



SEARI Short Course Series

Course: PI.26s Epoch-based Thinking: Anticipating System and Enterprise Strategies for Dynamic Futures

Lecture: Lecture 5: Perceptual Aspects of Epoch-based Thinking

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This course was taught at PI.26s as a part of the MIT Professional Education Short Programs in July 2010 in Cambridge, MA. The lectures are provided to satisfy demand for learning more about Multi-Attribute Tradespace Exploration, Epoch-Era Analysis, and related SEARI-generated methods. The course is intended for self-study only. The materials are provided without instructor support, exercises or “course notebook” contents. Do not separate this cover sheet from the accompanying lecture pages. The copyright of the short course is retained by the Massachusetts Institute of Technology. Reproduction, reuse, and distribution of the course materials are not permitted without permission.



Systems Engineering Advancement Research Initiative

***[PI.26s] Epoch-Based Thinking: Anticipating System
and Enterprise Strategies for Dynamic Futures***

Lecture 5

Perceptual Aspects of Epoch-Based Thinking

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Outline

- Overview of perceptual aspect
- Impact of stakeholder preference change
- Cognitive biases
- Open questions

Five Aspects Taxonomy

| | |
|-------------------|---|
| STRUCTURAL | related to form of system components and their interrelationships |
| BEHAVIORAL | related to function/performance, operations, and reactions to stimuli |
| CONTEXTUAL | related to circumstances in which the system or enterprise exists |
| TEMPORAL | related to the dimensions and properties of systems over time |
| PERCEPTUAL | related to stakeholder preferences, perceptions and cognitive biases |

Rhodes, D. and Ross, A., *Five Aspects of Engineering Complex Systems: Emerging Constructs and Methods*, IEEE Systems Conference, April 2010

Perceptual Aspect

- Considers individual stakeholder preferences, and how preferences vary across stakeholders
- Considers changes in preferences as response to context shifts over time as stakeholders interact with system in its environment
- Includes cognitive limitations, biases, and preferences of stakeholders

Systems are valuable only when perceived as such by stakeholders

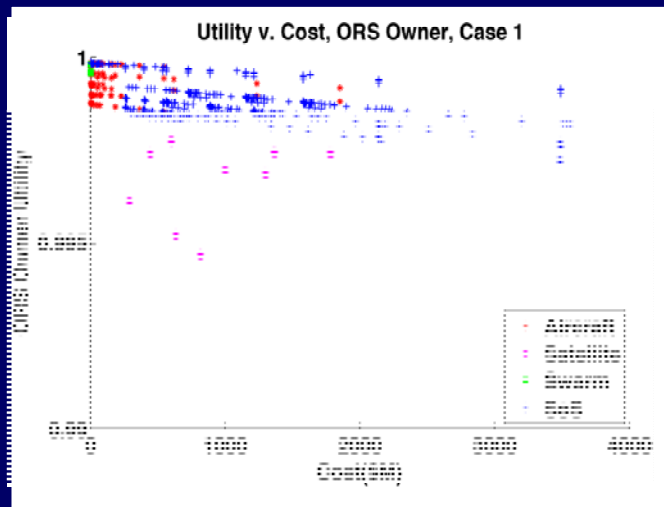
Accordingly methods need to address perceptual aspects of engineering systems

As systems grow increasing complex, the human-system dimensions present greater challenges

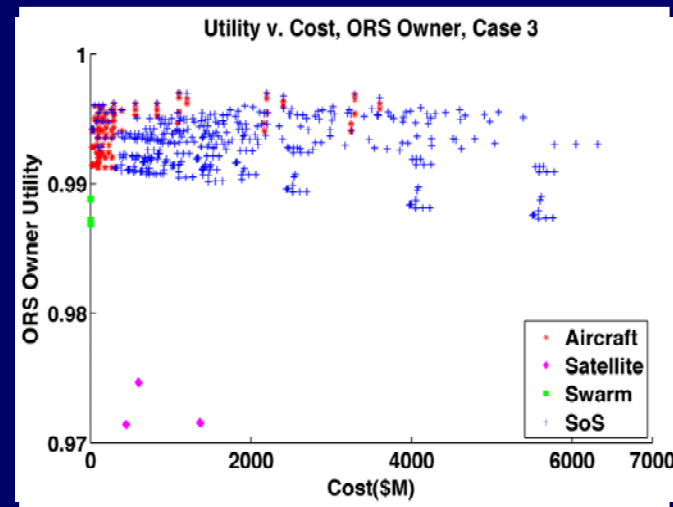
Perceptual Aspect: Shift in What Stakeholder Values

Perceptual aspect can relate to need to understand ‘goodness’ of design concepts as a stakeholder’s preferences shift over time. Exogenous factors such as economic changes, available technology, threats and other factors may influence relative importance of what a stakeholder values.

Original Attribute Relative Weights



Changed Attribute Relative Weights



Impact of Change in Stakeholder Weighting of Desired System Attributes in Tradespace showing Utility vs Cost for a Multi-Concept System

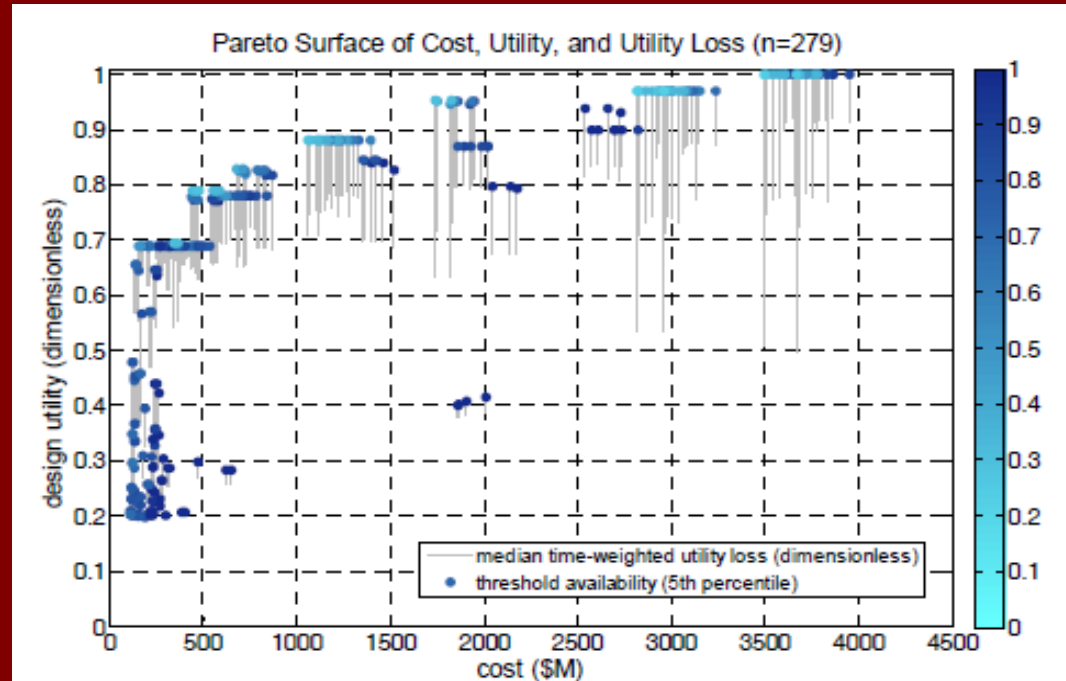
D. Chattopadhyay, A.M. Ross and D.H. Rhodes, " Demonstration of System of Systems Multi-Attribute Tradespace Exploration on a Multi-Concept Surveillance Architecture," *7th Conference on Systems Engineering Research*, Loughborough University, UK, April 2009

Duration Time and Outcome Delay in Decision Making

Temporal and Perceptual Aspects of Visualizing Complex Data Sets

What visual construct can combine:

- **temporal aspect** (effective display of time-based impacts) and
- **perceptual aspect** (ability of decision maker to cognitively process complex tradespace information)?



Richards (2009): Perceptually understandable display of value for cost of satellite radar designs with time-based information on survivability of system as it experiences possible finite disturbances over its lifespan

Amount of information and complexities within a set of information are challenges, in that human cognitive limits for processing the visual display must be considered, as well as mechanism to compute and display synthesis of temporal analysis (survivability over system life)

Duration: What Matters?

When evaluating alternatives, three aspects of duration matter:

- Duration of the alternatives themselves
- Anticipated expected time of their realization
- Time available for making decisions

Klapproth, F. Time and decision making in humans, *Cognitive, Affective & Behavioral Neuroscience*, 2008, (4) p 509-524

Duration Neglect

Various researchers have found...

- Decision makers usually resort to non-temporal features of experience when evaluating it
- People ignore or severely underweight the duration of consequences
- Evaluation of experience tends to be on intensities of experience rather than duration

However, subsequent other studies have found counter evidence; so there appears to be mixed evidence that duration plays a role when people select among alternative courses of action

Kahneman et al. 1993; Redelmeier and Kahneman 1996, as described in Klapproth, 1993

Hyperbolic Discounting

Hyperbolic Discounting: tendency to have a stronger preference for more immediate payoffs relative to later payoffs, where the tendency increases the closer to the present the payoffs are

Open question: in epoch-based thinking, how will this impact choices that will not be realizable until points in the future?

What kinds of incentives would motivate people to shift their preference for more immediate pay-off?

Cognitive Biases

Examples of Well Known Cognitive Biases

Bandwagon Effect: tendency to do/believe things because many other people do/believe) it

Wishful Thinking: formation of beliefs and making decisions according to what is pleasing to imagine instead of by evidence or rationality

Need for Closure: the need to reach a verdict in important matters; to have an answer and to escape the feeling of doubt and uncertainty

Have you seen examples of these in your work?

Anchoring and Adjustment Heuristic (Tversky and Kahneman)

Anchoring and adjustment:
psychological heuristic that influences the way people intuitively assess probabilities, where people start with an implicitly suggested reference point (the "anchor") and make adjustments to it to reach their estimate

Example: an audience is first asked to write the last two digits of their social security number and consider whether they would pay this number of dollars for items whose value they did not know, such as wine or chocolate.

They were then asked to bid for these items -- result was that audience members with higher two-digit numbers would submit bids 60 to 120 percent higher than those with the lower social security numbers, which had become their anchor

(Teach, 2007)

Choice-Supportive Bias

Choice-Supportive Bias: a tendency to retroactively attribute positive attributes to a previously selected option

- Henkel and Mather (2007) found that giving people false reminders about which option they chose in a previous experiment session led people to remember the option they were told they had chosen as being better than the other option.

Choice-supportive biases arise in large part when remembering past choices, rather than being the result of biased processing at the time of the choice

Confirmation Biases

- **Confirmation Bias:** tendency to favor information that confirms preconceptions or hypotheses whether or not true
 - As a result, people gather evidence and recall information from memory selectively, and interpret it in a biased way.

Confirmation biases contribute to overconfidence in personal beliefs and can maintain or strengthen beliefs in the face of contrary evidence. Hence they can lead to disastrous decisions, especially in organizational, military, political and social contexts. (Wikipedia, accessed July 2010)

Focusing Effect

Focusing effect: tendency to place too much importance on one aspect of an event, causing an error in accurately predicting the utility of a future outcome.

In epoch-based thinking, this could be particularly impactful since any a certain aspect may be important in one epoch but respectively not as important in another

Competency and Environment

An Open Question

- Some researchers assert people can be differentiated in their proneness and ability to look into the future
- Whether future temporal perspective is a trait or subject to manipulation is an open question

Can this epoch-based thinking competency be learned or is it innate? What is your experience with this?

Klapproth, F. Time and decision making in humans, Cognitive, Affective & Behavioral Neuroscience, 2008, (4) p 509-524

Epoch-based Thinking Decision Environments May Shape Outcomes

- Research into why people look favorably on a product shows that -- as in real life -- everything is relative.
- What we think of a product or brand, or how positively or negatively we assess it, **depends on the context** in which it is viewed.
- "Although they generally think their judgments reflect the true quality of the products, many **irrelevant contextual factors** from the weather to another product brand can influence consumers' evaluations"

Chien, et al., ScienceDaily (Mar. 22, 2010)

Summary

- Perceptual aspect relates to stakeholder preferences, perceptions and cognitive biases
- Stakeholder preference change over time is important to consider in analysis
- Visualization of complex data sets introduces perceptual/temporal challenge
- Duration and outcome delays factor into epoch-based thinking
- Many cognitive biases come into play in epoch-based thinking
- Environment used to perform epoch-based thinking may be highly relevant to outcome
- Many interesting questions drive ongoing research