Acquiring 21st Century Blitzkrieg via Physic-Based Gaming

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<td>12 AUG 2014</td>
<td>Briefing Charts</td>
<td>03-02-2014 to 21-06-2014</td>
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<tr>
<td>Briefing Charts for GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM (GVSETS), SET FOR AUG. 12-14, 2014</td>
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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18
Agenda

• ESP in Systems Engineering
• Whole System Trade Analysis
• Defense Acquisition University MindRover/ Dragonfly
  – MAJ Keena’s MindRover Tradespace Analysis
• Conclusions
Finding the sweet-spot among competing objectives (performance, unit cost, O&S costs, development risk, and growth potential) is a non-trivial task. Ultimate metric is **affordable mission success**.

Ground vehicles are complex systems with many interrelated subsystems.

Materiel and Tactical Employment are not separable in real world.
ARCIC Early Synthetic Prototyping (ESP)

- MG Hix tasked LTC Vogt to setup a persistent game environment for Soldiers to play emerging technologies.
  - ARCIC is looking for >20 year out concepts for the Army to try out in a gaming environment
  - End state: 1000 Soldiers in **persistent** environment
- Initially pursuing robotic wingman concept as pilot study
- First person shooter environment to start (VBS3 currently)

Random Fact: After one month of the release of Call of Duty Black Ops, gamers accumulated 68,000 years of play.
Early Synthetic Prototyping NPS Pilot Study: Robotic Wingman

- Robotic wingman based on actual demonstrator system
- Three scenarios:
  1. Track a red convoy (AI) to a specific location, then eliminate it. 4 blue
  2. Assault a defended, fixed location to free prisoners. 2 blue/2 red
  3. Defend an urban location for five minutes. 2 blue/2 red

Big Takeaways:
- Soldiers very enthusiastic about playing game – especially head-to-head
- Game interface is very important (which key does what)
- Scenarios showed definite desire to tailor platform for mission

Capture and synthesize analyses being conducted by Soldiers AND subject matter experts into visualizations designed to facilitate rapid and complete understanding of the trade-space to stakeholders and provide drill down capability to supporting rationale.
How do you develop a system if you do not know what it is supposed to do?

108 SE’s surveyed:
- 36% never had CONOPS
- 73% did not complete CONOPS by program start
- 50% did not update CONOPS
- 30% did not 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
- 50% of IEEE or ANSI standard elements were not included

NOTE: CONOPS = Concept of Operation
Magazine Racing: Where you pull out the specs and never run the race.

DATA Based: Maintenance, weather, driver tactics, trans type, component durability, run-to-run variation, etc

Camaro SS 2010
Engine: 6.2 Liter LS3
Power (SAE): 426 BHP @ 5900 RPM
Torque: 420 ft-lb @ 4600 RPM
Weight: 3,860 lbs

Mustang GT 2011
Engine: 5.0L V8
Power (SAE): 412 hp @ 6,500 rpm
Torque: 390 ft-lb @ 4,000 rpm
Weight: 3,605 lbs

NOTE: Performance specifications are notional. No particular company is endorsed.
Major driver of future acquisitions is to maximize combat success at a minimal cost:

**Tactical Utility** = Mission Success / Total Cost

- Mission Success resiliency *quantified by game data*
- Total Cost = development, acquisition, future customization, maintenance, disposal

Future will bring tension between two extremes and solution robustness:

1. Mass produced, but adaptable / flexible via modularity
2. Custom specific purpose “disposable” vehicles
Closer Look at WSTAT Tradespace Exploration

Whole System Trade Analysis was developed by TACOM to identify relationship between high level design decisions & stakeholder value. Contact: Shatiel Edwards.

shatiel.b.edwards.civ@mail.mil
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)
Priority weightings and value functions for each objective are well reasoned based on SME input and gaming data.
Sensitivity analysis allows decision makers to see how performance values for each alternative move as priority weightings change.
ESP Crowdsourced Demonstrator: Defense Acquisition University’s MINDROVER / DRAGONFLY

- PMT-352 Program Management teaching tool
- Ver 1: Mindrover based on commercial game
- Ver 2: Dragonfly simplifies the “wiring requirements” and tunes for teaching
- MAJ Keena example DOE using MindRover

JRATS = (Joint Reconnaissance and Targeting System) robotic combat vehicle
Keena Study: Over 1400 MindRover Runs Using 14 ROTC Cadets

Move to Contact Urban Scenario

JRATS screenshot during contact. In this shot, the guided missile has drifted left of the laser and has missed the threat vehicle.

Design screen: Build components are placed on a virtual breadboard. Logic components and interface modules are wired together to form the functional combat platform prototype.

Very similar to SysML or DARPA’s AVM META!

Keena’s Game Based Design of Experiments

- **DOE with 18 variants**
  - tracked vs wheeled
  - survivability 2 levels
  - lethality 2 levels
  - mobility 2 levels
  - 2 training vehicles

- **14 Operators**
  - 15 missions per randomly assigned variants
  - Result = ~100 missions per vehicle

- **1600 ground vehicle missions**

**OUTPUT METRICS:**

- rating of success or failure
- elapsed mission time (time mission)
- the friendly vehicle’s remaining health (blue mission %)
- and threat vehicle’s remaining health (red mission %)

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

Performance is the sum of the normalized values for variant win %, blue %, red %, and time % divided by the number of \textit{a posteriori} metrics (4). \textit{Cost} is the per vehicle cost normalized with respect to the variant with the lowest per vehicle cost. Schedule is the normalized schedule index with respect to the variant with the lowest schedule index.
Relative Contributions and Interactions of Survivability, Lethality, and Mobility on Ground Combat Vehicle Performance

Average variant win record (XTV and XWV) in a survivability, lethality, and mobility domain. An XTV and XWV variant coincident at a point share the same relative levels of survivability, lethality, and mobility.

Effects of principal attributes on \textit{a posteriori} performance metrics for XTVs and XWVs. A red bar indicates a negative effect on the metric, and a green bar indicates a positive effect on the metric. The length of the bar has been scaled in length with respect to the greatest effect for that metric in the XTV or XWV block.

During training sessions group discussed tactics, techniques, and procedures (TTPs)
Training missions conducted on tracked and wheeled training vehicle variants (TTV and TWV)
Operators instructed to move in a clockwise fashion until the enemy vehicle was spotted
Non-training sessions Win % calculated after just 5 missions versus final average at 15 missions per operator

- Enhanced survivability platform had the greatest learning curve
  - Variant had the lowest mobility performance, with no gain in lethality
  - Operators presumably struggled initially to maneuver around the city
- Aside from the baseline variant (XTV1), all other variants had a learning curve less than 3%.

What Other Useful Metrics Might be Collected From Game Analytics?

- Replays of winning tactics (directly obtained CONOPS)
- Discussion board chatter
- Sector engaged from in azimuth around vehicle
- Rounds expended
- How much available power and speed actually used

Lower images from: http://www.slideshare.net/acagamic/game-metrics-and-biometrics-the-future-of-player-experience-research
Enough Game Data Allows The Teasing Apart of Modularity and Customization Needs

Which configuration elements can remain constant?

Which things need to be made modular?

Can a whole custom system be fabricated less expensively than a changeable system?

How robust is the solution in different scenarios?

Variety of Missions/Vehicle Designs

Mission Success Rate

Width of distributions might indicate level of needed robustness

LRIP Custom Vehicle?

Mass Produced Base Chassis w/ Changeable Modules?

Fitness: Optimality vs. Resilience

Variation from nominal conditions
Defense Acquisition University’s DRAGONFLY Screenshots

- Dragonfly simplifies the “wiring requirements” and tunes for teaching
- Gives some clues as to complexity in a game for acquisitions
# Parameters Tracked in Dragonfly

<table>
<thead>
<tr>
<th>Chassis</th>
<th>FRACU</th>
<th>Scorpion</th>
<th>Mole</th>
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<tbody>
<tr>
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<td>Hover</td>
<td>Tracked</td>
<td>Wheeled</td>
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<tr>
<td>Vehicle Size</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Engine Size</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Frame</td>
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<td>Aluminum</td>
<td>Titanium</td>
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## Power

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<td>5</td>
<td>Mk-I Batteries</td>
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<tr>
<td>1</td>
<td>Mk-I Fuel Cell</td>
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<tr>
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<tbody>
<tr>
<td>1</td>
<td>Mk-I Targeting Laser</td>
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<td>Mk-I Targeting Laser</td>
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<td>Mk-I Targeting Laser</td>
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<tr>
<td>1</td>
<td>Mk-I Radio Transmitter</td>
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<td>1</td>
<td>Mk-I Linear Mine Detector</td>
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<td>Mk-I Linear Mine Detector</td>
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## Weapons

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<td>1</td>
<td>Mk-I Mini Gun</td>
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<td>1</td>
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## Properties

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<td>Weight (kg)</td>
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<td>1450</td>
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<td>Combat Survivability</td>
<td>330</td>
<td>275</td>
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<td>Idle Power (watts)</td>
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<td>Active Power (watts)</td>
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<td>Produced Power (watts)</td>
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<td>Acceleration (m/sec^2)</td>
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<td>Top Speed (mph)</td>
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<td>Length (m)</td>
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<td>Probability Index (PI)</td>
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## Costs

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<th>Unit Procurement</th>
<th>Disposal</th>
<th>MFTE</th>
<th>Total</th>
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<tr>
<td>FRACU</td>
<td>$141M</td>
<td>$1730M</td>
<td>$6835M</td>
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<td>$58.5M</td>
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<td>$19475M</td>
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<td>Mole</td>
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<td>$1730M</td>
<td>$11085M</td>
<td>$6.78M</td>
<td>$118.5M</td>
<td>$355.5M</td>
<td>$4115.5M</td>
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Design Mode: Chassis Options

**Engine Size**
- Small
- Medium
- Large

**Frame Material**
- Aluminum
- Composite
- Titanium

**Armor Type**
- None
- Steel
- Tungsten

**Vehicle Data**
- Idle Power: 10 Watts
- Max Power: 12 Watts
- Max Speed: 12 m/s
- Acceleration: 6 m/s²
- Development Cost: $10.5M
- Procurement Cost: $240M
- Unit Procurement Cost: $0.28M
- Total Cost: $1112M

**Chassis Performance Statistics**
- Weight: 210 kgs
- Survivability: 75
- Max Weight: 5000 kgs
- Development Cost: $13.5M
- Procurement Cost: $180M
- Unit Procurement Cost: $0.36M
- Total Cost: $184M

**Vehicle Cost Statistics**
- Development Cost: $24M
- Procurement Cost: $640M
- Unit Procurement Cost: $0.64M
- Total Cost: $664M

**Main Menu**
- Save Vehicle
- Customize Controls
- Launch Test
“Mission Load” screen for “Field Test” test mode

MISSION LOAD

SELECT MISSION

SUCCESS/ATTEMPTS MISSION TYPE

0/0 SEEK & DESTROY (PASSIVE)
0/0 SEEK & DESTROY (ACTIVE)

0/0 INTEROPERABILITY (PASSIVE)

SINGLE FIREBIRD
AC-130
MULTIPLE FIREBIRDS

0/0 INTEROPERABILITY (ACTIVE)

SINGLE FIREBIRD
AC-130
MULTIPLE FIREBIRDS

0/0 MINE DETECTION

BRIEFING

Seek & Destroy (Passive)

The student must locate and destroy 3
moving AI and 1 target building. The AI
would not be hostile.
The students must locate and destroy 3 moving AI and 1 target building. The AI would not be hostile.
Conclusions

• Pilot studies indicate it is possible to get useful data from virtual combat (i.e. games)
  – Have only scratched the surface on true utility of this

• 21st Century Blitzkrieg requires tactics and materiel be tightly coordinated
  – Alternative is 21st century Maginot Line

• Crowdsourced gaming might provide enough data to allow acquisitions to understand growth, modularity, and maybe custom vehicle needs
  – Maximize tooth, minimize tail