# SEAri Short Course Series

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

Lecture: Lecture 8: Scenario Building and Analysis Using Ordered Sequences of Epochs

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

**Lecture 8**
**Scenario Building and Analysis Using Ordered Sequences of Epochs**

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# Outline

- Epochs as building blocks for eras
- Constructing Eras
- Generating and evaluating evolution strategies

# Various Epochs Define the World for our Systems…











(Slide courtesy of Andrew Long, Booz Allen Hamilton, 2010)

# … and can be assembled into possible Eras (futures)

Our Path Today

Cold War → War on Terror





Alternative Eras





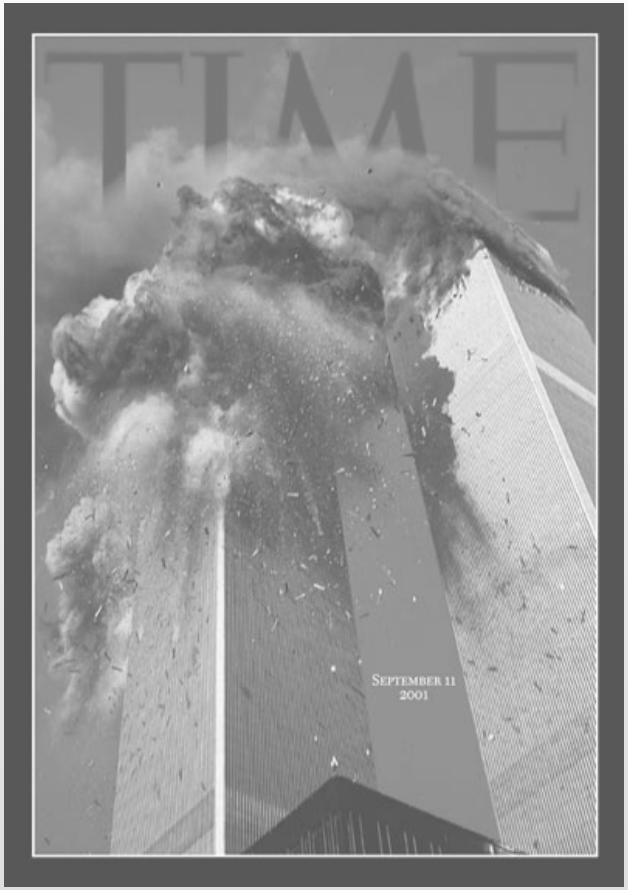







(Slide courtesy of Andrew Long, Booz Allen Hamilton, 2010)

# Example: Modern HMMWV

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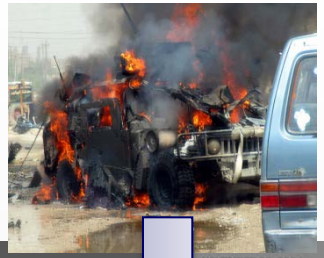


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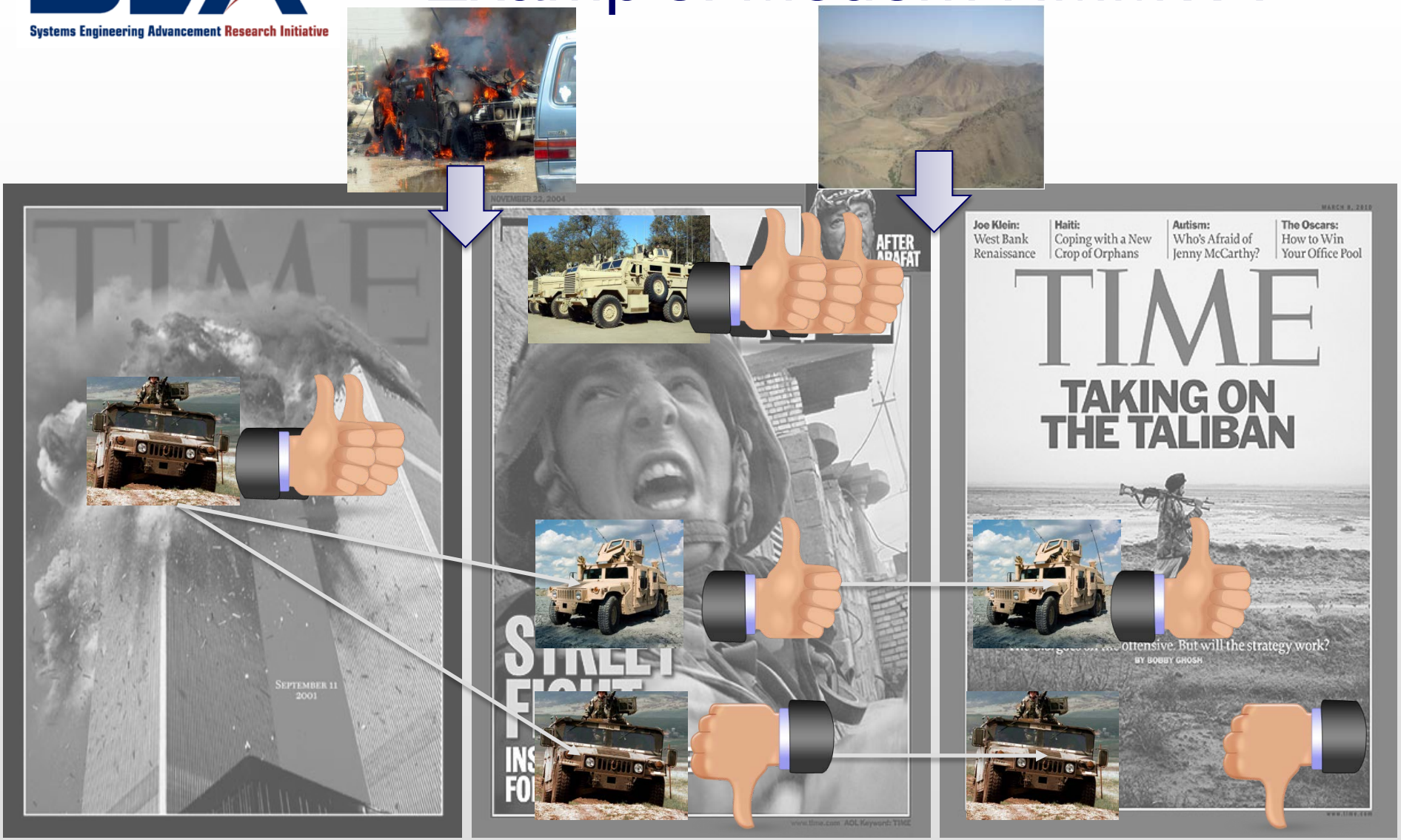


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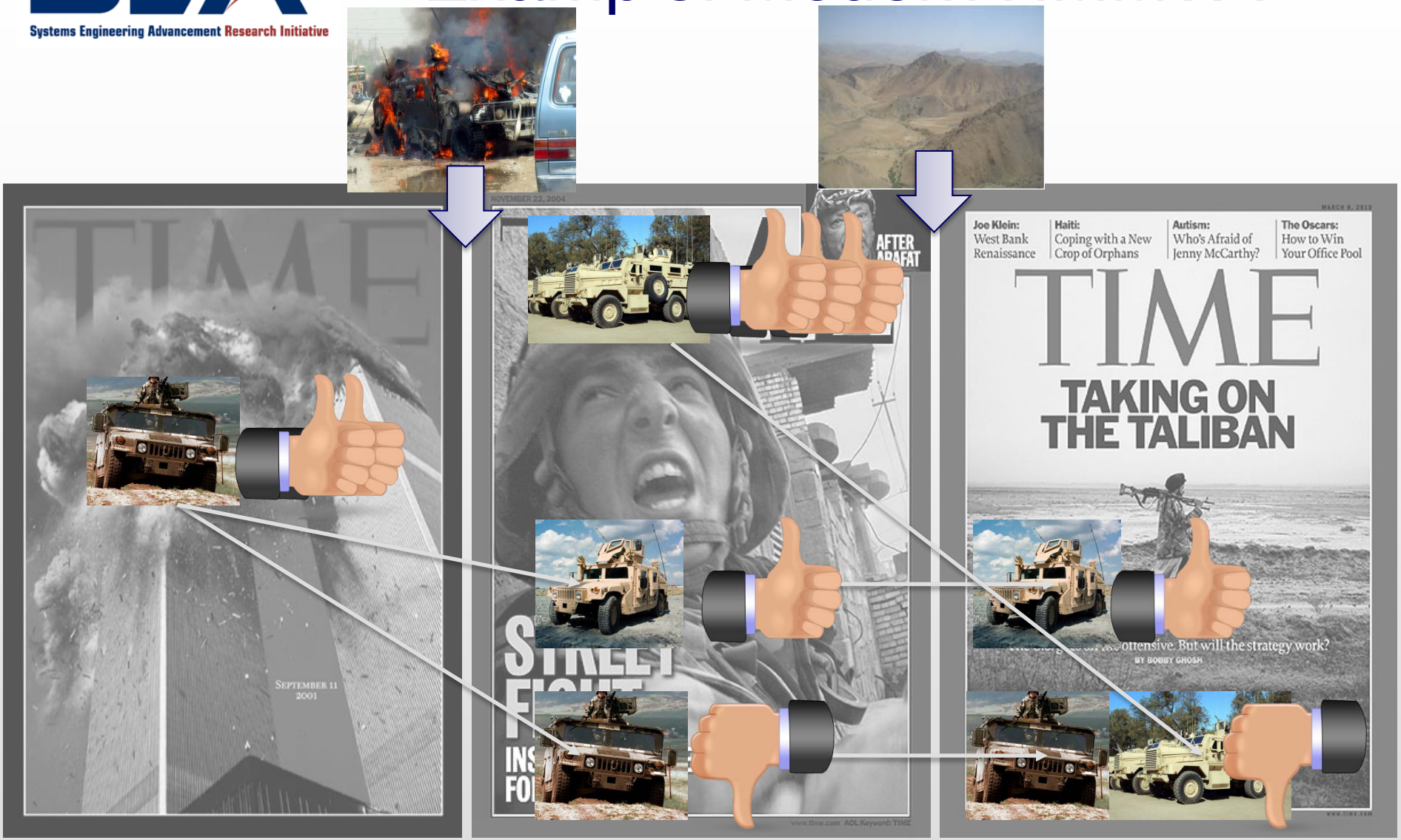


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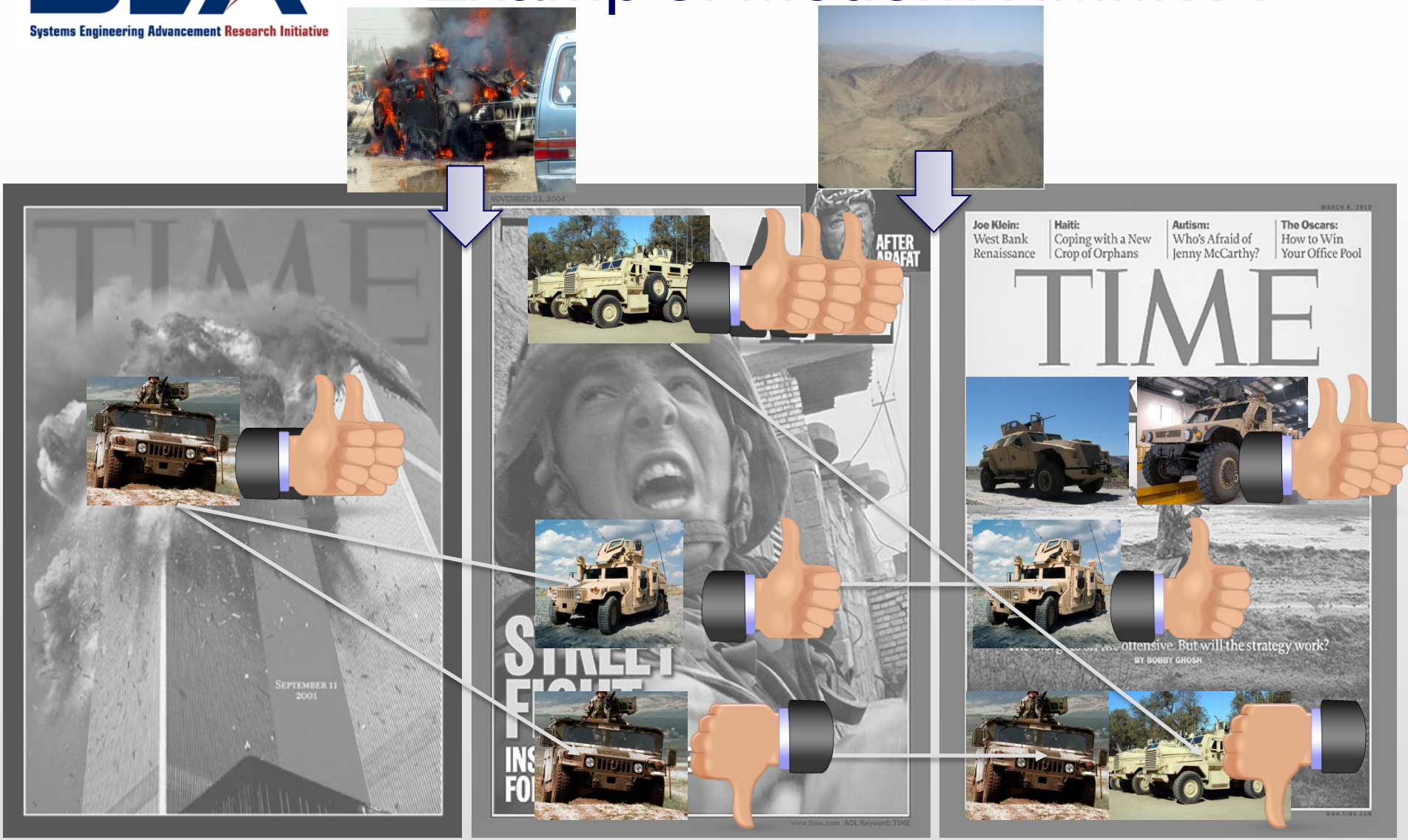
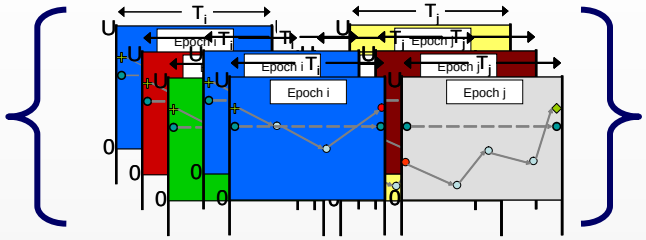



(Slide courtesy of Andrew Long, Booz Allen Hamilton, 2010)

# Epoch-Era Analysis

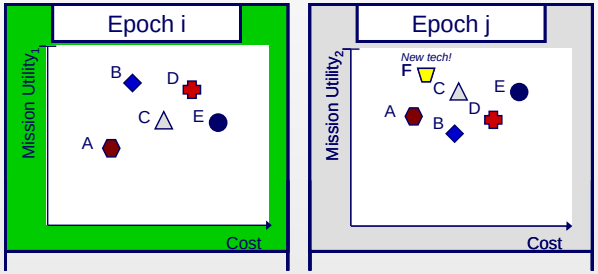
## Epoch Characterization

Epoch set represents potential fixed contexts and needs



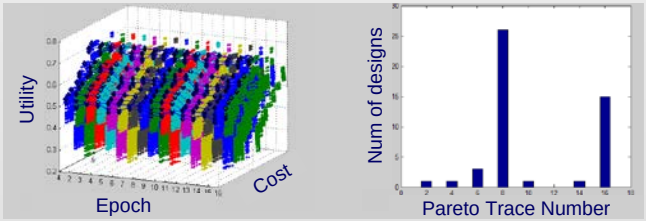

## Compare Alternatives

Static tradespaces compare alternatives for fixed context and needs (per Epoch)



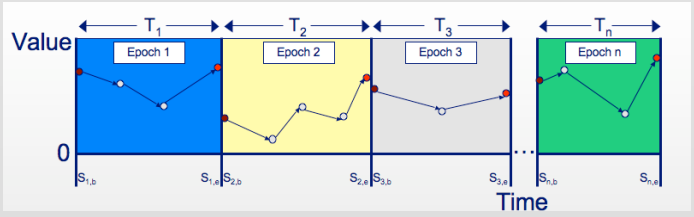

## Multi-Epoch Analysis

Analysis across large number of epochs reveals "good" designs




## Era Construction

Eras represent ordered epoch series for analyzing system evolution strategies



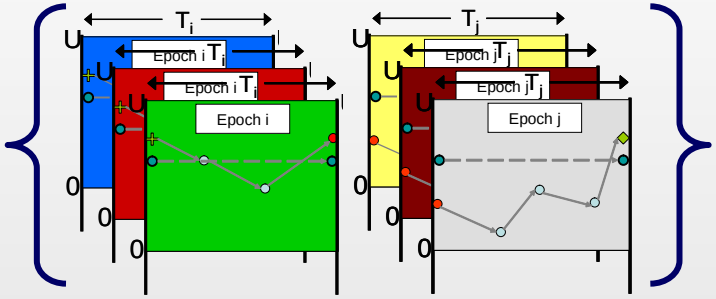
# Era Construction

## Definition of Era:

System life with varying contexts and needs, formed as an ordered set of epochs; characterized by varying constraints, design concepts, available technologies, and articulated attributes

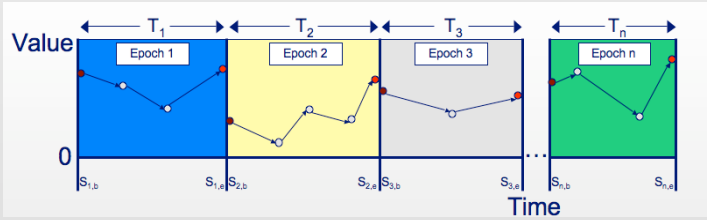
### Define Epochs

- Potential Contexts
- Potential Needs




### Construct Eras

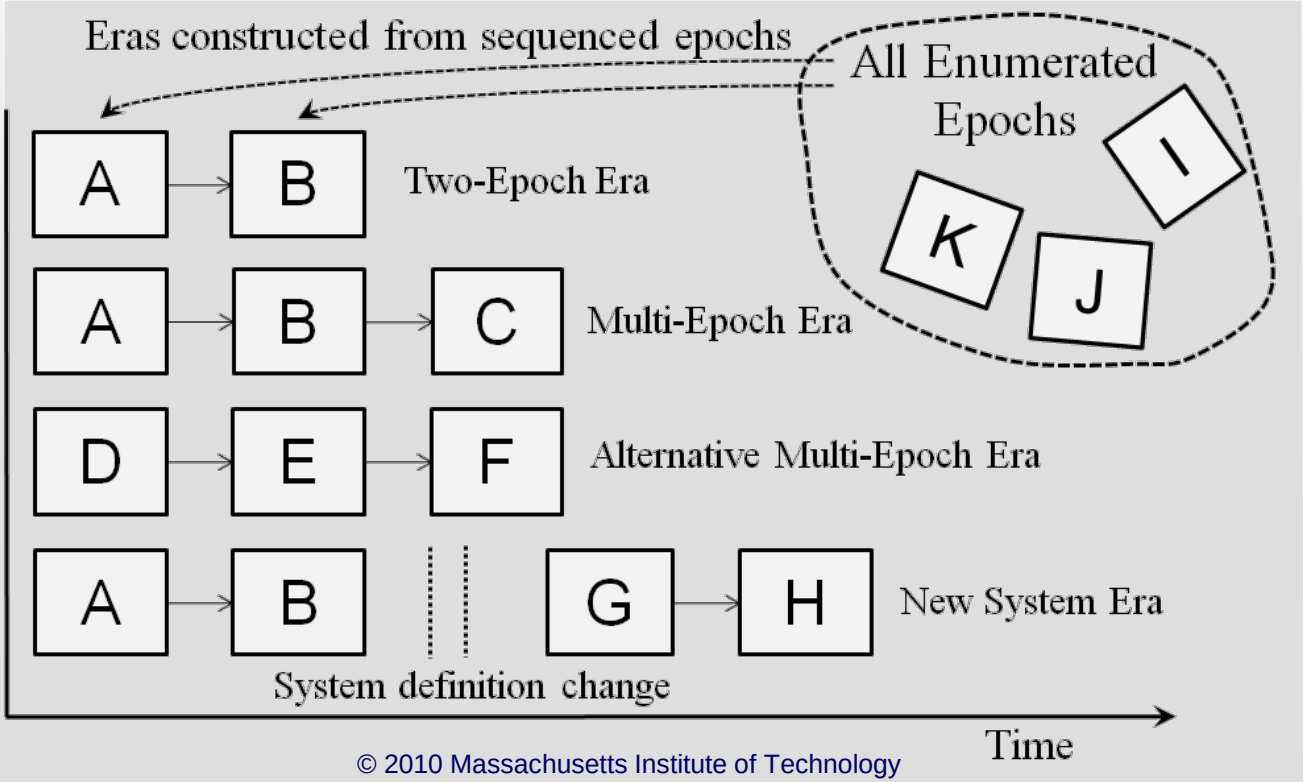
- Epoch Series
- Dynamic Strategies




Discretization of change timeline into short-run and long-run enables analysis. Allows evaluation of system varying performance over possible futures or scenarios

# Epoch-Era Analysis Steps

1. Multi-stakeholder value definitions
2. Epoch characterization (define possible futures)
3. Era construction (generate, sample, and assemble futures)
4. Value-based comparison of competing designs



# Questions Addressed using EEA

*Q: What is the expected value distribution given an uncertain future environment?*

- Scenario planning method that provides a structured way to analyze temporal system value
- System lifecycle (comprising an era) is divided into epochs
- Each epoch is described by an epoch vector that defines its key exogenous factors describing the system context

"Top-down" or "bottom-up" "possibilistic" and temporal-based view of uncertainty

***How does one account for exogenous uncertainties?***

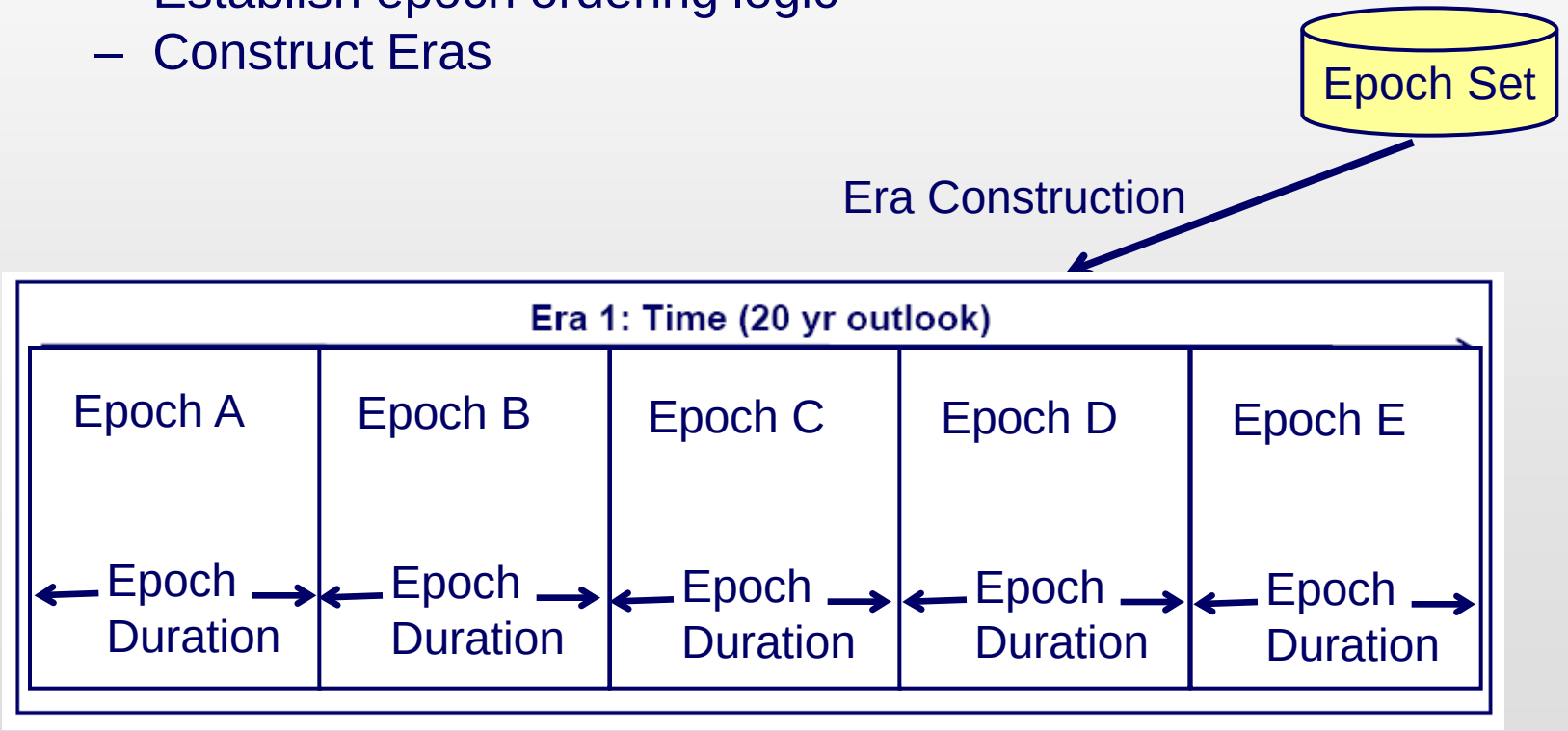
Identify possible, likely, or consequential uncertain exogenous factors from categories below

Epoch variable categories

- Policy
- Funding
- Infrastructure
- Technology
- Environment

# Activities of Era Construction

- Era construction involves four activities
  - Specify era duration
  - Characterize epoch durations (clockspeeds)
  - Establish epoch ordering logic
  - Construct Eras



# Contrast: Scenario Planning

- Scenario planning refers to a broad set of methods used to make strategic decisions

| | **Narrative** | **Computational** |
|---|---|---|
| **Description** | Thickly-descriptive, Internally consistent | Parametric enumeration of future contexts |
| **Pros** | Compelling, more detail, plausible | Many futures, surface counterfactuals |
| **Cons** | Few future contexts considered | Computationally intensive |

(Wack 1985, Ringland 1998, Eriksson 2002, Lempert et al 2003, Harries 2003)

- Differing degrees of automation in computational scenario generation
  - Morphological
  - Expert systems

Epoch and Era-based approaches leverage both computational and narrative techniques

Scenario planning allows strategic management of uncertain contexts

# Era Construction using Narratives

## 7 Sample Era Narratives

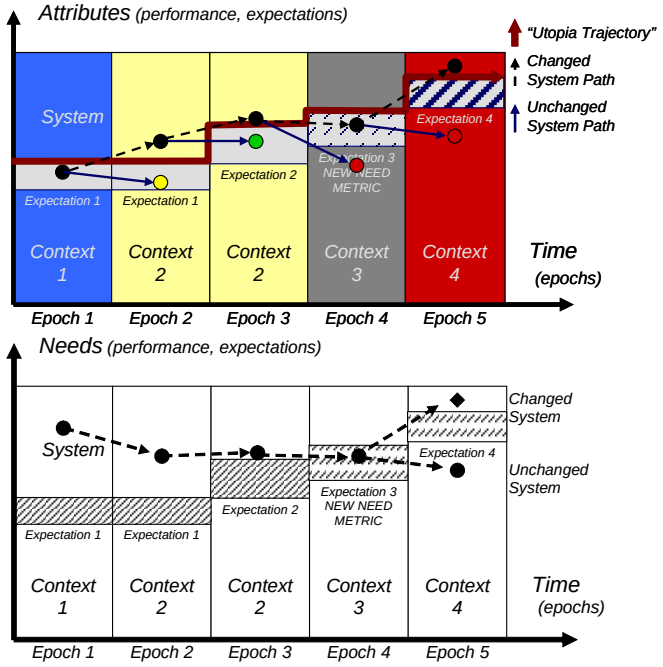
- **Eras 1 - 3:**
  Emphasize shift from imaging mission to tracking mission;
  Modeled after real world historical scenario
- **Eras 4 & 5:**
  Focus on evaluation of advanced technology across strained operations
- **Era 6:**
  Evaluate importance of infrastructure advancements
- **Era 7:**
  Major force on force conflict

Key difference between eras and typical “scenarios” is that eras include the path dependence of the context, while typically scenarios only consider starting and ending contexts

# Using Eras to Generate System Evolution Strategies

Develop time-based strategy for selecting designs that continue to deliver value to stakeholders across epochs

- Relevant metric: Minimized distance from "Utopia trajectory" of a system's performance in a given strategy




Trajectories across a system ***Era*** can be defined:

1. Set of expected Epochs
2. Strategy for selecting designs in each Epoch (e.g. min cost, max utility, etc.)

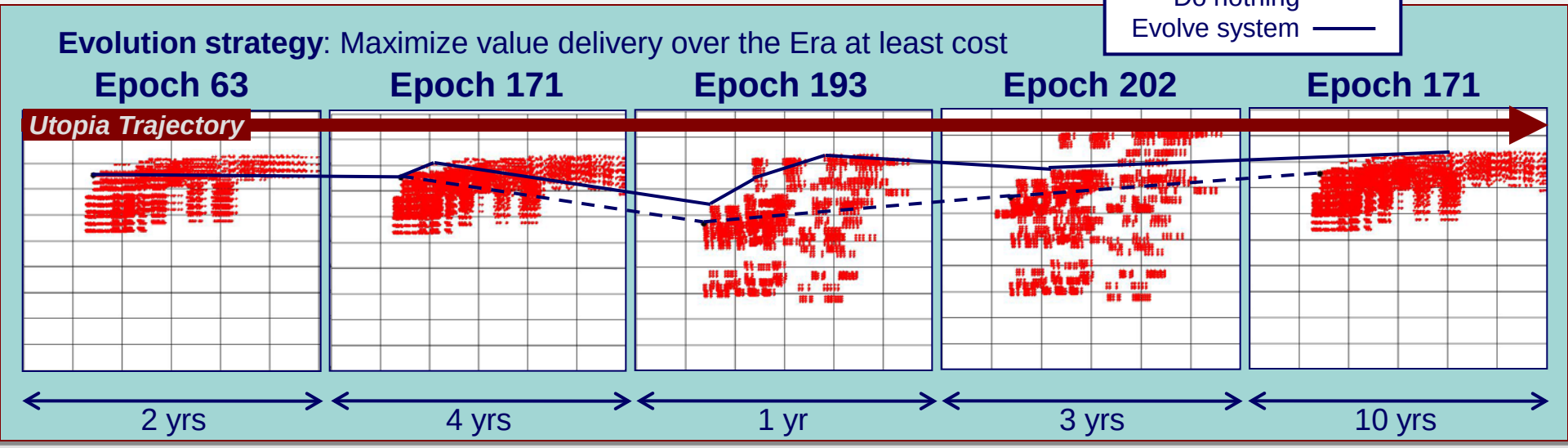
Multiple Eras defined and system selection strategies compared to "Utopia trajectory"

# Using Eras to Evaluate System Evolution Strategies

Utilize optimization approaches to derive time-based system evolution strategies that sustain / maximize stakeholder value delivery

Example strategies include:

- Maintain minimum distance from utopia trajectory
- Maximize delivered system value given a fixed budget




Epoch-Era Analysis can be used to determine system designs and transition strategies that deliver the highest value over the entire system lifecycle or within a particular context

# What About Desiring Change?

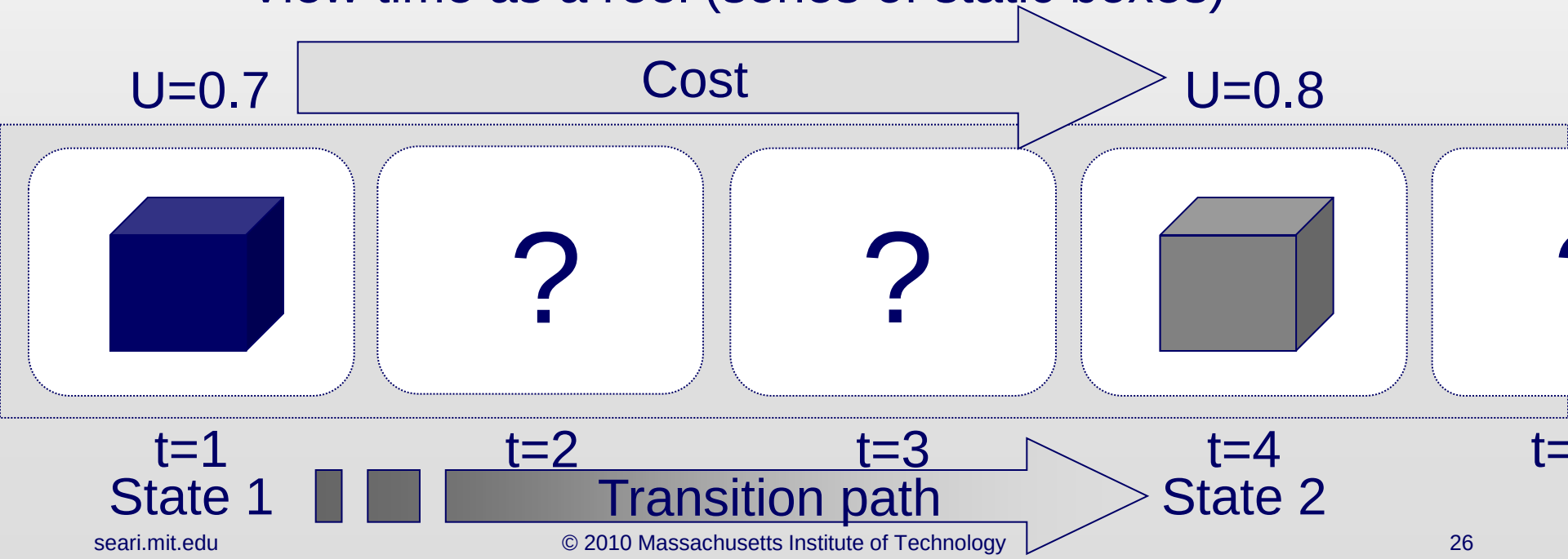
To assess change, three things must be defined

1. State 1
2. State 2
3. Transition path from 1 to 2

"Changeable" alternatives may perform better across an era

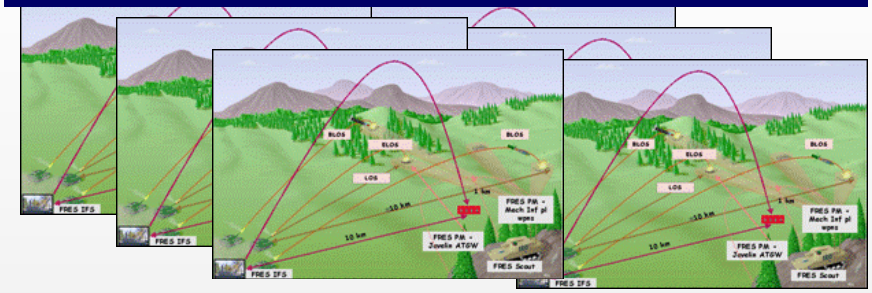
More in lecture 11

View time as a reel (series of static boxes)

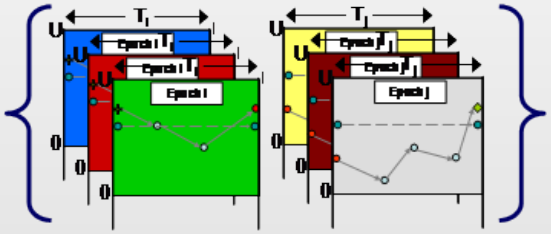


# Boundary Spanning Activity

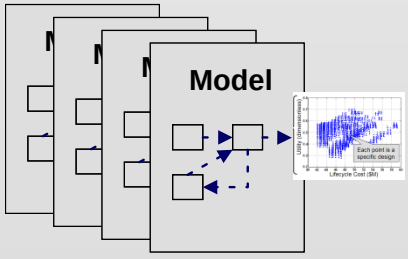
## Possible Scenarios and Trajectories



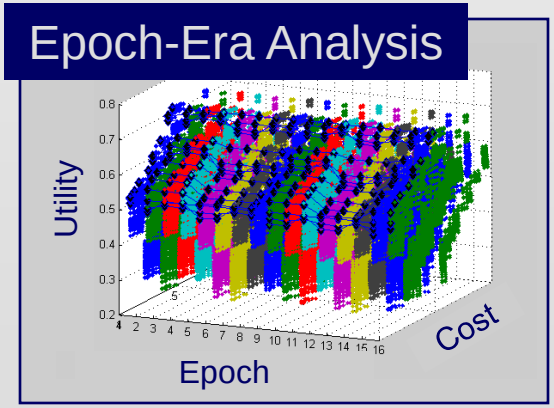
## Possible Epochs and Eras



## System models




## Epoch-Era Analysis




- Architect develops possible "scenarios" and "system trajectories"
- Working with analyst, enumerates epochs and eras
- Analyst uses epochs to develop context-dependent models for tradespace exploration
- Software used to generate visualizations and analytically based system trajectories
- Results incorporate perspectives of architects, analysts, and stakeholders

**Facilitates discussion and insight**

# Characteristics of Epoch-Era Analysis

- Eras can be numerically or narratively formulated
- Particularly well suited to mental-model building, even when knowledge of probabilities is unknown
- Epochs can be “hand-picked” to fit imagined scenarios, or automatically selected
- Structured framework guides utility vs. cost tradeoff throughout alternative possible futures
- Sequential ordering of epochs produces an ***emergent path dependence*** of value over time (i.e., the optimal design may depend on *order* of future events)
- Results dependent on epoch enumeration, epoch sampling, and era construction

(Roberts et al. 2009)

# Insights from Epoch-Era Analysis

- Changes in static analysis assumptions should not be a post-analysis consideration (*e.g.,* "sensitivity analysis")
- Multi-Epoch Analysis makes such considerations a central part of trade studies
- Metrics can be used to gain insight into:
  - Differential impact on systems of non-subtle, discrete changes in ***needs*** and ***contexts***
  - Epoch-specific valuable families of solutions
  - Inclusion of "satisficing" designs (*i.e.,* slightly "suboptimal")
- Across an era, path analysis can be done to trade off short term and long term strategies, revealing "lock-in" and other potential barriers to success (*i.e.,* system "path dependencies")

Metrics are most useful as indicators for further investigation
(e.g., What is "so special" about these designs? In what epochs do they perform well and why?)

# Summary

- Era is a construct to represent long run futures
- Can be constructed as time-ordered series of epochs
- Can be used to evaluate system evolution strategies
  - Order of epochs matters!
  - Dynamic relevance (value robustness) empowered by this type of analysis