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Title:	ROLES FOR ELICITATION IN INFORMATION INTEGRATION
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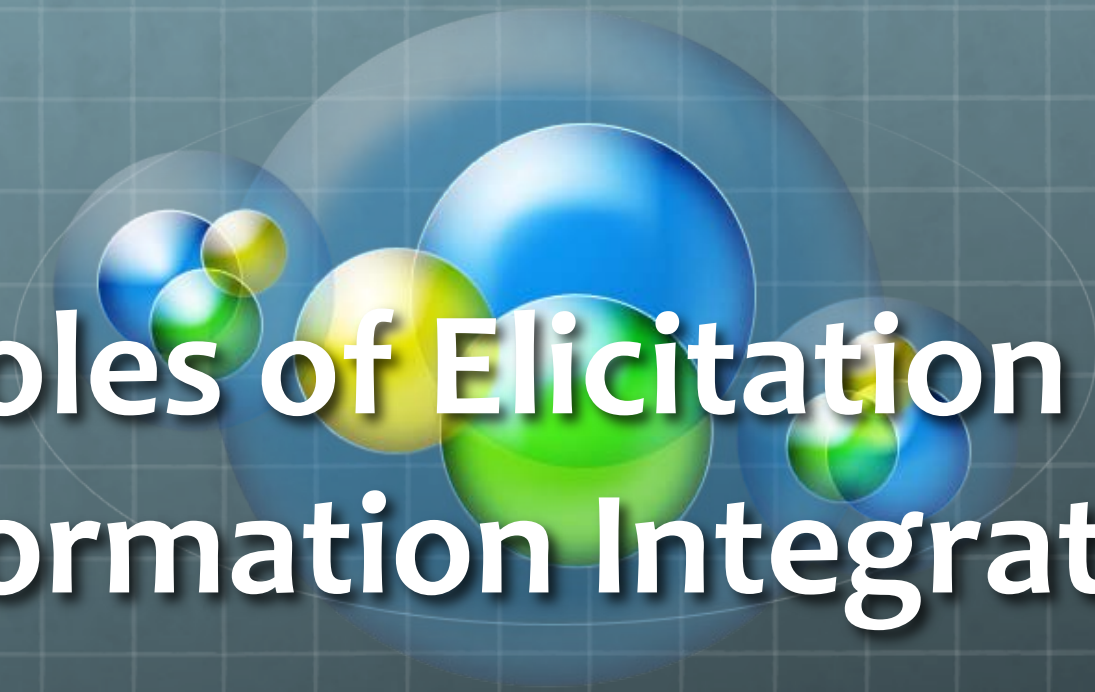

Roles of Elicitation in Information Integration

Jane M. Booker (retired!)

Timothy J. Ross
University of New Mexico

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Los Alamos National Laboratory

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Abstract: Twenty years ago, Meyer and Booker published their practical guide on formal elicitation of expert knowledge. Their expert-oriented, bias minimization approach established the important linkage between elicitation and the subsequent analysis of the expert's knowledge in physical science and engineering applications. The NRC's reactor safety study (NUREG 1150) and Los Alamos' reliability of nuclear weapons program were the first to utilize their methods. From those, they formalized the use of expertise to formulate the structure of complex problems — the second role for elicitation of expert knowledge. By 1999, the first Information Integration methodology, PREDICT, was developed. Elicited knowledge became a primary source of information along with data and models, and experts' predictions were validated. In today's Information Integration, experts provide multi-faceted products, including experts taking on the role of hunter and gatherer of data, information and knowledge to be integrated in a *waste nothing* philosophy, and they play a prominent role in providing "glue" for the integration. LA-UR-11-04498

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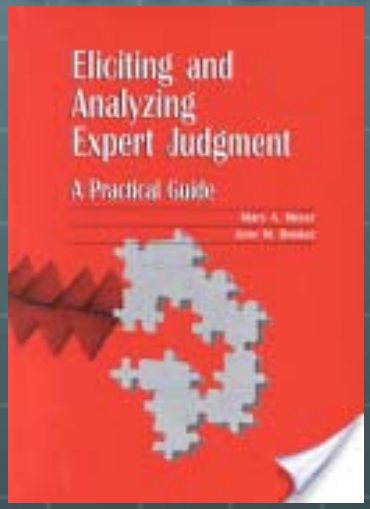
1991 & 2001 Formal Elicitation



Mary A. Meyer (anthropologist) and
Jane M. Booker (meteorologist & statistician)

Eliciting and Analyzing Expert Judgment: A Practical Guide

Linking elicitation methods with analysis—two sides of the same coin.

Bias minimization, expert-oriented elicitation methods.

NOT talking about these methods *per se*—you can still buy the book.

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Some Definitions

Expert Judgment —aka—Expert Knowledge is more than "the man on the street" opinion. It reflects the current state of what is known (or unknown) according to the Experts in a field.

Experts—those recognized by their peers as knowledgeable; having expertise from experience.

Bias minimization—Bias is anything that alters or changes the expert's fundamental knowledge. Often bias occurs between what the expert knows or understands and what the expert verbalizes. Sometimes biases distorts basic knowledge, memories (experiences), problem solving abilities, decision making and thinking.

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More Definitions

Expert-oriented elicitation methods—Permit subject matter experts to determine definitions, question phrasing and response modes, aggregation methods uncertainty types, analysis methods, etc. —all consistent with the "Community of Practice"

—Reliance upon detailed elicitation methods to capture the experts' cognitive and problem solving processes.

What you will hear from me today.

Analysis—what can be done with elicited knowledge? Some of my experience in answering that question follows

First a Little History/Background

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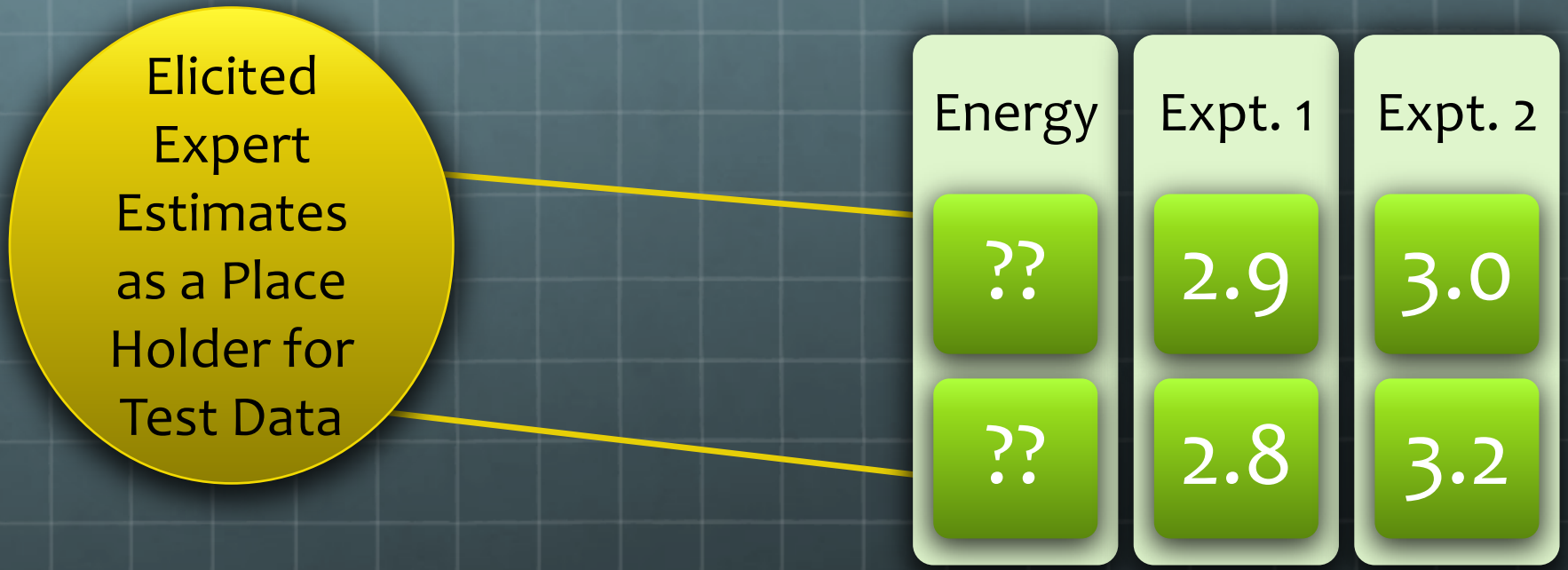
Applications of Elicited Expert Knowledge

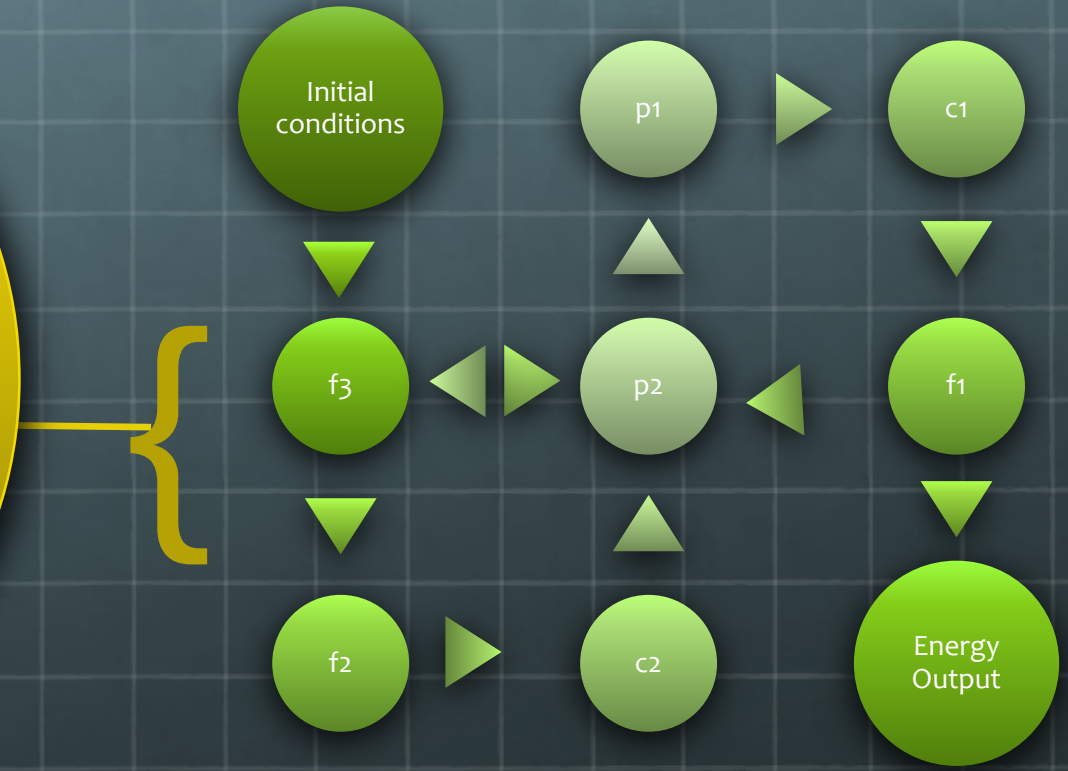
- NUREG 1150—Nuclear Regulatory Commission's nuclear reactor probabilistic risk assessment.
- Los Alamos weapons in conjunction with GM/Delphi Systems—PREDICT reliability methodology in the absence of testing.
- Turbine jet engine performance in aerospace companies—high cycle fatigue studies.
- Articles "Model choice considerations and information Integration using Analytical Hierarchy Process", "Inference Uncertainty Quantification Instead of Full-Scale Testing"

First Role for Formally Elicited Knowledge



Second Role for Formally Elicited Knowledge

Expert Provides Structure for complex or challenging physics processes problem



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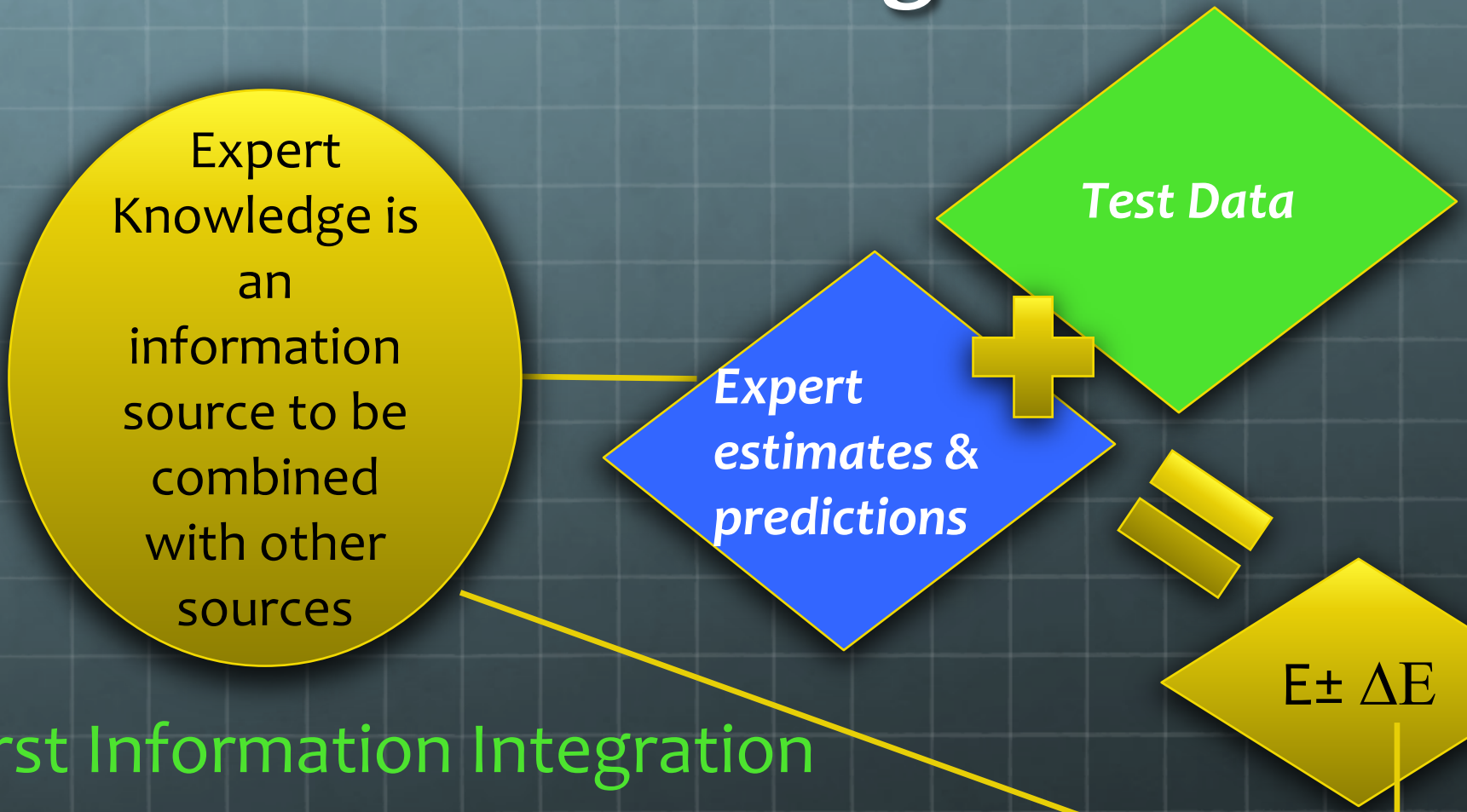
Third Role for Formally Elicited Knowledge



First Information Integration

PREDICT Performance & Reliability Evaluation with Diverse Information Combination & Tracking

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My perspective on expert elicitation:

what is the expert thinking (and hence) doing when they are doing it?

And why does this matter to you?

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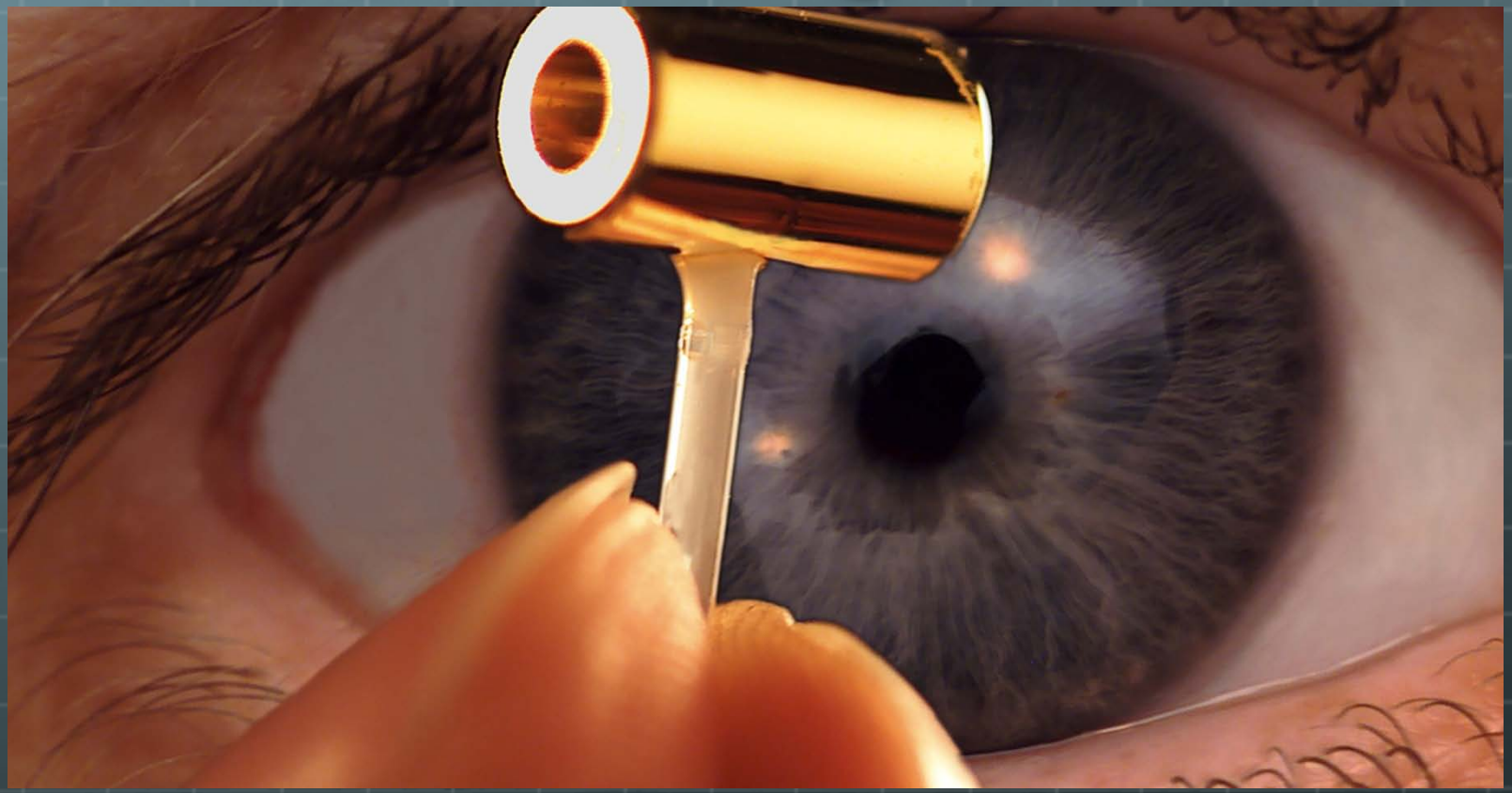
What is the expert doing?



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What is the Expert Doing?

Code to Experiment Evaluation

Space of Experimental Input Parameters

What is the Expert Doing?

Code to Experiment Evaluation

Space of Simulation Output Parameters

Looking at the Models as an experimentalist

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What is the Expert Doing?
Evaluating Reason to Integrate

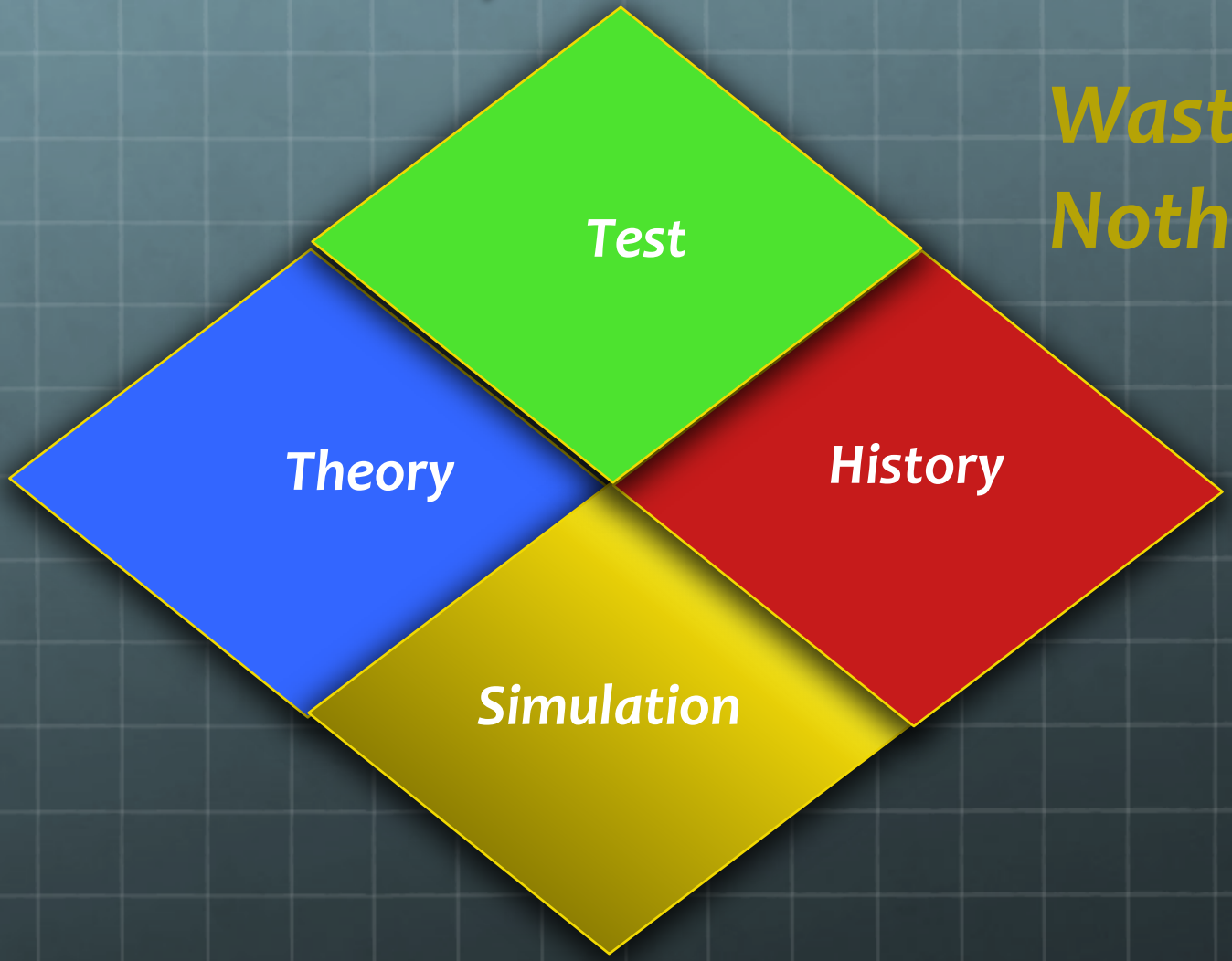
- Each of these has its strengths and weaknesses.
- Can hope to build on both.

Reality
Experiment

Small
Statistical
Inference
Code
Output

"Hunter & Gatherer" Expert:

Available Data, Information & Knowledge



Waste Nothing

Our 4-Box Approach to Information Integration

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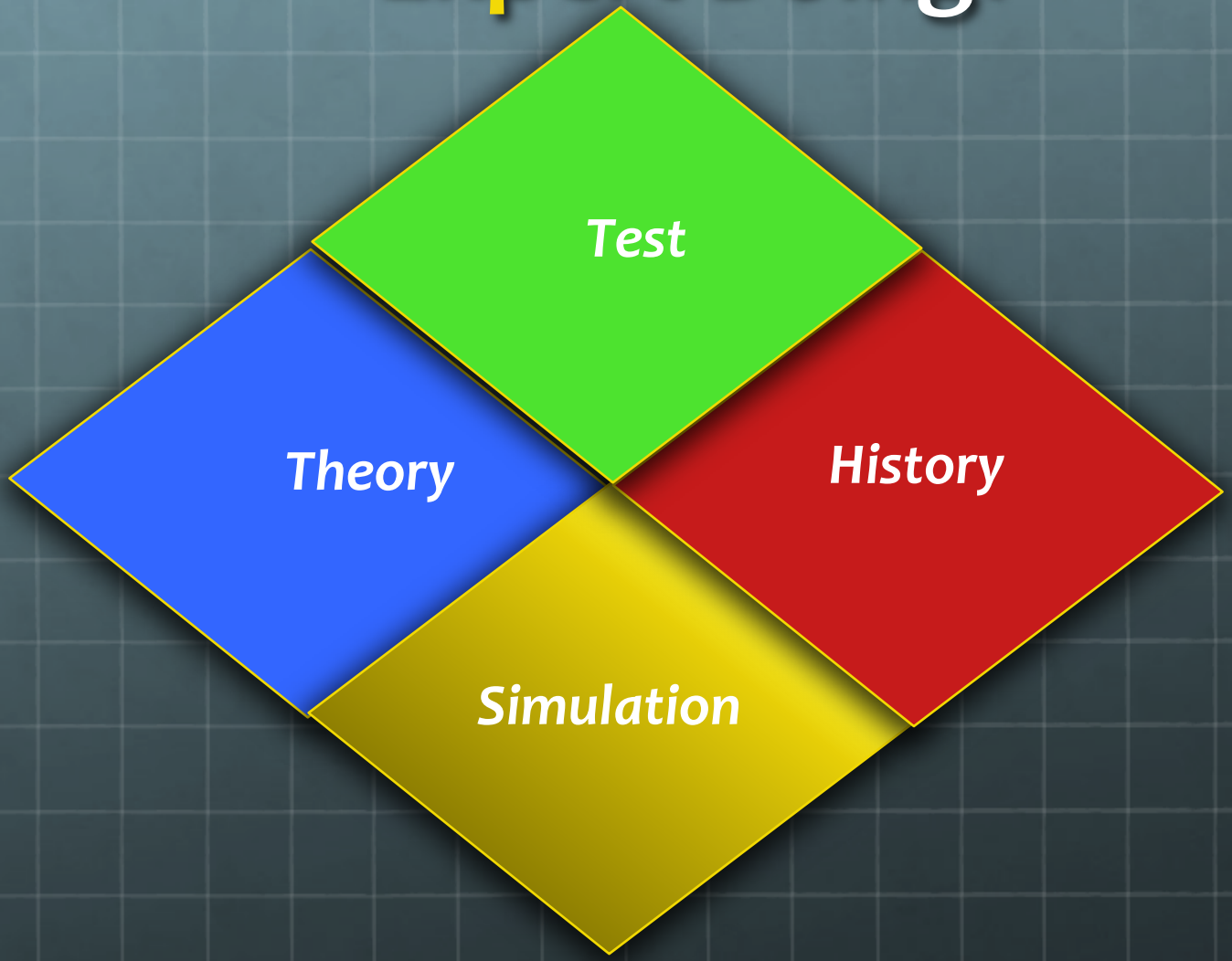
What is the Hunter &Gatherer Expert Doing?



Determines what's inside these boxes . . .

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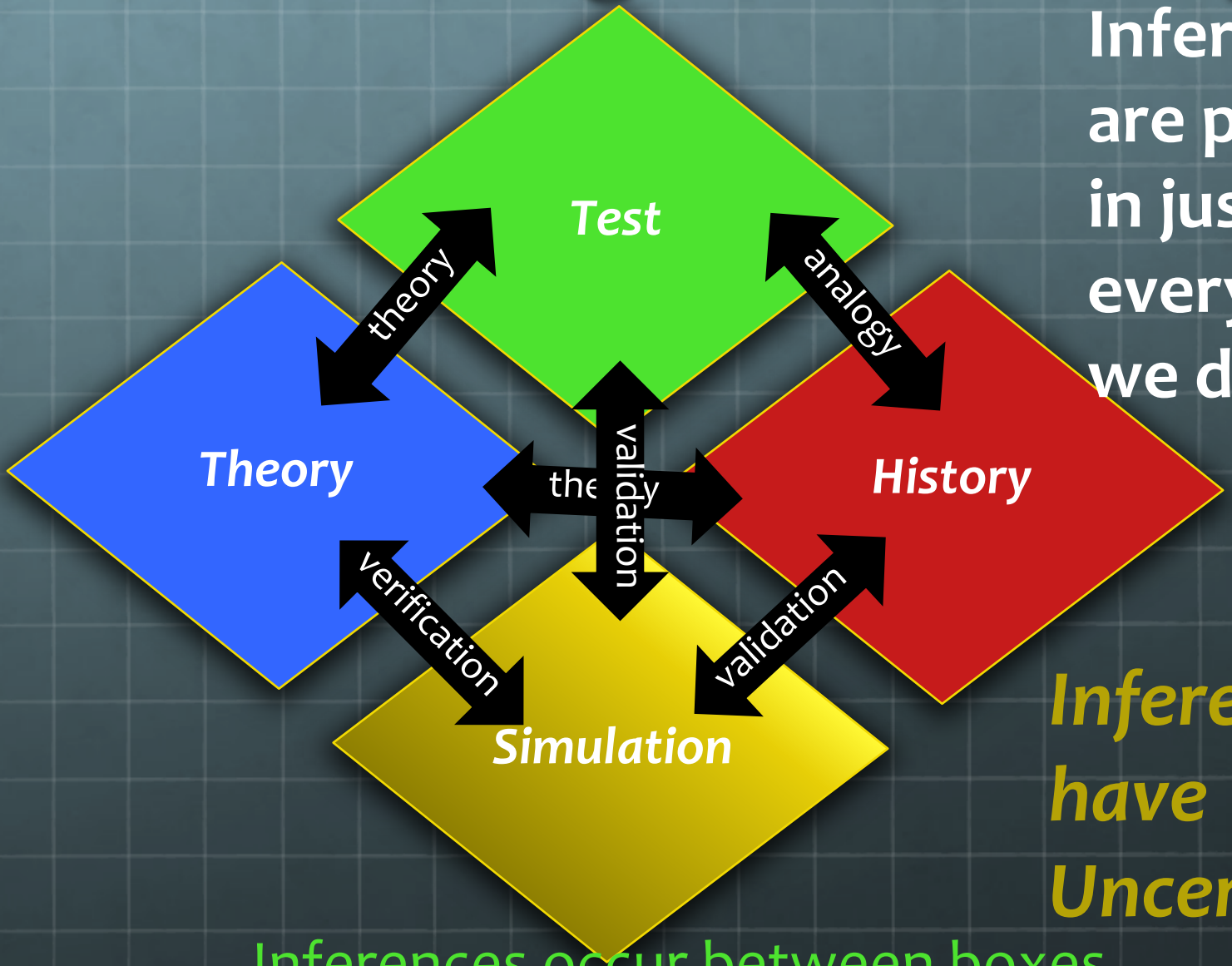
Understanding Inferences Expert:



Inferences are present in just about everything we do.

Inferences have Uncertainty!

Inferences occur between boxes.

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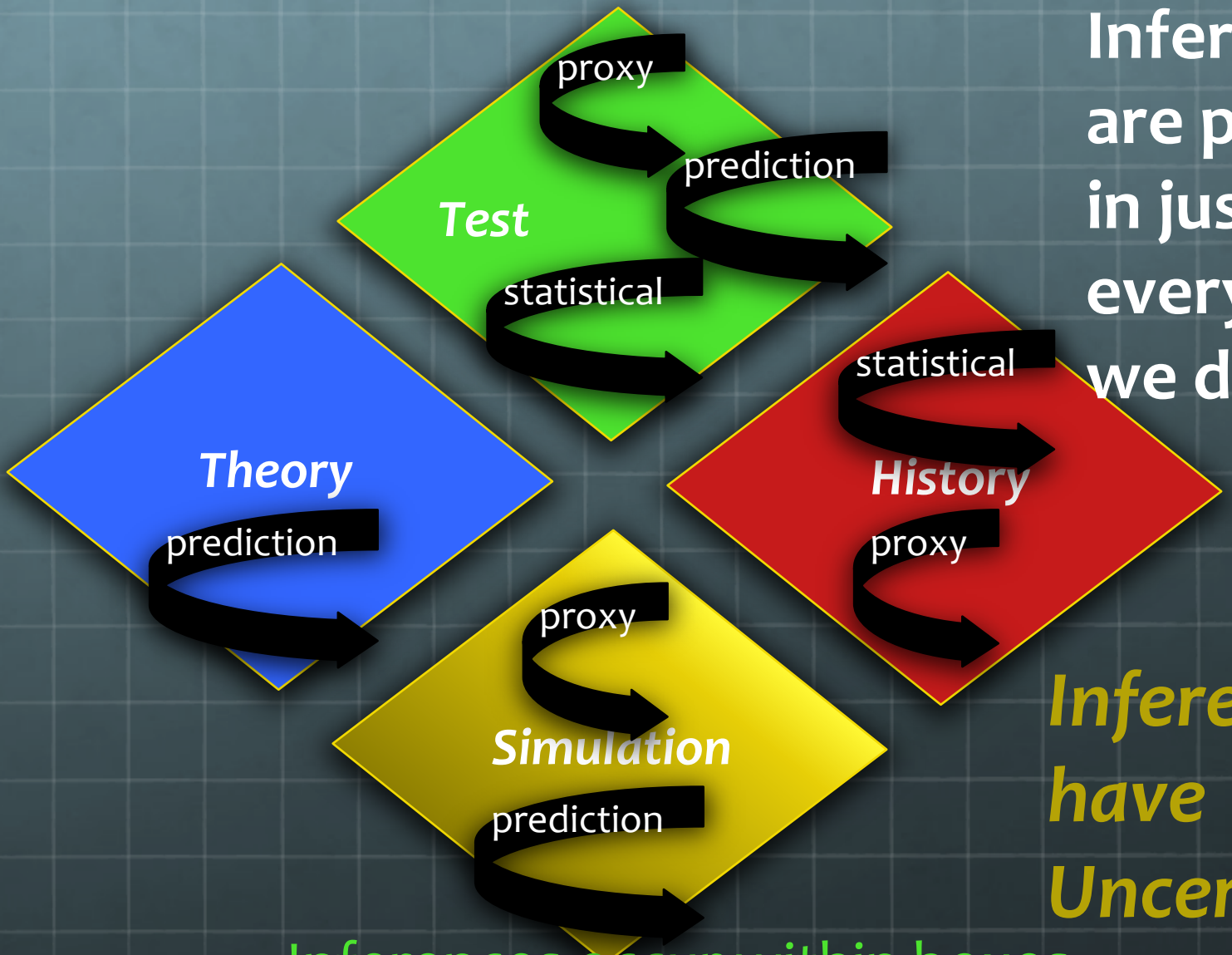
Understanding Inferences Expert:



Inferences are present in just about everything we do.

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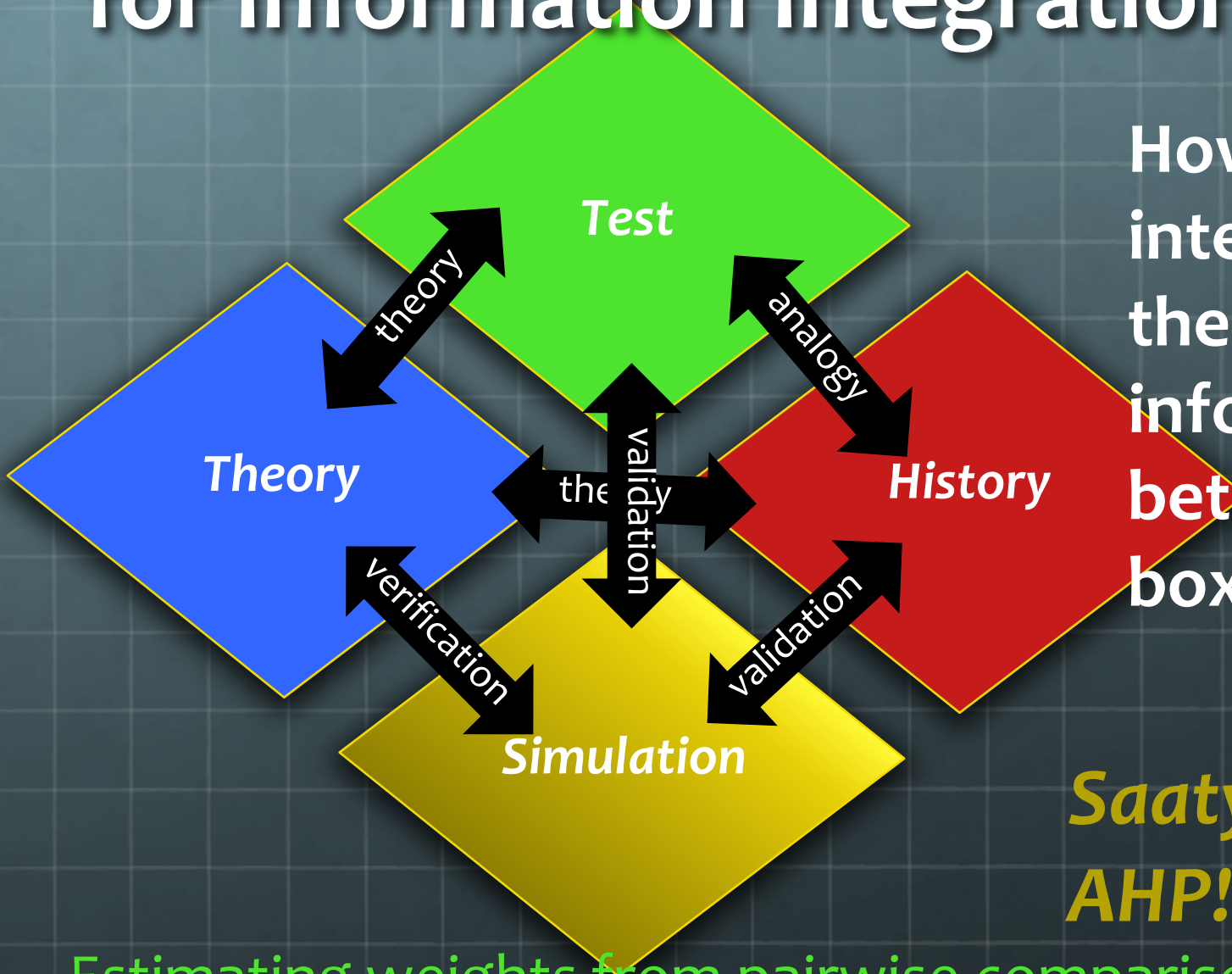
Estimating Weights Expert for Information Integration



How to integrate the information between boxes?

Saaty's AHP!

Estimating weights from pairwise comparisons.

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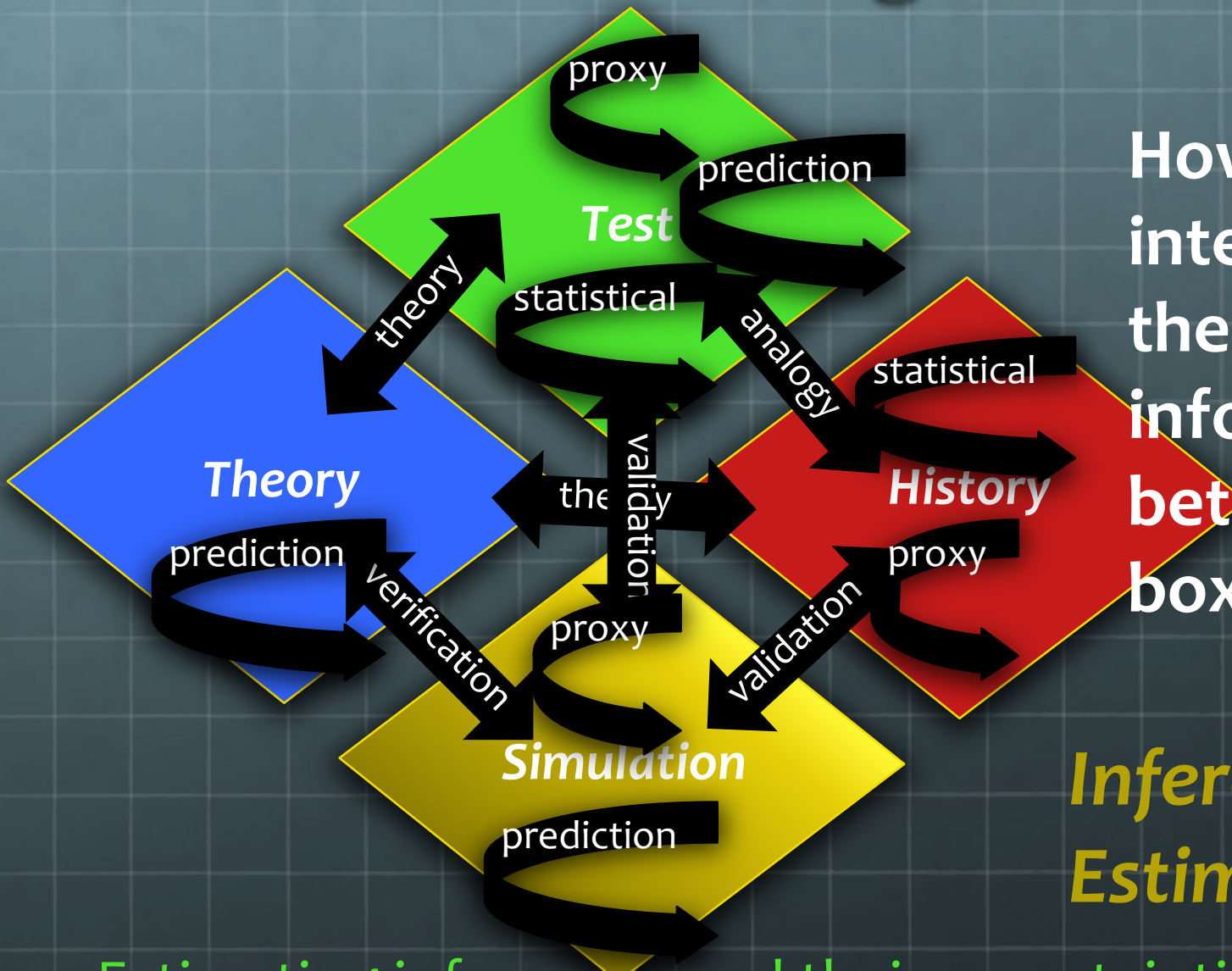
Information Integration



How to integrate the information between boxes?

Inference
Estimation

Estimating inferences and their uncertainties.

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Example 1: Inference Uncertainty Quantification Instead of Full-scale Testing

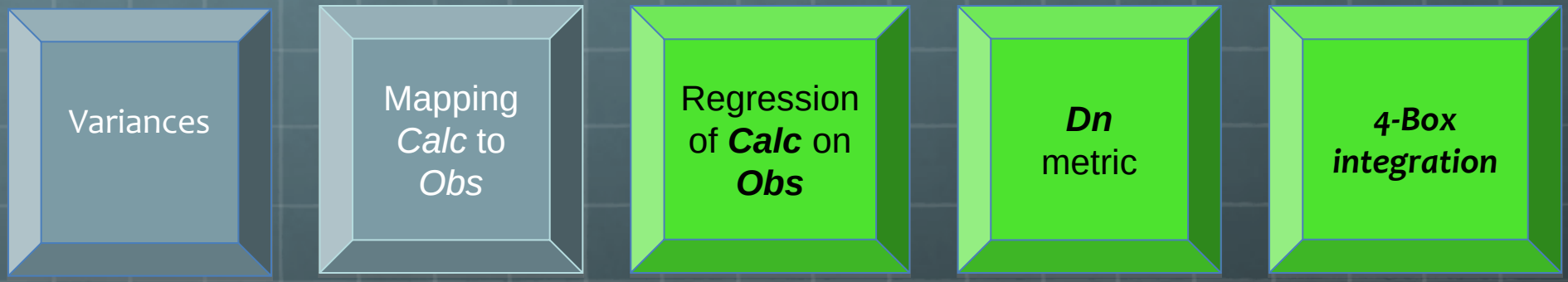
We have developed and successfully applied a set of formal techniques to mathematically combine all sources of data/information/knowledge into an overarching process for assessment & prediction.

Goal: *Combine everything we know (information integration) along with how well we know it (uncertainty assessment).*

Quantification of uncertainty arising from inference has an important role to play in lieu of full-scale testing. System-level uncertainties may not be observable by observing separate effects tests. Little attention has been paid to this inference uncertainty, which is prevalent in numerous scientific applications. An example of information integration illustrates the beginning of the research effort into understanding and utilizing uncertainty from inference.

Example 2: Validation Inference—How many ways are there for this?

Comparison of 5 validation methods:



Increasing Information Content Used to Draw Conclusion

The work for Variance Comparison, and Mapping is in our paper, as are the details of estimating the validation inferences and their uncertainties from the 4-boxes.

Summary of Roles for Experts in Information Integration

- Elicited Expert Estimates as a Place Holder for Test Data
- Expert Provides Structure for Complex or Challenging Physics Processes
- Expert Knowledge as an Information Source to be Combined with Other Sources
- Code to Experiment Evaluation by Experts
- Evaluating Reason to Integrate Experts
- Hunter & Gatherer of Data, Information and Knowledge Expert
- Expert as an Estimator of Weights for Information Integration
- Understanding Inferences and Inference Uncertainties Expert
- Experts Providing the Big Picture for Quality Processing

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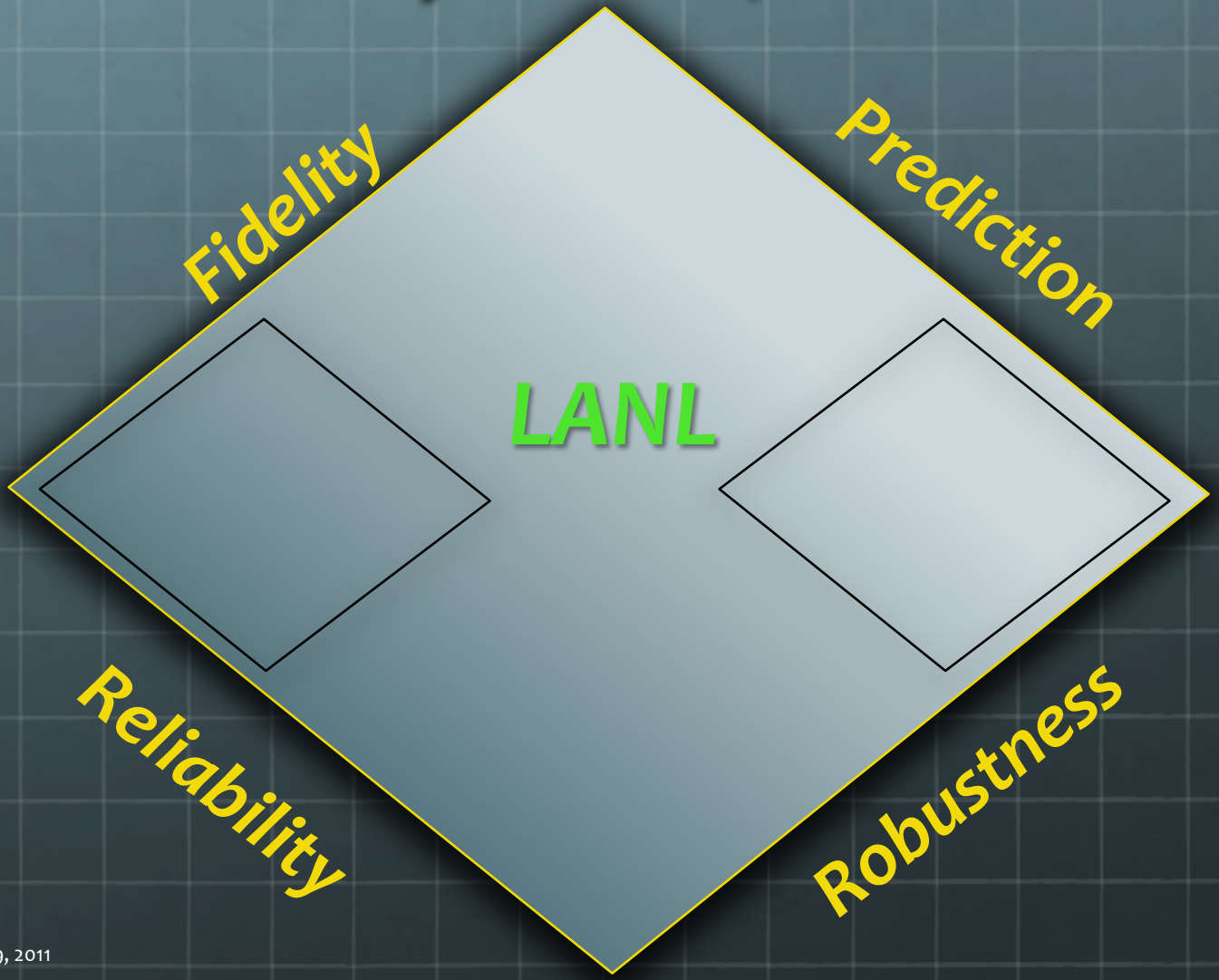
Big Picture:

A Larger Integration Process beyond the 4 boxes



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Examples of Common Cognitive Biases

- **Anchoring:** Experts (in their thinking and responses) cannot move from their preconceptions. The inability to adequately update in light of new information.
- **Inconsistency:** Confusion, such as from differing assumptions or definitions or high uncertainty, can lead to inconsistencies in thinking / responses. Memory problems fatigue and lack of knowledge also contribute.
- **Underestimation of Uncertainty:** Humans often think we know more than we really do. *Classic (and deadly) example is the "unsinkable" Titanic.*
- **Availability:** Depending upon personal experience, experts cannot accurately account for rare events. *Someone recently in a car accident will overestimate the likelihood of another and someone never in one will underestimate it.*

Examples of Motivational Biases

- **Group Think:** Group social pressure to slant responses or silently acquiesce to what experts believe will be acceptable to the group. *Classic (and deadly) example is the Bay of Pigs*
- **Misinterpretation:** Inadequate translation of knowledge into response. *Example, analyst changes expert's "likelihood" response to a probability.*
- **Wishful Thinking:** Experts' hopes or wishes about how they think things should be influence their responses. Not necessarily restricted to positive outcomes, but for outcomes according to expert's wishes (to be right).
- **Impression Management:** Responding according to politically correct or current managerial interpretations.

Formal Elicitation of Expert Knowledge

- Uses expert-oriented elicitation methods from research and implementation in many applications.
- Draws from cognitive psychology, decision analysis, uncertainty quantification, statistics, sociology, risk analysis, cultural anthropology, and knowledge acquisition.
- Minimizes common biases arising from human cognition and behavior.
- Adds rigor, defensibility, and increased ability to update the knowledge (i.e., traceability).

A formal elicitation is designed like an experimental physicist plans and implements the experiment—controlling the environment and determining the initial conditions.