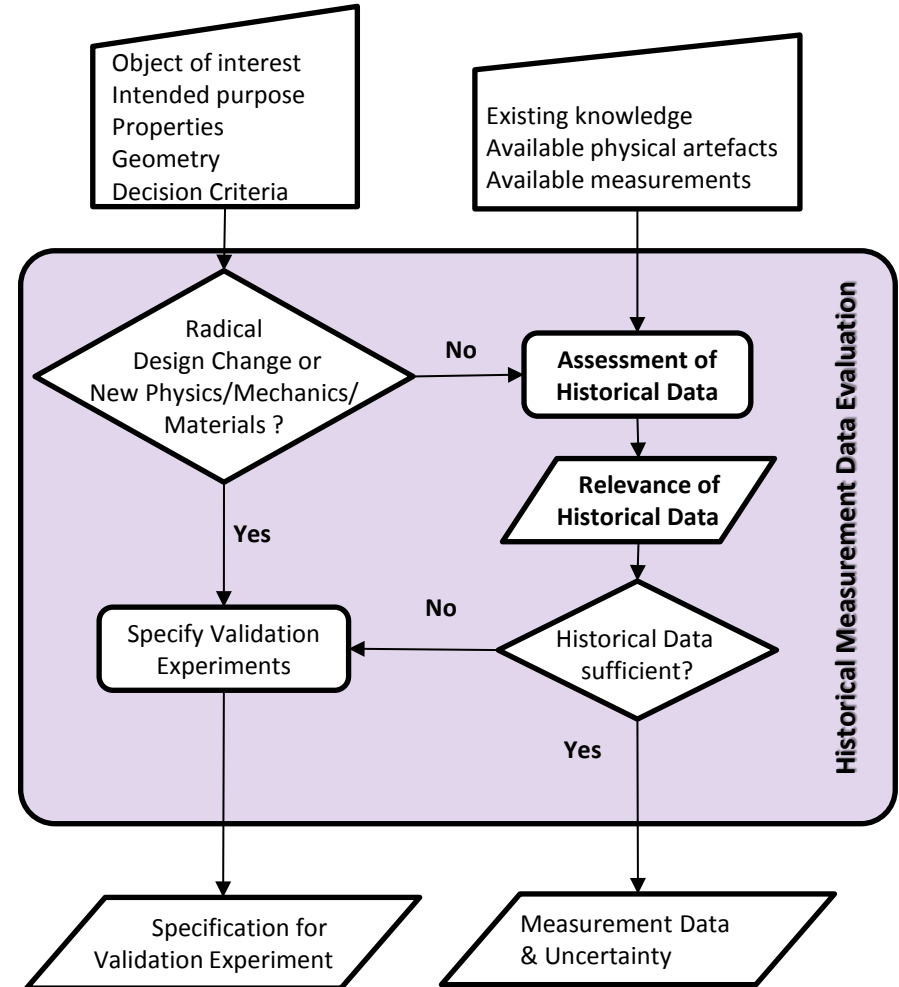


Modified 'validation' flow-chart including Historical Data



Historical Measurement Data

- **Unexplored region?**
 - Radical design change
 - New physics
 - New materials
- **Explored region**
 - Similar artefacts available
 - Similar test data available
 - Small changes in geometry due to manufacturing or defects



Implementation

- **Most historical data is inadequate**
 - Metadata is incomplete, measurement uncertainty unknown
 - Data format is often unreadable
- **Make all sources of information available for validation**
 - Harvest all available information
 - Exploit prior “incomplete” or “failed” results or data
- **Implement a Data Management Plan**
 - Define format, style and accessibility of data (recognised standard)
 - Archive data with full metadata for potential later use: material specs, loads, bc, uncertainty quantification, assumptions, models,...
- **Incorporation of historical data is likely a future event**



Challenges



Model



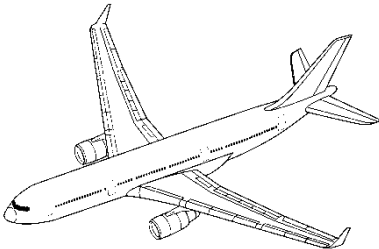
Many realisations



Digital twins

«Historical Data»
of an older
aircraft

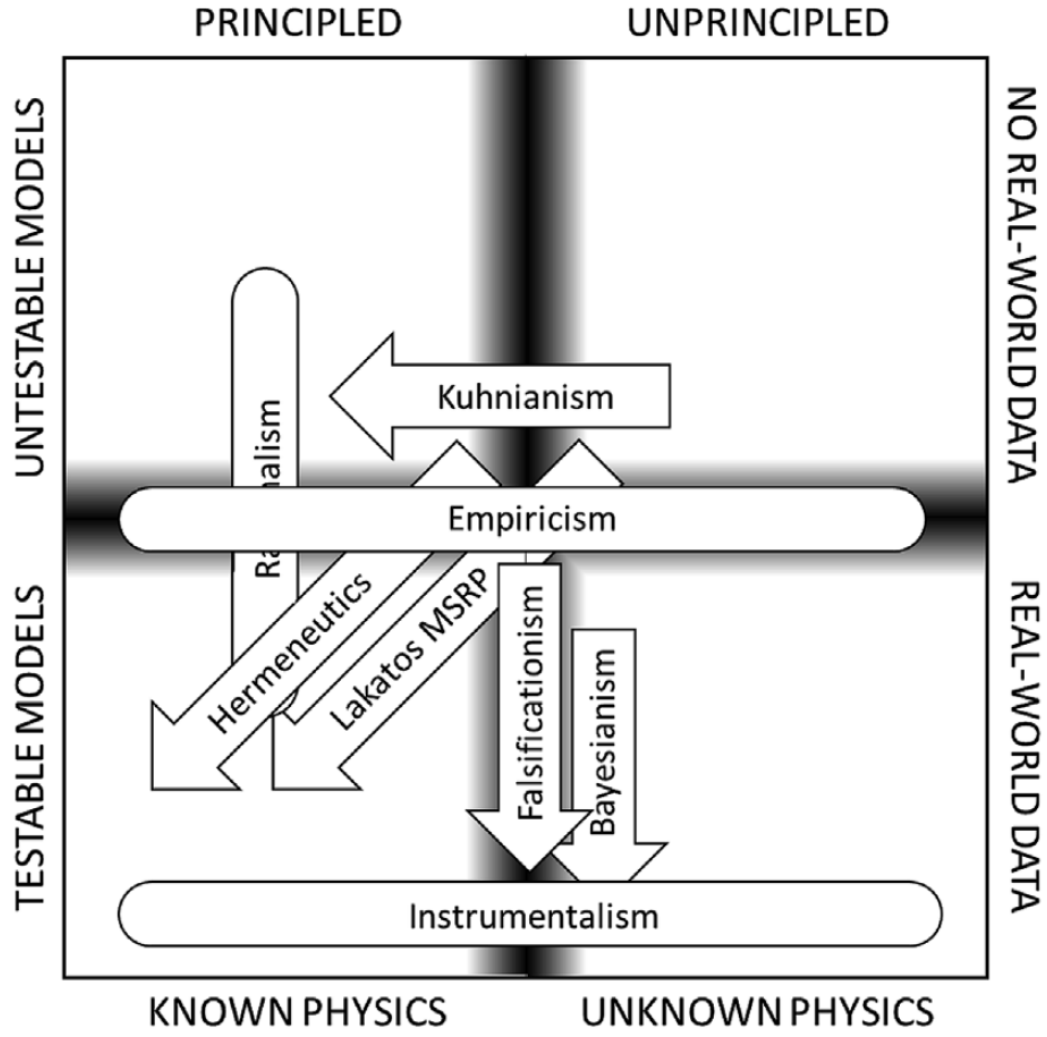
«Historical Data» over time
(model updating)

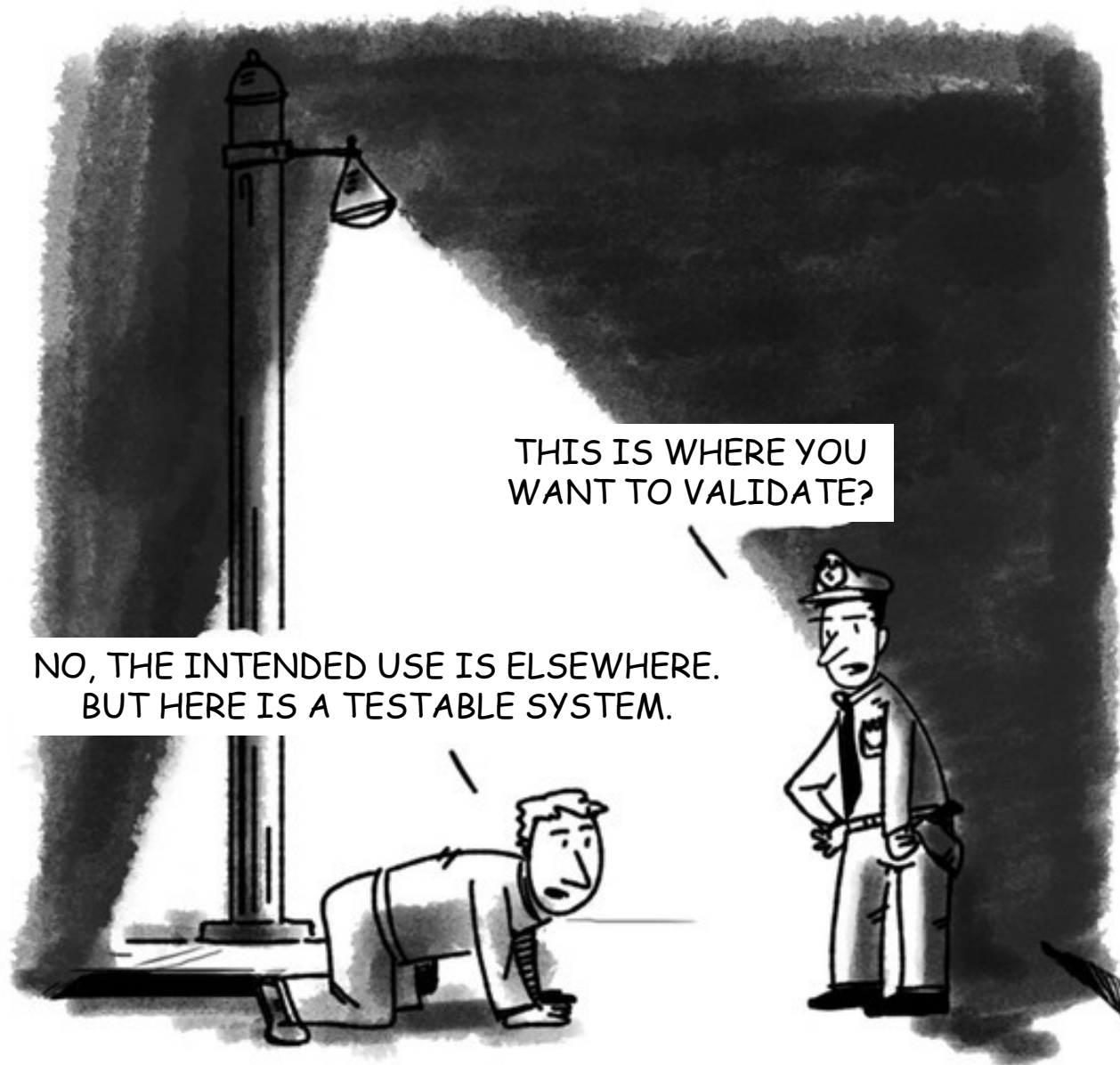


Incremental change?



Challenges



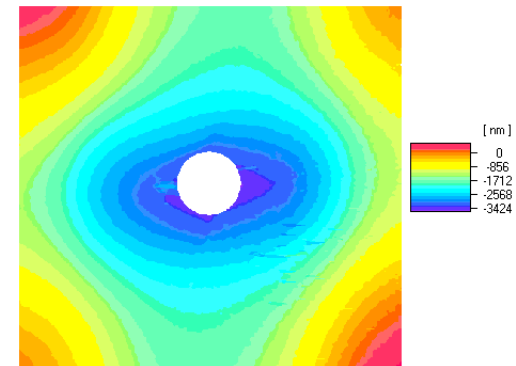
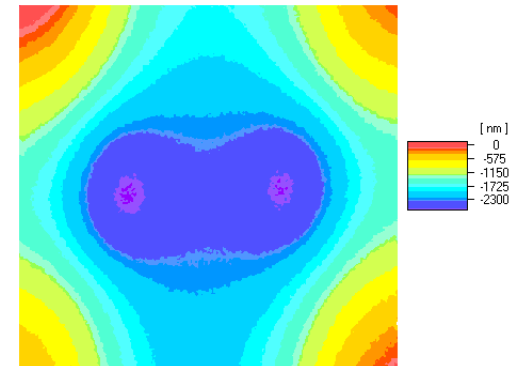


THIS IS WHERE YOU
WANT TO VALIDATE?

NO, THE INTENDED USE IS ELSEWHERE.
BUT HERE IS A TESTABLE SYSTEM.

Conclusions and Outlook

- **Validation is about credibility**
 - Increase body of evidence by exploring historical data
- **Data management is crucial**
 - Consistent format of data base
 - Facilitate data mining within a continuously growing data base
- **Similar concepts apply for**
 - Digital twin
 - Creating a continuum of data through validation, manufacturing and service (NDE) ²



Change of deformation field due to impact defect (ADVISE)

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MOTIVATE website: www.engineeringvalidation.org

