# Interactive Games for Accelerated Insights into Dynamic System Strategies

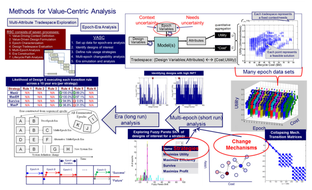
**Summer Project 2011 Team**

Undergraduates
- Praynaa Rawlani
- Elaine Han
- Andrew Moran
- Yi-an "Morgan" Lai
- Ami Greene
- Tobe Okoro

Graduate Students
- Paul Grogan
- J. Clark Beesemyer
- Dan Fulcoly
- Matt Fitzgerald

## Motivation and Goals

Ten Years of Research on Methods and Metrics




It often takes graduate students *over a year* to understand and apply SEAri methods and metrics

**In order to impact practice, we need to simplify & accelerate knowledge transfer**

### *Summer Project 2011 Goals*

- To develop a "game" to let players better understand the "ilities" and the effects of changing contexts & needs on valuation
- To develop useful visual and interactive constructs to communicate short run and long run scenario analysis using SEAri constructs
- To be able to gather player game data (to compare how users "optimize" and make decisions in this dynamic decision environment to strategies derived through SEAri algorithms)
- To have a software platform that enables easy modification to demonstrate the universality of the problem type across various system problem applications

Summer: June 6 to August 16, 2011

*A game is a problem-solving activity, approached with a playful attitude.* Schell 2008, pg 37

Schell, Jesse, *The Art of Game Design: A book of lenses*, Elsevier, 2008.

## SEAri Constructs

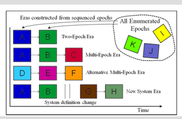
**The following constructs form the core "elements" for the project**


1. **"design" choices**
   - Includes "initial" and "delayed" alternative generation and selection

2. **utilities**
   - The benefit accrued from a design choice (subjectively defined, varies by person and across time)

3. **costs**
   - The expended resources required to achieve the utilities, incurred initially, over time, and at the end (may not be $$)


4. **epochs**
   - The short run "fixed" context and cost/utility expectations for a choice; outside of a "designer's" control; looking to the future, many possible epochs exist, one for each uncertain version of reality

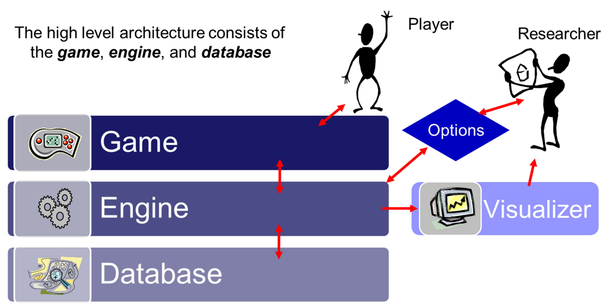



5. **eras**
   - The long run, time-ordered sequences of epochs; captures "path-dependency" of uncertain timelines, allowing for strategy development of "choices" over time

6. **"ilities"**
   - Temporal system properties that represent the ability of a choice to change over time or not need to change over time, often in response to a revealed "disturbance"

## Software Architecture

The high level architecture consists of the ***game***, ***engine***, and ***database***




The software architecture was developed such that the game would be *reusable* and *extensible*, leveraging existing, as well as future, research datasets in a database

**The summer project 2011 goal was to develop the engine and the game**

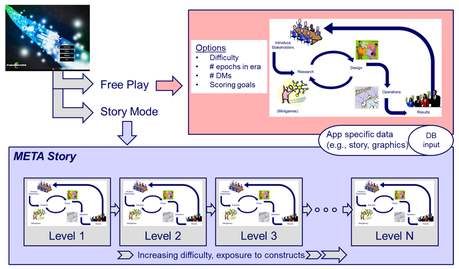
## Learning Objectives

In order to appeal to a broad array of possible "players," the following set of game learning objectives were proposed. Subsets of these objectives would relate to particular player "types" (e.g., "graduate student" or "sponsor")

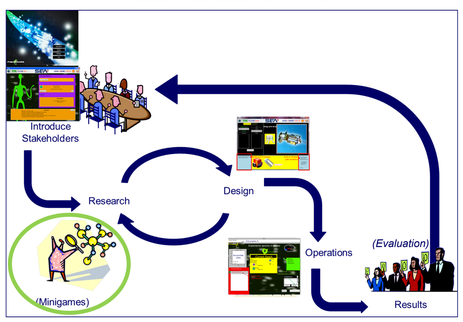
- Familiarity with SEAri constructs
  - Epochs, eras, design choices, utilities, costs, ilities
- Basic understanding of dynamic relationships among constructs
  - Choices have costs/utilities in tension
  - Ilities only useful over time (across epoch shifts and eras)
  - Ordering of epochs in eras matter
- Advanced understanding of dynamic relationships among constructs
  - "Best" choice varies per epoch
  - Value of ilities dependent on epoch ordering and strategic goals
  - Portfolio of ilities may be desired
- Examples applied to different types of systems
- System customization and data-logging options for research data
- Examples of non-technical application of the constructs
- Application of constructs to strategy formulation and investment decisions
- Application of constructs to a specific problem
- Demonstration of specific constructs

## Game Outline

### Game Architecture




### Game Level Flow

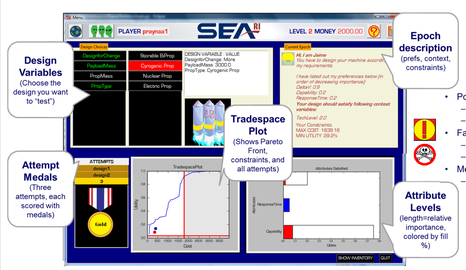


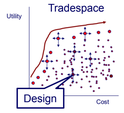

**The intent for the flow of each level is to "experience" a simplified lifecycle, with opportunities to interact with SEAri constructs and gain feedback**

## Minigames

### *Hit the Pareto*

**Goal:** Propose a design as close as possible to Pareto Frontier, within constraints
**Gameplay:** Make a design given an epoch
**Constraints:** Maximum cost and minimum utility, depends on difficulty level



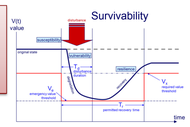



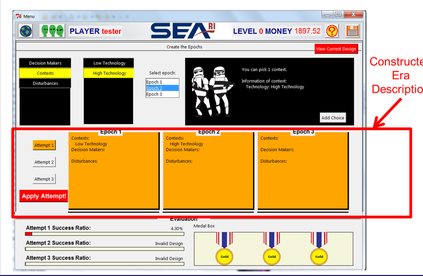

#### Scoring

- Points
  - Based on Fuzzy Pareto Number
  - Normalized to 1000
- Failures
  - *Infeasible*: Not following constraints
  - *Invalid*: Negative Utility
- Medals
  - Depends on points and difficulty level

### *Destroy Your Design*

**Goal:** Discover a three-epoch era where your level design will achieve poorly
**Gameplay:** Construct a difficult to survive era
**Constraints:**
- Up to 3 decision makers who have a preference set in each epoch
- One context for each epoch
- Up to 2 disturbances for each epoch (order matters!)



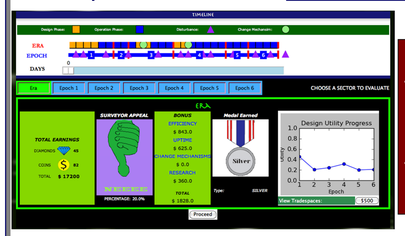

#### Scoring

The goal is to achieve the lowest fraction utility remaining possible, which is determined by the ratio of the utility of current design over maximum achievable utility of the era

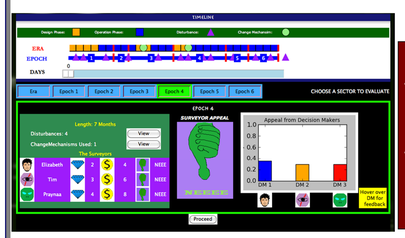
| Medal | Fraction Utility Remaining (X) |
|---|---|
| Gold | 0% < X < 10%, or invalid design |
| Silver | 10% < X <25% |
| Bronze | 25% < X <50% |


## Results and Evaluation

- Directly follows Operations (Mission)
- Provides feedback to players to enforce lessons
- Layout in Timeline and Tabs *Visually organizes Mission by Era, Epoch, Days (Scrollable)*




**Era Tab**
- Scoring
  - Total Earnings
  - Surveyor Appeal
  - Bonus
  - Medal Earned
- Graph
  - Visual diagram
  - View More option




**Epoch Tab**
- Scoring
  - Point & utility distributions for each DM
- Graph
  - Options to view disturbances & executions
  - Audio of DM based on performance


## Game Scoring

- Total Earnings
  - Diamonds: Effective Utility in Operations (experienced utility)
  - Coins: Basic Utility in Design (decisional utility)
- Surveyor Appeal
  - Percentage that player pleased all decision makers
  - Averages all DMs with "Thumbs Down" weighted more
- Bonus
  - Cost Efficiency — *Compares cost of design to that on the Pareto Line*
  - Uptime — *Percentage in era when design is valid in operations*
  - Change Mechanisms — *Compares design effective utility before and after execution*
  - Research — *Averages points and high scores achieved in minigames*
- Medal
  - Averages above three percentages with maximum possible value
  - Type: -Gold -Silver -Bronze

Future goal: "unlockables" and "trophies"

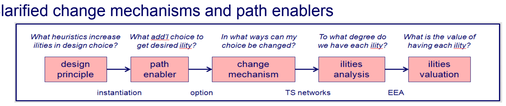
**Scoring scheme allows players to receive targeted feedback on mastery over learning objectives**

## Accomplishments

- Integrated several distinct lines of research
  - Multi-Attribute Tradespace Exploration (MATE), descriptive tradespace metrics (FPN), dynamic events illustrating design "ilities" (change mechanisms and disturbances)
- Experienced teaching SEAri concepts to a non-SE, younger audience
- Developed a first iteration of a serious game that looks at complex systems engineering from many perspectives
  - Tradespace Exploration – Hit the Pareto
  - Identifying Weaknesses – Destroy Your Design
  - Era Analysis – Operations Mode
- Experienced using game constructs to illustrate SEAri constructs
- Developed extensible architecture (engine) for future game development

## Lessons Learned

- Ility perspective shift within SEAri
  - Ilities as outcomes
  - Ility interaction
  - Future research area
- Clarified change mechanisms and path enablers




- Six construct format is an effective method for quickly teaching SEAri concepts, even to students not familiar with systems engineering

## Next Steps

- Since development is just demonstration, low level of maturity
  - Perform additional development spirals with playtesting
- Demonstrate additional "skins" (i.e., "SpaceTug") that can be applied to the engine using the reusable database
- Propose and develop additional minigames
- Perform further work to improve gameplay experience (including usability)
- Verify learning objectives are met for both developers and players
- Refine first pass of "meta story"



For more information, please visit: http://seari.mit.edu