Early Synthetic Prototyping for Sytems Engineering

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Early Synthetic Prototyping / TVEC

Early Synthetic Prototyping (ESP)

- End state: 1000s of Soldiers in **persistent** game environment
- 1 Million Hours of usable replay hours per month

TARDEC Virtual Experiments Capability (TVEC)

- Smaller 20-30 person experiments independent of ESP
- Construct/validate models that go into ESP
- Ability to implement kiosks or high-fidelity motion-based experiments

Random Fact: After one month of the release of Call of Duty Black Ops, gamers accumulated 68,000 years of play.

From AirLand… to Win in a Complex World

Known enemy: AirLand Battle

- Focus on technical differentiation
- Even if it took 10 years build, ROI was differentiation for 20 or 30 years
- Enemy has T-55 tank, build M1

Unknown enemy

- Focus on **rate of innovation**
- **Take risks**: measure the rate of failure
- Innovation is our ability to turn ideas into valued outcomes
- Requires change from Congress all the way down

The "Big Five"

1970s - Today

…fight outnumbered and win


M1


UH-60


AH-64


PATRIOT


M2

PL Future LD/LC

XXXX

PL Future LD/LC

2015 - 2025

…win in a complex world


Optimized Soldier and Team Performance


Capabilities Overmatch


Joint/Interorganization Interoperable


Scalable and Tailorable Joint Combined Arms Forces

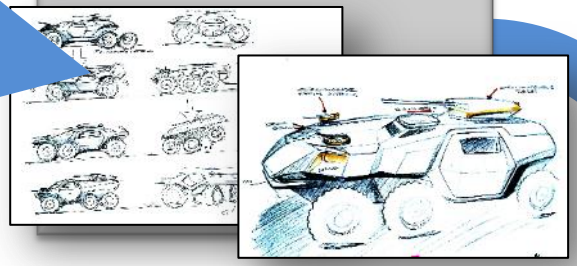

Adaptive Professionals and Institutions to operate in complex environments

Leveraging Soldier Involvement to Accelerate Innovation

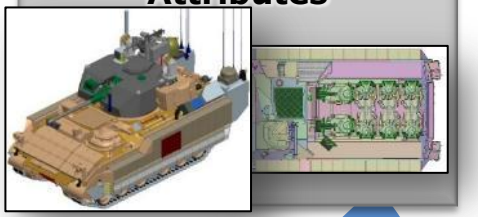
= Soldier-Driven Process

Soldier Innovation Workshop

Full System Ideations



Engineering Concepts w/ Performance Attributes



System Prototypes

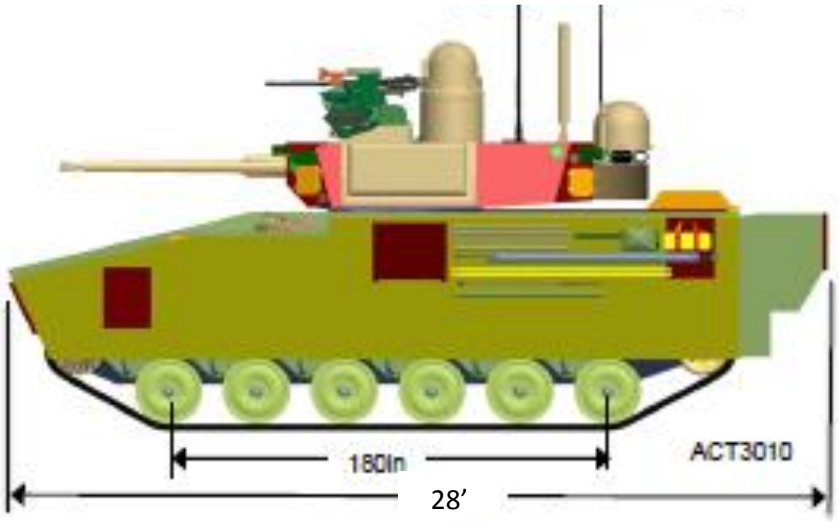
Maneuver Event

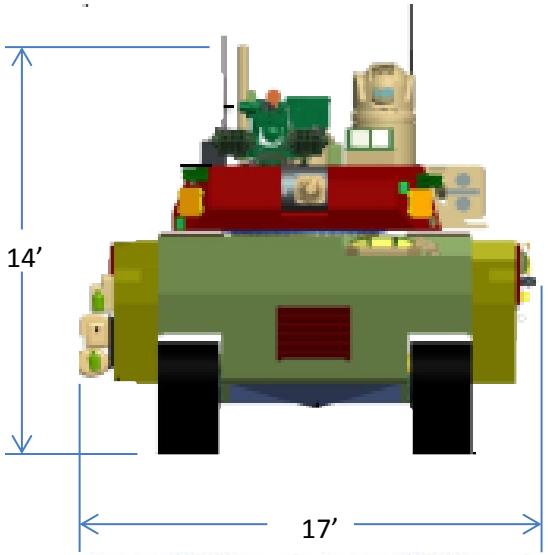
SCMM to Ft. Hood in 6 Months

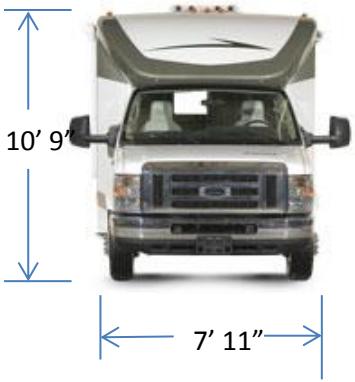
Digital Prototyping and Experimentation

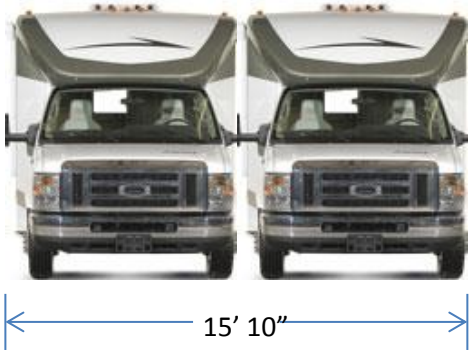
GCV

Standard procurement practice is to ensure maximum capabilities for our warfighters for every contingency. That means requirements **grow and grow**. GCV can't fit down a road.

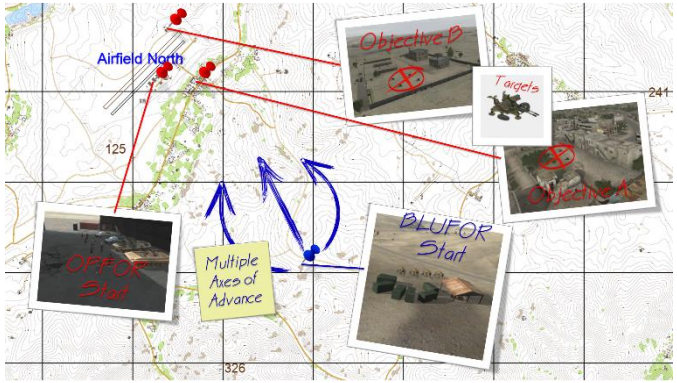






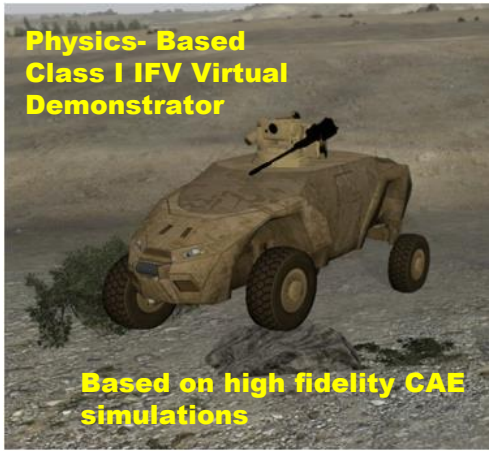


NEXT GENERATION CLOSE COMBAT VEHICLE STUDY
VIRTUAL DEMONSTRATOR TEST
Ft. Bliss, Brigade Modernization Command, Dec. 2014

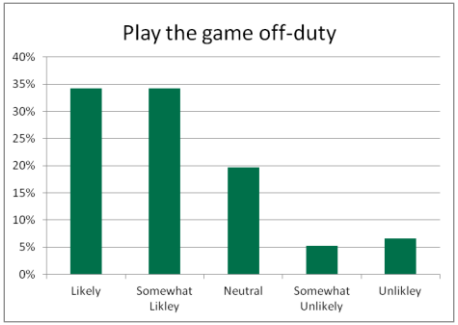


TEST DESIGN
- What would motivate Soldiers to participate?
- How to get data useful to concept developers?
- 76 Soldiers over two days
- Soldier vs. Soldier

AIRFIELD SEIZURE MISSION
- Airborne unit jumps in with NGCCVs
- Goal capture the airfield to land heavier assets
- Framed in a way that made it feel more like a game to participants



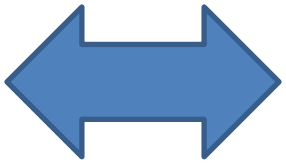
TEST EXECUTION
- 4 rows of 6 workstations
- BLUFOR on left, OPFOR on right
- Used either a mouse and keyboard or steering wheel and pedals, if driving



Materiel Solutions Should Co-Evolve Simultaneously with User's Concept of Operation

Users at All Echelons

Soldier-centric battlefield performance at operational, strategic, and tactical levels.



APD Specifications	Goal	Unit
Acceleration (0-30 MPH)	10.5	sec
Max Speed (Hardball)	50	mph
Max Speed (Cross Country)	28	mph
Generator Output	197	hp
Fuel	JP8, Diesel	
Battery Energy	21.8	
Battery Max Power		
Traction Motor Power		
Power/Weight Ratio		
Peak Torque (Sum 6 Wheel [illegible])		
Steering Radius		in
Vertical Ob[illegible]	39	in
Trench	39	in
[illegible]	108	in
[illegible]	4-25	in
[illegible]	30	%
[illegible]ope	60	%
[illegible]	20	in
Gross Vehicle Weight	9.3	ton
Normal Operating Height	87	in
Minimum Crouched Height	76	in
Overall Length	182	in
Overall Width	98	in
Operating Temperatures	-4 to 113	°F
Available Direct Current Voltages	750, 350, 28 VDC	
Standby Power Available (Genset and Batteries)		
Mechanical Redundancy (6WD, Battery and/or Engine Power)		

Performance

Acquisitions

Finding the sweet-spot among competing objectives (performance, unit cost, O&S costs, development risk, and growth potential) is a non-trivial task.

No Existing Way to Measure Battlefield Impact of Tradespace Choices

Tactical Utility = Mission Success / Total Lifecycle Cost

Future will bring tension between two extremes :

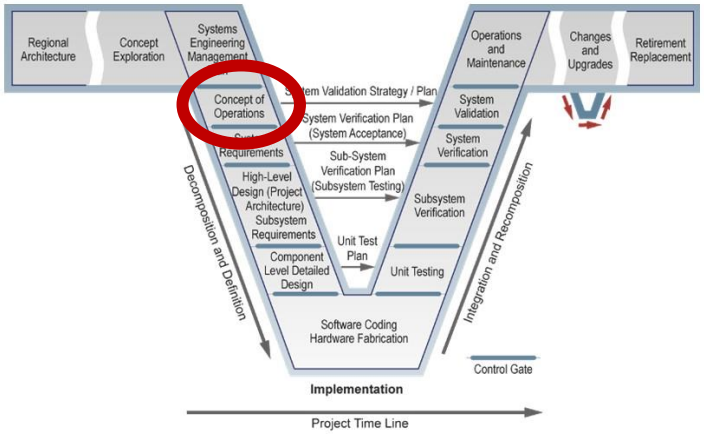
1. Mass produced, but adaptable / flexible via modularity
2. Custom specific purpose "disposable" vehicles

…But they DON'T

How do you develop a system if you do not know what it is supposed to do?

108 SE's surveyed (18 DOD Orgs. and Major Contractors)

- 36% never worked a program with a CONOP
- 73% did not complete CONOPS by program start
- 50% did not update CONOPS
- 30% did not even involve a user



60 CONOPS examined:

- took 3-30 months to complete
- 25% did not state mission needs
- 80% did not discuss system risks
- 50% did not include operational scenarios

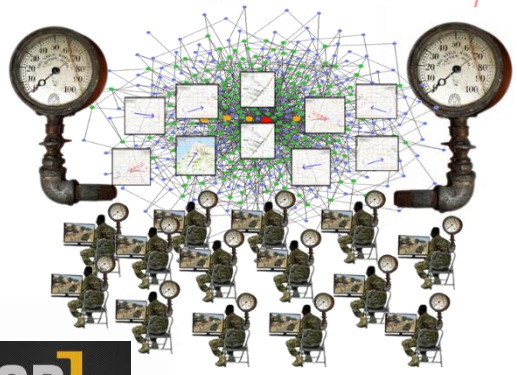
NOTE: CONOPS = Concept of Operation

SOURCE: Roberts, N., & Edson, R. (2008). *System Concept of Operations: Standards, Practices and Reality.* NDIA Systems Engineering Conference, San Diego CA.

How do you develop a system if you do not know what it is supposed to do?

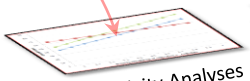
High-Fidelity CAE Models
And Concepts

Technology Candidates



Value Curves

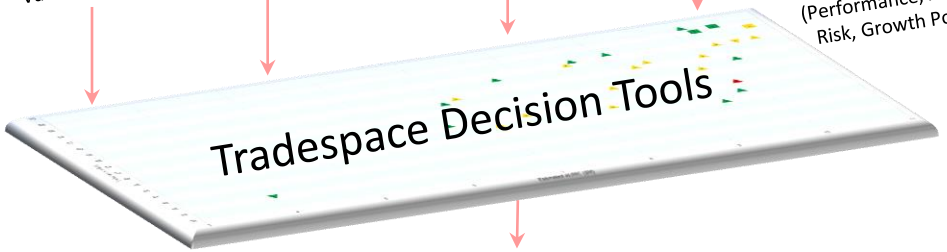
Priority Weightings

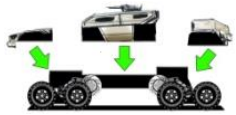


Sensitivity Analyses

Technology-Matched CONOPS

Stakeholder Value Scatterplot
(Performance, AUMC, Development Risk, Growth Potential, O&S Costs)

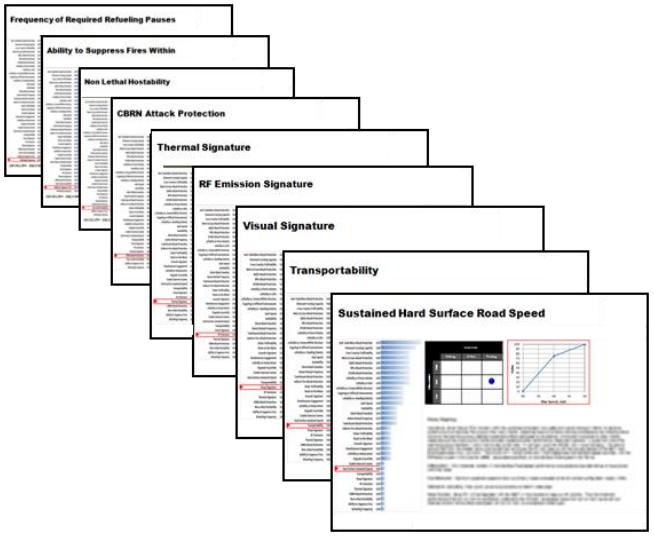




Robust / Adaptable System

[ESP]
EARLY SYNTHETIC PROTOTYPING

Relative Feature Priority / Value Functions



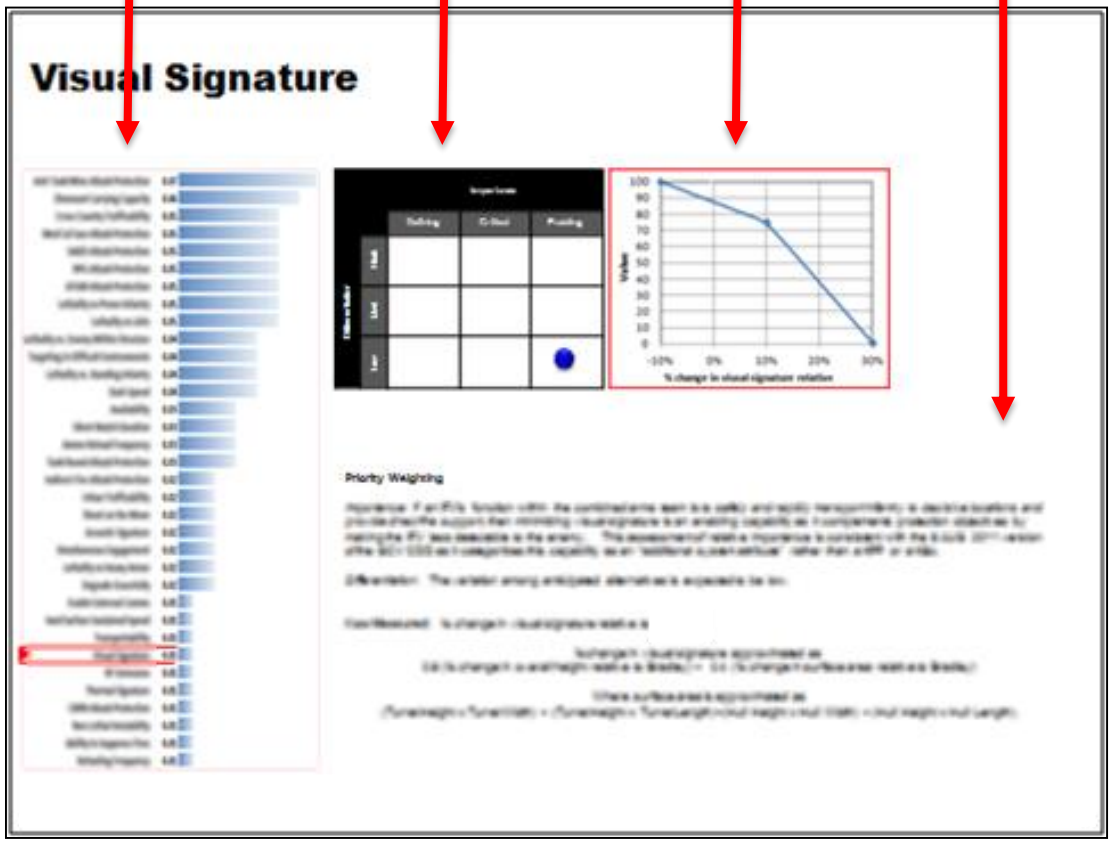
Priority weightings and value functions for each objective are well reasoned based on SME input and gaming data.

Relative Priority Weighting Indicator

Swing Weight Matrix (Performance Gap vs. Importance)

Value Function (knee in the curve)

Supporting Narrative



Goal: Inform Tradespace Decision Tools

Legend

Development Risk

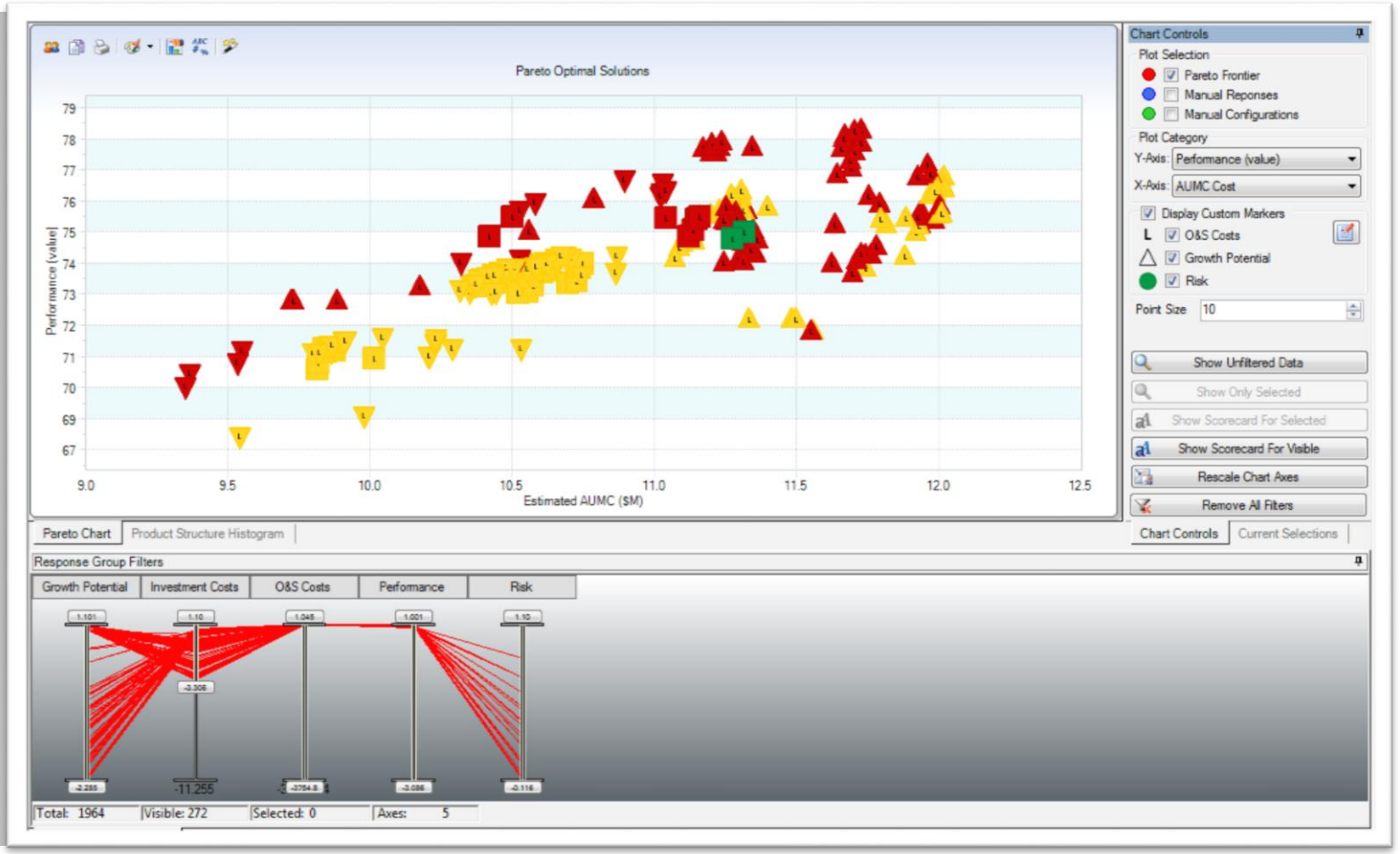
- High Risk
- Moderate Risk
- Low Risk

Growth Potential

- high growth potential
- moderate growth potential
- low growth potential

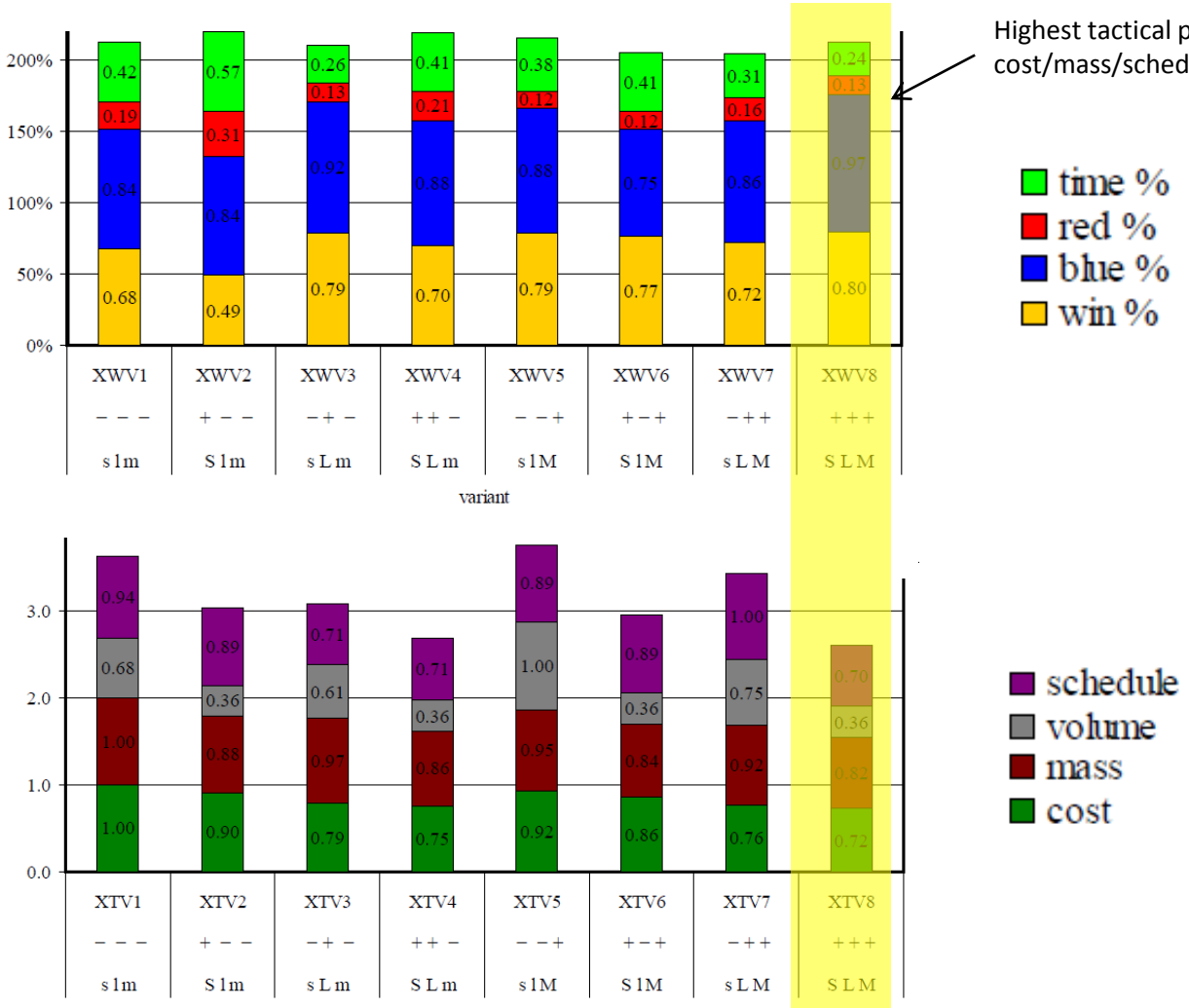
O&S Costs

- (H) High O&S Costs
- (M) Moderate O&S Costs
- (L) Low O&S Costs



The stakeholder value scatterplot synthesizes data to show each system alternative's response in dimensions of stakeholder value (unit cost, O&S cost, performance, development risk, growth potential)

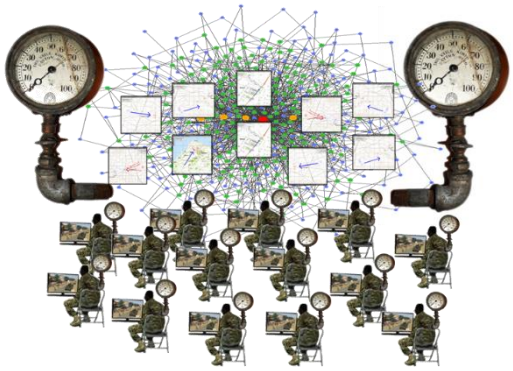
Example Output Data
(Could be weighted/ normalized multiple ways)



Source: "Demonstration of Decision Support Tools for Evaluating Ground Combat System Survivability, Lethality, and Mobility at the Tactical, Operational, and Strategic Levels of War." MAJ Joshua Keena PhD Dissertation. University of Texas as Austin, August 2011.

Game Analytics Research:
How Do We Extract Meaningful Tech+ Tactics Data?

Virtual Physics-Based Gaming Environment

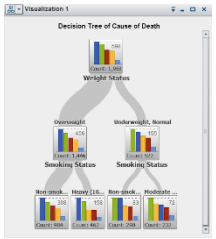


>120,000 hours of Soldier gameplay per year

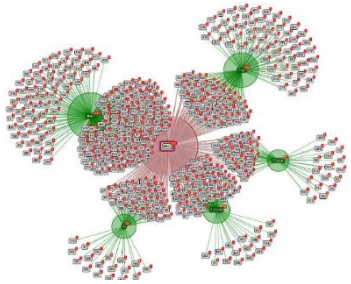
Data Mining

- What are they doing?
- Why they are doing it?
- How effective is this?
- Where are they looking?
- Terrain versus movement choices
- What are they talking about/ when/ how often
- Optimal Force structure

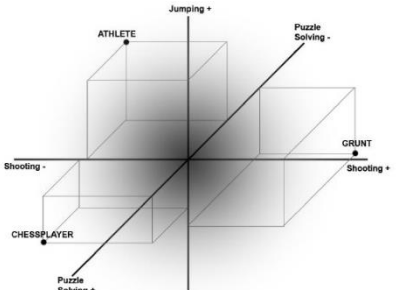
Visualization



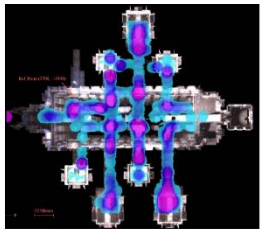
Decision Trees



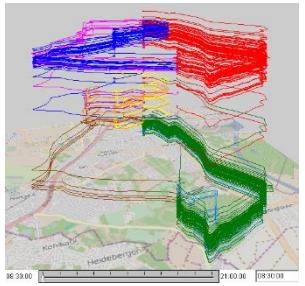
Clustering Cause of Death



Player Personas



Heat Maps



Multi-Run Movement Plots