Exploring Stakeholder Value Models via Interactive Visualization

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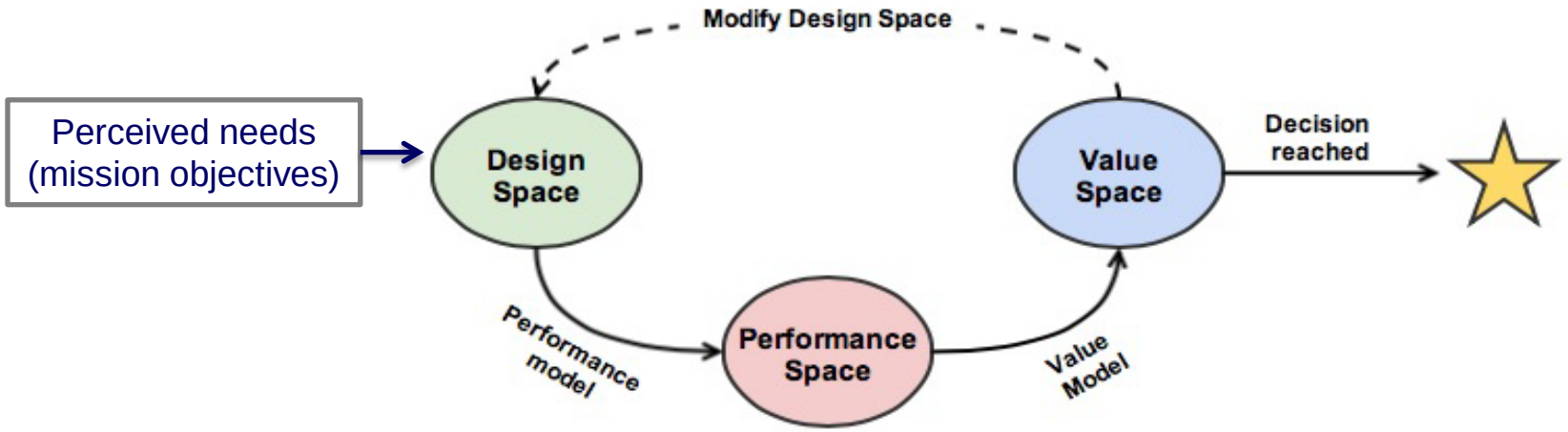
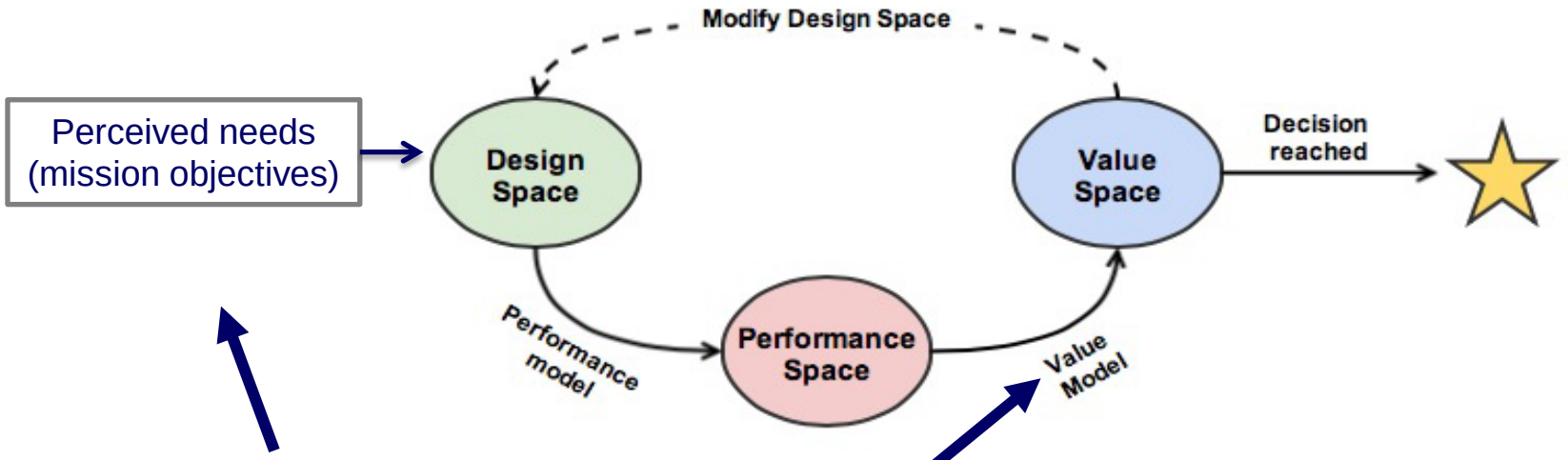
Motivation


Modify Design Space
Perceived needs (mission objectives)
Design Space
Value Space
Decision reached
Performance model
Performance Space
Value Model

Motivation



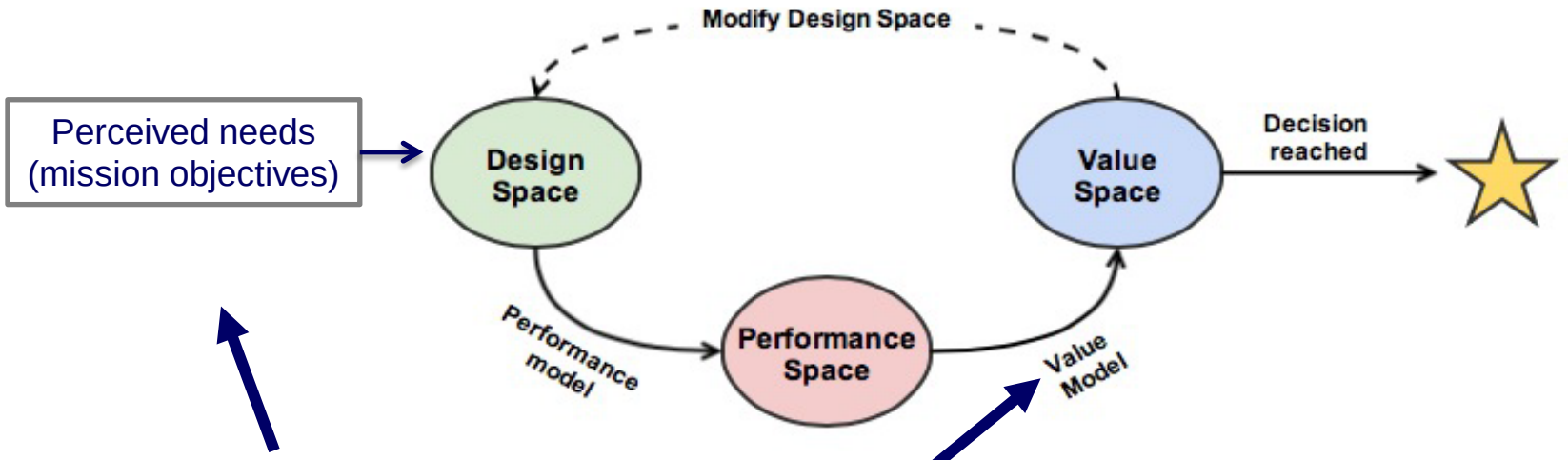
Eliciting needs and mapping value to those needs is a challenging process:

-Unknowns, lack of clarity and trust in interviews and statements, and other factors inhibit adequate capturing of the value space

-Demonstrated by the large amount of requirements change in modern systems (Lane & Boehm 2007)

-Multiple value constructs are used to address this problem (e.g., requirements statements, utility functions, net present value)

Motivation



Eliciting needs and mapping value to those needs is a challenging process:

…leading to any or all of the following in the early design phases:

-**failure to adequately represent** the needs/value space

-stakeholder **decisions hedged against** value models perceived as probably "incorrect" or incomplete

-**unjustifiably confident** decisions based on inadequate representation of needs/value space

Hypothesis

Visual Interaction + Constructed Value Models → Better Decision Outcomes

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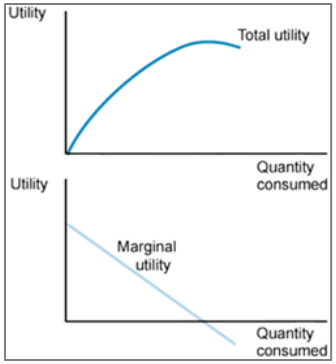

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Overview

Agenda

- Our context: Systems Design
- Our framework for:
  - Increasing Trust in Constructed Value Models
  - Increasing Truthfulness of Constructed Value Models
- Case Example

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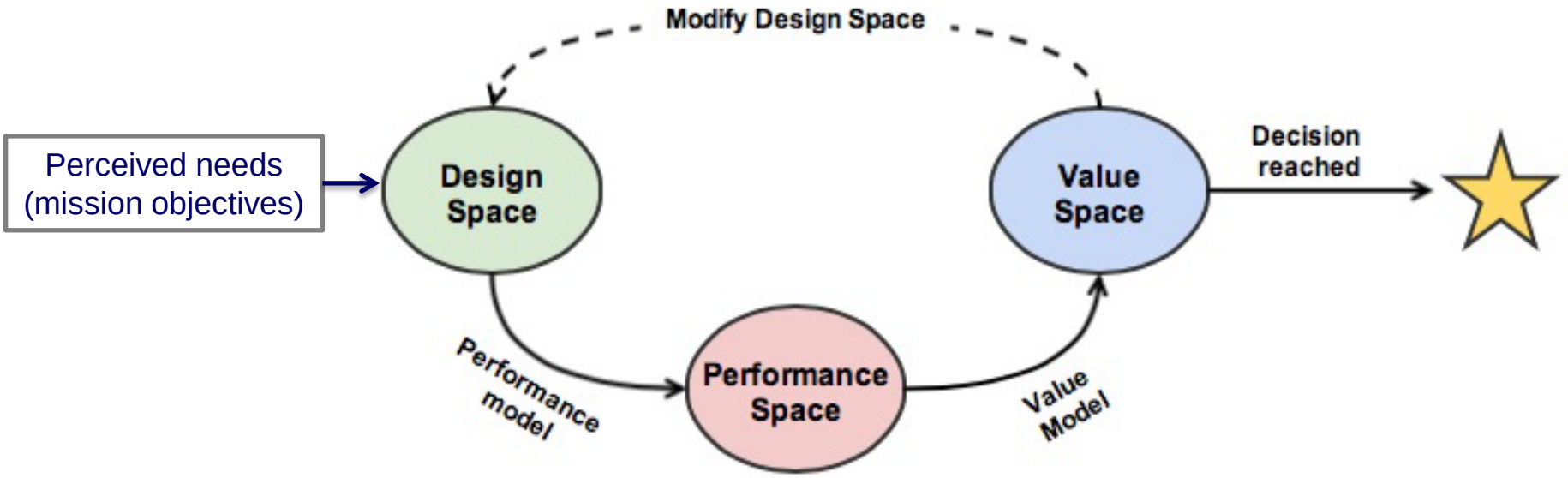
Also related (but beyond today's scope):

- **Visual Analytics of Scientific Data**
- **Visualization Techniques**

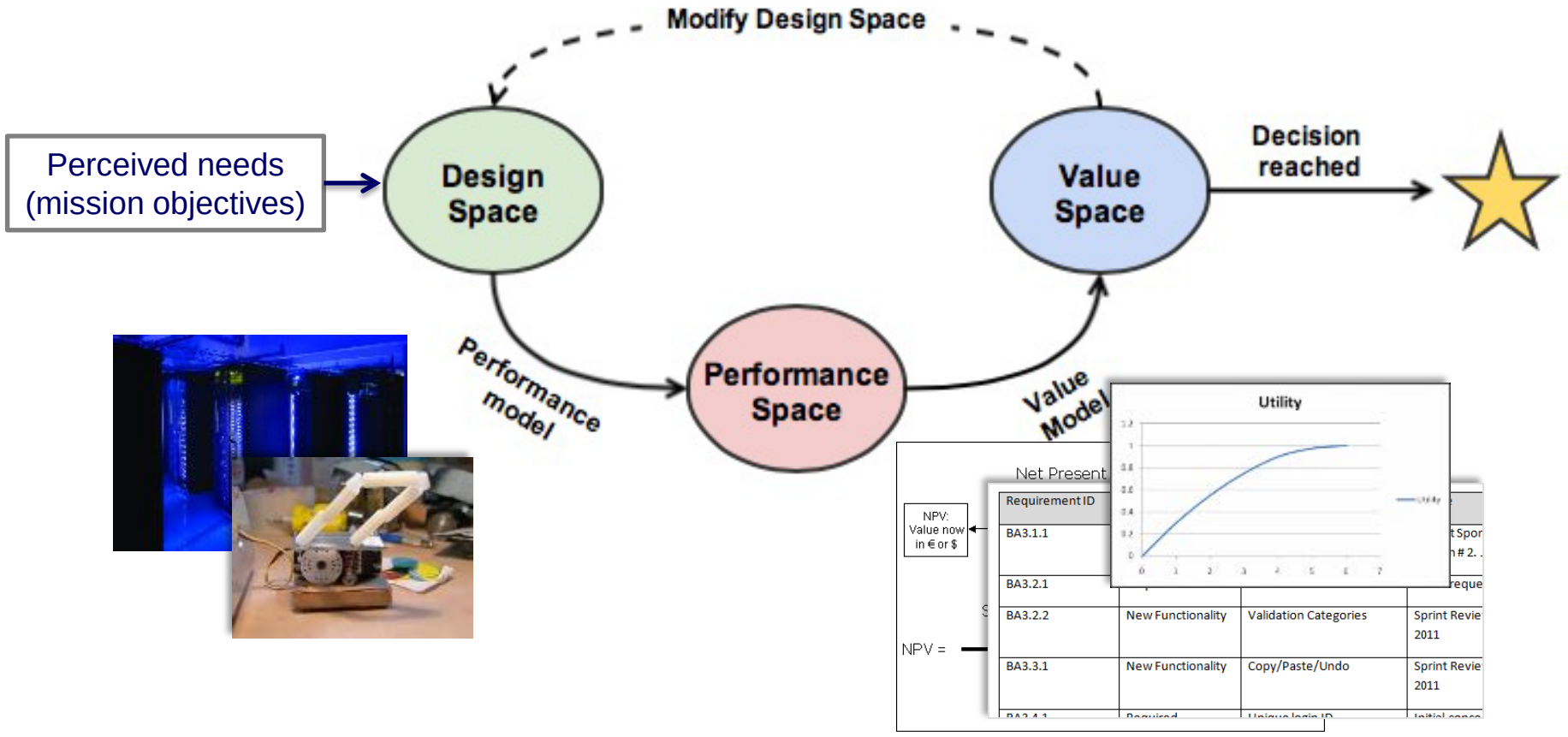
Our Context: Systems Design

The Design-Performance-Value Loop



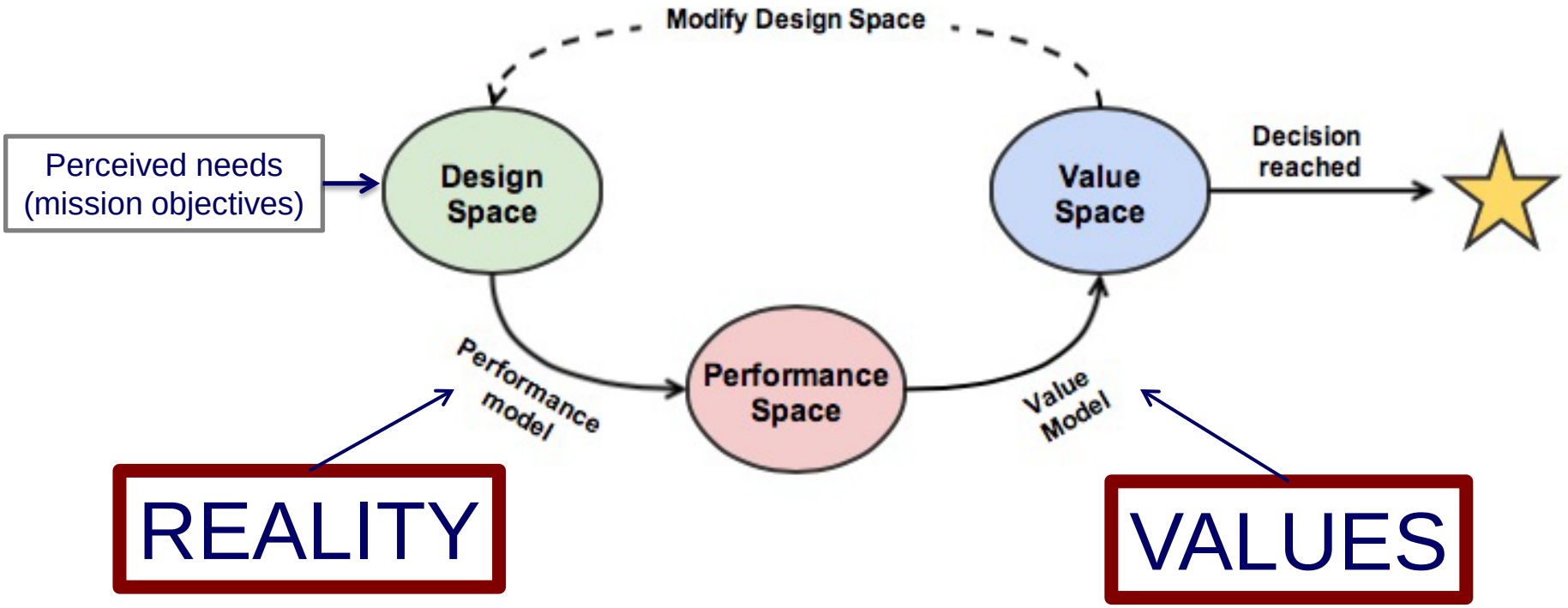
Systems Design: 2 Purposes of Models

The Design-Performance-Value Loop



Systems Design: Reality vs. Values

The Design-Performance-Value Loop

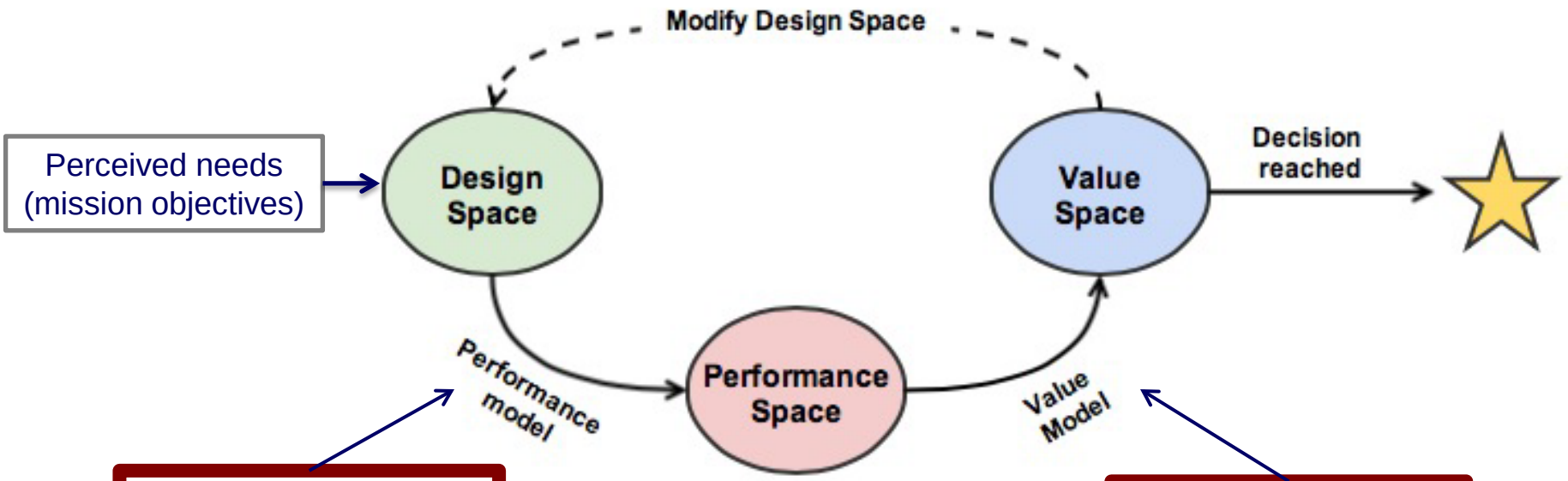


"Two things fill the mind with ever-increasing wonder...
the starry heavens above me and the moral law within me."

– Immanuel Kant, Critique of Practical Reason (1788)

Systems Design Models: Consolidative vs. Exploratory

The Design-Performance-Value Loop



REALITY

Consolidative Model
-Gather facts
-Analyze behavior

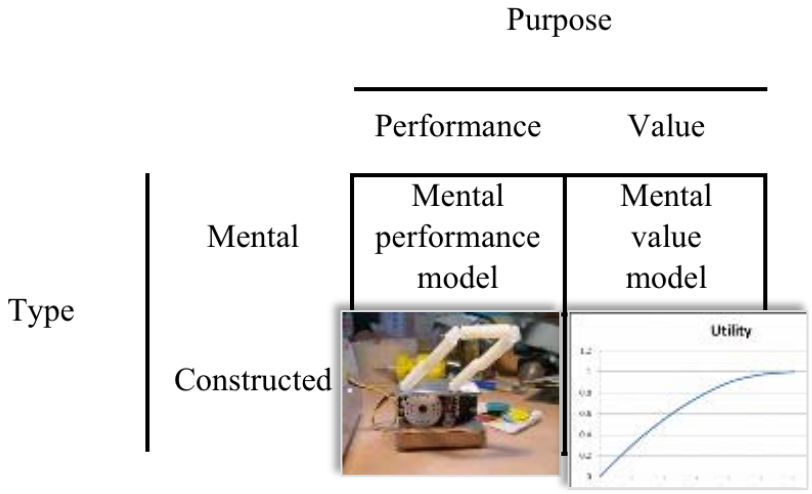
(Pielke Jr, 2003)

VALUES

Exploratory Model
-Question assumptions
-Examine consequences

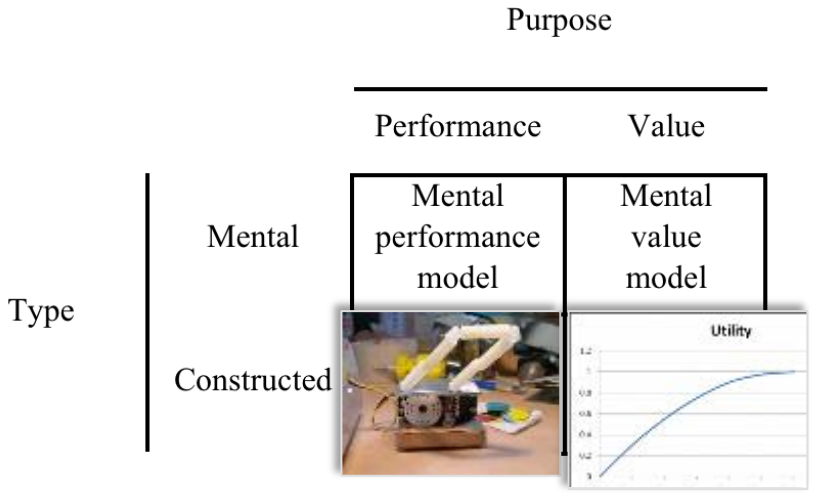
Systems Design Models: Meta-dimensions

- **Model Purpose**
  - **Performance models**
    - Approximate reality
  - **Value models**
    - Approximate values

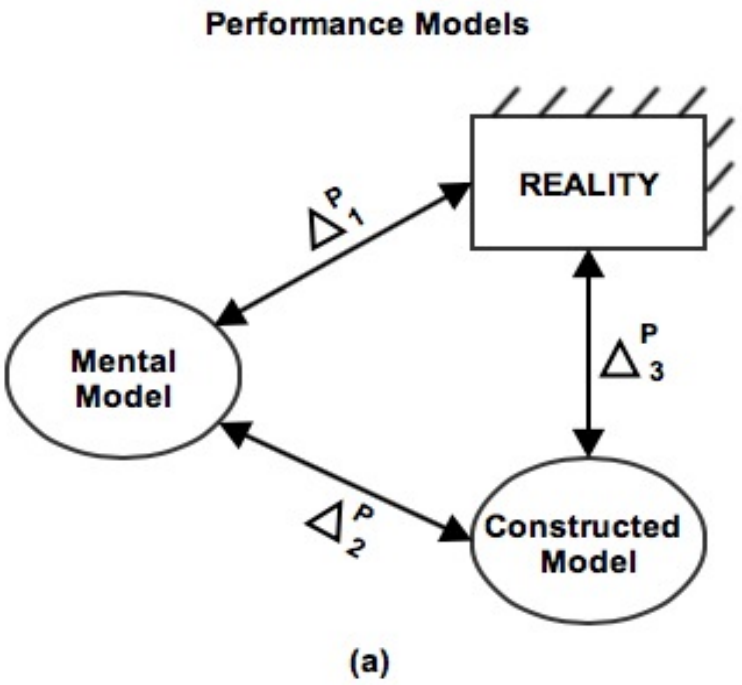


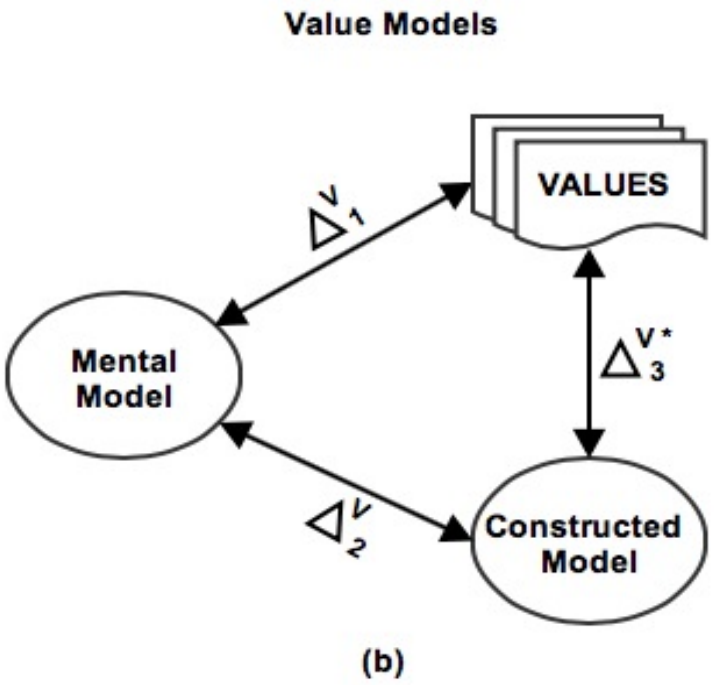
Systems Design Models: Meta-dimensions

- Model Purpose
  - Performance models
    - Approximate reality
  - Value models
    - Approximate values
- **Model Type**
  - **Mental models**
    - "Represents entities and persons, events and processes, and the operations of complex systems", and reside in the mind (P.N. Johnson-Laird)
  - **Constructed models**
    - Formalization of (one or more) mental model(s), and it can reside on paper, in a physical model, computer simulation, etc.

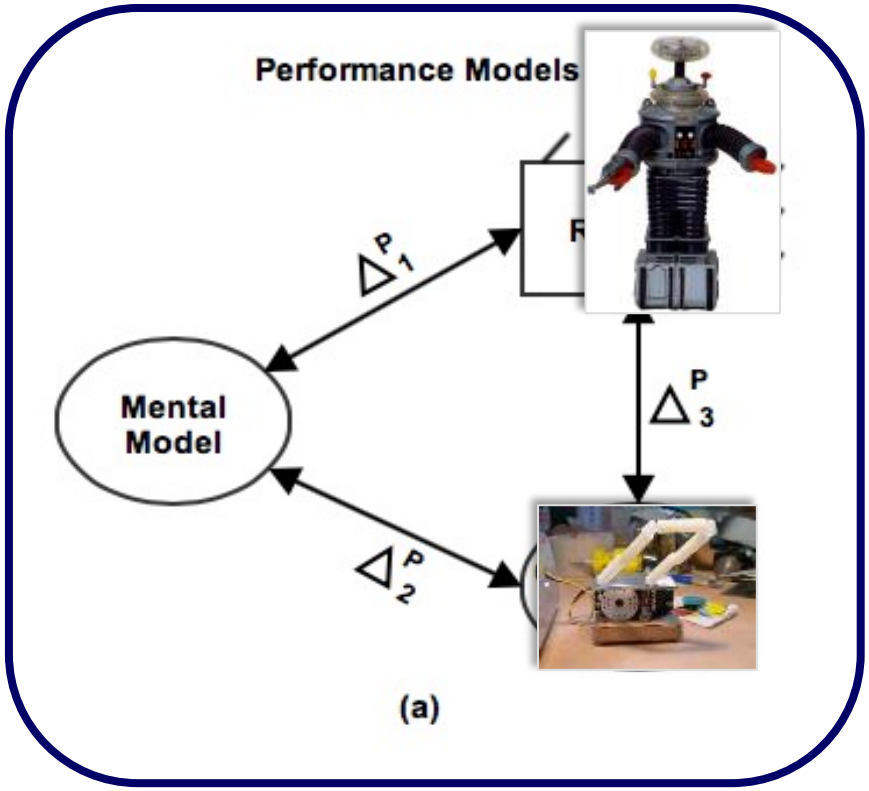


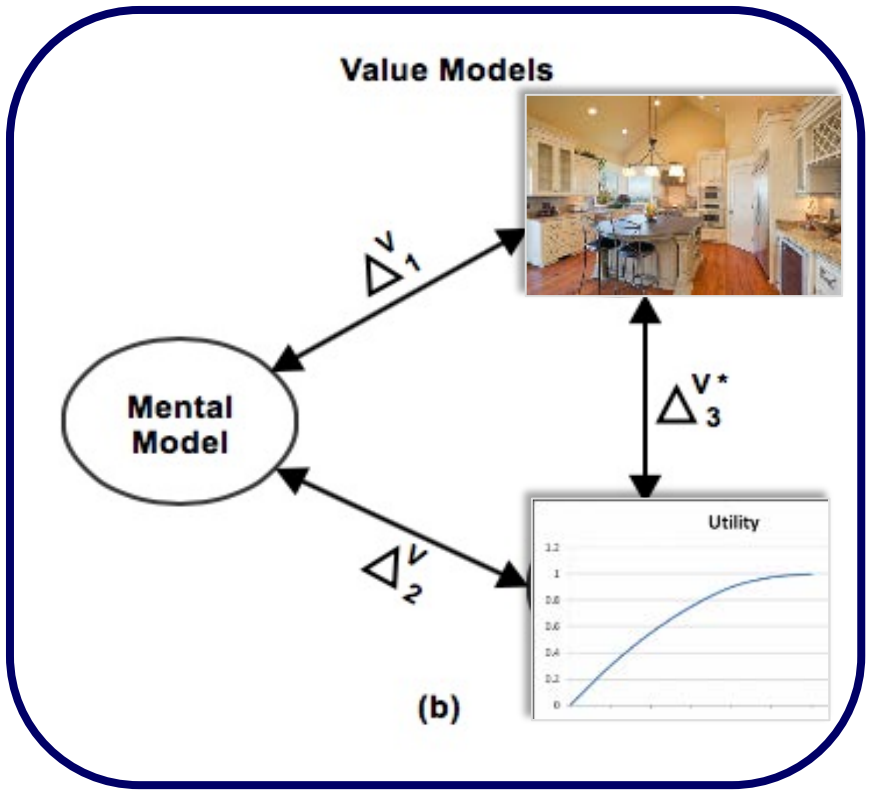
Systems Design Models: Coupled Three-Body Problems





Systems Design Models: Knowledge vs. Decision Making





Knowledge Assessment

Consolidative Model

-How big will B9 be?

-How fast will he move?

Decision Making

Exploratory Model

-How to measure “clean”?

-How much do I care?

Overview

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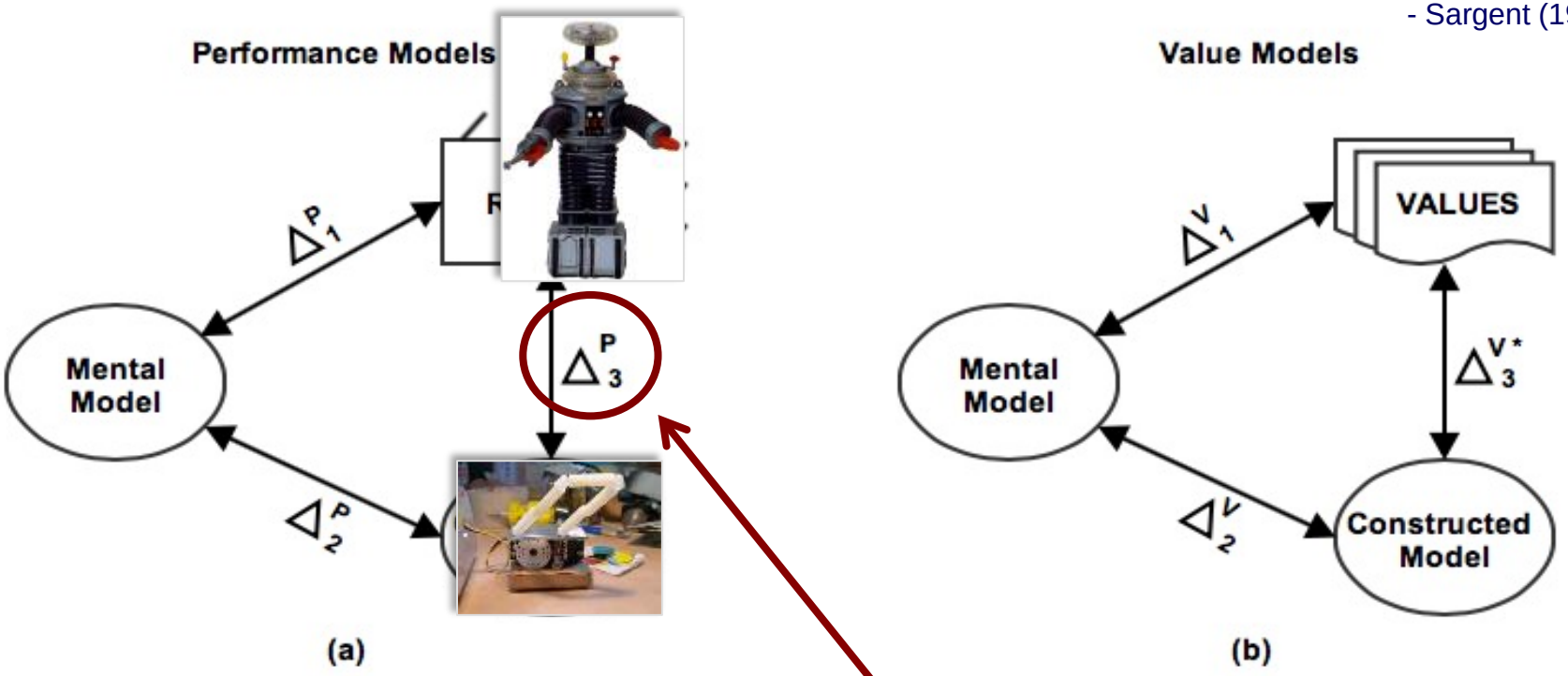
- Our context: Systems Design
- **Our framework for:**
  - **Increasing Trust in Constructed Value Models**
  - **Increasing Truthfulness of Constructed Value Models**

Constructed Performance Models: Objective Validation

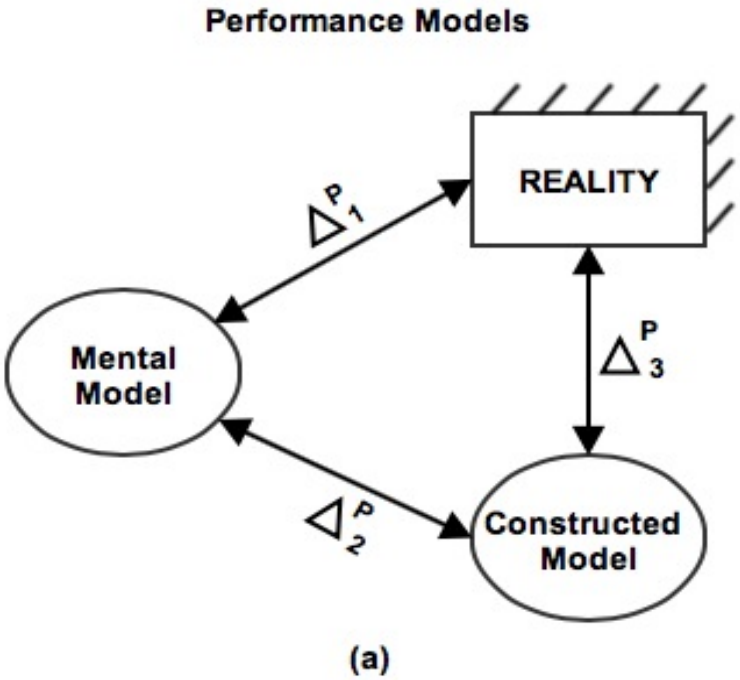
"A model should be developed for a specific purpose (or application) and its validity determined with respect to that purpose."
- Sargent (1998)

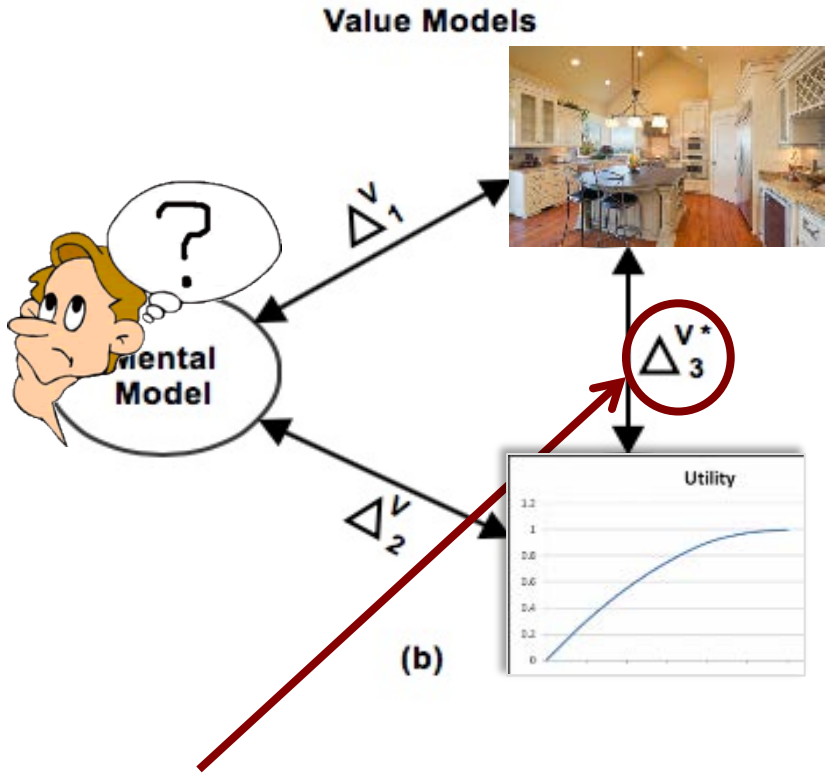


Classic model ***validation***: Reduce Δ_3^P for a specific purpose

Reference of reality is objective, albeit changing (e.g., geopolitical shifts, technology advancement)

Constructed Value Models: How to Validate?





Constructed Value Models: Can We Elicit Values?

Baruch Fischoff discusses a spectrum of philosophies:

Decision Making

Articulated Values ⟷ **Partial Perspectives** ⟷ **Basic Values**

- Values are **self-evident**
- Common among economists and surveys
- Examples:
  - Demand curves
  - Value of life (Viscusi)

- **Some values are** self-evident, but **many aren't**
- People don't have answers to all questions, but they also don't need to start from scratch every time.

- Values **aren't well-differentiated** for most evaluation questions
- People must derive valuations from some basic values through an **inferential process**
- MAU (Keeney and Raiffa)

Constructed Value Models: Can We Elicit Values?

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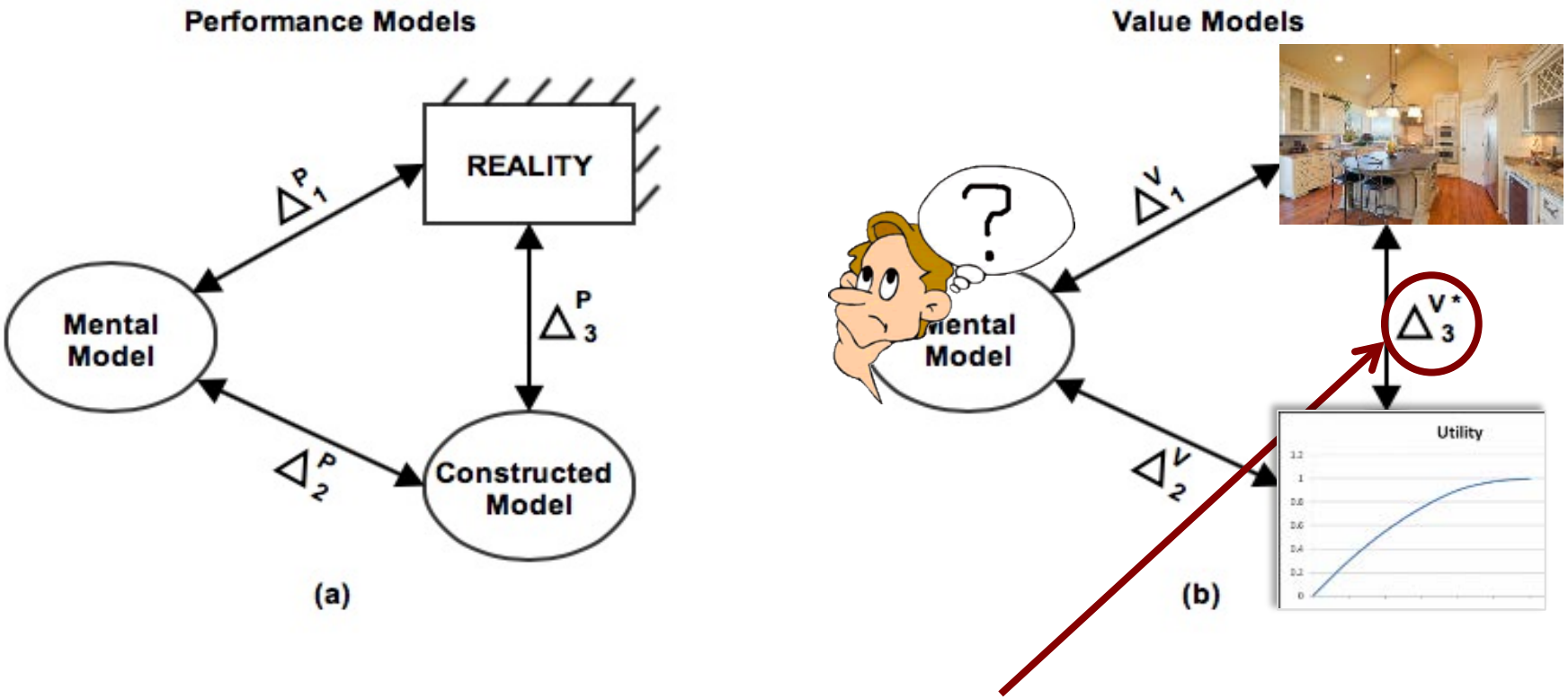
Constructed Value Models: How to Validate?



PROBLEM: since values are not directly observable, **Δ_3^{V*} is also unobservable**

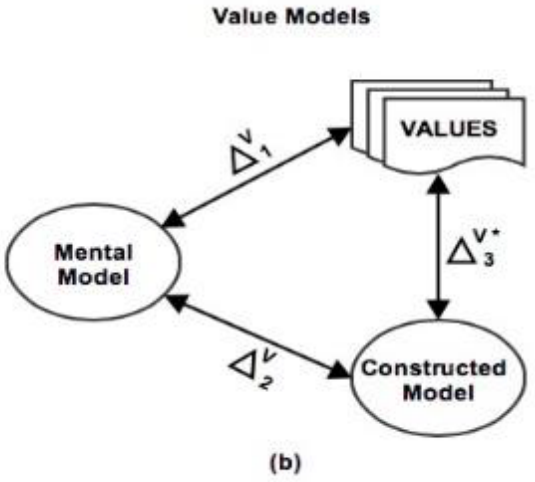
If Δ_3^{V*} is unobservable, we cannot validate constructed model w.r.t. values.

Framework Ideas: Trust and Truthfulness

Value Models

- The concept of **trust** is inversely related to the magnitude of Δ_2^V
- The concept of **truthfulness** is inversely related to the magnitude of Δ_1^V

Constructed Model v. Mental Model	Mental Model v. Values: Low Δ_1 (truthfulness)	High Δ_1
Low Δ_2 (trust)	**Correct Trust:** Trust present. Correct representation of values.	**Type I error:** Trust present. Incorrect representation of values.
High Δ_2	**Type II error:** Trust not present. Correct representation of values.	**Justified Mistrust:** Trust not present. Incorrect representation of values.



*Flanagan 2012 contains an alternative formulation of this matrix

Simply assuming that a constructed model of values (e.g., requirements, utilities) is **valid**:
→ **High risk of Type I error**

"…to design the wrong value system is to design the wrong system." (Hall, p. 110).

Framework Ideas: Increasing Truthfulness

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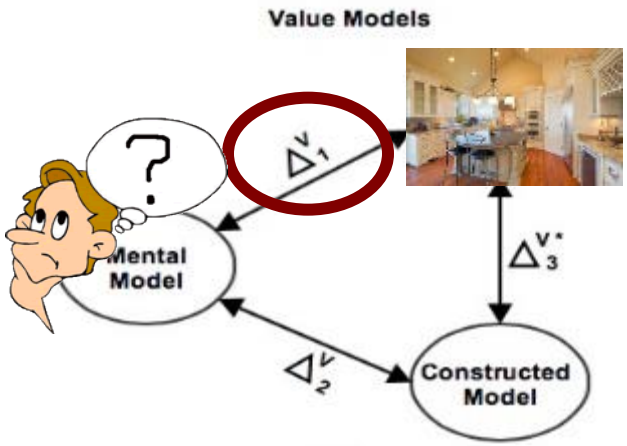

Goal: Correct Trust

→ reduction of both Δ_2^V and Δ_1^V

- Several methods exist for **reducing Δ_1^V** (reducing cognitive biases):
  - Allow Decision Makers (DMs) to **simulate a decision**, noting regrets.
  - Allow DMs to **consider the ramifications of their expressed values** (i.e. mental model) for many different situations and outcomes (e.g., MATE).
  - Directly **discuss and uncover biases** that skew a person's understanding of his/her actual values (e.g., anchoring, availability).
  - **Introduce new attributes** to DMs, noting any change in preferences.

Framework Ideas: Increasing Trust

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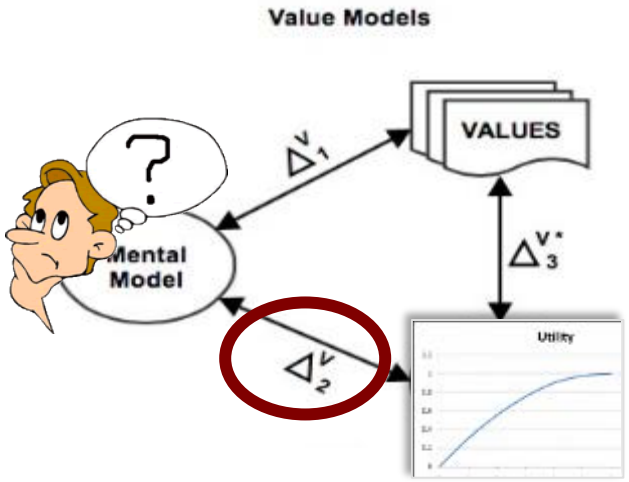


Goal: Correct Trust

→ reduction of both Δ_2^V and Δ_1^V

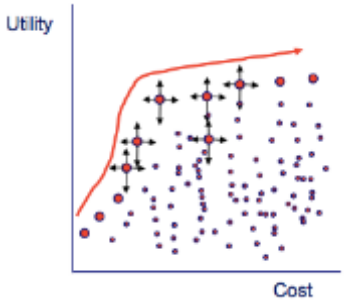
- Several methods exist for **reducing Δ_2^V** (i.e., increasing truth and credibility):
  - **Rigorous interview process** for the construction of utility functions, which reduce framing and other biases that may be present in standard requirements-as-value-statements
  - **Comparison of ranked list** of alternatives from stakeholder with a ranked list produced by a constructed value model
  - **Comparison of two or more** constructed value models' ranked lists

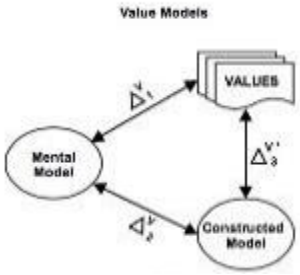
Hypothesis: Interactive Visualization for Δ Reductions

Steps in Interactive Visualization:

1. **displaying a constructed value model** alongside its outcomes (e.g., ranked list of design alternatives)
2. **allowing real-time modifications** to the constructed model (simulating different sets of preferences, introduction of new attributes)
3. **providing instant feedback** on the newly changed constructed model, as well as providing comparison of the new results with previous results

Value models → SAU and MAU functions





Hypothesis: Interactive Visualization for Δ Reductions

Each of these steps allows a DM to explore:

- **simulate** making a decision
- **observe** mental model of values **propagating** throughout the design space
- **discover biased regions** of their mental model
- **compare expectations** of preferred designs with the model's prediction

Hypothesis:

Interactive visualization of constructed value models can facilitate the reduction of Δ_2^V and Δ_1^V through an iterative process, enabling better decisions.

Mental Model v. Values

Constructed Model v. Mental Model		Low Δ_1 (truthfulness)	High Δ_1
	Low Δ_2 (trust)	**Correct Trust:** Trust present. Correct representation of values.	**Type I error:** Trust present. Incorrect representation of values.
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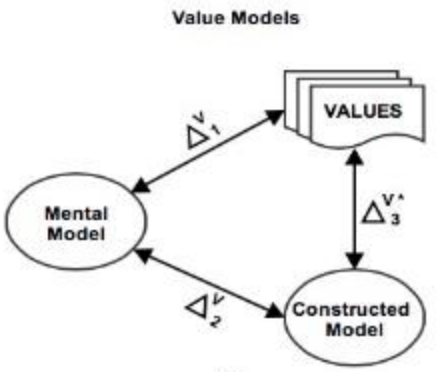

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- Our context: Systems Design
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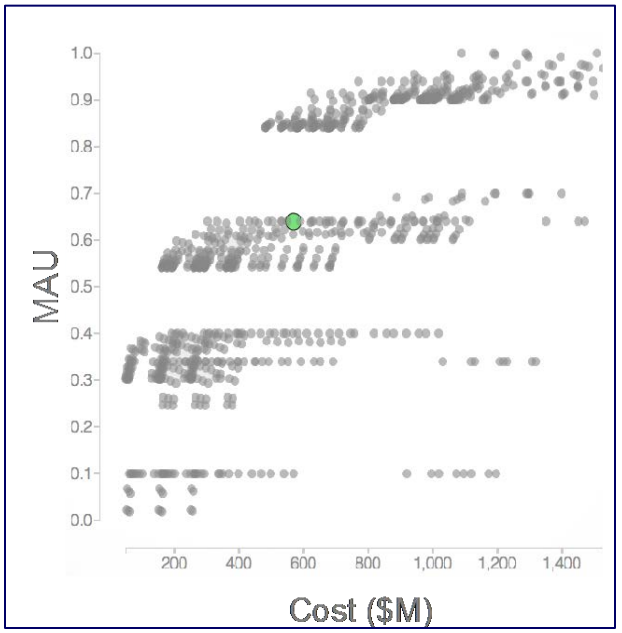
  - Increasing Truthfulness of Constructed Value Models
- **Case Example**

Interactive Visualization: Case Example

System:
"Space Tug" Satellite
Simplified to 2 attributes:
Speed and Delta V

Stakeholder:
Involved in creation of the constructed performance and value models for system



Interactive Visualization Step 1:
Allow stakeholder to interact with the intitial tradespace, encouraging exploration of the **ramifications of stated preferences** on all designs

Interactive Visualization: Case Example

System:

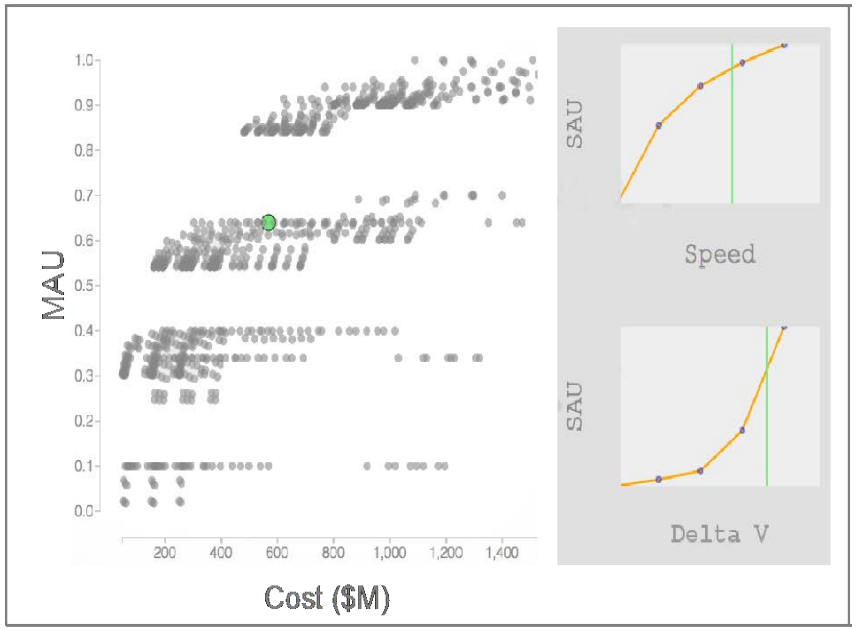
"Space Tug" Satellite

Simplified to 2 attributes:

Speed and Delta V

Step 1:

Allow stakeholder to interact with initial tradespace



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Start

Interactive Visualization Step 2:

Allow stakeholder to **compare expectations of preferred designs** with constructed value model's output.

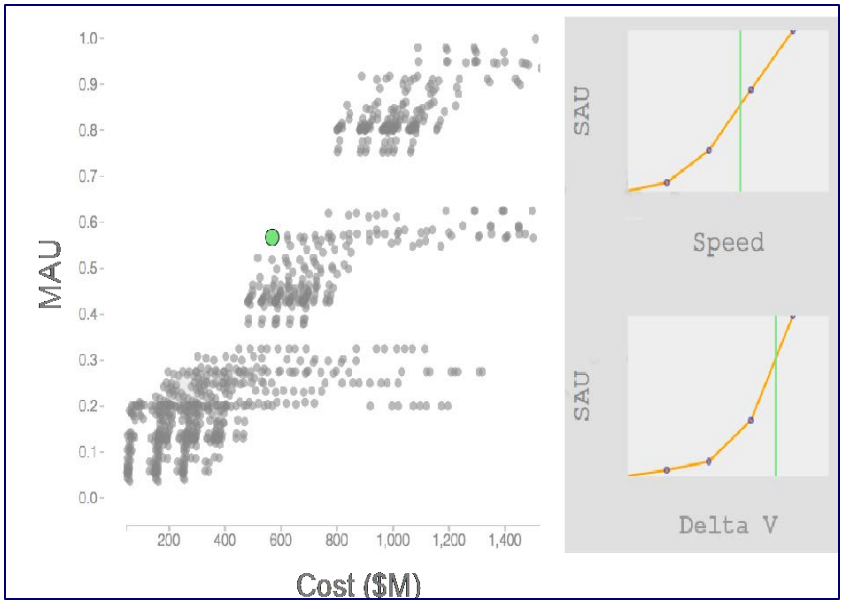
Display constructed value models alongside their outcomes.

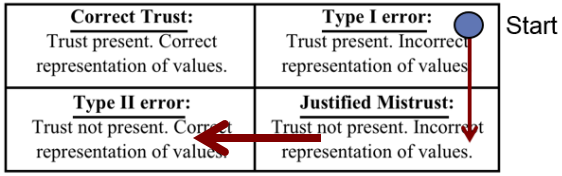
Interactive Visualization: Case Example

System:
"Space Tug" Satellite
Simplified to 2 attributes:
Speed and Delta V

Step 1:
Allow stakeholder to interact with initial tradespace

Step 2:
Compare expectations with outputs
Display constructed value models





Interactive Visualization Step 3:
Identify misrepresented portions of the value model
Allow stakeholder to **change constructed models (i.e., increase truthfulness)**
Instantly update the outcomes on the tradespace

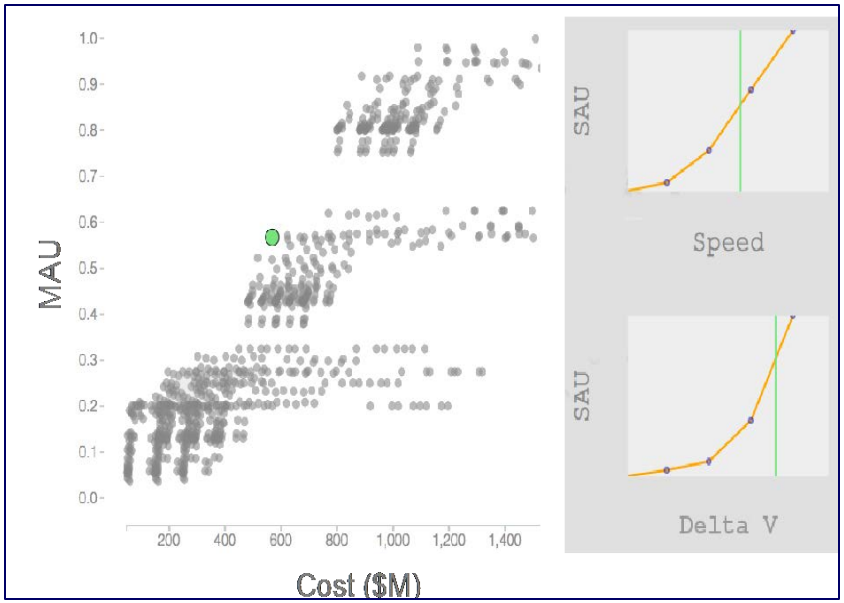
Interactive Visualization: Case Example

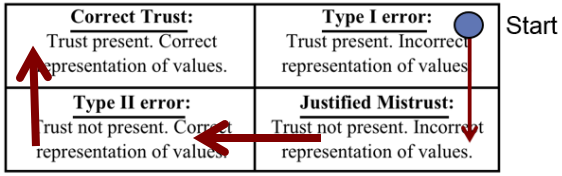
System:
"Space Tug" Satellite
Simplified to 2 attributes:
Speed and Delta V

Step 1:
Allow stakeholder to interact with initial tradespace

Step 2:
Compare expectations with outputs
Display constructed value models

Step 3:
Build truthfulness
Instantly update the outcomes





Final Step:
Allow stakeholder to explore the tradespace (return to Step 1), **building trust.**

Interactive Visualization: Hypothesis Revisited

Visual Interaction + Constructed Value Models → **Trusted, Truthful** Outcomes

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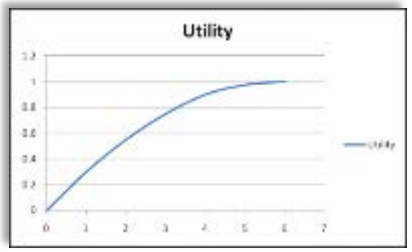

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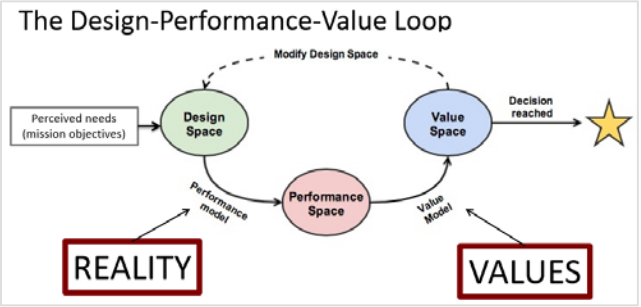
Exploring Stakeholder Value Models: Summary/Conclusion

- The System Design Loop:
  - Performance Models (for Reality)
  - Value Models (for Values)



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- The System Design Loop:
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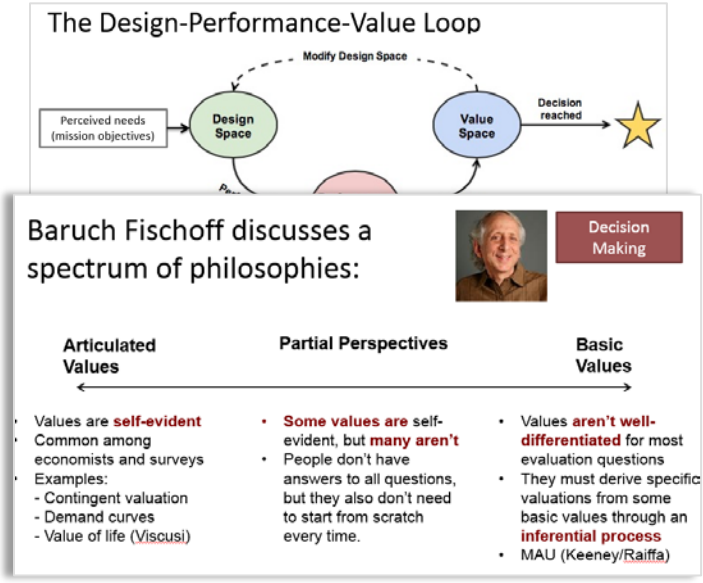
- Value Models
  - Fall somewhere on Fischoff's spectrum



Exploring Stakeholder Value Models: Summary/Conclusion

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- Value Models
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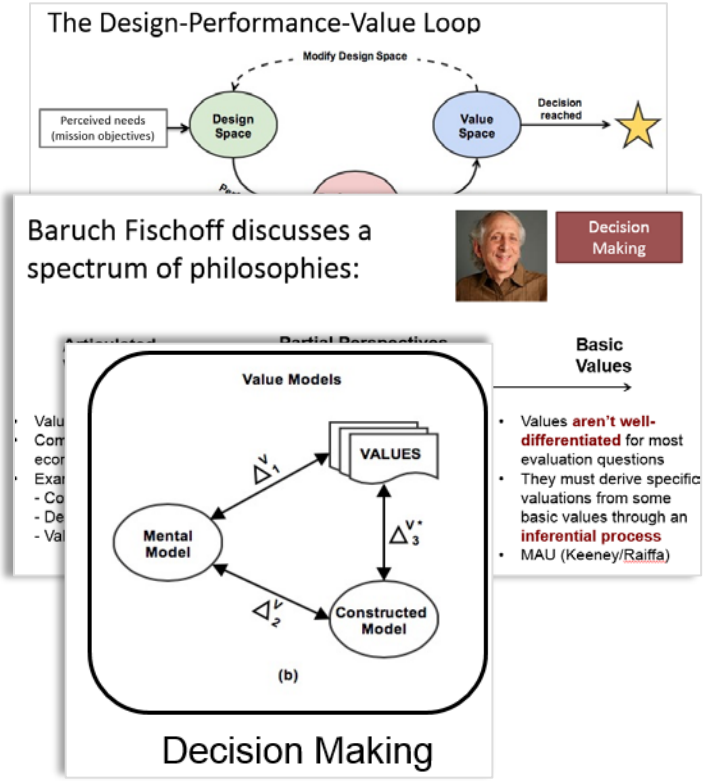
  - Basic Values and the 3-Body Problem



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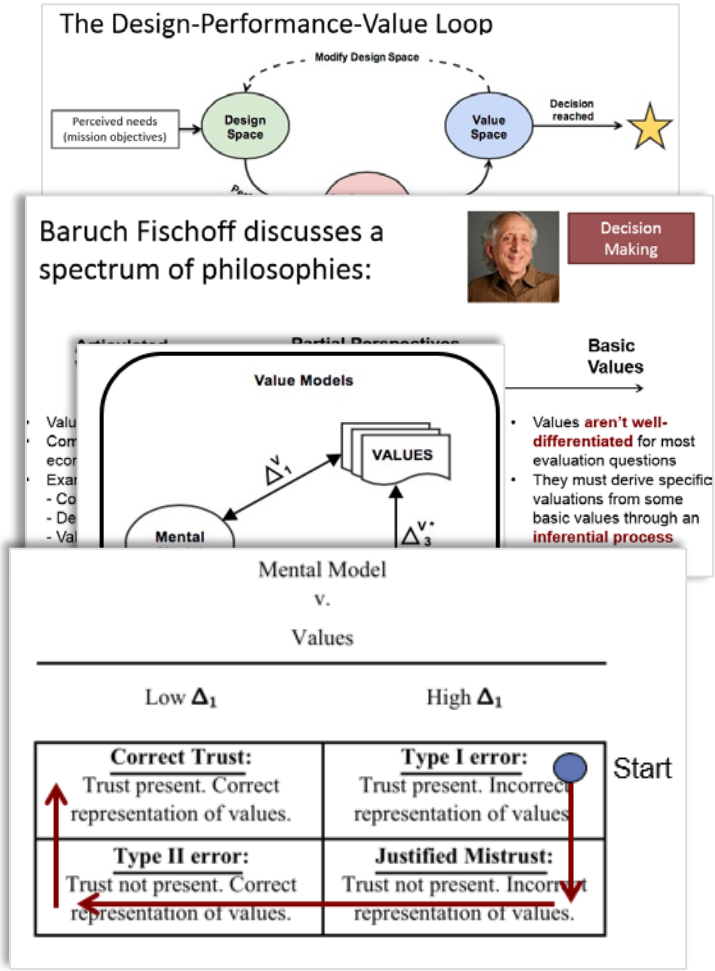
  - Value Models (for Values)
- Value Models
  - Fall somewhere on Fischoff's spectrum
  - Basic Values and the 3-Body Problem
- Interactive visualization can help
  - Enables trajectory of delta reductions
  - Leading to **trusted, truthful decisions**



Exploring Stakeholder Value Models through Interactive Visualization

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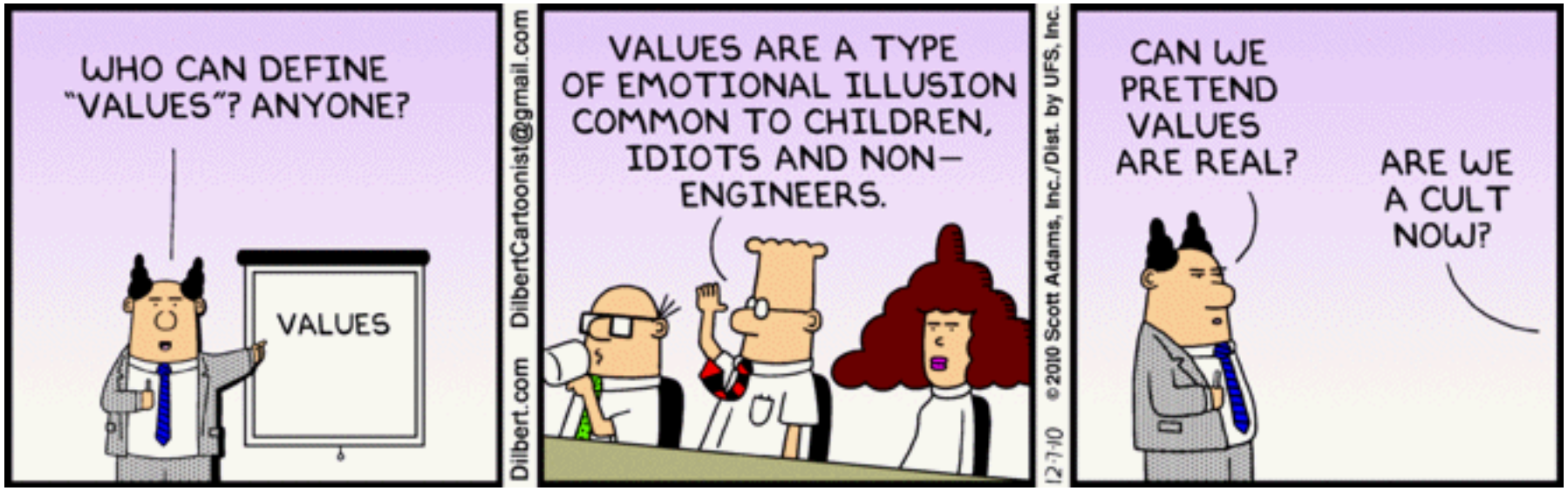

WHO CAN DEFINE "VALUES"? ANYONE?
VALUES
Dilbert.com DilbertCartoonist@gmail.com
VALUES ARE A TYPE OF EMOTIONAL ILLUSION COMMON TO CHILDREN, IDIOTS AND NON-ENGINEERS.
12-7-10 ©2010 Scott Adams, Inc./Dist. by UFS, Inc.
CAN WE PRETEND VALUES ARE REAL?
ARE WE A CULT NOW?

Backup Slides

Slides included in Backup are not intended to be coherent outside of the original presentation. They are included here only for reference, and only to be used/read at the sole discretion of the viewer.

Artificial Data in the Design Loop

- **Model Purpose**
  - **Performance models**
    - **Approximate*** reality
  - **Value models**
    - **Approximate*** values

Type	Purpose: Performance	Purpose: Value
Mental	Mental performance model	Mental value model
Constructed	Constructed performance model	Constructed value model

*When designing systems of the future, the data used is **artificial**…and that means that there must remain some significant departures from reality.

*"Artificiality connotes **perceptual similarity** but **essential difference**."*

- Herbert Simon

"Trust" related to "Perception": Regardless of the amount of "essential difference", it is the "perceived similarity" to reality that leads to model *credibility (i.e., trust).*

Values (Mis)diagnosis

A **basic values philosophy** is assumed hereafter, as the risk of misdiagnosis is less severe for large-scale systems

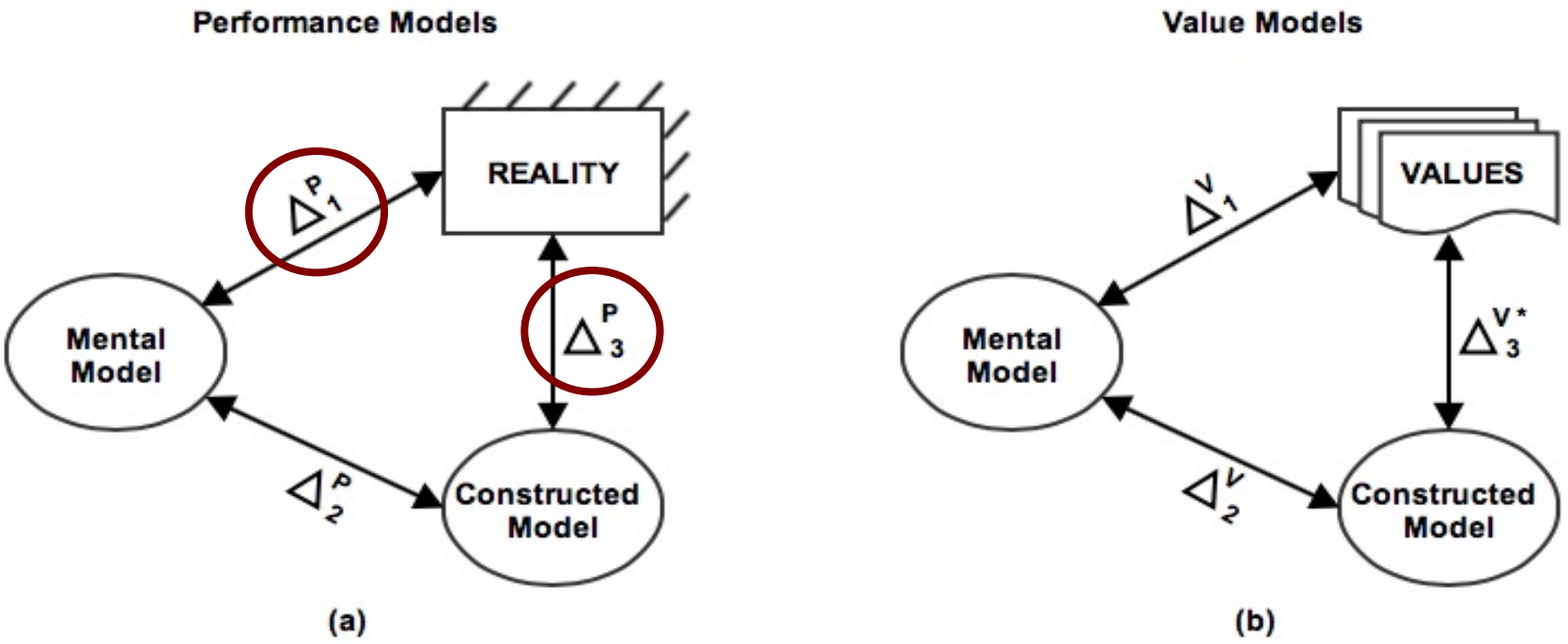
Table 1
Risk of Misdiagnosis

Assumption made	Proper assumption: Articulated values	Partial perspectives	Basic values
Articulated values	—	Get incomplete values Inadvertently impose perspective	Get meaningless values Impose single perspective
Partial perspectives	Promote new perspectives Distract from sharpening	—	Impose multiple perspectives Exaggerate resolvability
Basic values	Shake confidence Distract from sharpening	Discourage Distract from reconciliation	—

Note. Above diagonal: misplaced precision, undue confidence in results, missed opportunity to help. Below diagonal: needless complication, neglect of basic methodology, induced confusion.

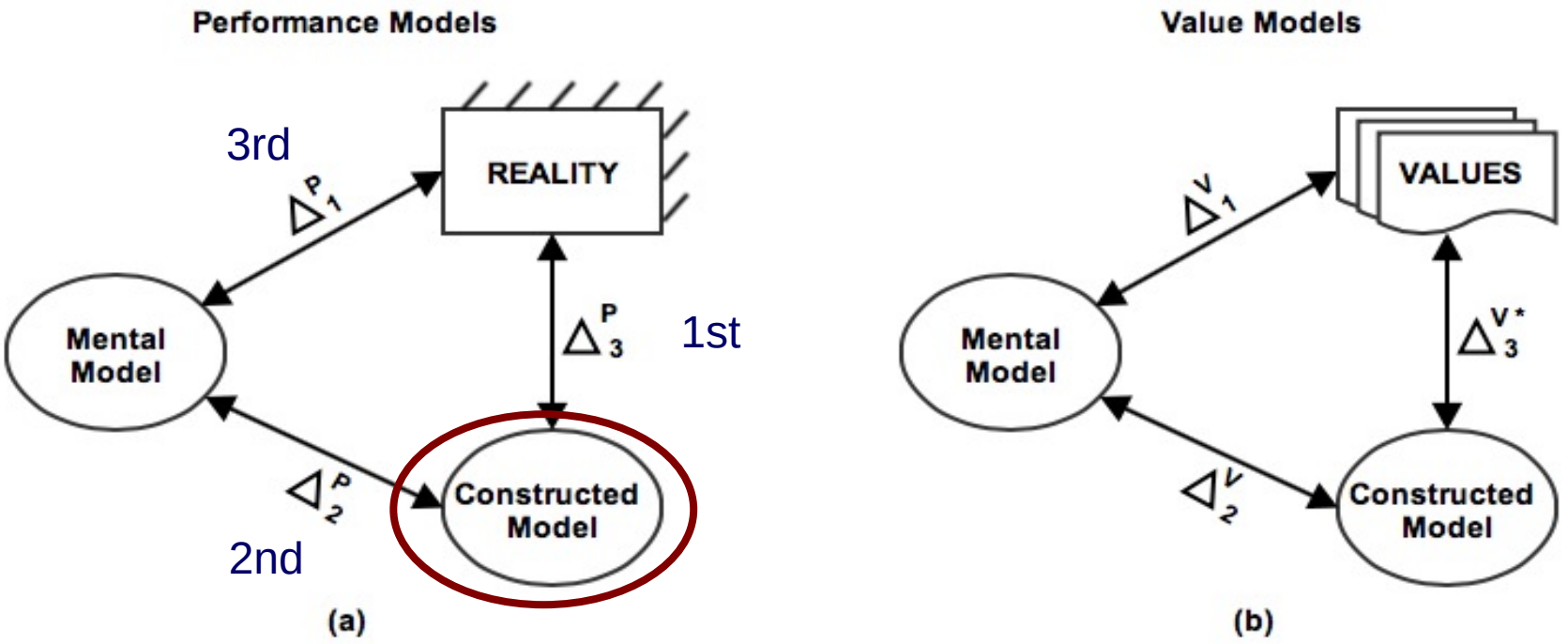
Fischhoff B. "Value elicitation: is there anything in there?" *American Psychologist* 46(8), 1991: 835.

Knowledge Assessment



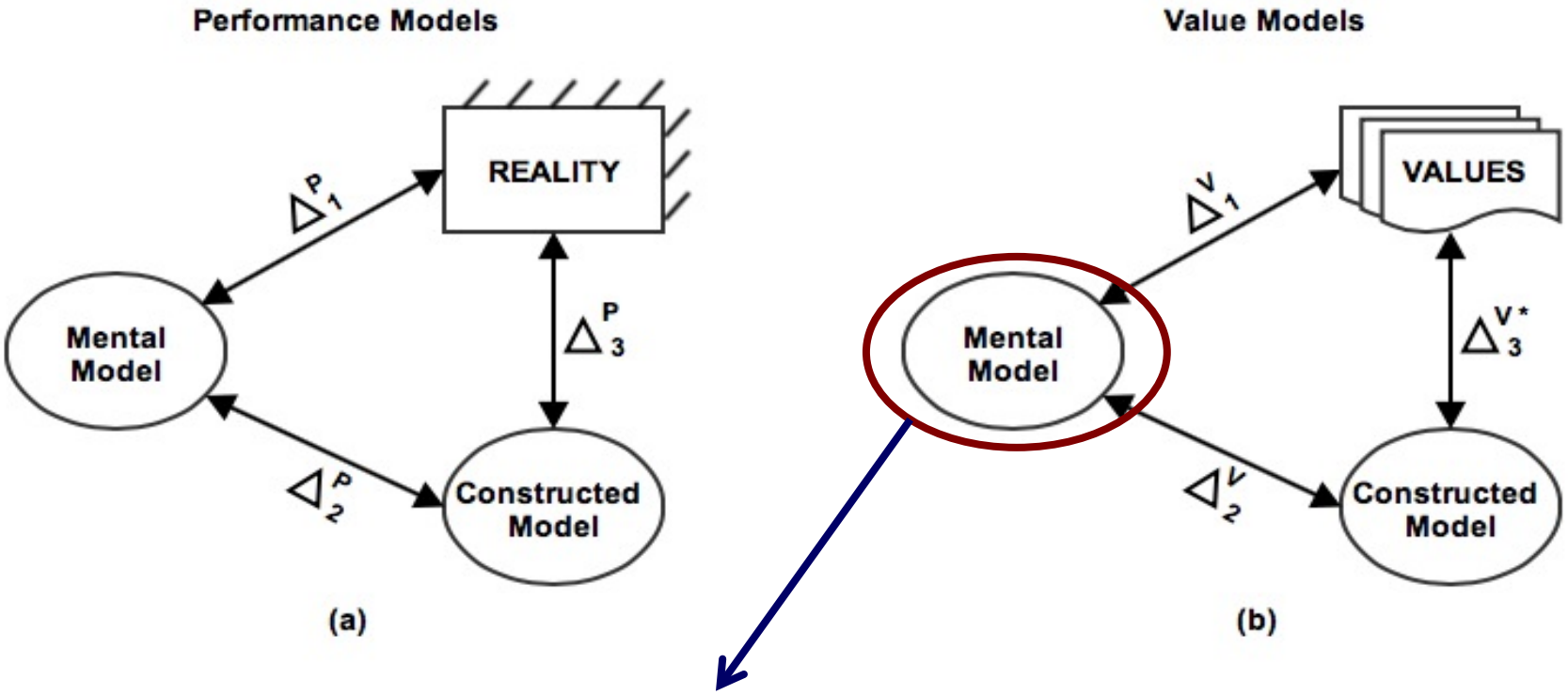
Simon's "essential difference"

Knowledge Assessment



- Once *perceived similarity* of the constructed model and reality is enough: Mental model can update from constructed: Δ^{P}_{2} is reduced.
- Leads to reduction of Δ_{1}^{P} , the **goal of constructing a model**

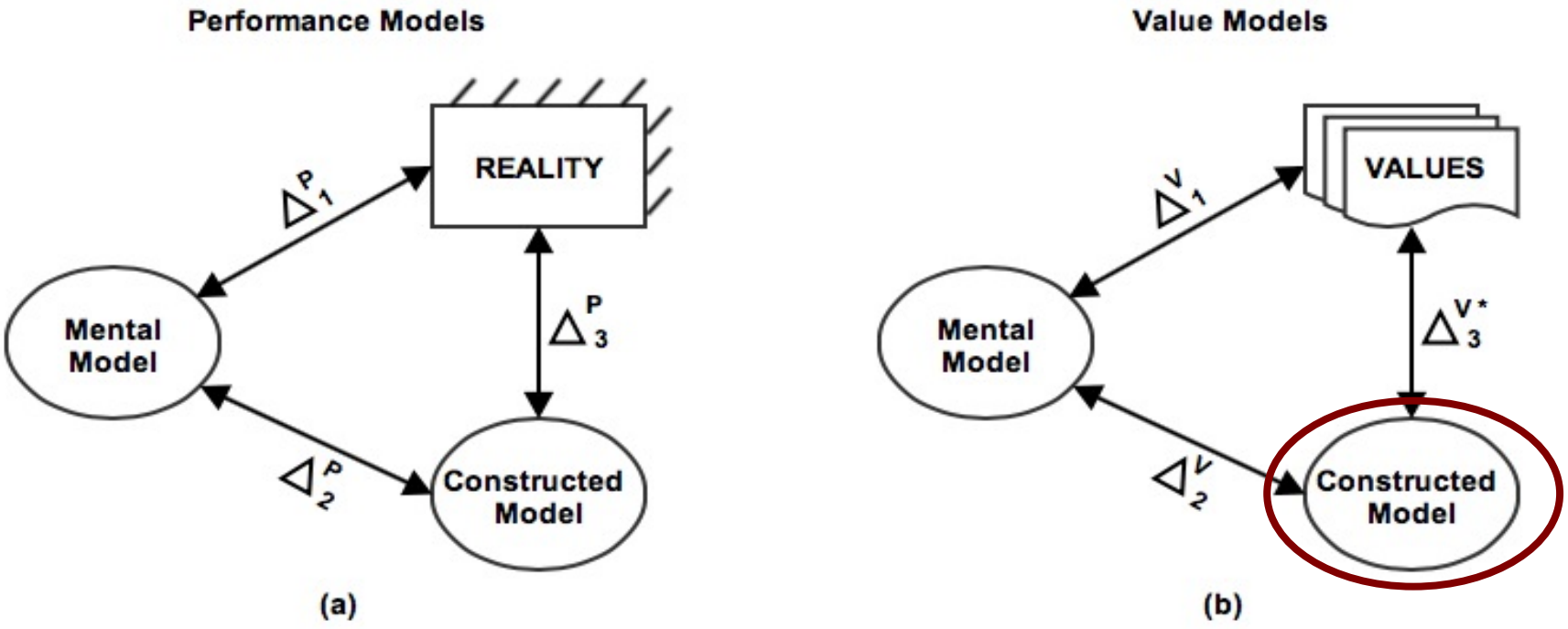
Decision Making



- Two kinds of mental models:
- Fast, automatic, emotional and subconscious **(System I)**
- Slow, effortful, logical and conscious **(System II)**

- Kahneman

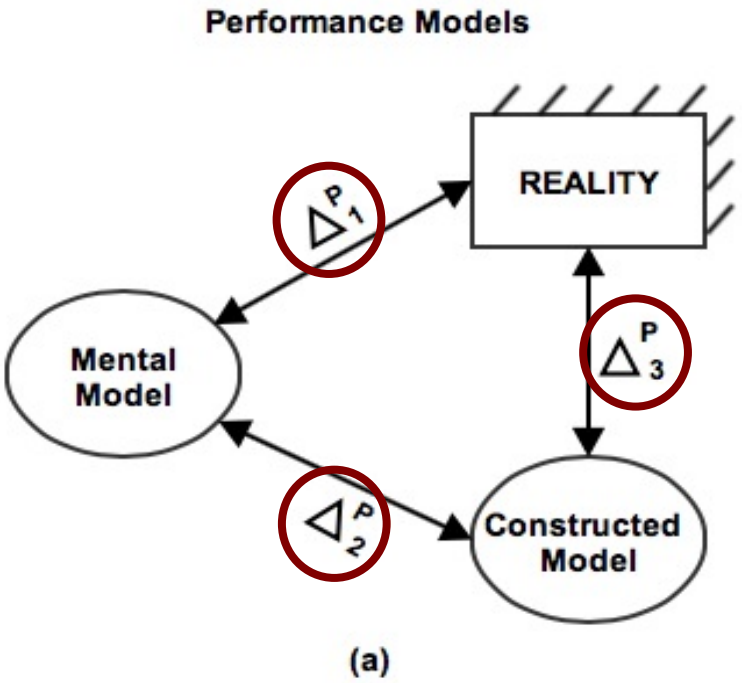
Decision Making

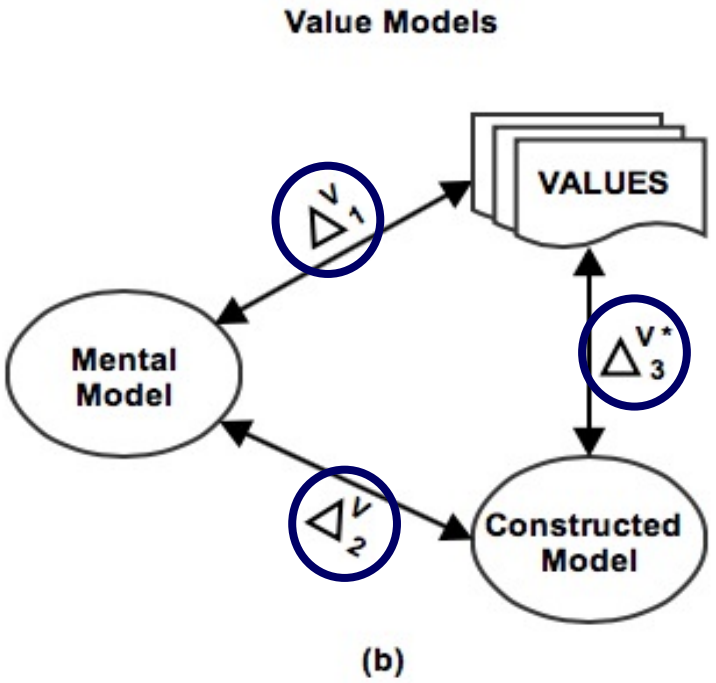


For **complex decisions:**

- **Multiple** *objectives*, a **variety** of *decision criteria*, **multitude** of *alternatives*
- The decision maker can use a **constructed model** of values (e.g. AHP, Pugh, Utility, requirements, etc), constructed with the help of "System II" mental model (Kahneman)
- Constructed model extends decision makers' ***bounded valuation***

Barriers to Delta Reductions





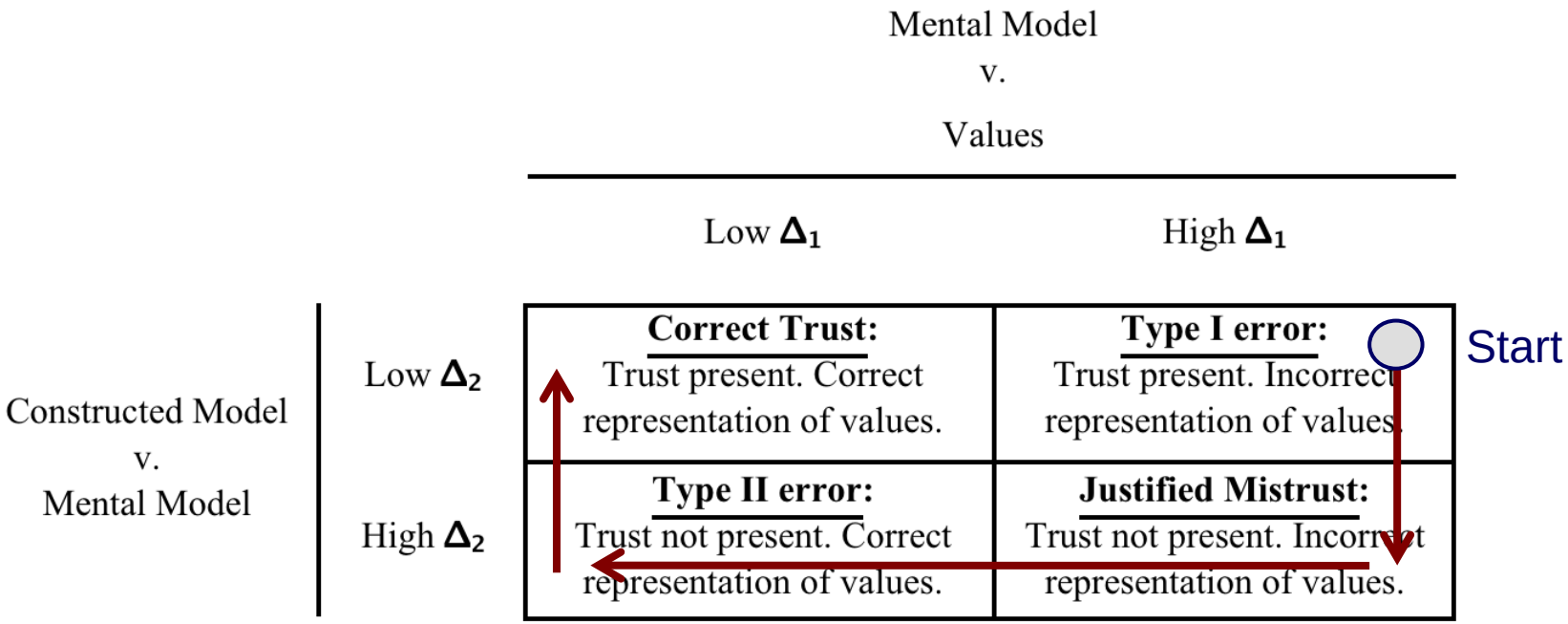
Knowledge assessment delta reductions:

- Δ_3^P = lack of ***experience*** or existence of ***appropriate abstractions*** (e.g., modelling fluid dynamics prior to calculus)
- Δ_2^P = lack of ***trust*** in the constructed model.
- Δ_1^P = ***bounded rationality*** of to grasp complex systems.

Decision making delta reductions:

- Δ_1^V = ***cognitive* biases** (e.g. anchoring, availability), as well as ***bounded valuation***
- Δ_2^V = ***explanation*-related *biases*** (e.g., elicit utility functions through interviews); biases present in ***value model choosing***.
- Δ_3^V = function of Δ_2^V and Δ_1^V

Delta Reduction Trajectory



Iterative process of delta reductions traces a clockwise trajectory

1. If the model is not accurate, *(proper) mistrust* of the models ensues.
2. The model is then changed incrementally to build *truthfulness* (reduce Δ_1^V).
3. The model is confirmed to be a “good” representation of mental model, building *trust*.