



Capturing Unarticulated Value: System Properties and Multi-Attribute Tradespace Exploration

**Presented By
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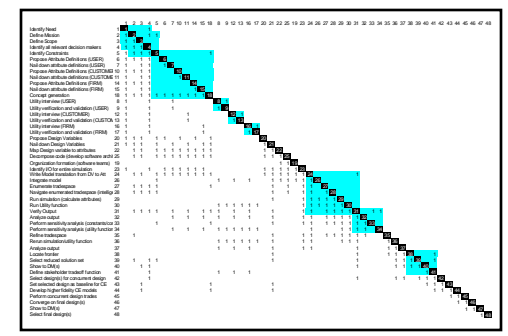
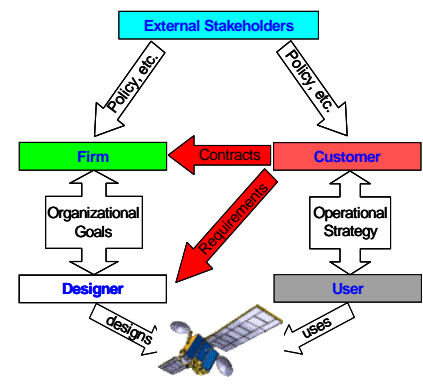
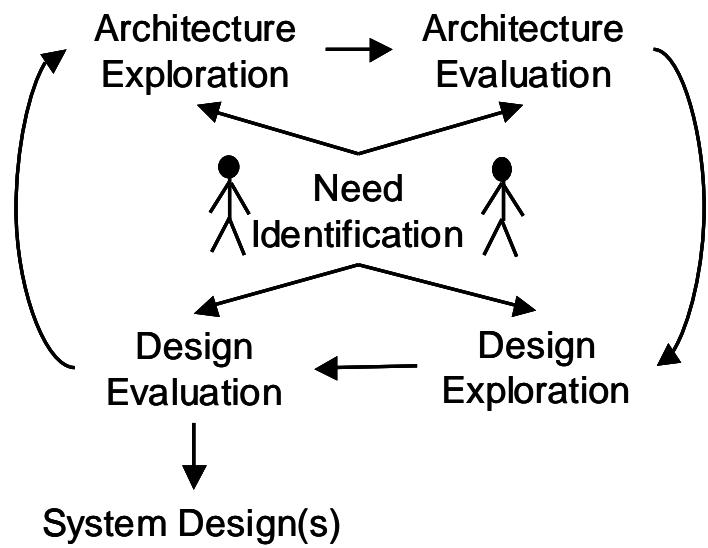
Goal of design

Create a system that fulfills some need while efficiently utilizing resources

Question

How can a system designer cope with poorly defined needs?

MATE-CON Overview

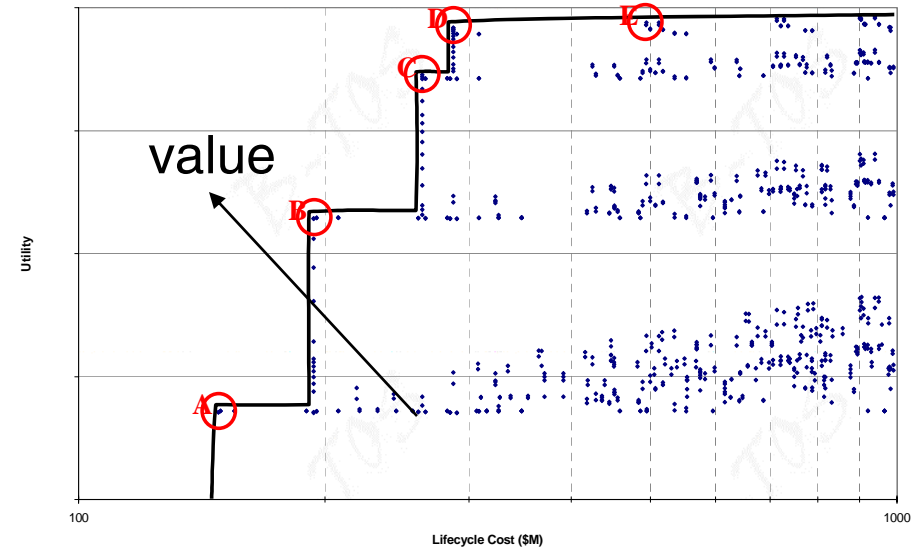


Decision Makers Formal Framework

MATE-CON is...

- A Decision Maker preference-directed tradespace exploration process
- Robust to changes and concepts
- A formalized framework
- A flexible philosophy

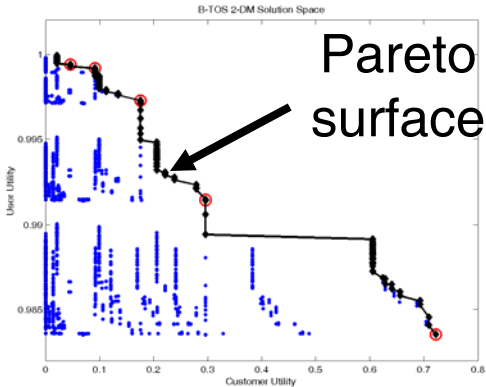
web.mit.edu/lean



Tradespace Solution Spaces

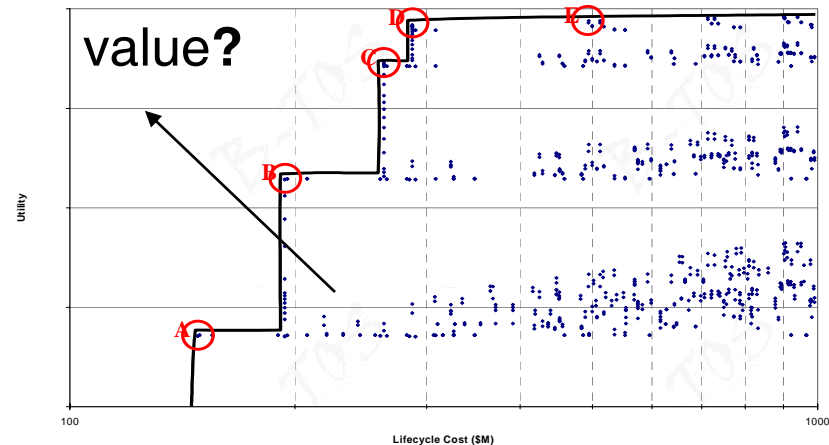
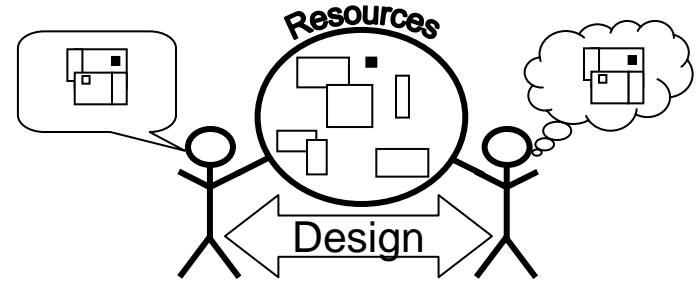
Capturing System Properties: Tradespace “ilities”

Q: What if Decision Maker(s) cannot/do not articulate everything that will result in VALUE?



P1	Flexibility	0.66
P2	Agility	0.54
P3	Robustness	0.88
P4	Failsafe	0.15
P5	Adaptability	0.65
P6	Scalability	0.70
P7	Modularity	0.45
P8	Safety	0.99
P9	Durability	0.34
P10	Sustainability	0.24
P11	Quality	0.87
P12	Reliability	0.96
P13	Reparability	0.08
P14	Maintainability	0.11

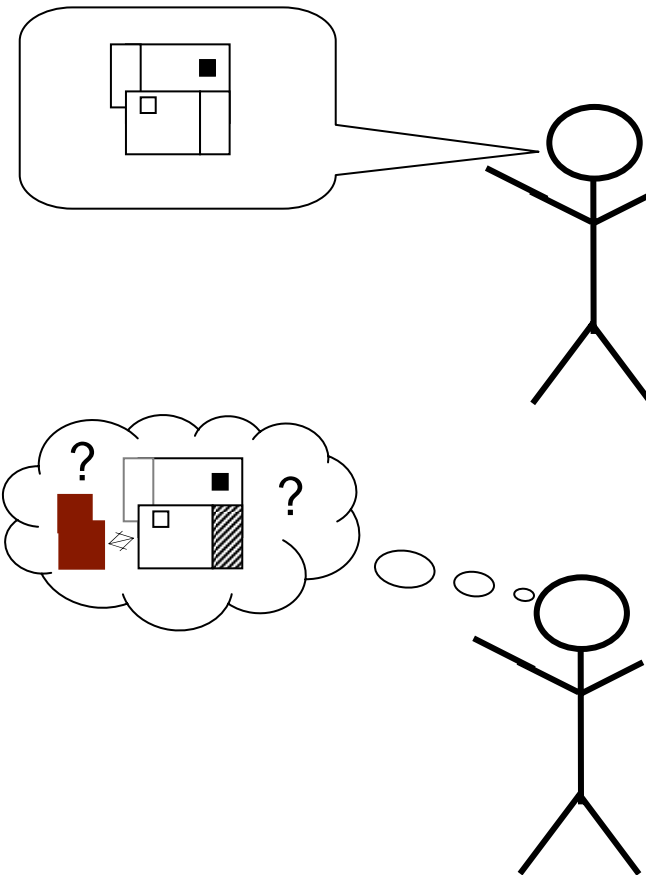
Do these ilities apply to entire tradespace, or to each solution?



A: Attempt to assess system properties

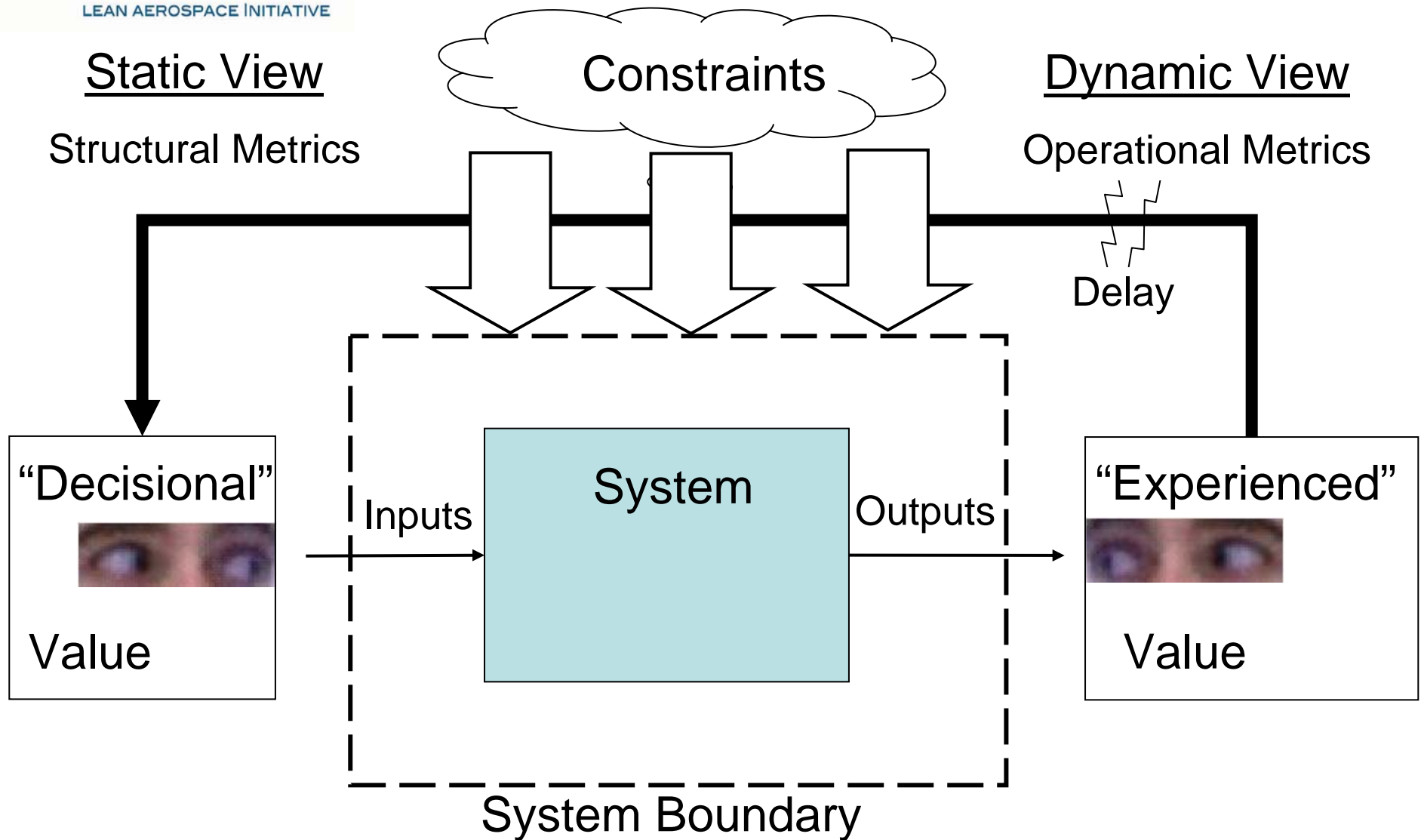
“Articulated” versus “Unarticulated” Value

- **Articulated Value**
 - Traditional requirements
 - Objectives, attributes
 - “Desirements”
 - “Must haves”
- **Unarticulated Value**
 - Fuzzy desires, objectives
 - Emergent applications
 - “Good to haves”
 - System properties?



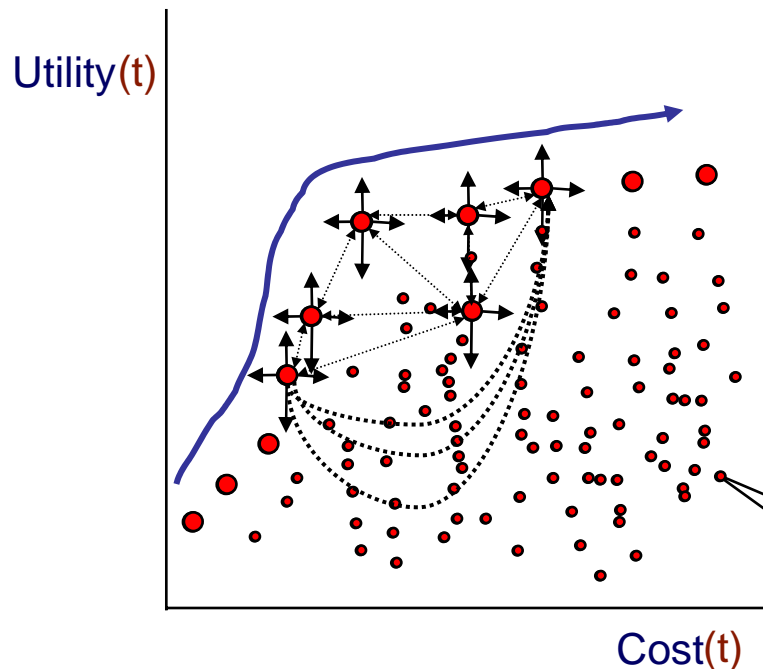
“A flexible system is a good thing, but what is it and how much?”

System Context: Value Lenses



Tradespace Exploration: Avoiding Point Designs

Differing types of trades



1. Local point solution trades
2. Frontier subset solutions
3. Frontier solution set
4. Full tradespace exploration
- 4b. Tradespace utilities (**NEW**)

$$\text{Design}_i = \{X_1, X_2, X_3, \dots, X_j\}$$

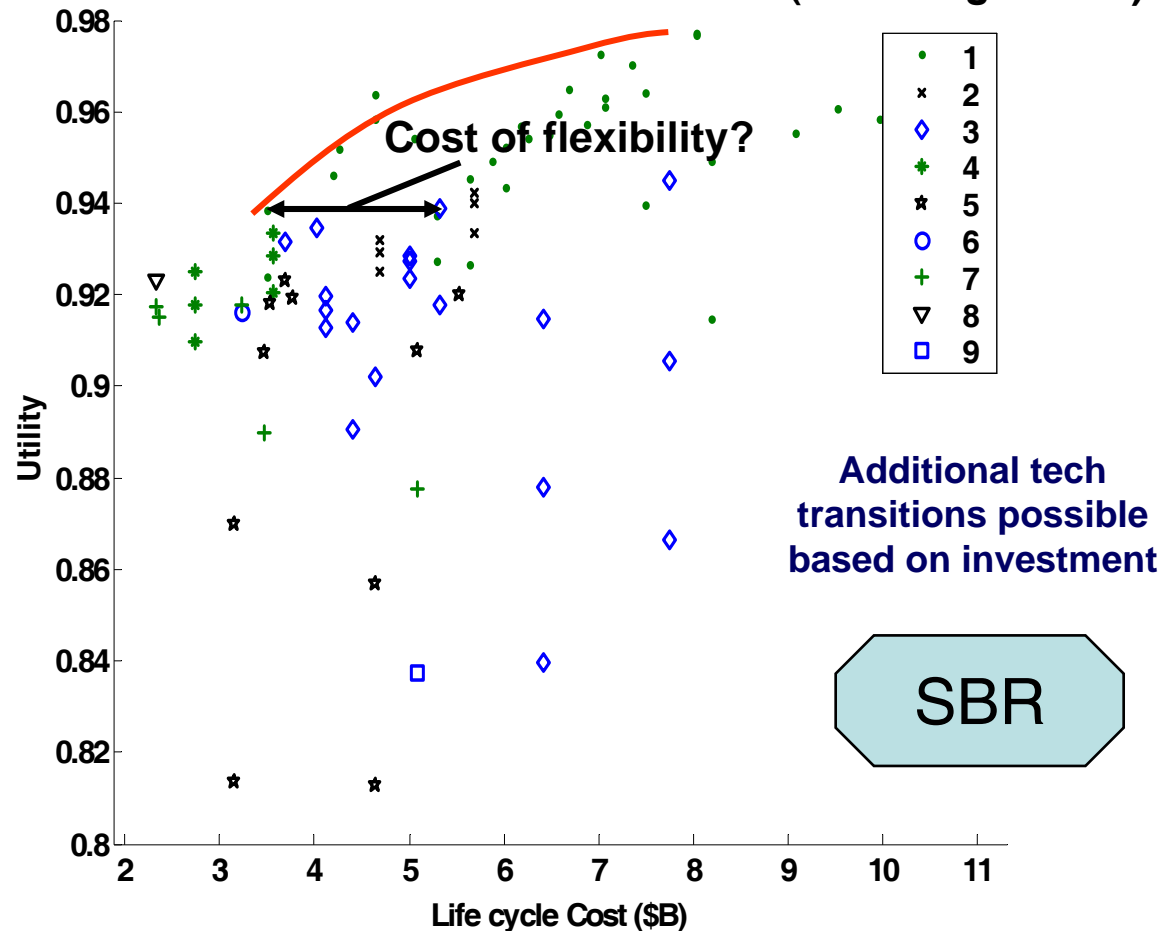
Tradespace exploration enables big picture understanding

Flexibility Over Time: SBR

Technology and Programmatic Flexibility Over Time for Space-Based Radar

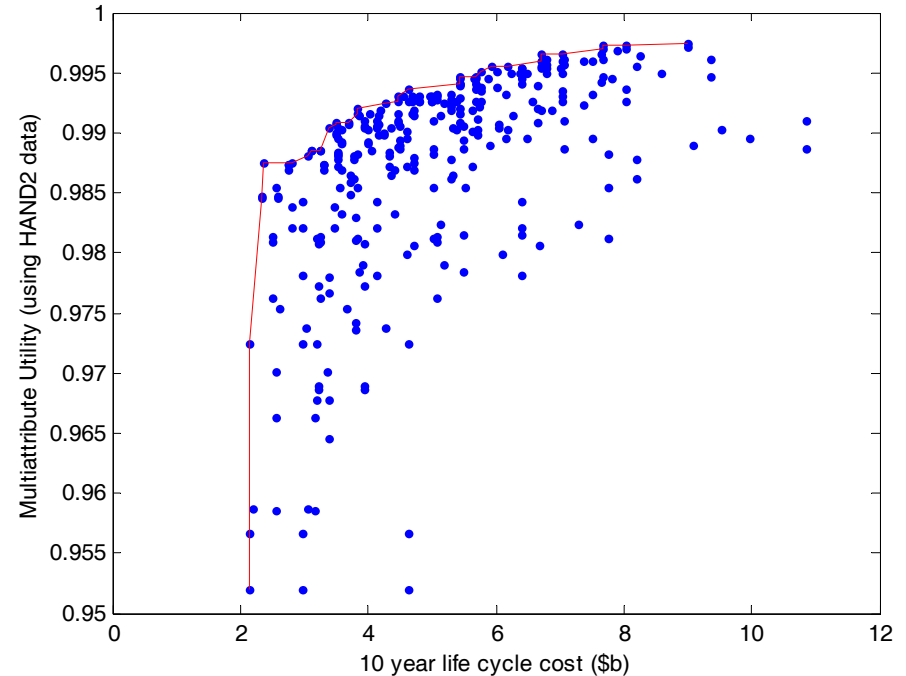
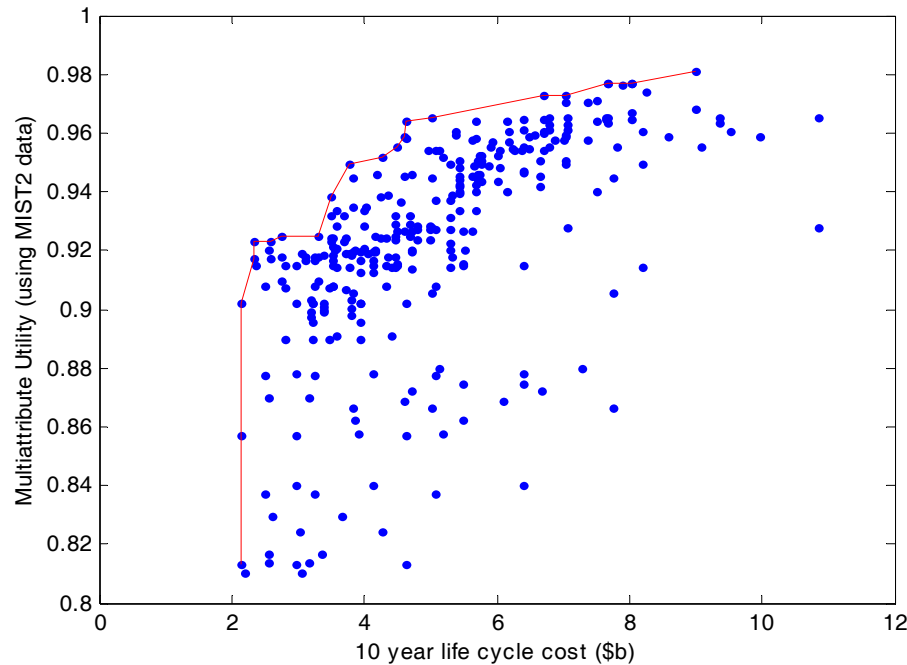
- “Transitionability” relates to “distance” between architectures
- Transition costs vary widely based on transition path
- Pareto Front may not provide best answers
- “Optimality” not defined when fitness function changes over time

Number of Transition Possibilities: 2002 to 2005 (decreasing altitude)



Example Tradespace Change: Pareto Set Shift

What happens when preferences change?



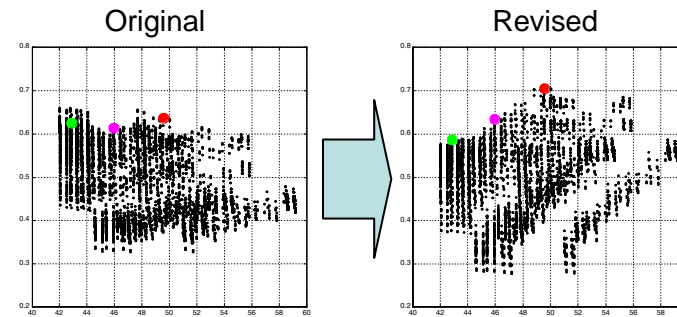
From Spaulding, 2003

Dynamic tradespaces may reveal dynamic properties

Research Design: Experiments

- **Computer experiments**
 - Isolateilities
 - Utilize past data (X-TOS, B-TOS, SpaceTug)
- **Experiment set #1: Dynamic context**
 - Question: How is a tradespace affected when articulated value changes?
 - Two classes of “value” changes:
 - Single DM changing over time
 - Addition of new/different DM
 - Post-process X-TOS dataset
 - Vary input preferences, collect statistics on output tradespace, including Pareto Set

“Optimized” solutions may be poor choices under changing value





Research Questions

- “New” research questions:

1. What are the relationships between *flexibility*, *adaptability*, *robustness*, and *scalability* for *space systems* and how do they relate to *unarticulated value*?
2. How can these *ilities* be *quantified* and/or used as *decision metrics* when exploring *tradespaces* during *Conceptual Design*?

- Questions guide exploratory research design
 - Inheritance, Theory, Experiments, Case studies



Expected Findings

Contributions of research

- **Concrete quantification of flexibility, robustness, adaptability, and scalability in a value-centric tradespace framework**
- **Insight into how unarticulated value may be assessed**
- **Useful and expanded process/framework for Conceptual Design trade studies**
- **Suggestions for future work**



Questions?