



2011 SEARi Annual Research Summit

## Research Topic

“Using Serious Gaming to Experience Dynamic Uncertainties and Ilities”

Dr. Adam M. Ross

October 21, 2011

Cambridge, MA

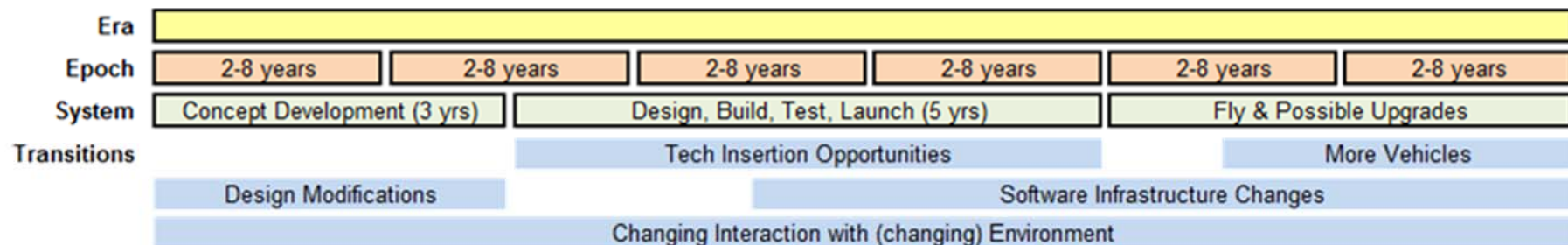
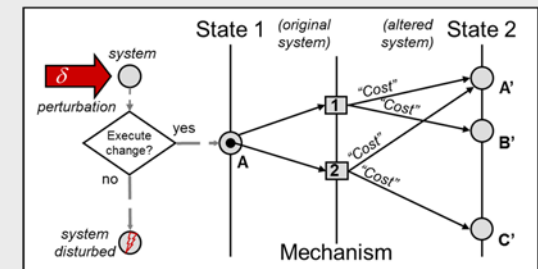
Massachusetts Institute of Technology



Engineering Systems Division

# Designing for a Dynamic World

- SEARi has a decade of research on designing “value robust” systems
- Specifically targets the high leverage *early concept phase*
- Methods and metrics inform selection of promising concept designs for further analysis
- Uses exogenous uncertainties to frame the need for the ability of a system to respond to *perturbations*



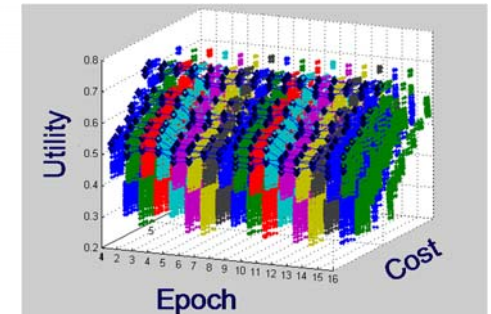
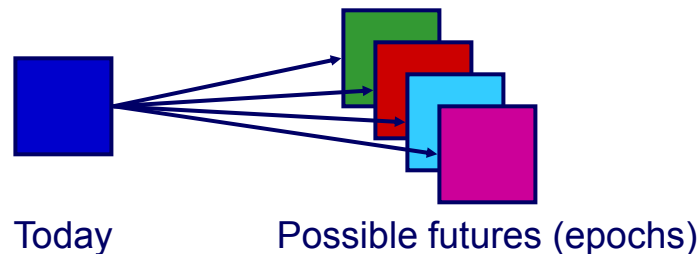
*Systems developed in a dynamic world must accommodate shifts in context and needs (epoch) across their lifespan (era)*

Success for modern systems is strongly determined by being able to respond to perturbations on appropriate timescales

# Encapsulating Uncertainties Epochs

Many possible contexts and needs may unfold in the future, impacting actual and perceived system utility and cost

“Epoch-based thinking” can be used to structure anticipatory scenario analysis



## ***Example triggers for epoch shifts impacting a system***

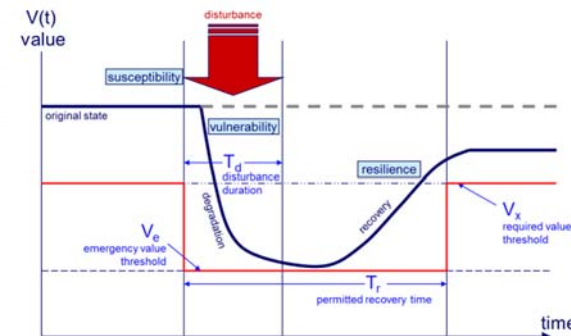
- Change in political environment
- Entrance of new competitor in market
- Emergence of significant new or changed stakeholder need(s)
- Policy mandate impacting product line, services or operations
- New threat environment with non-state actors using improvised attacks

Categories of uncertainties can aid in thinking about key changing factors

*E.g., Resources, Policy, Infrastructure, Technology, End Uses (“Markets”), Competition, etc.*

# Related “ilities”

## Changeability and Survivability



<b>value robustness</b>	ability of a system to maintain value delivery in spite of changes in needs or context
<b>changeability</b>	ability of a system to be intentionally altered in form or operations, and consequently possibly in function, at an acceptable level of “cost”
flexibility	ability of a system to be altered by a system-external change agent
adaptability	ability of a system to be altered by a system-internal change agent
<b>survivability</b>	ability of a system to minimize the impact of finite-duration disturbances on value delivery
susceptibility	reduction of the likelihood or magnitude of a disturbance
vulnerability	satisfaction of minimally acceptable value level during and after disturbance
resilience	timely recovery to an acceptable value level after a disturbance

**A *valuably changeable* system is one that can be intentionally altered, typically in response to a perturbation (such as a change in context), in order to improve its value**

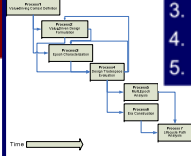
# Ten Years of Research on Methods and Metrics

## Methods for Value-Centric Analysis

### Multi-Attribute Tradespace Exploration

RSC consists of seven processes:

1. Value-Driving Context Definition
2. Value-Driven Design Formulation
3. Epoch Characterization
4. Design Tradespace Evaluation
5. Multi-Epoch Analysis
6. Era Construction
7. Lifecycle Path Analysis



### Epoch-Era Analysis

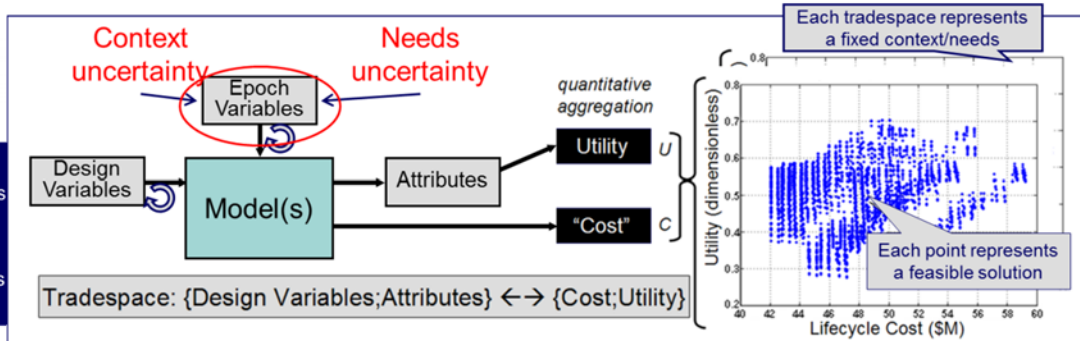
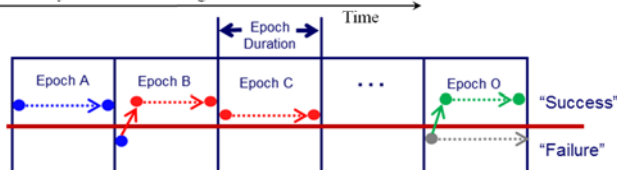
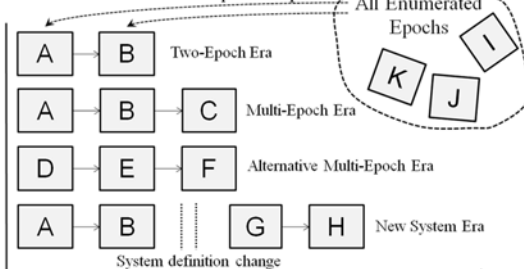
#### VASC

1. Set up data for epoch-era analysis
2. Identify designs of interest
3. Define rule usage strategies
4. Multi-epoch changeability analysis
5. Era simulation and analysis

Likelihood of Design E executing each transition rule across a 10 year era (per strategy)

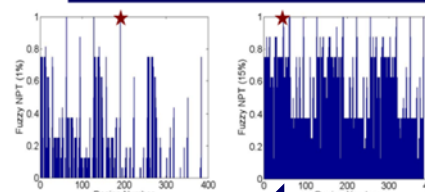
Strategy	Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6
MaxU	N/A	N/A	N/A	✓ 100.0%	✓ 89.2%	N/A
MaxEff	N/A	N/A	N/A	✓ 100.0%	✓ 97.1%	N/A
Survive	N/A	N/A	N/A	✓ 94.9%	✗ 0.0%	N/A
MaxP	N/A	N/A	N/A	✓ 96.8%	✗ 31.5%	N/A

Eras constructed from sequenced epochs



Many epoch data sets

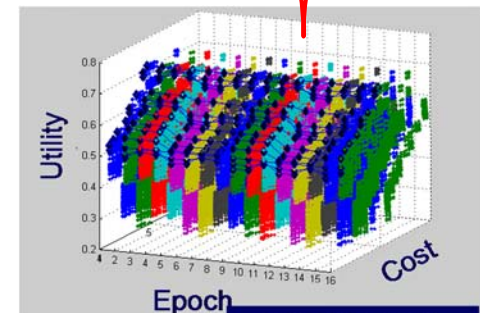
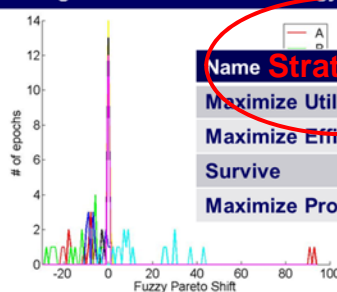
Identifying designs with high INPT



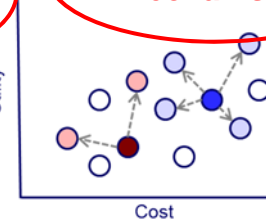
Era (long run) analysis

Multi-epoch (short run) analysis

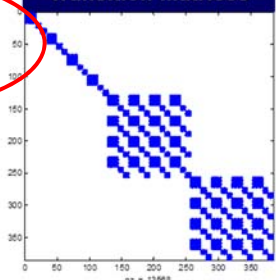
Exploring Fuzzy Pareto Shift of designs of interest for a strategy



Change Mechanisms



Collapsing Mech. Transition Matrices





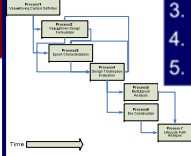
# Ten Years of Research on Methods and Metrics

## Methods for Value-Centric Analysis

### Multi-Attribute Tradespace Exploration

RSC consists of seven processes:

1. Value-Driving Context Definition
2. Value-Driven Design Formulation
3. Epoch Characterization
4. Design Tradespace Evaluation
5. Multi-Epoch Analysis
6. Era Construction
7. Lifecycle Path Analysis



### Epoch-Era Analysis

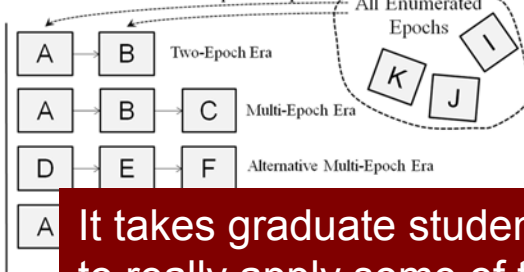
#### VASC

1. Set up data for epoch-era analysis
2. Identify designs of interest
3. Define rule usage strategies
4. Multi-epoch changeability analysis
5. Era simulation and analysis

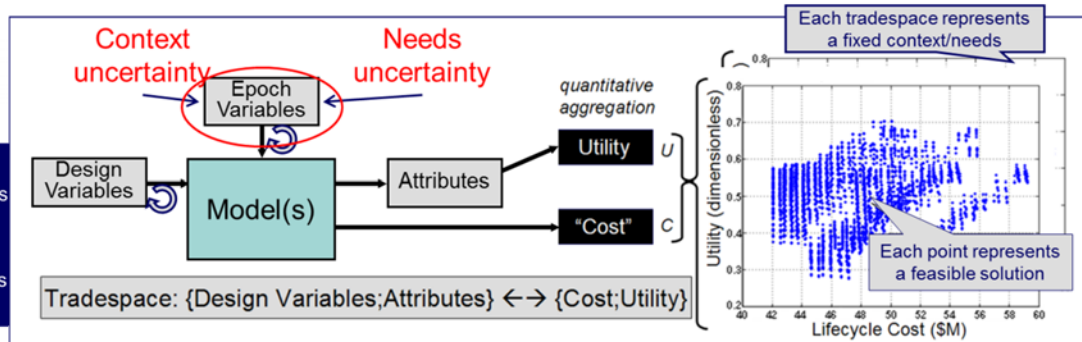
Likelihood of Design E executing each transition rule across a 10 year era (per strategy)

Strategy	Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6
MaxU	N/A	N/A	N/A	✓ 100.0%	✓ 89.2%	N/A
MaxEff	N/A	N/A	N/A	✓ 100.0%	✓ 97.1%	N/A
Survive	N/A	N/A	N/A	✓ 94.9%	✗ 0.0%	N/A
MaxP	N/A	N/A	N/A	✓ 96.8%	✗ 31.5%	N/A

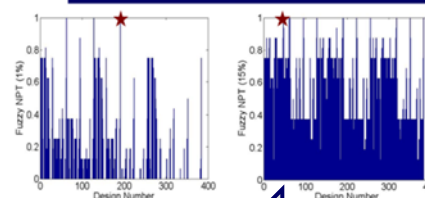
Eras constructed from sequenced epochs



It takes graduate students over a year to begin to really apply some of this...



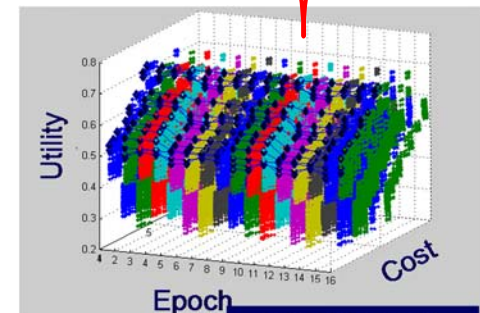
Identifying designs with high INPT



Era (long run) analysis

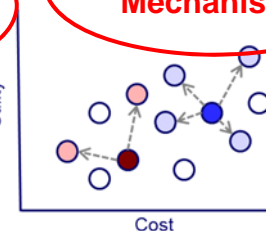
Multi-epoch (short run) analysis

Exploring Fuzzy Pareto Shift of designs of interest for a strategy

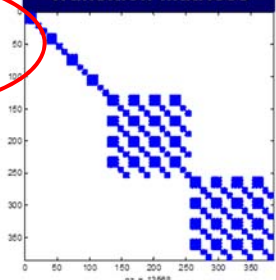


Many epoch data sets

Change Mechanisms



Collapsing Mech. Transition Matrices



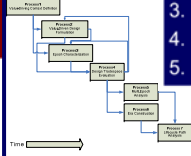
# Ten Years of Research on Methods and Metrics

## Methods for Value-Centric Analysis

### Multi-Attribute Tradespace Exploration

RSC consists of seven processes:

1. Value-Driving Context Definition
2. Value-Driven Design Formulation
3. Epoch Characterization
4. Design Tradespace Evaluation
5. Multi-Epoch Analysis
6. Era Construction
7. Lifecycle Path Analysis



### Epoch-Era Analysis

#### VASC

1. Set up data for epoch-era analysis
2. Identify designs of interest
3. Define rule usage strategies
4. Multi-epoch changeability analysis
5. Era simulation and analysis

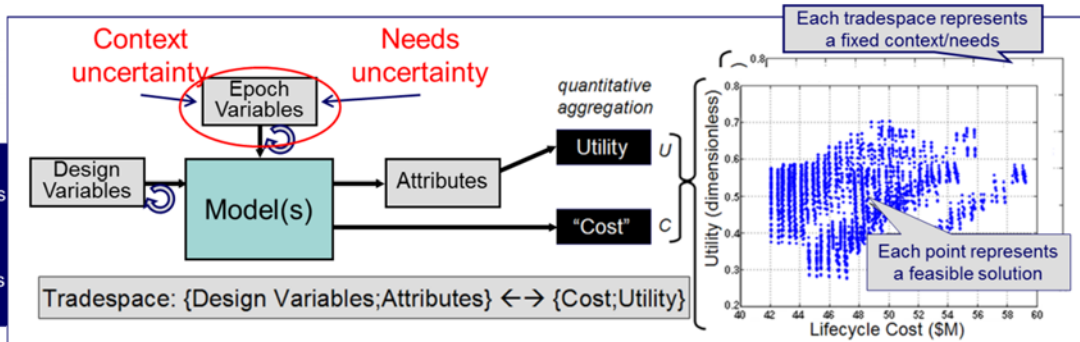
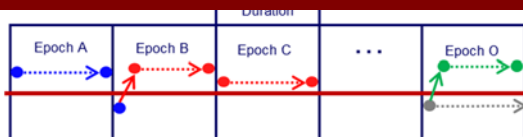
Likelihood of Design E executing each transition rule across a 10 year era (per strategy)

Strategy	Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6
MaxU	N/A	N/A	N/A	✓ 100.0%	✓ 89.2%	N/A
MaxEff	N/A	N/A	N/A	✓ 100.0%	✓ 97.1%	N/A
Survive	N/A	N/A	N/A	✓ 94.9%	✗ 0.0%	N/A
MaxP	N/A	N/A	N/A	✓ 96.8%	✗ 31.5%	N/A

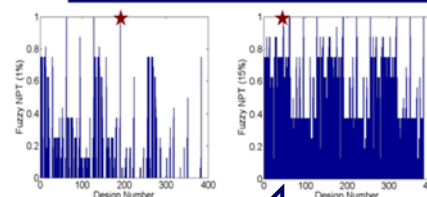
Eras constructed from sequenced epochs



It takes graduate students over a year to begin to really apply some of this...



Identifying designs with high INPT



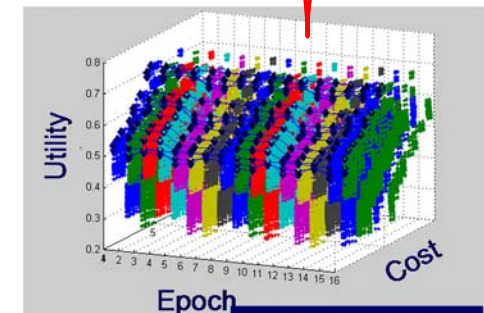
### Era (long run) analysis

### Multi-epoch (short run) analysis

Exploring Fuzzy Pareto Shift of designs of interest for a strategy

Strategies

Change Mechanisms



Collapsing Mech. Transition Matrices

SEARi's goal is to impact practice, so we need to find a better way to teach the research

# Tackling Problems using “Games”

There is growing interest in using the medium of games for learning how to solve both complex and complicated problems

the education arcade

home | projects | research | community | links

about

[www.educationarcade.org](http://www.educationarcade.org)

moving learning games forward

obstacles  
opportunities  
& openness

#### About the Education Arcade

The Education Arcade explores games that promote learning through authentic and engaging play. TEA's research and development projects focus both on the learning that naturally occurs in popular commercial games, and on the design of games that more vigorously address the educational needs of players.

[more...](#)

#### Two White Papers Released

THE EDUCATION ARCADE releases two white papers to guide the development and dissemination of educational games (and other technologies): *Moving Learning Games Forward* and *Using the Technology of Today in the Classroom Today*. These papers are part of TEA's ongoing mission to establish games as important learning tools, crucial to the successful development of 21st century students of all ages.

[more...](#)

#### Latest Post

The New York Times Magazine has a lengthy article *Quest to Learn* about a public secondary school around games and other literacies. The school's colleague Katie Salen and I are co-authors of the Ed A Games Forward, available



T-Xchange

T-XCHANGE NEWS HOW DOES IT WORK? PORTFOLIO

www.txchange.nl

## Serious gaming is serious business

How to get more than thirty parties to a proposed alternative to the Airport Twente? How do you like best architect your vision? How do you determine which strategy works in conflict and crisis situations, where in addition to soldiers and politicians, aid organizations and the media play a role?

The answer is playful. With a serious game, a dynamic information model in which participants in an accessible way to determine the outcome each other through interaction. In a mixed-reality environment or synthetic visualize the relevant information and let you see how the actions of the players sorts. That you support moderated the human reasoning and decision making. A picture is worth 1000 words. And a game says more than 1000 pictures. And playing a game is in our DNA.

In recent years, T-Xchange, the research institute in the field of serious gaming, and process facilitation, in some fifty cases show that a scientifically based approach to serious gaming pays off: the parties are faster to a better solution, that is getting on base can count.

T-Xchange | PO Box 1123 | 7500 BC Enschede | 053-7112460 | [info@txchange.nl](mailto:info@txchange.nl)

Is this an applicable medium for SEARi research?



# The Four Freedoms of Play

- Freedom to Experiment
- Freedom to Fail
- Freedom to Try on Identities
- Freedom of Effort

Work

Play



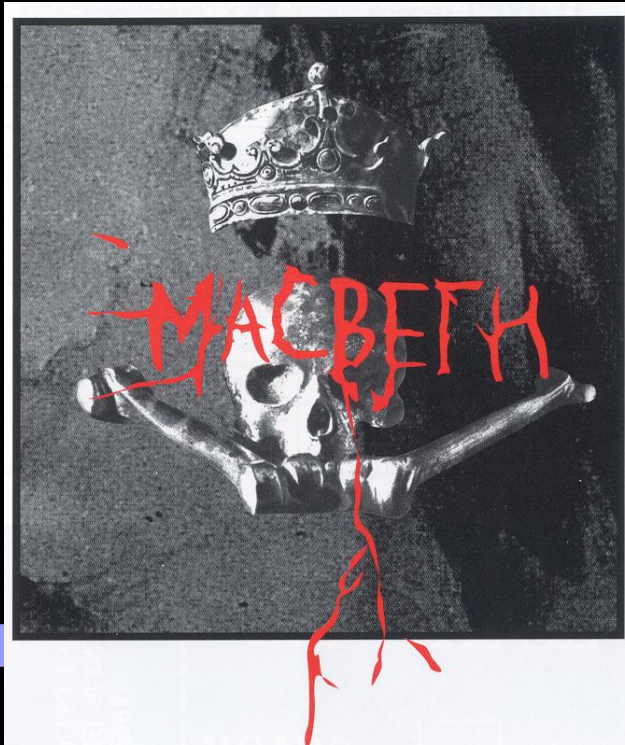
Learning

Fun

From Scot Osterweil of The Education Arcade, "Keeping the Play in Learning Games", 6/9/2011

Work

Play



Learning

Fun

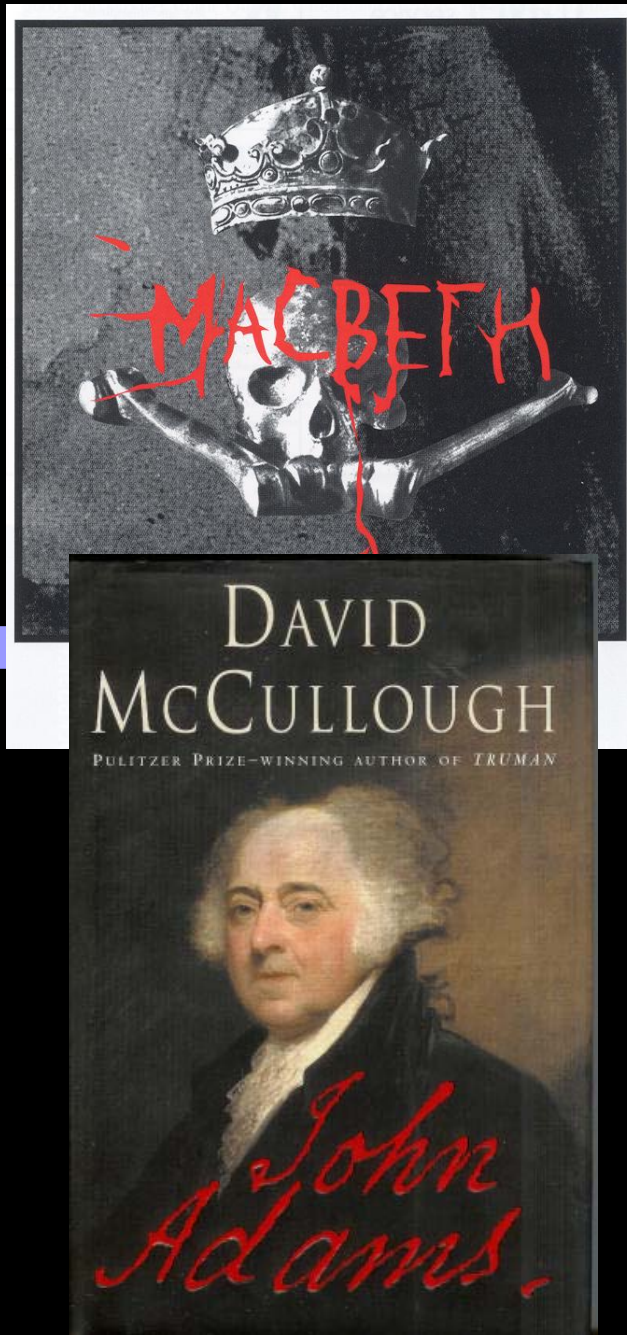
From Scot Osterweil of The Education Arcade, "Keeping the Play in Learning Games", 6/9/2011

Work

Play

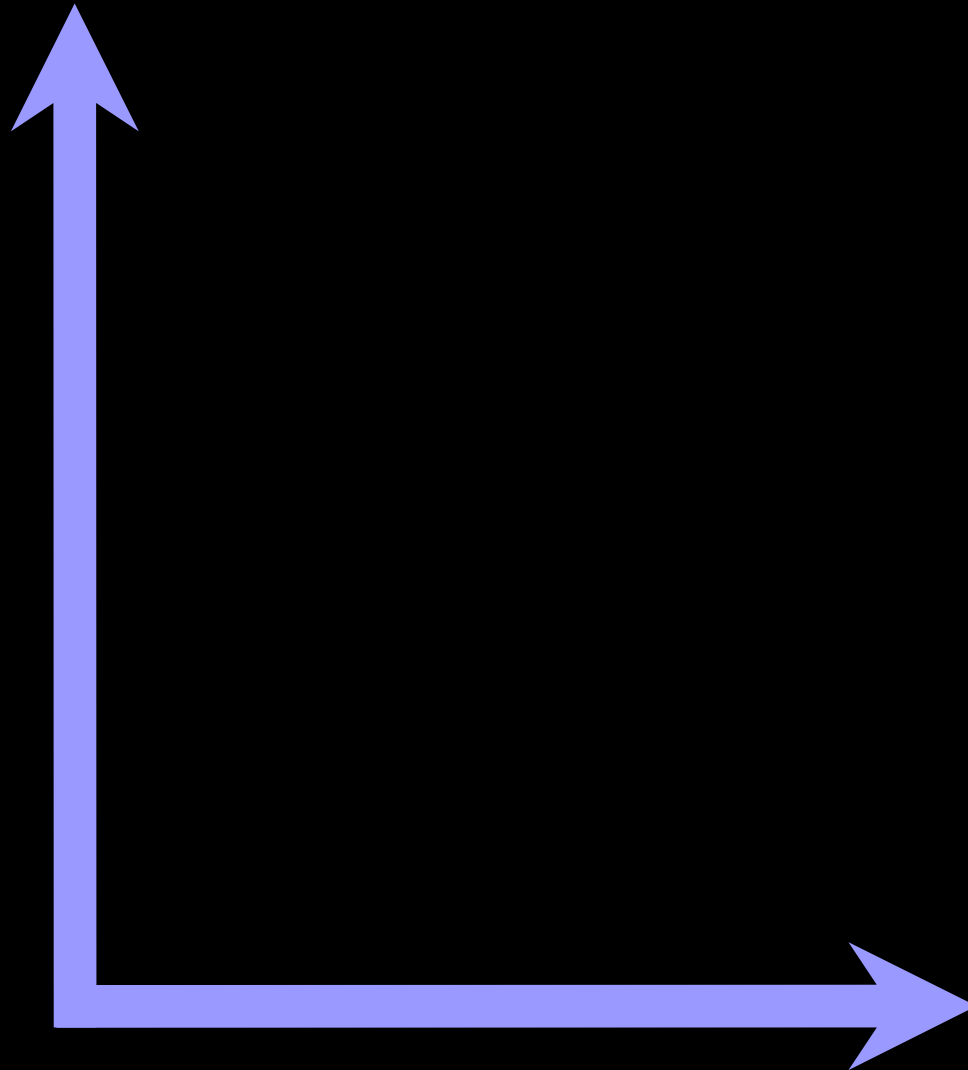
Learning

Fun



From Scot Osterweil of The Education Arcade, "Keeping the Play in Learning Games", 6/9/2011

Learning

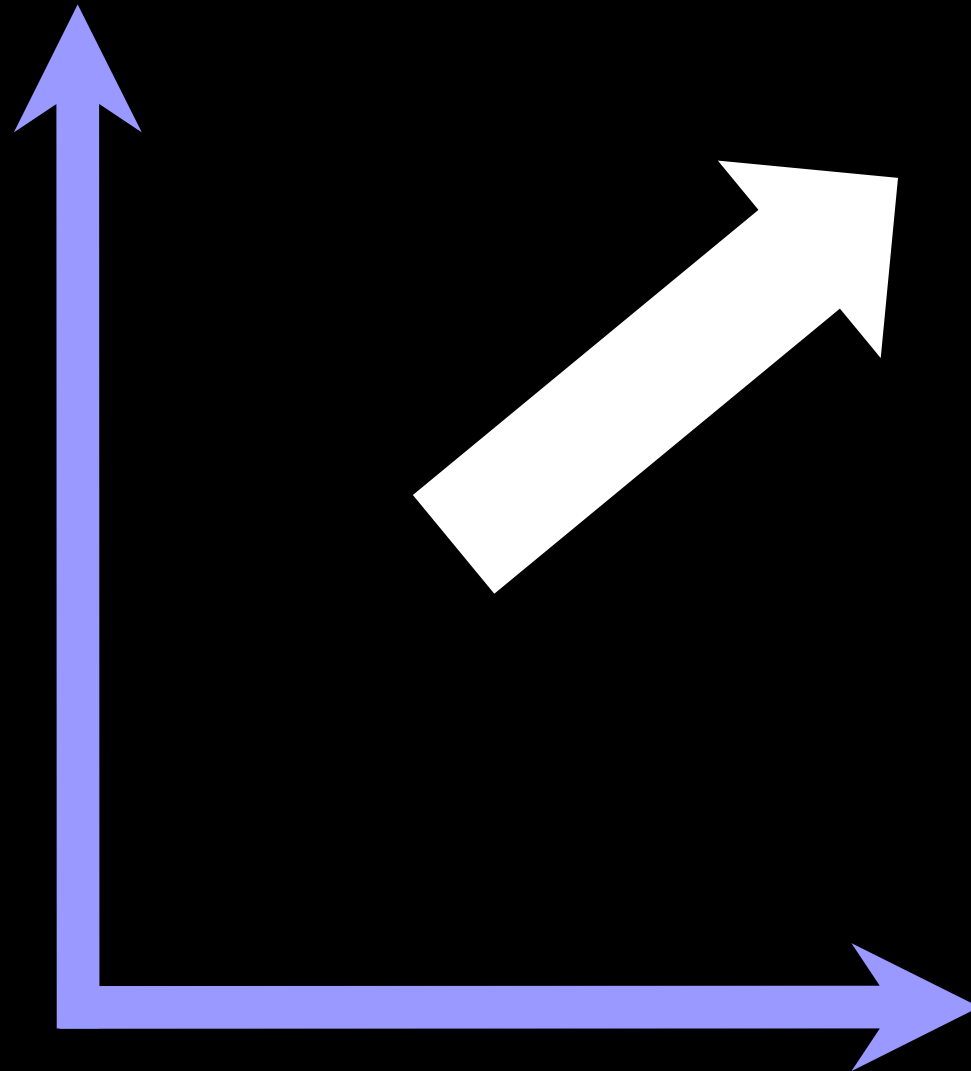


Fun

From Scot Osterweil of The Education Arcade, "Keeping the Play in Learning Games", 6/9/2011



Learning



Fun

From Scot Osterweil of The Education Arcade, "Keeping the Play in Learning Games", 6/9/2011

# A Game is More than Monopoly

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

- Entertainment
- “Edutainment” = “Serious” games
- Education
- Simulations
  - Management flight simulators
  - Aircraft flight simulators

(Aldrich 2009)



**Monopoly:** Classic family board game by Hasbro; buy and sell properties in Atlantic City



**Windfall:** a strategy game about building wind farms to create clean energy profitably. *Persuasive Games* (<http://www.persuasivegames.com>)



**Microsoft Flight Simulator X: Gold Edition:** Experience realistic flights with day/night and weather effects, multiplayer races and over 80 missions worldwide

Whether stated goal is to teach a lesson or to escape reality, the main purpose of games is to create an “experience” in the mind of the player

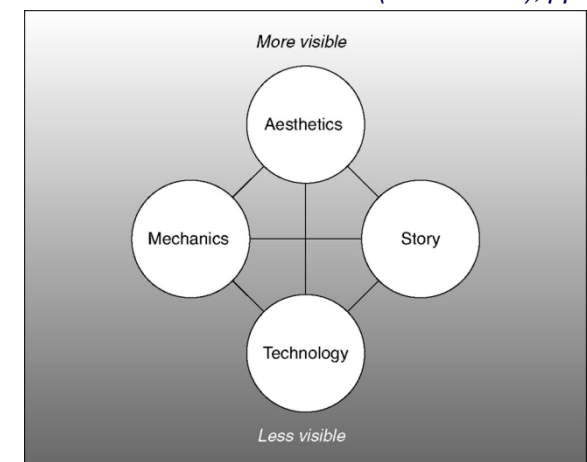
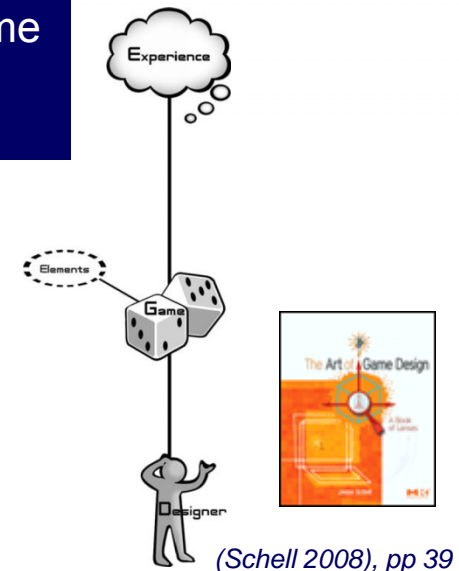
# Game Design is both Art and Engineering

Material from his work as professor of entertainment technology and game design at Carnegie Mellon's Entertainment Technology Center (ETC):  
Schell, Jesse, *The Art of Game Design: A book of lenses*, Elsevier, 2008.

## Four Basic Elements of a Game

- **Mechanics**
  - Procedures and rules of a game
  - Describe the goals, how players can and cannot try to achieve them, and what happens when they try
- **Story**
  - Sequence of events that unfolds in a game
  - Linear and pre-scripted, or branching and emergent
- **Aesthetics**
  - How a game looks, sounds, smells, tastes, and feels
  - Has most direct impact on game experience
- **Technology**
  - Any materials and interactions that make a game possible, such as paper and pencil, plastic chits, or high-powered lasers
  - Is the medium in which aesthetics take place, in which mechanics occur, and through which a story is told

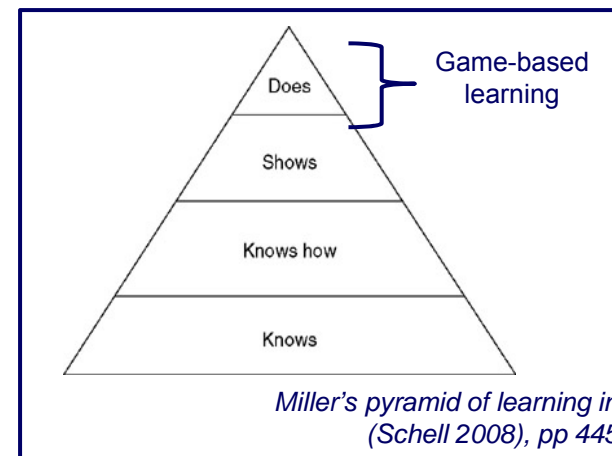
(Schell 2008), pp 41-43



# More than Just “Play”

## Transformation and Responsibility

- Good for us
  - Emotional maintenance
  - Connecting
  - Exercise
  - Education
    - Facts
    - Problem Solving
    - New Insights
    - Curiosity
- Bad for us
  - Violence
  - Addiction
- Responsibility
  - Intend to do good
- Being accountable
  - Do no harm



Games are a powerful medium that creates  
(potentially transforming) experiences in players

# Summer Project Motivation

- Summer 2009 (updated 2010)
  - VisLab created as means to “experience” the data
  - Users have fun while gaining insight and learning



# Summer Project Motivation

- Summer 2009 (updated 2010)
  - VisLab created as means to “experience” the data
  - Users have **fun** while gaining insight and learning  
**UNEXPECTED!**

# Summer Project Motivation

- Summer 2009 (updated 2010)
  - VisLab created as means to “experience” the data
  - Users have **fun** while gaining insight and learning  
**UNEXPECTED!**
- Summer 2011
  - Find a way to develop a “game” to teach, clarify, simulate SEARi constructs
  - And be fun!

# Summer Project Motivation

- Summer 2009 (updated 2010)
  - VisLab created as means to “experience” the data
  - Users have **fun** while gaining insight and learning  
**UNEXPECTED!**
- Summer 2011
  - Find a way to develop a “game” to teach, clarify, simulate SEARi constructs
  - And be fun!

**GOAL:** *Develop interactive games for accelerated insights into dynamic system strategies using six SEARi constructs (“design” choices, utilities, costs, epochs, eras, and “ilities”)*

# High Level Project Goals

## *Interactive Games for Accelerated Insights into Dynamic System Strategies*

June 6 to August 16, 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

These goals were presented at the summer project kickoff meeting

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

3 Methods and 6 Constructs for Summer Project

# **SEARI METHODS AND CONSTRUCTS**



# SEARi Methods

- The following **methods** were developed by SEARi:
  1. **MATE** (Multi-Attribute Tradespace Exploration)  
(sometimes just “TSE”)
    - Guides the exploration of many design choices (tradespace) in terms of benefits and costs to different stakeholders
  2. **EEA** (Epoch-Era Analysis)
    - Analyzes short run and long run impacts of changing contexts and needs on design(s)
  3. **RSC** (Responsive Systems Comparison)
    - Combines MATE and EEA into 7 process structured method
- The methods generate and manipulate the constructs

SEARi methods seek to improve the way engineers and decision makers generate, characterize, evaluate, and select “design” choices in a dynamic world

# SEARi Constructs

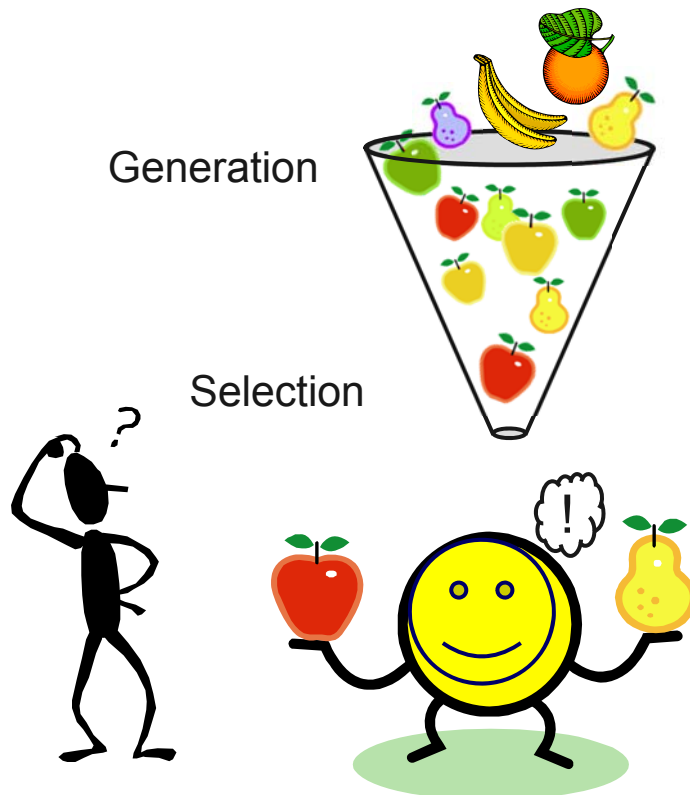
The following constructs form the core “elements” for the summer project:

- 1. “design” choices**
- 2. utilities**
- 3. costs**
- 4. epochs**
- 5. eras**
- 6. “ilities”**

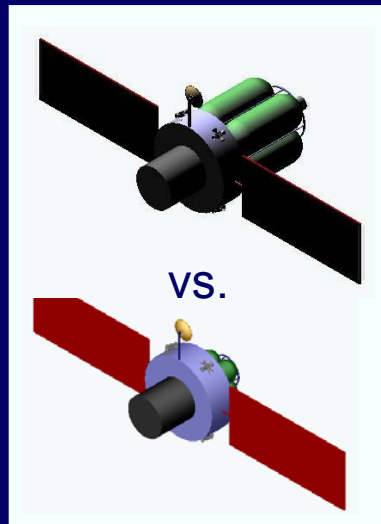
# “Design” Choices

Decisions on a “design” alternative that is in the control of the “Designer”

- Can be on entire alternative or aspect(s) of an alternative
- Can be done during generation or selection of alternatives
- Can be done initially or later in the “lifecycle”



## Space Tug



**VS.**

**Design Space**

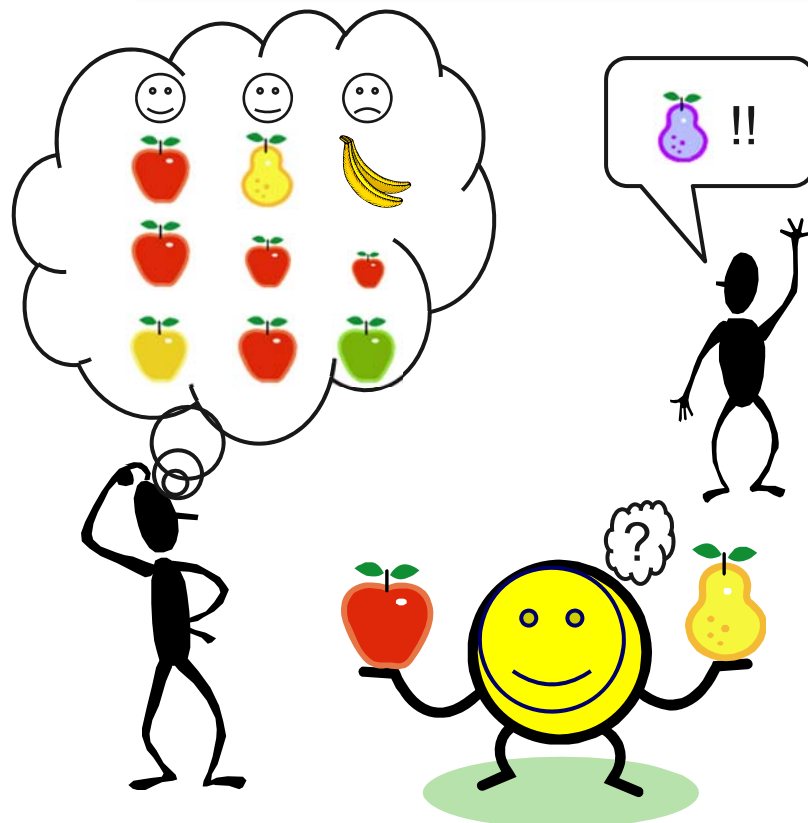
- > Manipulator Mass
  - Low (300kg)
  - Medium (1000kg)
  - High (3000 kg)
  - Extreme (5000 kg)
- > Propulsion Type
  - Storable bi-prop
  - Cryogenic bi-prop
  - Electric (NSTAR)
  - Nuclear Thermal
- > Fuel Load - 8 levels

**Related Concepts:** designs, design vectors/variables, concepts, configurations, alternatives, choices, selections

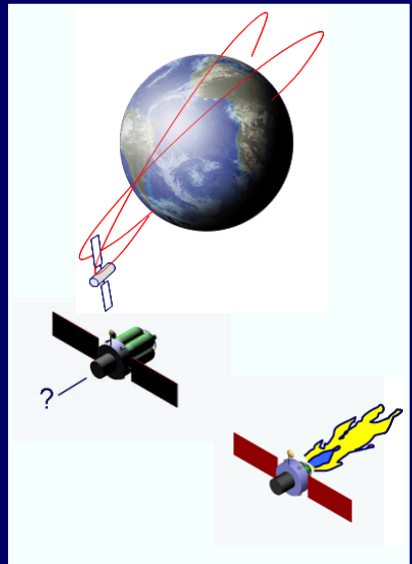
# Utilities

The benefit accrued from a “design” choice

- Is subjectively defined, varying by person
- Can be multi-criteria
- Can vary over time



## Space Tug



### Utility Space

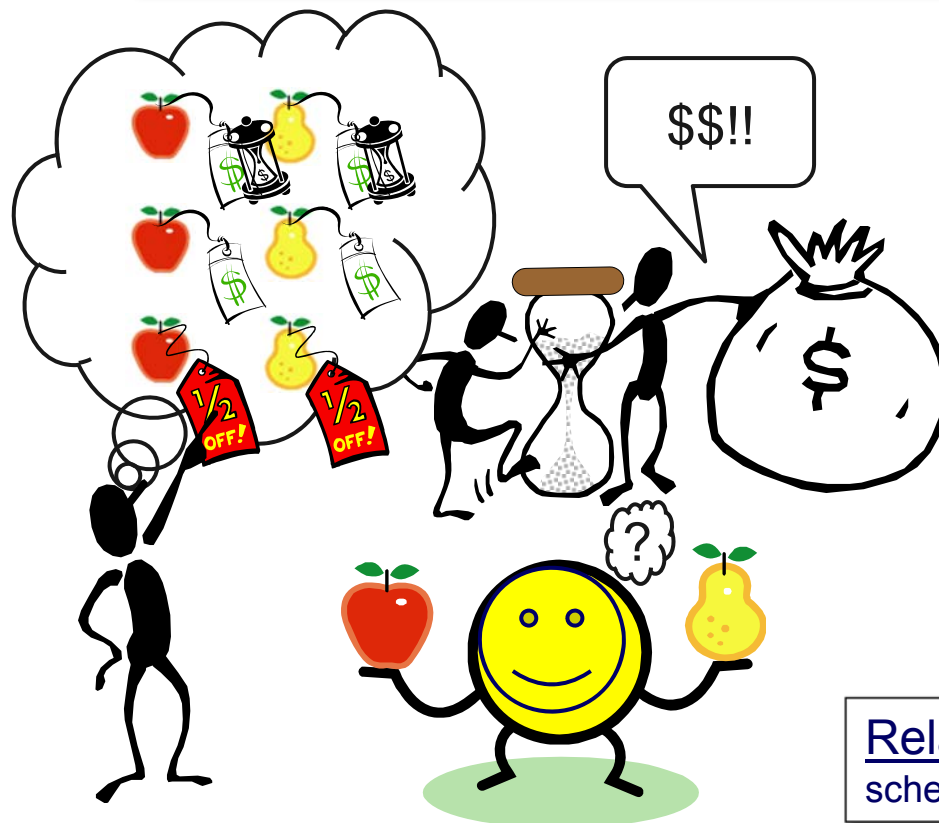
- >Delta-V
  - Velocity the vehicle can impart (km/sec) [ $>0 \rightarrow 12$ ]
- >Interaction Capability
  - What the vehicle can do to target (kg) [ $>0 \rightarrow 5000$ ]
- >Speed
  - Can change orbits quickly (binary) [ $0 \rightarrow 1$ ]

Related Concepts: attributes, single attribute utility, multi-attribute utility, benefits, criteria, score, performance, rewards, effectiveness

# Costs

The expended resources for a design choice to achieve the utilities

- Can be incurred initially, over time, and at end of life
- Can be multi-criteria (not necessarily dollars)
- Often subject to constraints (such as budgets and schedules)



## Space Tug

\$\$

$$C = c_w M_w + c_d M_d$$

### Cost Space

- > Dollar cost
  - Dry mass
  - Fuel cost
- > Simple parametric model

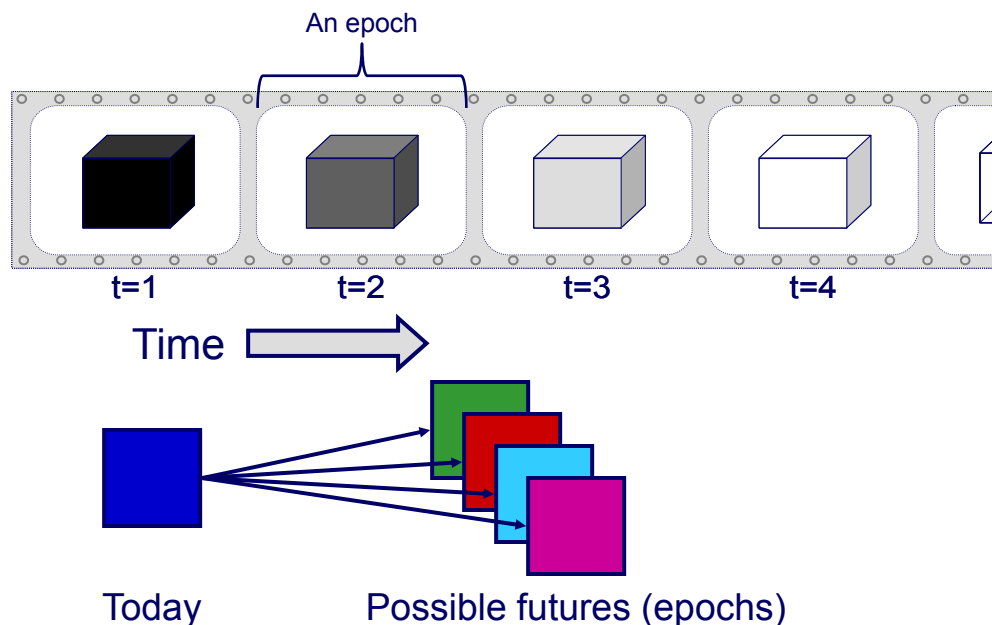
Related Concepts: costs, dollars, budget, time, schedule, expenses, resources, effort, penalties




# Epochs

The short run period of “fixed” context and expectations for a choice

- Defined by factors outside of “Designer” control (uncertainties played out)
- Can be many possible epochs
- Concept is relative to defined “fixed” factors that may vary in the future



## Space Tug



**Epochs**

> Expectations

- Rescue mission
- Military mission
- Tender mission
- Space Debris Collector
- Tech Demo
- Refueler

> Technology

- Cost of propulsion
- Mass density

DARPA Orbital Express

### Categories of key uncertainties → epochs

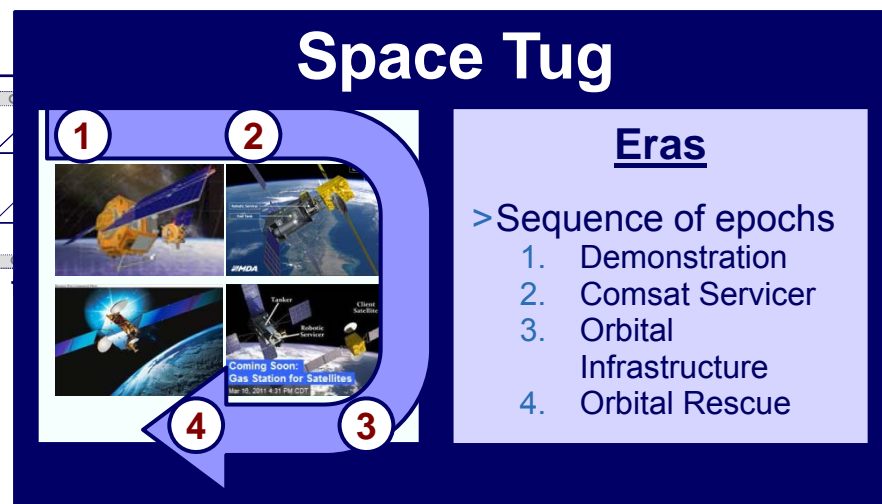
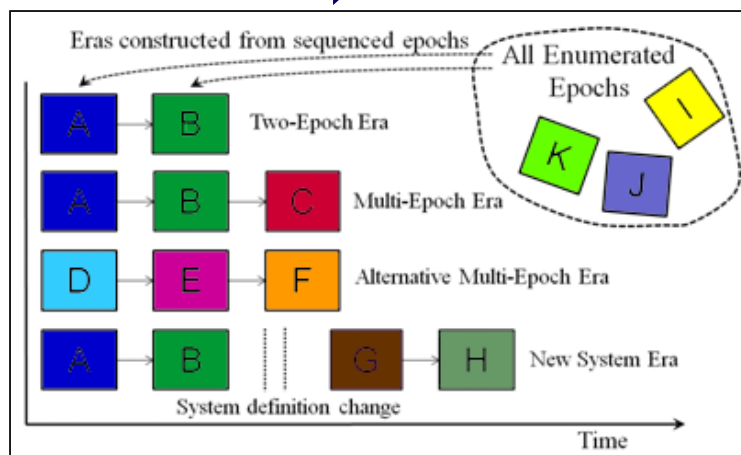
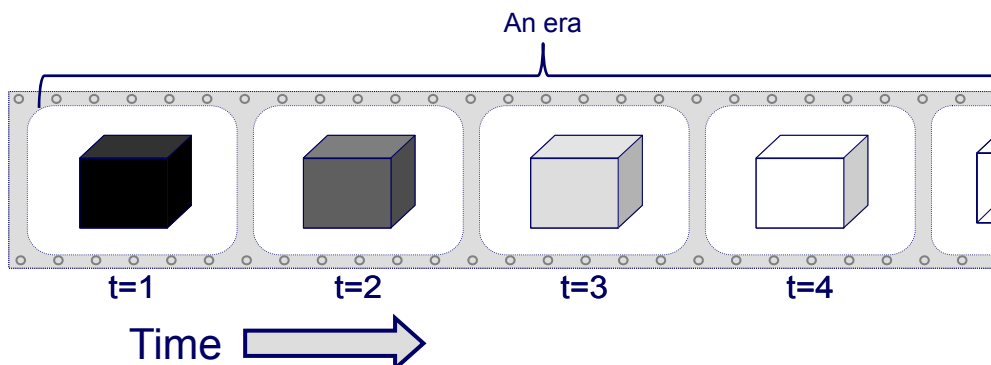
*Available resources, Policy, Infrastructure, Technology, End Uses (“Markets”), Competition, etc.*

Related Concepts: epochs, epoch variables, short run, contexts, expectations, futures, uncertainties

# Eras

The long run, time-ordered sequences of epochs

- Represents “path-dependency” of uncertain future timelines
- Allows for strategy development of choices over time
- Concept is relative to defined “fixed” factors that may vary in the future



IED attacks in Iraq:  
(Wired)

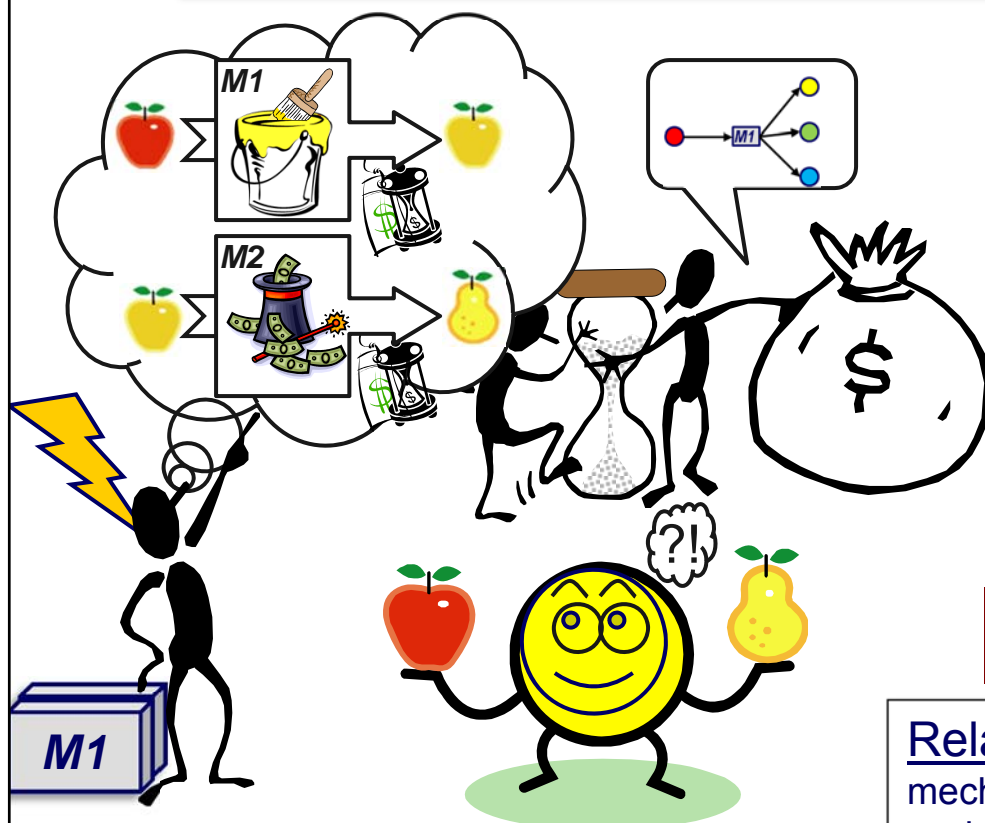


Related Concepts: eras, epoch ordering, long run, contexts, expectations, futures, uncertainties

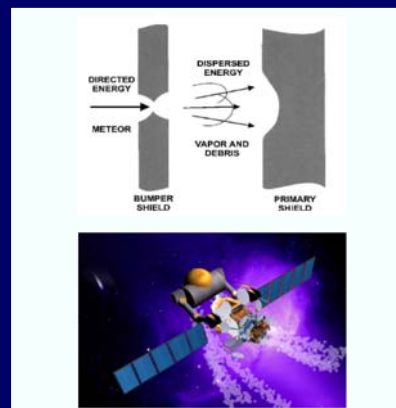
# “ilities”

The ability of a choice to change over time or not need to change over time

- Usually defined in reference to a perturbation (e.g. disturbance → survivability)
- Can be regarded in terms of “degree of” and “value of” each “-ility”
- Usually require an embedded “option” or “mechanism” to execute with costs



## Space Tug



### Ilities Space

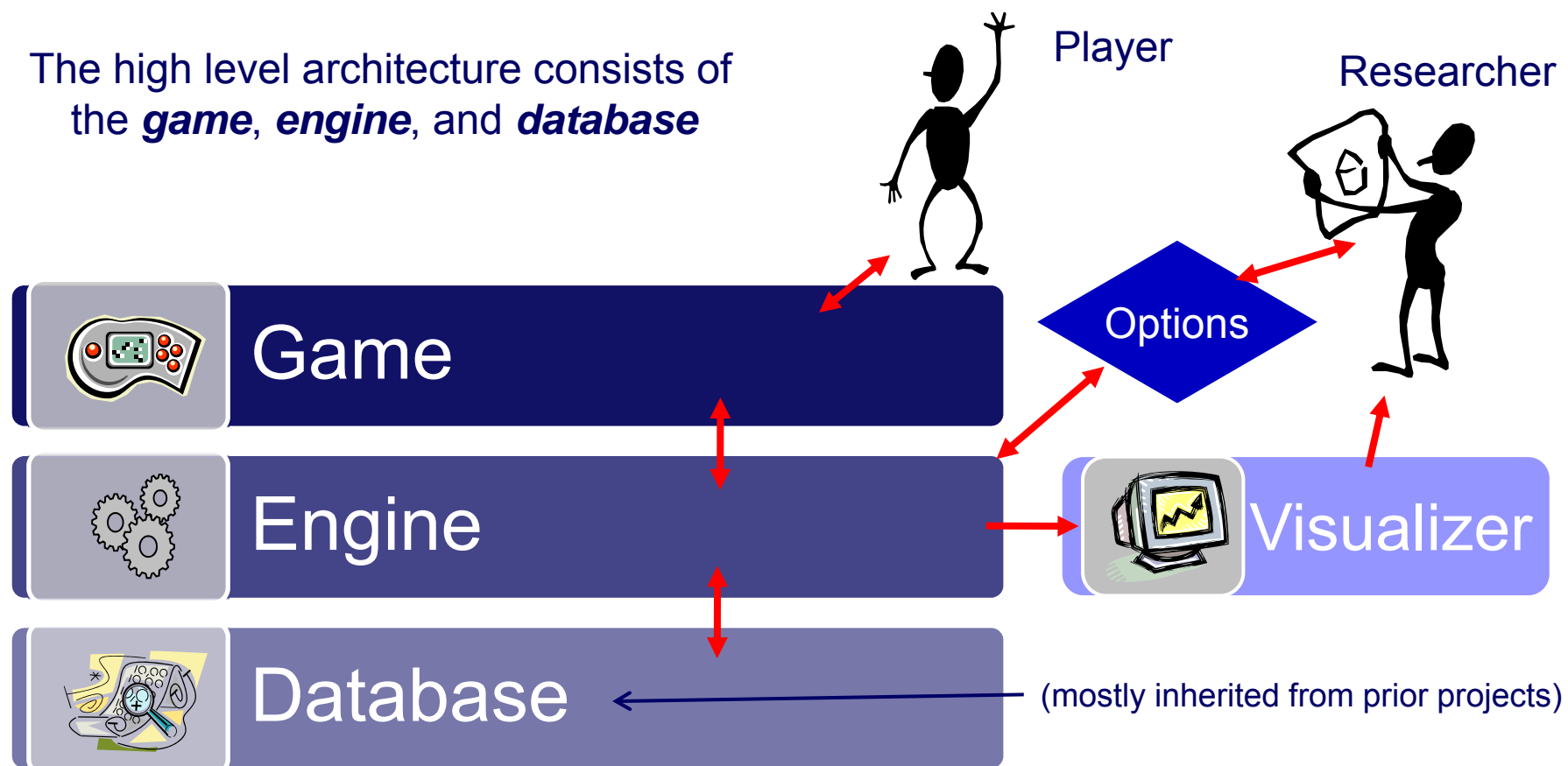
- >Survivability
  - Shielding
  - Avoidance
  - Replacement
- >Evolvability
  - Refuelability
  - Modular propulsion

Each “-ility” corresponds to a particular aspect of the choice over a particular range; multiple “ilities” can co-exist or conflict

Related Concepts: ilities, real options, change mechanisms, changeability, flexibility, adaptability, scalability, modifiability, robustness, survivability

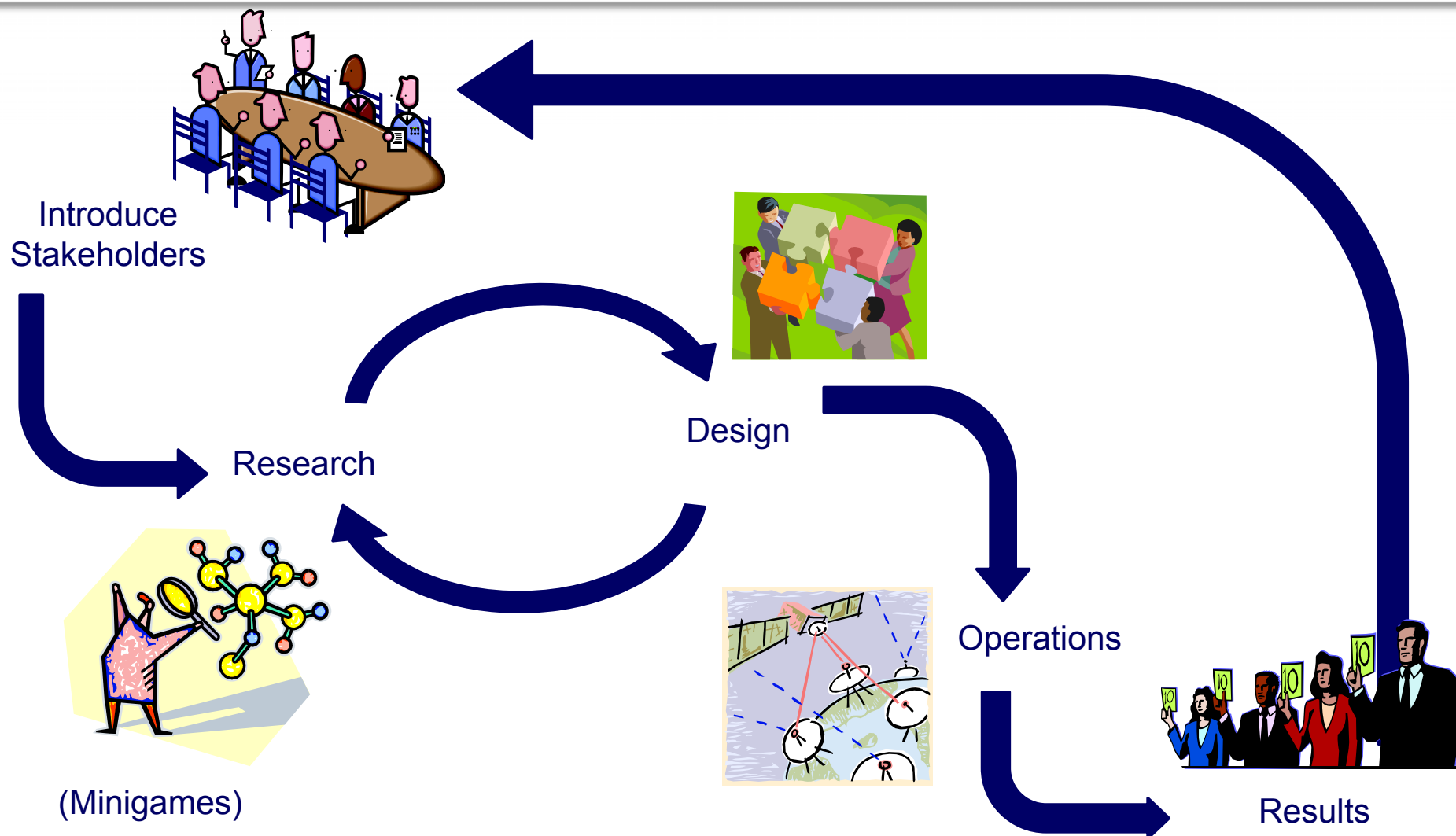
# Layered Architecture

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

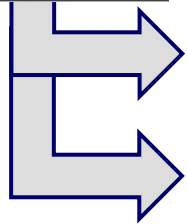


This summer's goal was to develop the engine and the game

# Game Conceptual Flow



# Game Architecture Outline



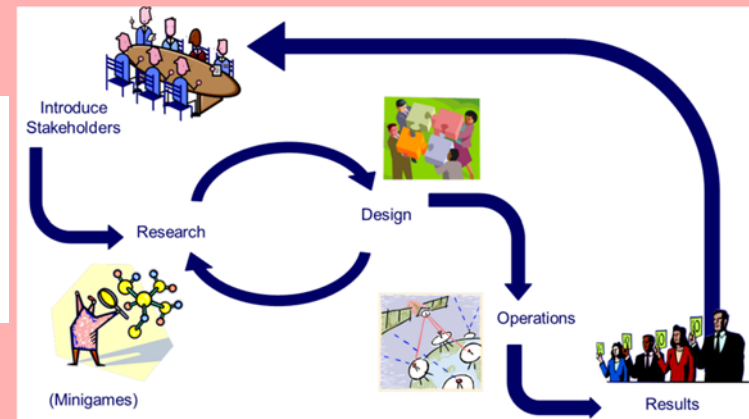
Free Play

Story Mode



## Options

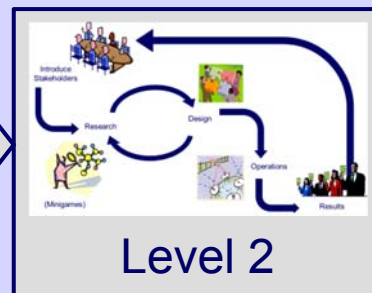
- Difficulty
- # epochs in era
- # DMs
- Scoring goals



App specific data  
(e.g., story, graphics)

DB  
input

## META Story



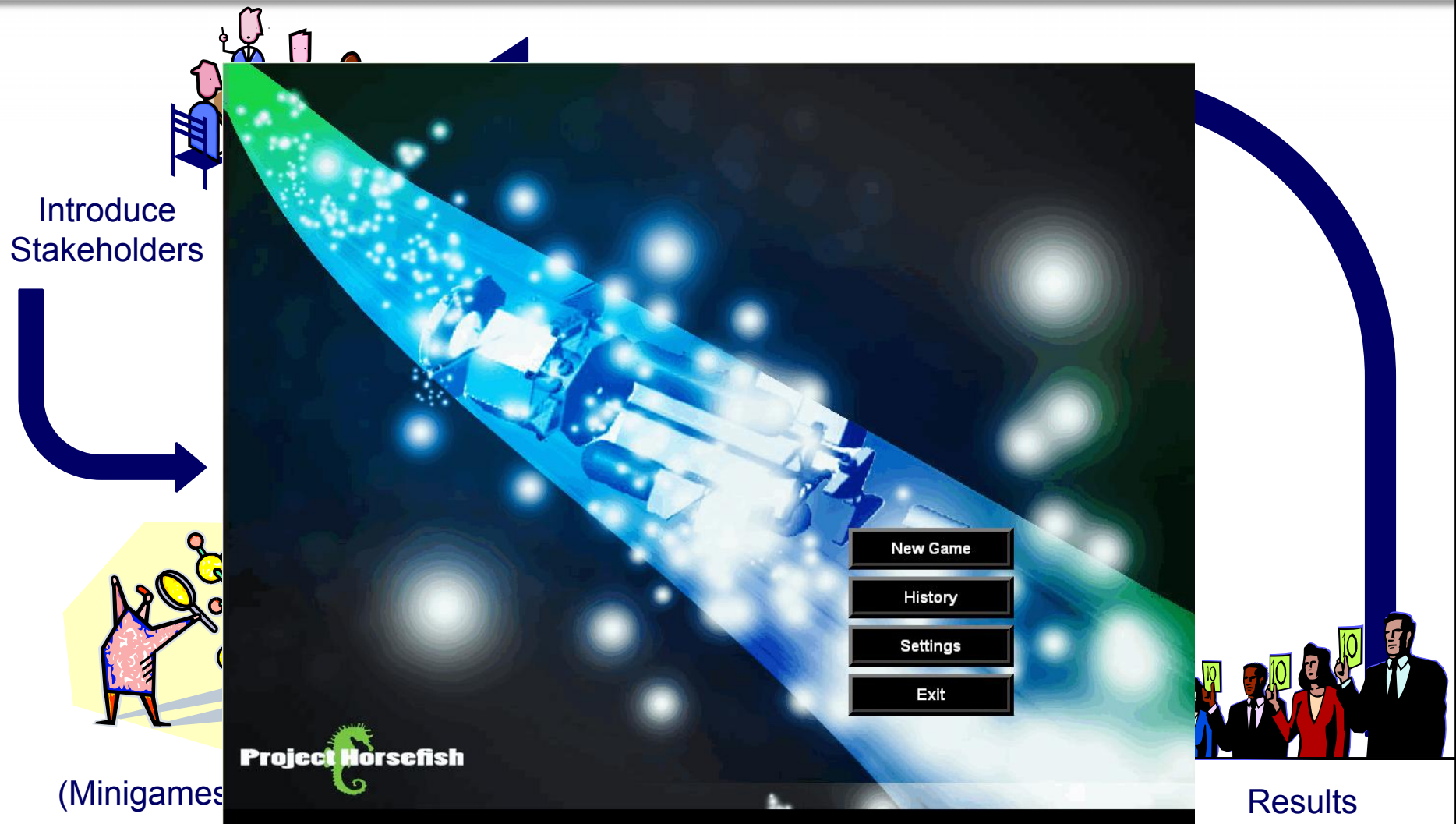
...



➤ Increasing difficulty, exposure to constructs ➤➤➤

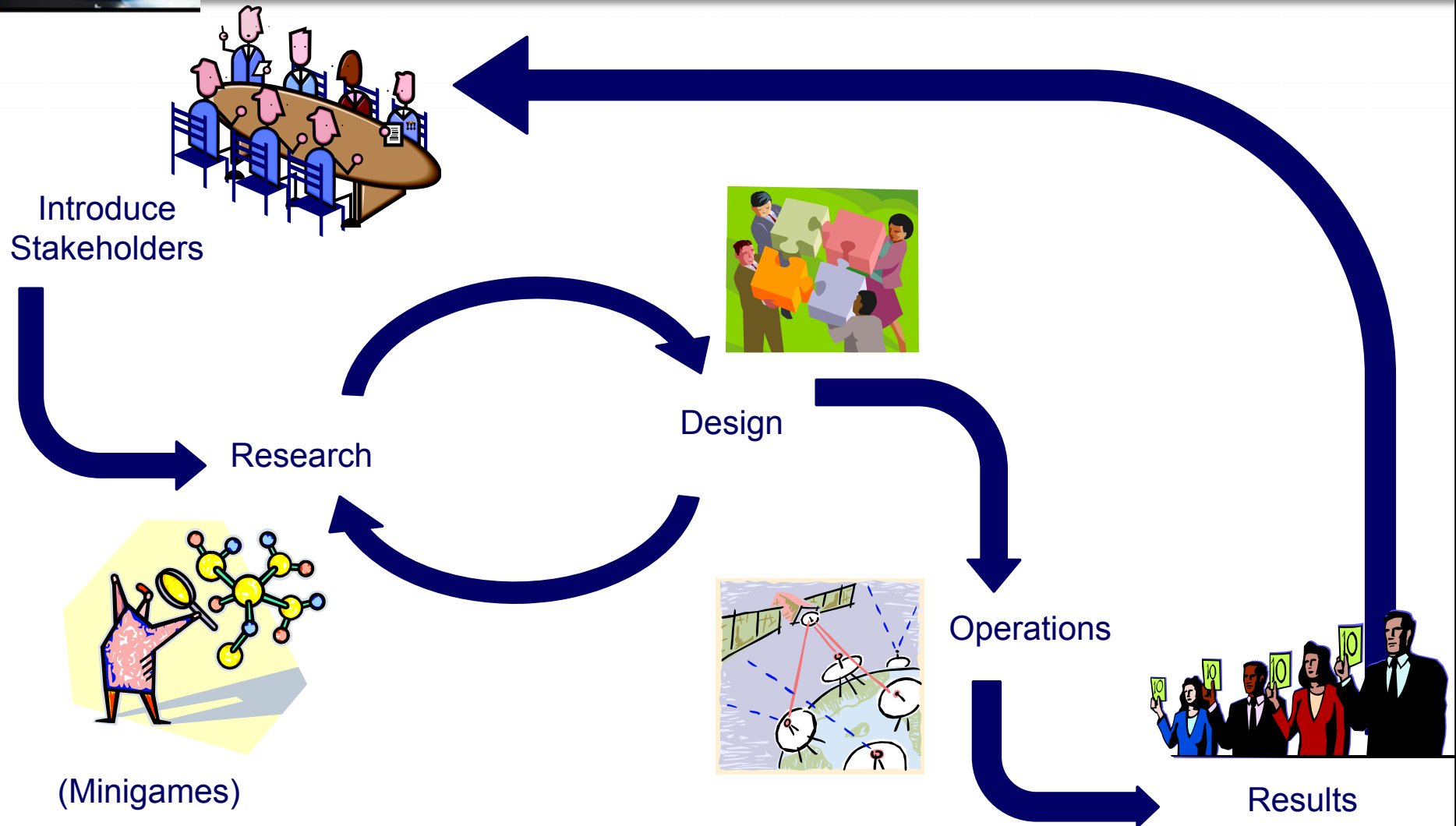


# Brief Game Outline





# Brief Game Outline







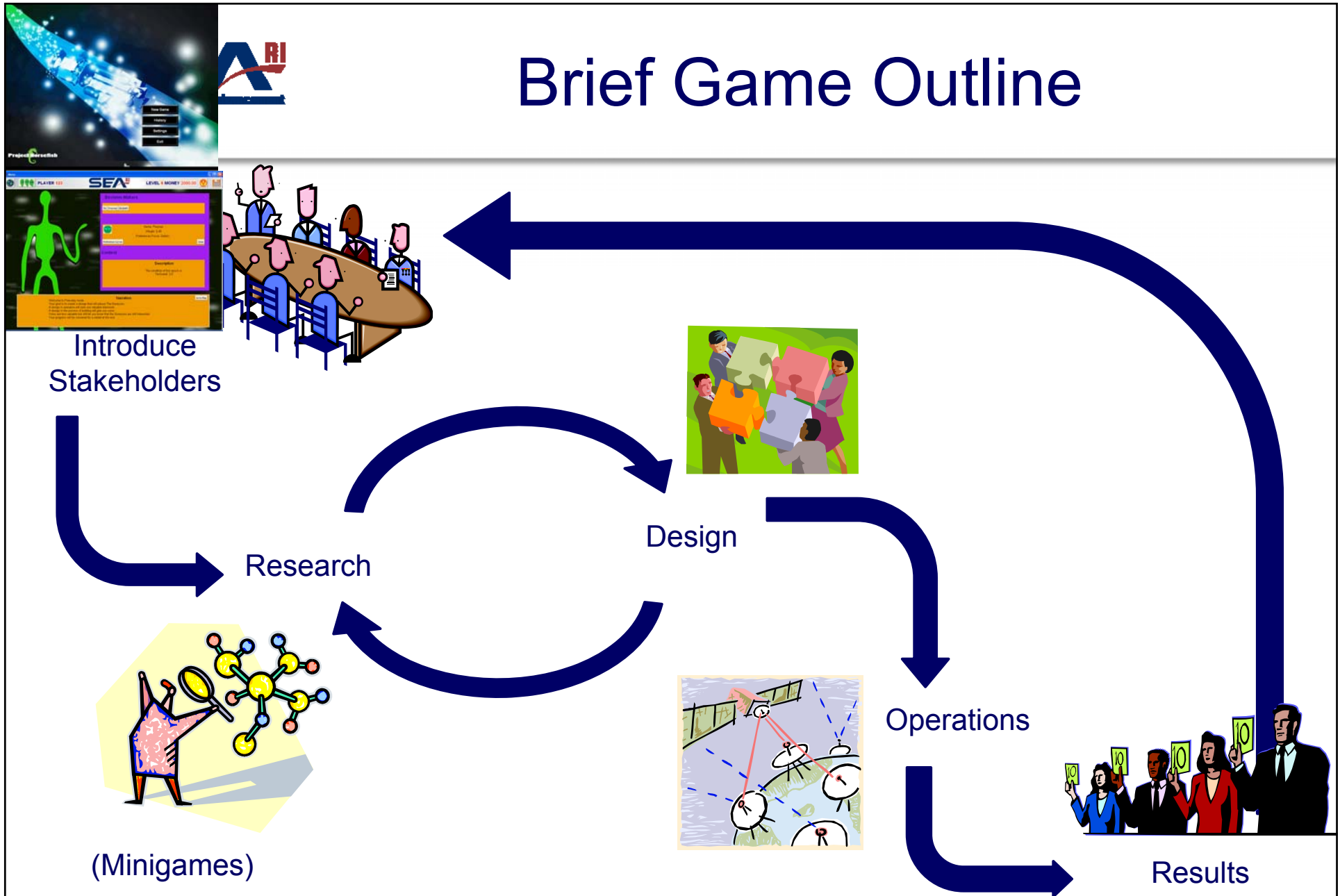
# Brief Game Outline

Introduce  
Stakeholders

(Mini)

Results

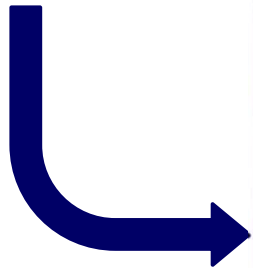
# Brief Game Outline



# Brief Game Outline



Introduce Stakeholders



**Design Variables**

DesignforChange	300.0
PayloadMass	1000.0
PropMass	3000.0
PropType	5000.0

**Path Enablers**

Drag and drop

Open inventory

**Build cost of design**

Cost of chosen path enablers

Not all design variables are selected. Adding choice...

Purchased generic path enablers (Default is 0 for all):

- Susceptibility: 0
- Vulnerability: 0
- Resilience: 0

Cost: 0

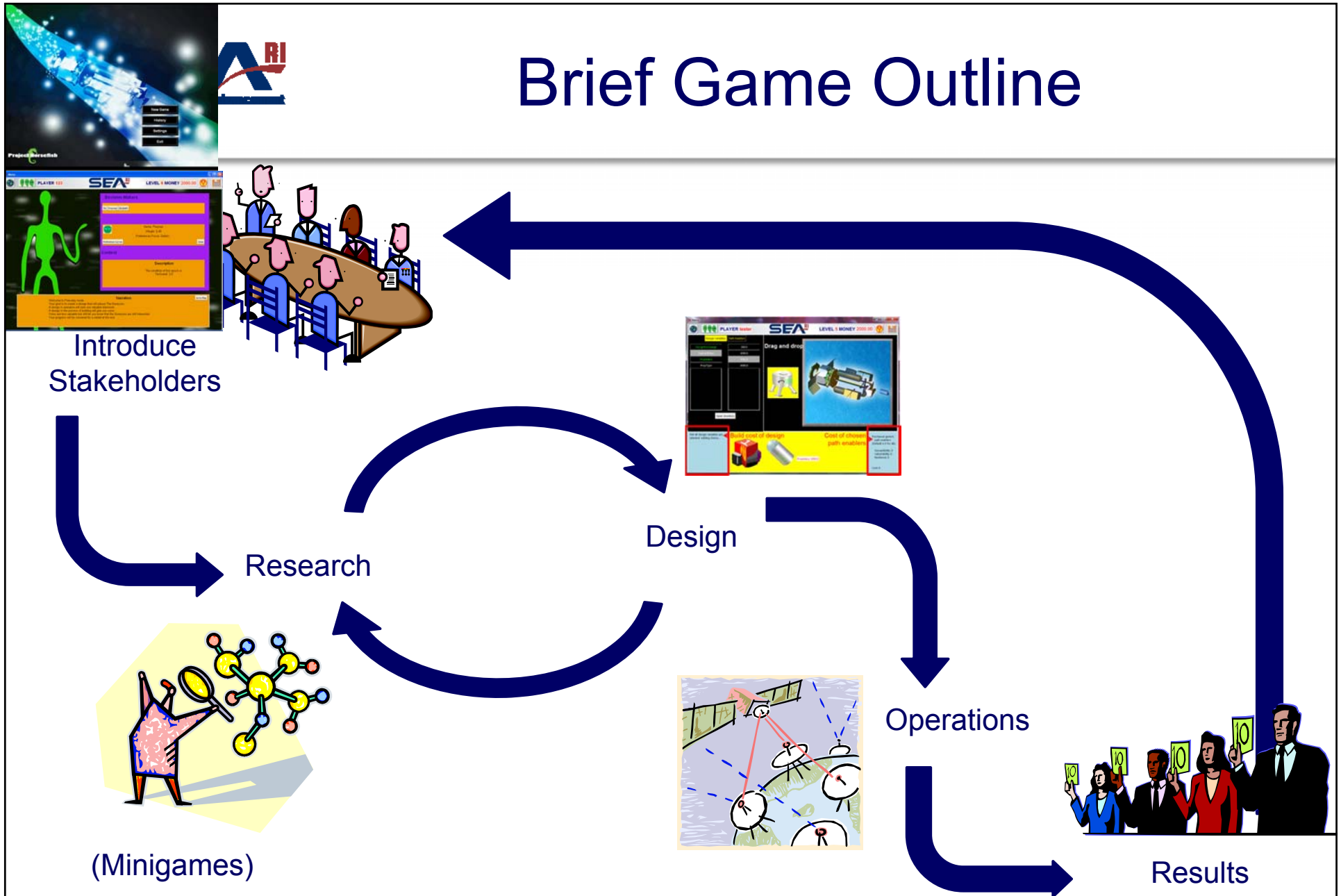
PropMass: 3000.0

(Minigames)

Results



# Brief Game Outline



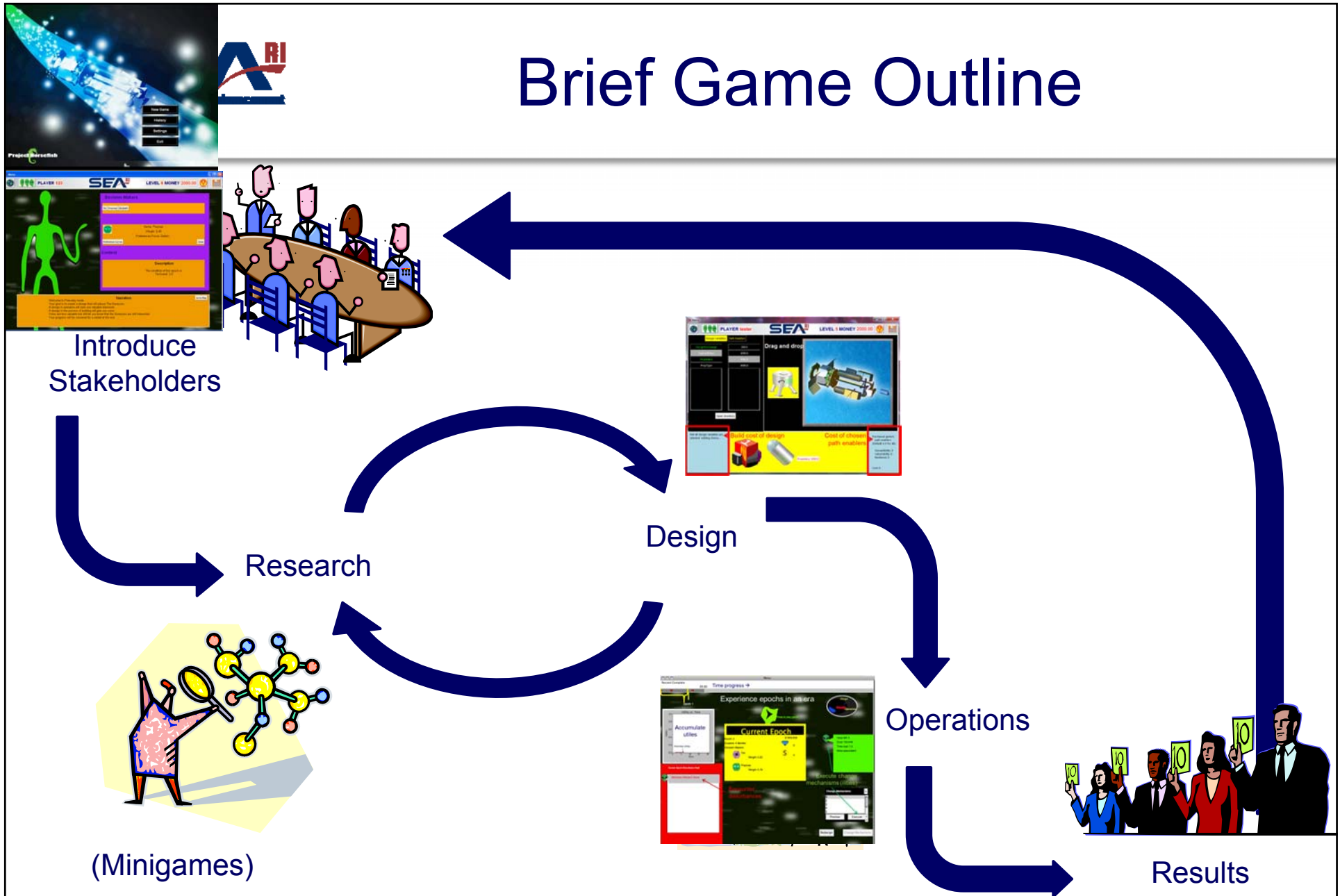


# Brief Game Outline

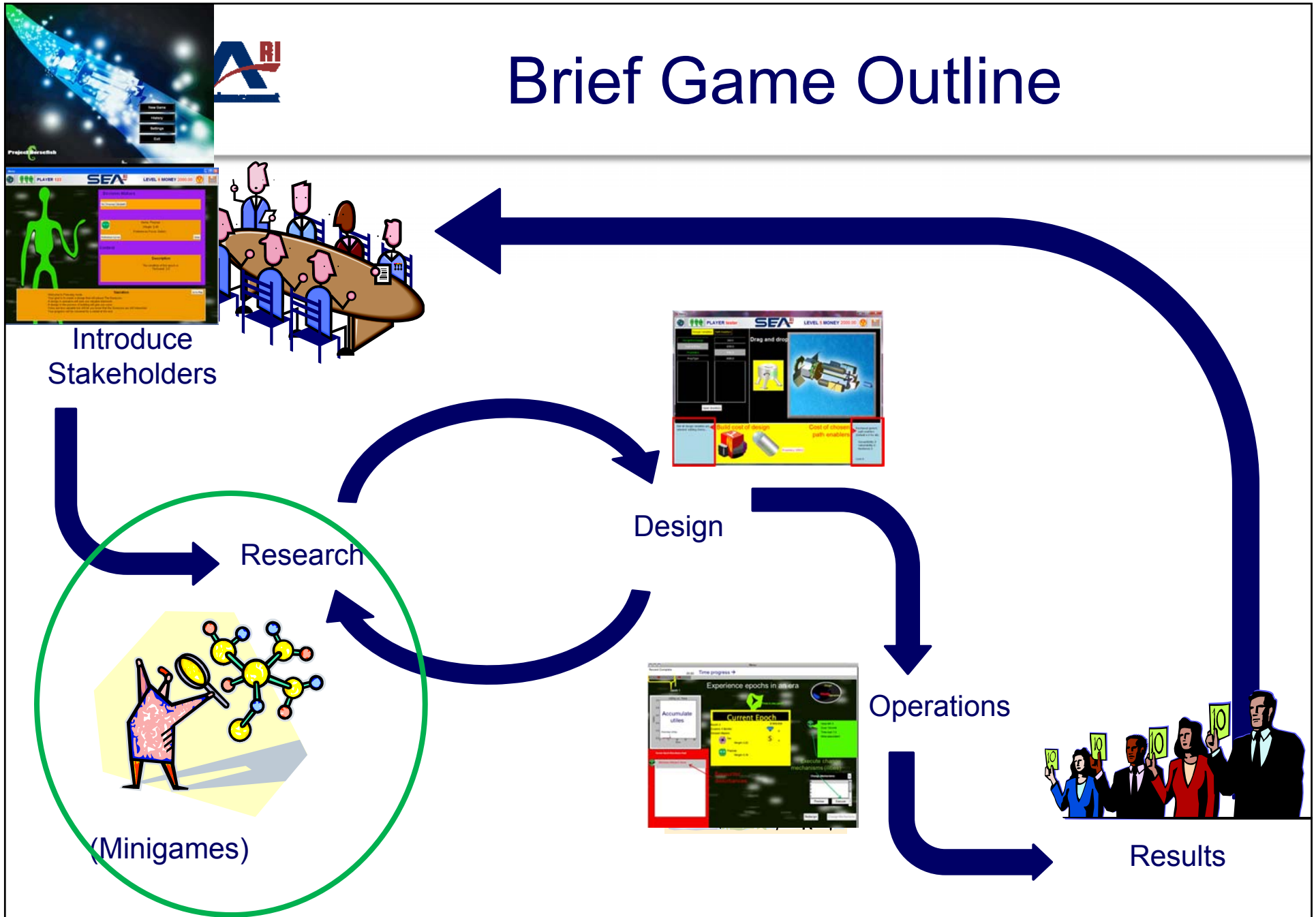
The screenshot shows the SEARi game interface with several key components and annotations:

- Top Bar:** Includes a "Menu" button, "Percent Complete" (20.00), and "Time progress" with a right-pointing arrow.
- Left Panel:** Features a green alien icon and a "PLAYER LIST" table. Below it, a blue arrow points from the text "Introduce Stakeholders" to the player list.
- Epoch 1:** A yellow line graph labeled "Epoch: 1" shows utility over time. Below it, a graph titled "Utility vs. Time" shows "Accumulate utiles" (sic) and "Potential Utility" over a time period of 0 to 20.
- Current Epoch Panel:** A yellow box displays "Current Epoch" information:
  - Epoch: 2
  - Duration: 4 Months
  - Decision Makers:
    - Tim (Weight: 0.22)
    - Praynaa (Weight: 0.78)
  - Resources: \$1899.956, 0 diamonds, 4 dollars.
- Disturbance Feed:** A red box labeled "Current Epoch Disturbance Feed" shows "Attributes Affected: None". A red arrow points from the text "Encounter disturbances" to this box.
- Design/Operation Cycle:** A circular diagram shows a cycle between "Design" and "Operation".
- Alien Interaction:** A green alien icon is shown with a green box listing:
  - Uses left: 3
  - Cost: 150.048
  - Time cost: 7.0
  - Ilities associated:
 A green arrow points from the text "Execute change mechanisms (ilities)" to this box.
- Change Mechanisms:** A window titled "Change Mechanisms:" shows a list of numbers (9, 2, 3, 4, 5) and buttons for "Preview" and "Execute". A green arrow points from the text "Execute change mechanisms (ilities)" to the "Execute" button.
- Bottom Panel:** Includes buttons for "Redesign" and "Change Mechanisms".
- Right Side:** A blue arrow points from the "Change Mechanisms" window to the text "Results". Below this, an illustration shows three people holding up signs with numbers.
- Minigame:** A small illustration of a minigame is shown with the text "(Miniga" below it.

# Brief Game Outline



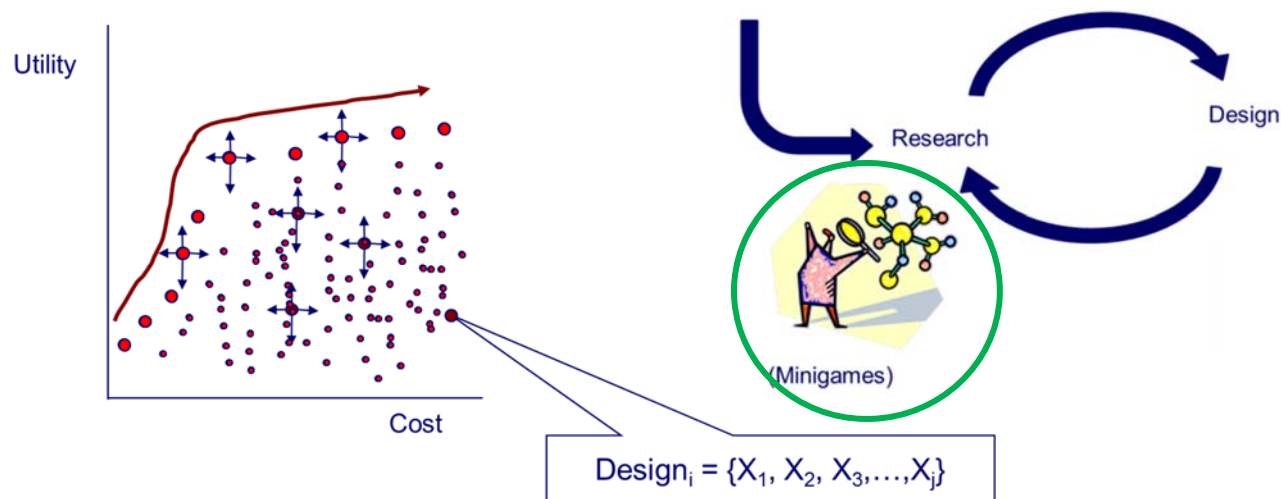
# Brief Game Outline



# Research Minigame 1

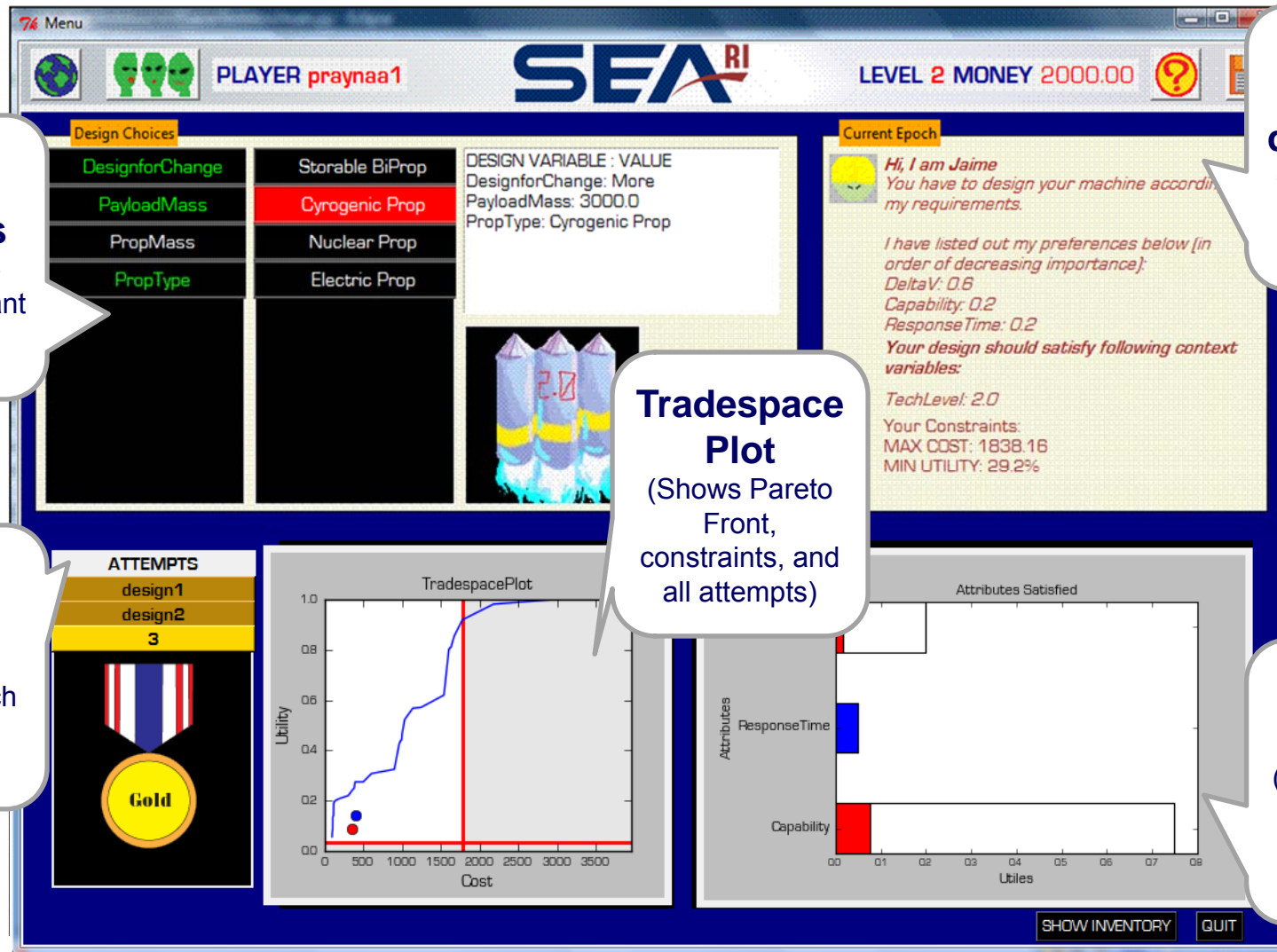
## Hit the Pareto

- 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





# Hit the Pareto Interface



**Design Variables**  
(Choose the design you want to "test")

**Attempt Medals**  
(Three attempts, each scored with medals)

**Epoch description**  
(prefs, context, constraints)

**Tradespace Plot**  
(Shows Pareto Front, constraints, and all attempts)

**Attribute Levels**  
(length=relative importance, colored by fill %)

# Hit the Pareto 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
  - E.g. for medium level:



Medal	Fuzzy Point Range	Point Range
Gold	0-3	800-1000
Silver	4-6	550-800
Bronze	6-10	200-550
Wood	>10	0-200

# Research Minigame 2

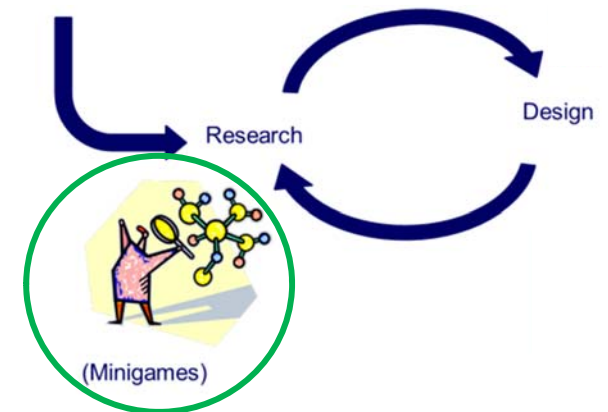
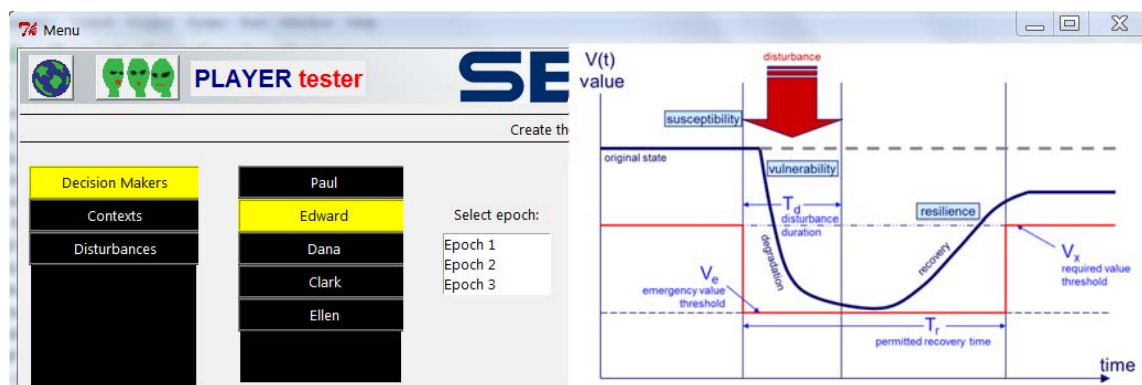
## Destroy Your Design

**Goal:** Discover a three-epoch era where your level design will achieve poorly

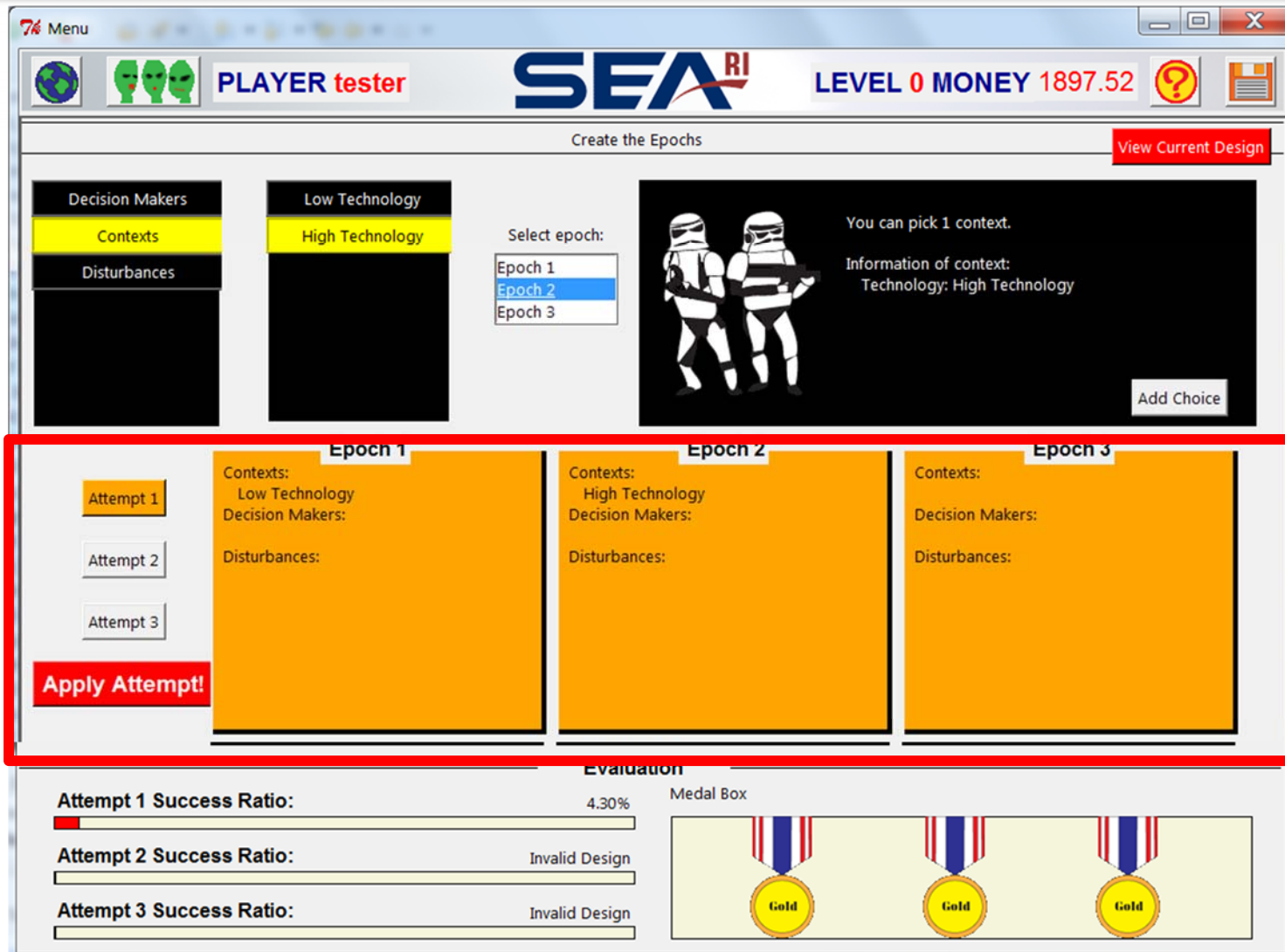
**Gameplay:** Construct a difficult to survive era

**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!)



# Destroy Your Design Interface



7% Menu

PLAYER tester

SEA<sup>RI</sup>

LEVEL 0 MONEY 1897.52

Create the Epochs

View Current Design

Decision Makers

Contexts

Disturbances

Low Technology

High Technology

Select epoch:

Epoch 1

Epoch 2

Epoch 3

You can pick 1 context.

Information of context:  
Technology: High Technology

Add Choice

Epoch 1

Contexts:  
Low Technology

Decision Makers:

Disturbances:

Attempt 1

Attempt 2

Attempt 3

Apply Attempt!

Epoch 2

Contexts:  
High Technology

Decision Makers:

Disturbances:

Epoch 3

Contexts:

Decision Makers:

Disturbances:

Evaluation

Attempt 1 Success Ratio: 4.30%

Attempt 2 Success Ratio: Invalid Design

Attempt 3 Success Ratio: Invalid Design

Medal Box

Gold

Gold

Gold

Constructed  
Era  
Description

# Destroy Your Design Scoring

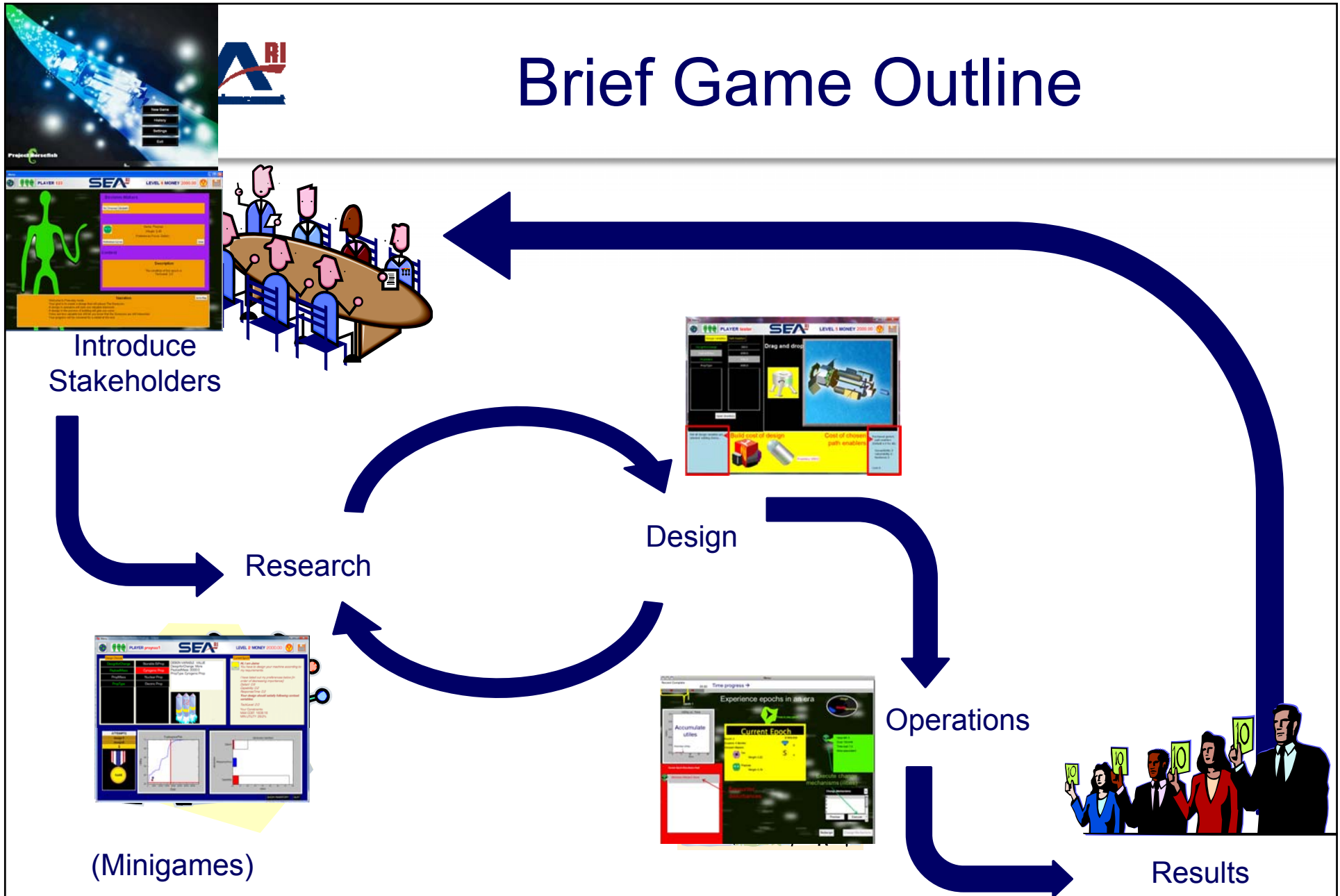
The goal is to achieve the ***lowest fraction remaining utility*** possible, which is determined by the ratio of the utility of current design over maximum achievable utility of the era



Medal	
Gold	$0\% \leq \text{remaining utility} < 10\%$
Silver	$10\% \leq \text{remaining utility} < 25\%$
Bronze	$25\% \leq \text{remaining utility} < 50\%$

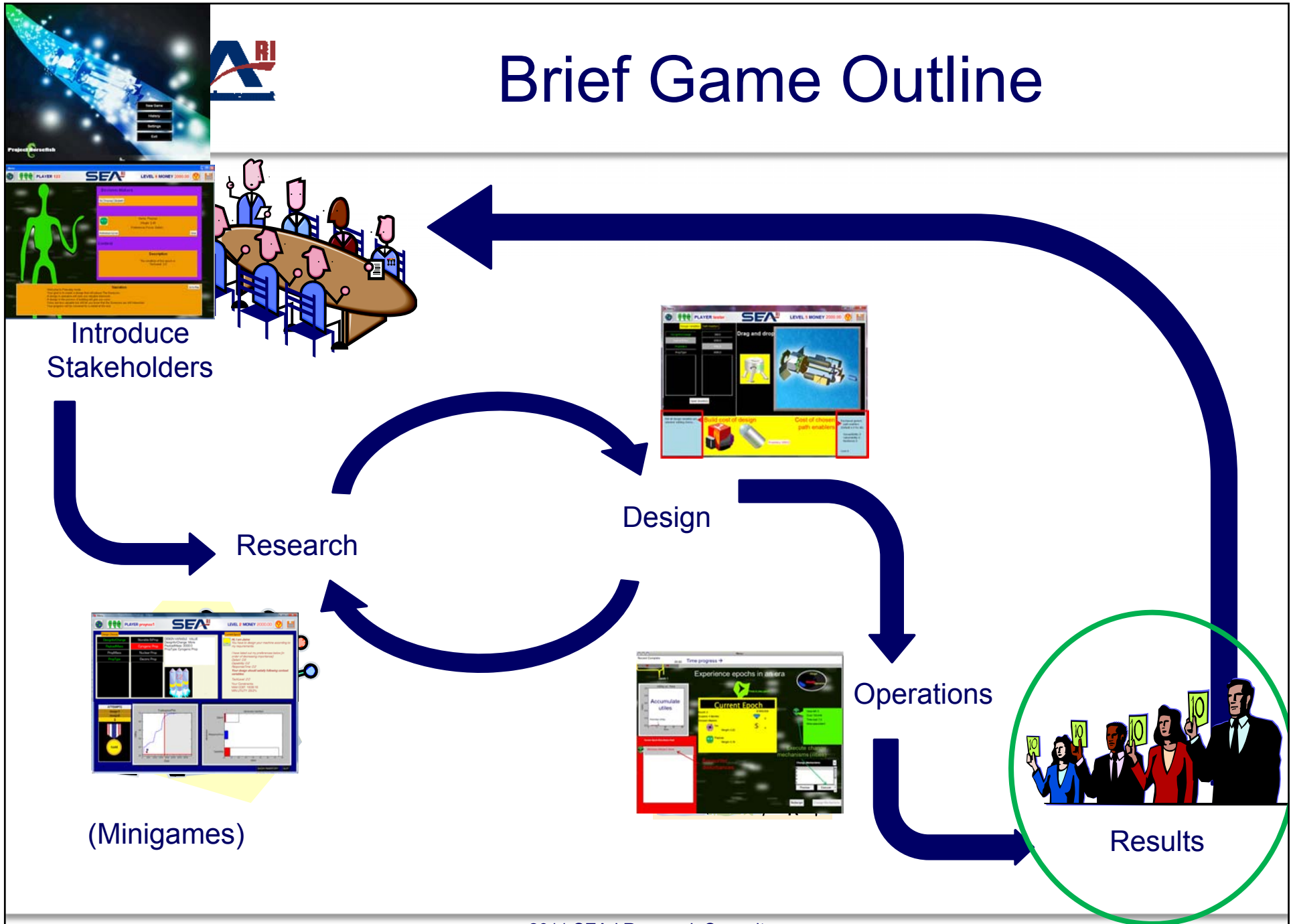
Success ratio = fraction of remaining utility

# Brief Game Outline





# Brief Game Outline



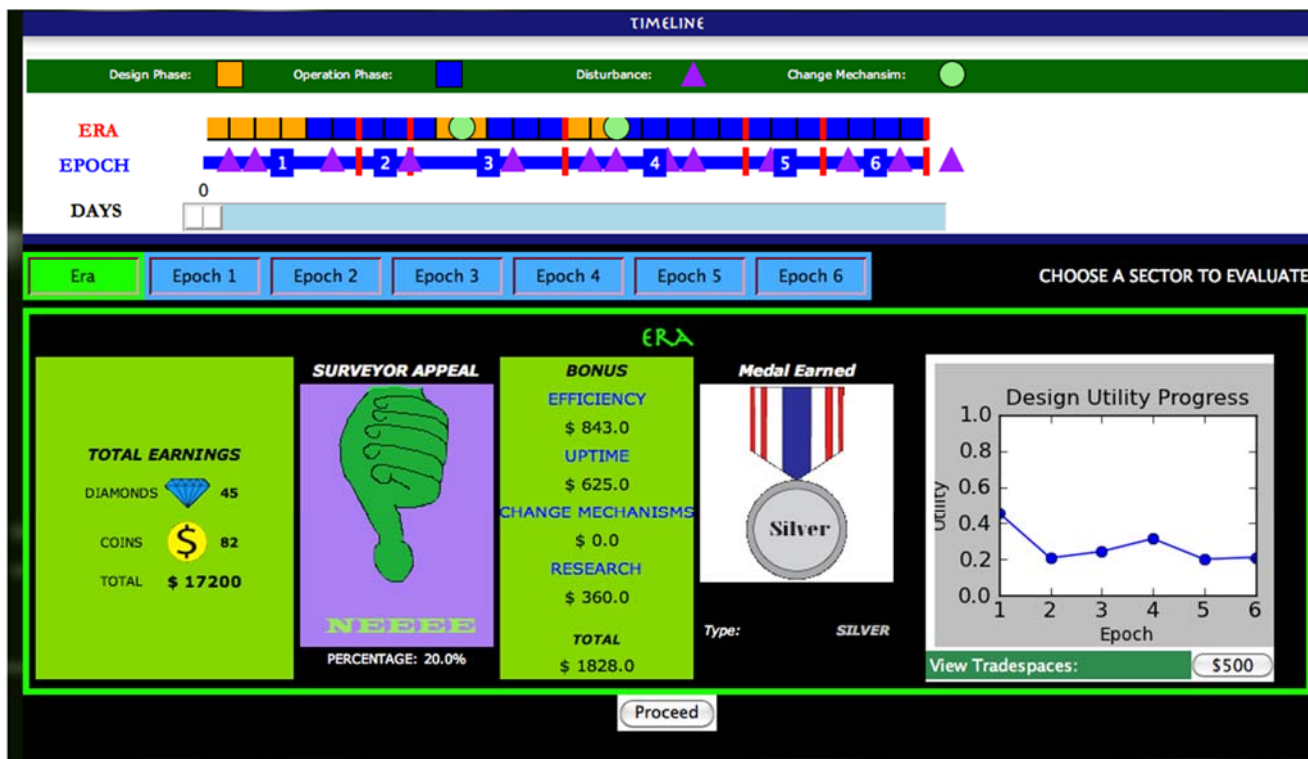
# Evaluation Screen

## Era View

- Directly follows Operations (Mission)
- Layout
  - Timeline
  - Tabs

*Visually organizes Mission by Era, Epoch, Days (Scrollable)*

*Easily cipher through to see Era/Epoch specific data*



### Era Tab

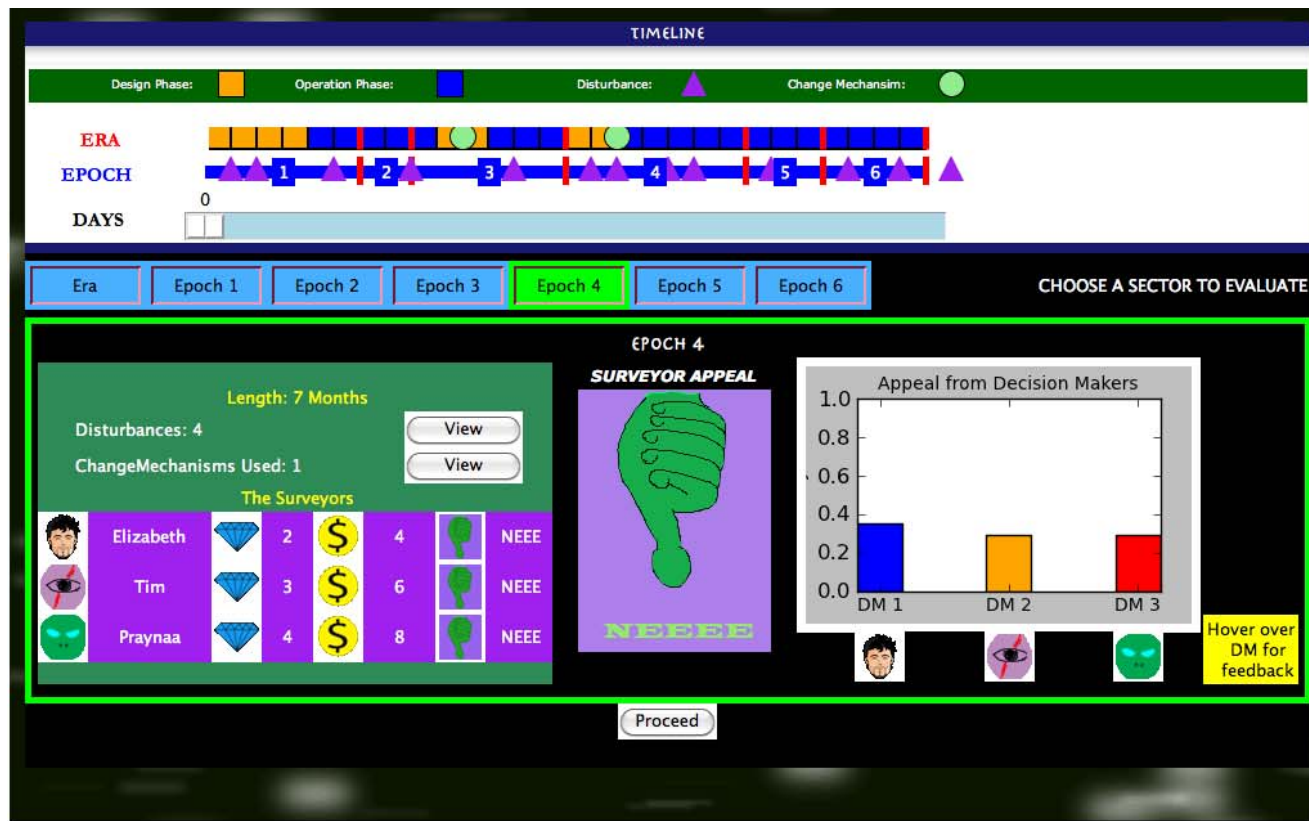
- Scoring
  - Total Earnings
  - Surveyor Appeal
  - Bonus
  - Medal Earned
- Graph
  - Visual diagram
  - View More option



# Evaluation Screen

## Epoch View

- Epoch Tab
  - Point / Utility Distribution among each decision maker
  - Options to view disturbances / executions
  - Audio of decision maker based on performance



# Evaluation Screen

## Overall Scoring

### Scoring

#### – Total Earnings

- Diamonds:
- Coins:



Effective Utility in Operations  
Basic Utility in Design

#### – Surveyor Appeal

- Percentage that player pleased all decision makers
- Averages all DMs with “Thumbs Down” weighted more



#### – Bonus

- Cost Efficiency
- Uptime
- Change Mechanisms
- Research

*Compares cost of design to that on the Pareto Line*

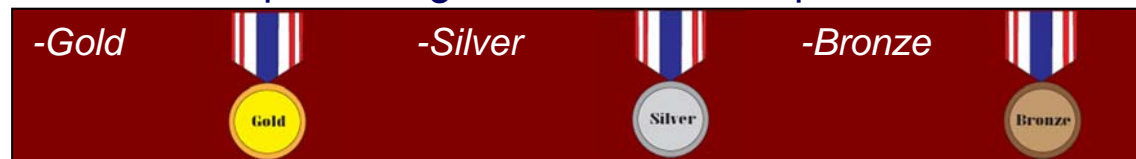
*Percentage in era when design is valid in operations*

*Compares design effective utility before and after execution*

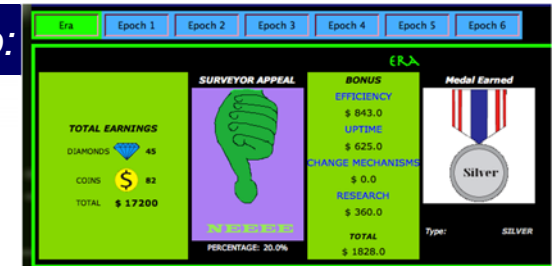
*Averages points and high scores achieved in minigames*

#### – Medal

- Averages above three percentages with maximum possible value
- Type:



*Four categories shown in Era tab:*



# Discussion

- Inheritance of VisLab software was key
- Development is just demonstration, low level of maturity
  - One spiral, little play testing
  - Still a promising product, showing potential for vision
- This game currently demonstrates only one “skin” (i.e., “SpaceTug”) that can be applied to the engine
- Designed with extensibility in mind, especially in the mini games
- Further work would vastly improve gameplay experience
- Learning occurs for both developers and players

The game and engine were developed such that students can pick up this project in future efforts

# Contributions

- Experience teaching SEARi concepts to a non-SE, younger audience
- 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
- Pioneering the use of serious games in systems engineering
- Experience using game constructs to illustrate SEARi constructs
- Extensible architecture (engine) for future game development

The SEARi Summer Project was a successful multi-disciplinary exercise in using new methods to communicate SEARi research

Hopefully to be continued...