Assessing Effects of Enhanced Fidelity for Ground Vehicle Mobility in Combat Models – Emerging Results –

MOVES Open House
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Agenda

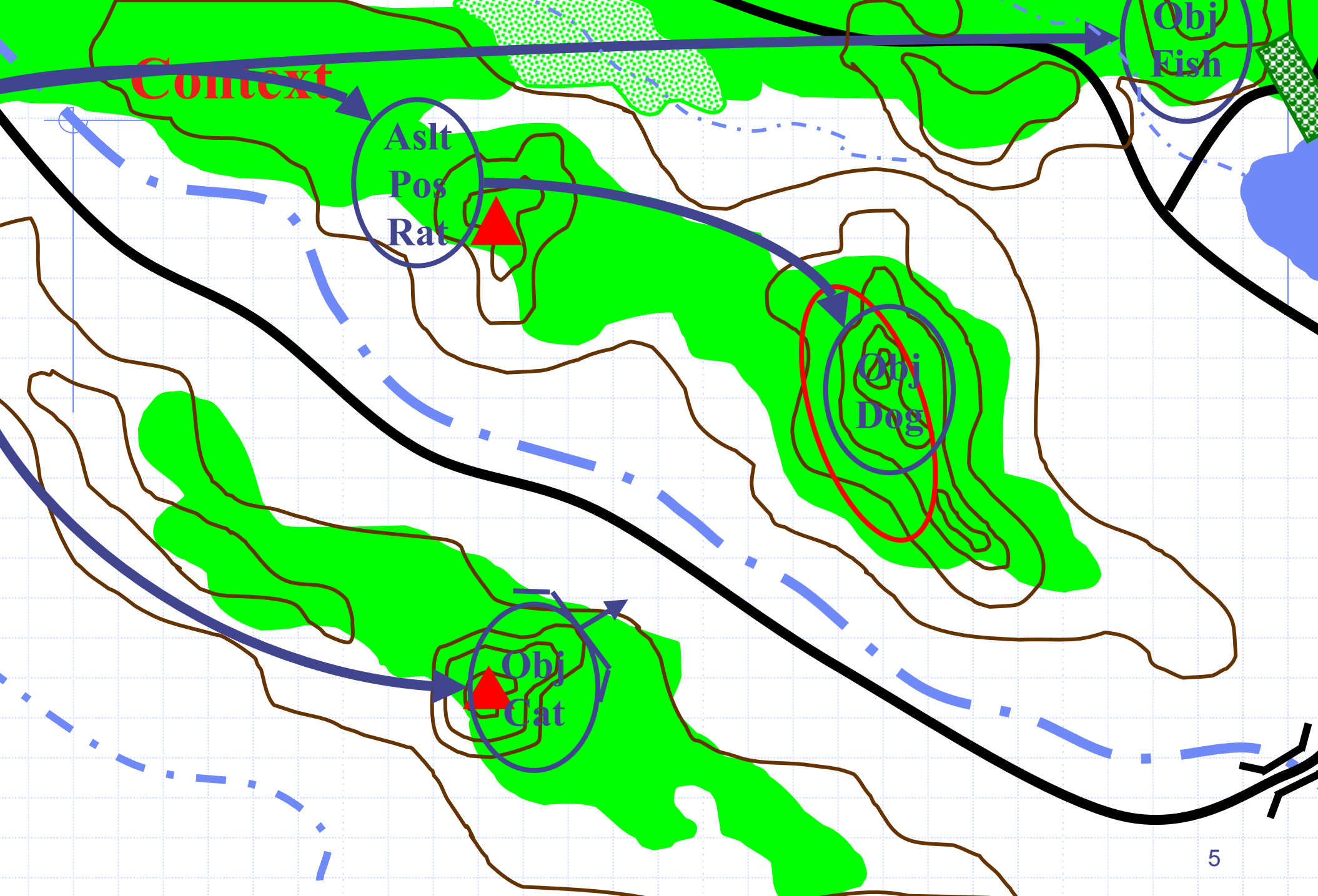
- Issues
- Goal & Payoffs
- Context
- Objectives and Scope
- Study Questions
- Study Methodology
- Analysis
- Summary
- Recommendations

Issues

- Ground vehicle movement representation is generally of low or limited fidelity in current DoD analytical and training models
  - Feature content of terrain databases is generally sparse (time, availability, cost, simulation design)
  - Use of command ordered or static speeds (study focus, eliminates complications caused by lack of synchronization)
  - Use of terrain unrestricted movement (study focus, eliminates complications caused by lack of synchronization)
- In reality, the terrain and environment effect the movement and maneuver on the battlefield
- The military is currently conducting critical analyses to address force structure, doctrine, and systems performance, especially in support of Army Transformation
- There is a need to assess the effects of representing environment/ terrain limiters on mobility in M&S and transition these findings to the analysis community in support of ongoing and future studies

Goal & Payoffs

- Goal
  - To demonstrate the potential effects of using more realistic ground mobility representation (increased levels of fidelity) in M&S analysis
- Payoffs
  - More realistic representation of entity capabilities in M&S analysis
  - Better informed decision making for improved decisions


Context
Aslt
Pos
Rat
Obj
Fish
Obj
Dog
Obj
Cat

Background

- Command ordered (static) and terrain unrestricted speeds vs higher fidelity mobility factors (past/current simulations)
  - Computer hardware/software limitations
  - Development and existence of terrain databases
  - Complications in scenario development and execution
  - Disruption of force synchronization during simulation execution
  - Time compression of training objectives
- STNDMob API (current/future simulations)
  - Currently creating suite of NATO Reference Mobility Model (NRMM) APIs that produce consistent representations of mobility across hierarchy of M&S
  - Products:
    - Architecture for tactical level API
    - Architecture for remainder of selected APIs
    - Documented APIs and results of experiments
  - Customer: Army and DoD M&S developers, Joint Virtual Battlespace (JVB), PM Future Combat Systems (FCS)

Background: STNDMob API Suite

- Aggregate Level API
  - Aggregation of multiple platform type units
    - e.g. Tank Teams, Armored Task Force, etc.
  - Division, Corps, and Theater level simulations
- Tactical/Entity Level API
  - Individual platform movement
  - Brigade and below simulations

FOCUS OF STUDY

- Engineering Level API
  - Virtual proving ground or simulator platforms

Background: STNDMob Entity Level API

- Four Degrees for Tactical/Entity Level API
  - Degree 1 (Fixed Vehicles/Fixed Terrain)
  - Degree 2 (Variable Vehicles/Fixed Terrain)
  - Degree 3 (Fixed Vehicles/Variable Terrain)
  - Degree 4 (Variable Vehicles/Variable Terrain)

FOCUS OF STUDY

- Degrees 1 and 2 Based on NRMM-derived speed data implemented in WARSIM
  - Platform type or nine generic vehicle bins
    - (High, Med, Low Mobility) Tracked
    - (High, Med, Low Mobility) Wheeled
    - (High, Med, Low Mobility) Towed
  - Sample inputs
    - Climate Zone
    - Platform Type or Vehicle Bin Classification
    - STGJ Soil Type
    - Visibility/Obstacle Spacing Pairing
    - Slope
    - Slip Condition (Normal/Dry or Slippery/Wet)

Objectives & Scope

- Study objectives: Conduct a series of experiments to address hypotheses concerning effects of utilizing command ordered versus terrain limited speeds on
  - Synchronization for mobile forces
  - Detection/acquisition of platforms
  - Target Location Error (TLE)
- Scope:
  - Ground vehicle mobility (platform and unit)
  - Analytical combat simulation models
  - STNDMob API implemented in COMBAT^{XXI}
  - Static and dynamic speeds
  - Effects of elevation, soil strength (type), vegetation, and visibility
  - Wheeled and tracked vehicles (standard representative vehicles)

Study Questions

- Study Question 1: Does the method for representing speed (terrain limited versus command ordered) have an effect on synchronization of mobile forces?
  - *Issues: ability to negotiate terrain, speed/time to reach objective*
  - Focus Question: Is there a significant difference in speed averaged over a route using command ordered speeds versus using terrain limited speeds?
  - Focus Question: Do command ordered speeds tend to exceed the terrain limited speeds?
  - Focus Question: Is there a significant difference in time to complete a route using command ordered speeds versus terrain limited speeds?

Study Questions, Cont.

- Study Question 2: Does the method for representing speed (terrain limited versus command ordered) have an effect on the probability of detection of a platform?
  - *Issues: speed/exposure time related to detection/acquisition*
  - Focus Question: Is there a significant difference in time in field of view (FOV) using command ordered versus terrain limited speeds?
  - Focus Question: Is there a significant affect on the likelihood of detection of a platform using command ordered versus terrain limited speeds?
- Study Question 3: Does the method for representing speed (terrain limited versus command ordered) have an effect on target location error (TLE) estimate for a platform?
  - *Issues: platform speed and direction, delay time for steel on target*
  - Focus Question: Is there is a significant difference between dead reckoning algorithms and actual platform location at time t+delta(t) using command ordered versus terrain limited speeds?

Study Methodology

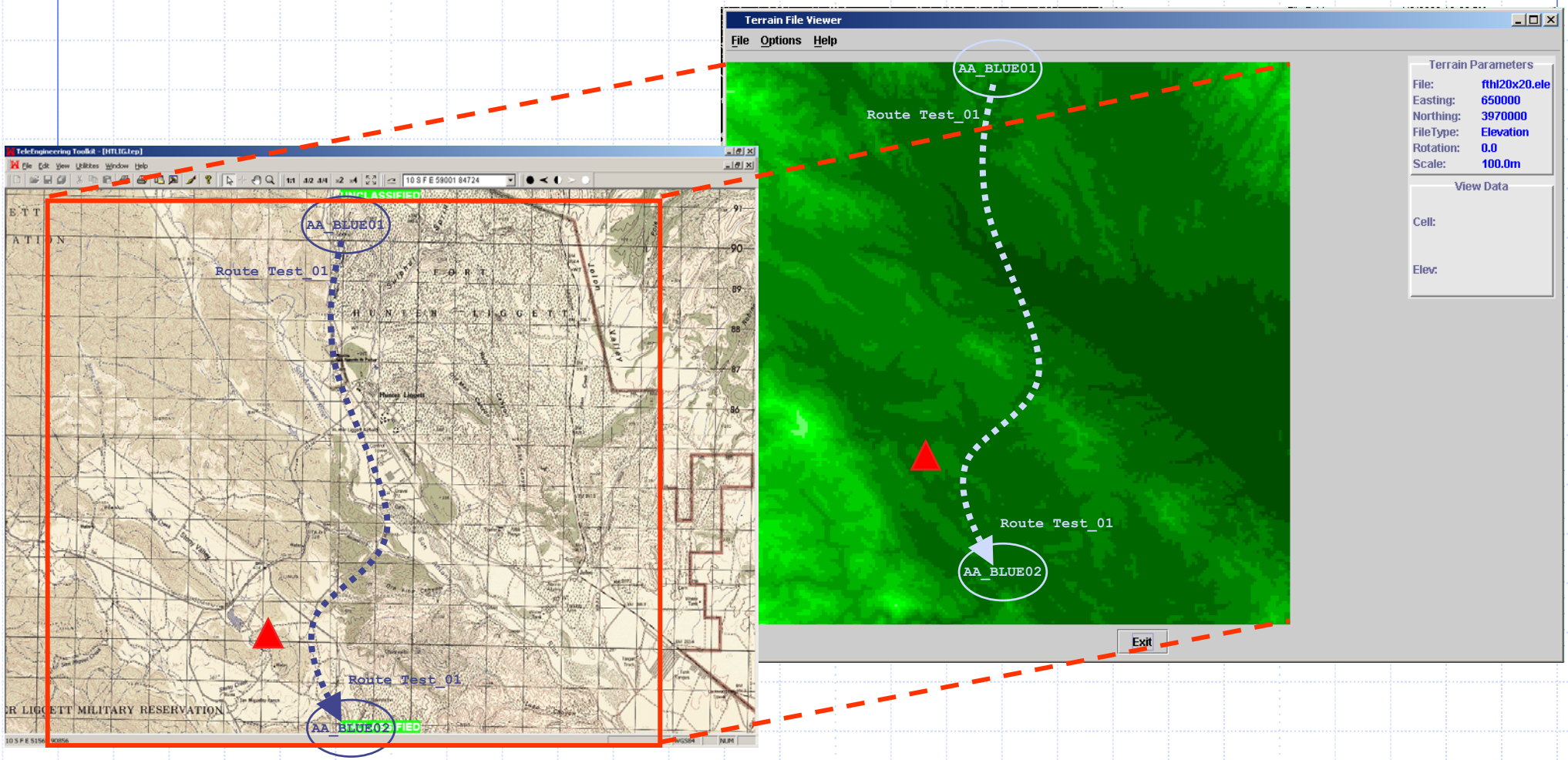
- Established focus questions and MOEs to address study questions
- Developed corresponding hypothesis tests
- Selected variables to use to investigate study question(s)
  - Terrain (elevation, soils, vegetation, weather condition)
  - Vehicles
  - Command ordered speeds
- Developed experimental design to investigate focus questions
  - Randomized block design for ANOVA
  - Paired t-test
  - t-test
- Constructed vignettes (test courses and routes)
- Developed test harness to implement ground movement and capture statistics
- Performed statistical analyses

Study Methodology

- MOEs
  - ability to negotiate terrain,
  - speed/time to reach objective
  - speed/exposure time related to detection/acquisition
  - platform speed and direction
  - delay time for steel on target

Study Methodology

- Fort Hunter Liggett, CA



Study Methodology

- Test Environments
  - Vehicles/Units
    - Vehicles
      - BIN01 (1): High Mobility Tracked Vehicle (M1A1)
      - BIN02 (2): Medium Mobility Tracked Vehicle (M113A2)
      - BIN03 (3): Low Mobility Tracked Vehicle (AVLB)
      - BIN04 (4): High Mobility Wheeled Vehicle (MTV)
      - BIN05 (5): Medium Mobility Wheeled Vehicle (M985)
      - BIN06 (6): Low Mobility Wheeled Vehicle (M911)
      - BIN07 (7): High Mobility Towed Vehicle (MTV-M1095)
      - BIN08 (8): Medium Mobility Towed Vehicle (M985-M989)
      - BIN09 (9): Low Mobility Towed Vehicle (M911-M747)
    - Units: Tank PLT, Mech Team, Armor Task Force

Study Methodology

- Sample Test Environments
  - Sample soil – vegetation combinations

255_Code	Name	FACC	USCS	STP	STGJ
29	Areal Physiography: DA010 Ground Surface Element; STP: CH	DA010	CH	12	280
43	Areal Vegetation: EA010 Cropland; FTC: Grazing, STP: ML	EA010	ML	9	375
79	Areal Vegetation: EA040 Orchard; STP: OL	EA040	OL	11	469
81	Areal Vegetation: EA040 Orchard; STP: MH	EA040	MH	13	471
92	Areal Vegetation: EA050 Vineyard; STP: SM	EA050	SM	7	479
94	Areal Vegetation: EA055 Hops; STP: ML	EA055	ML	9	495
115	Areal Vegetation: EB010 Grassland; STP: MH, VEG: Grassland with scattered trees	EB010	MH	13	541
124	Areal Vegetation: EB020 Scrub / Brush / Bush; BUD: Dense (>50%), STP: SW	EB020	SW	5	589
162	Areal Vegetation: EC030 Trees; STP: ML, VEG: Deciduous	EC030	ML	9	635
182	Areal Vegetation: EC030 Trees; STP: CH, VEG: Coniferous	EC030	CH	12	624
196	Areal Vegetation: EC030 Trees; STP: ML, VEG: Mixed Trees	EC030	ML	9	649

  - Weather
    - Dry
  - Elevations
    - Flat terrain
    - Undulating terrain

Study Question 1

- Study Question 1: Does the method for representing speed (terrain limited versus command ordered) have an effect on synchronization of mobile forces?
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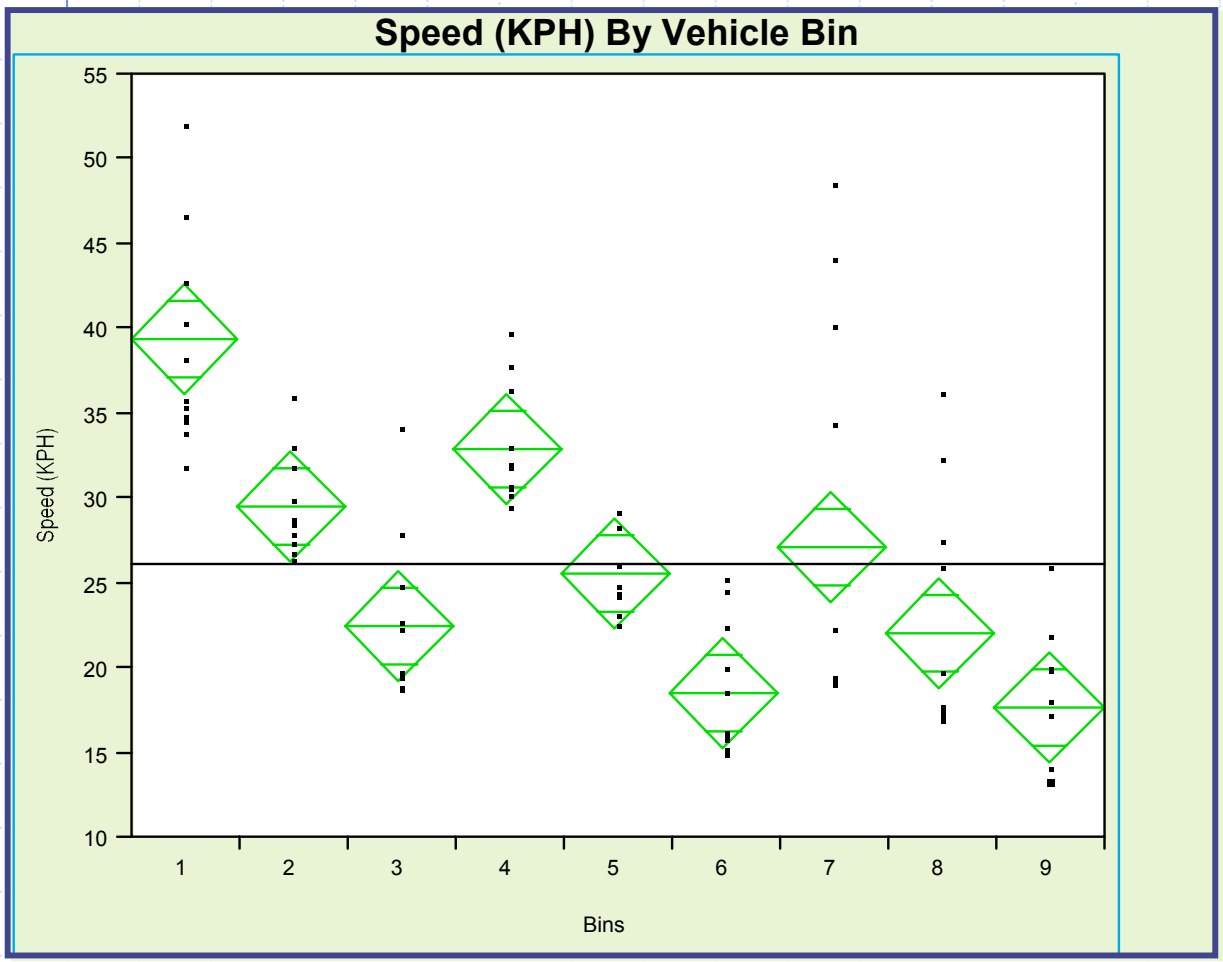
Analysis



Means and Std Deviations (KPH)

Bin	Reps	Mean	Std Dev
1	12	39.4807	6.3364
2	12	29.5314	2.8514
3	12	22.4679	4.6634
4	12	32.9655	3.2982
5	12	25.5242	2.2743
6	12	18.4906	3.7199
7	12	27.1259	11.3725
8	12	22.0597	6.7665
9	12	17.6605	4.0765

Analysis

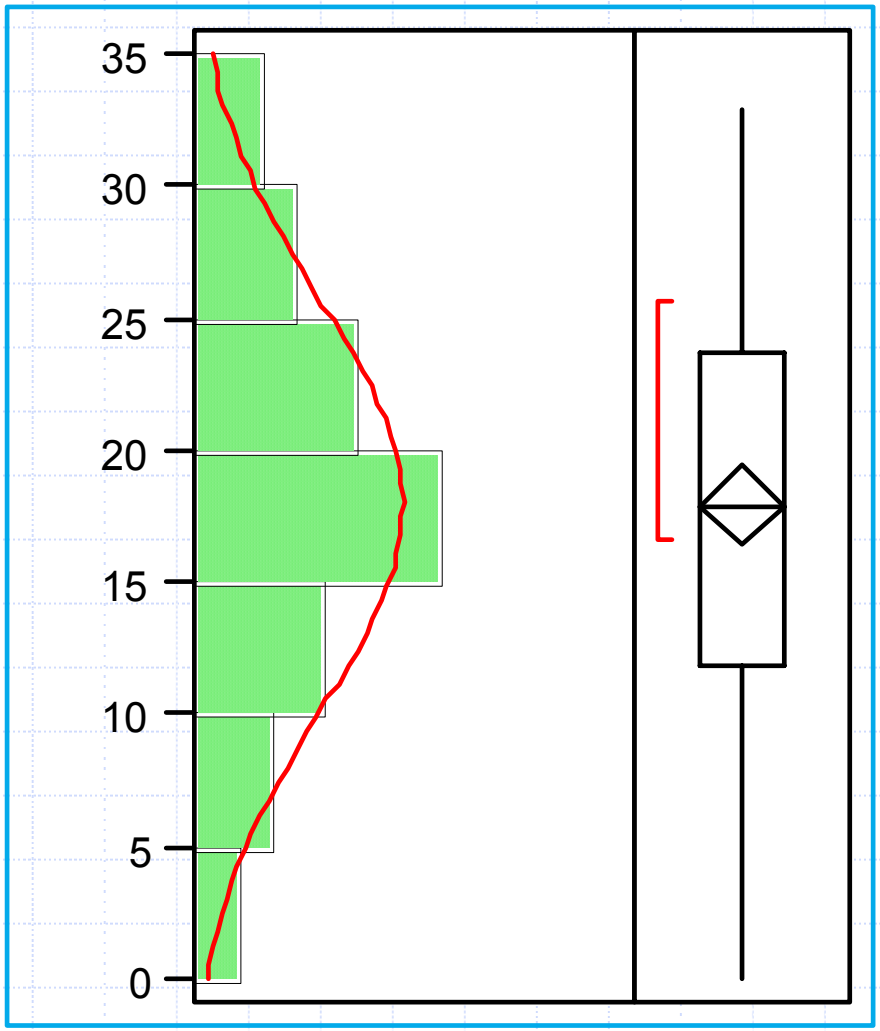
Test Mean = value
Hypothesized Value = 0 KPH
Actual Estimate = 17.9943 KPH

t Test
Test Statistic = 23.8952
Prob > |t| <.0001
Prob > t <.0001
Prob < t 1.0000

Result: Reject null hypothesis and conclude there is a statistically significant difference between Command Ordered (CO) speed and Terrain Limited (TL) speed, where TL speed is capped by the CO speed.

CO speed = 40 KPH; 9 vehicle bins

Distribution of Difference in Speed (KPH)
Command Ordered - MIN(Command Ordered, Terrain Limited)



Analysis

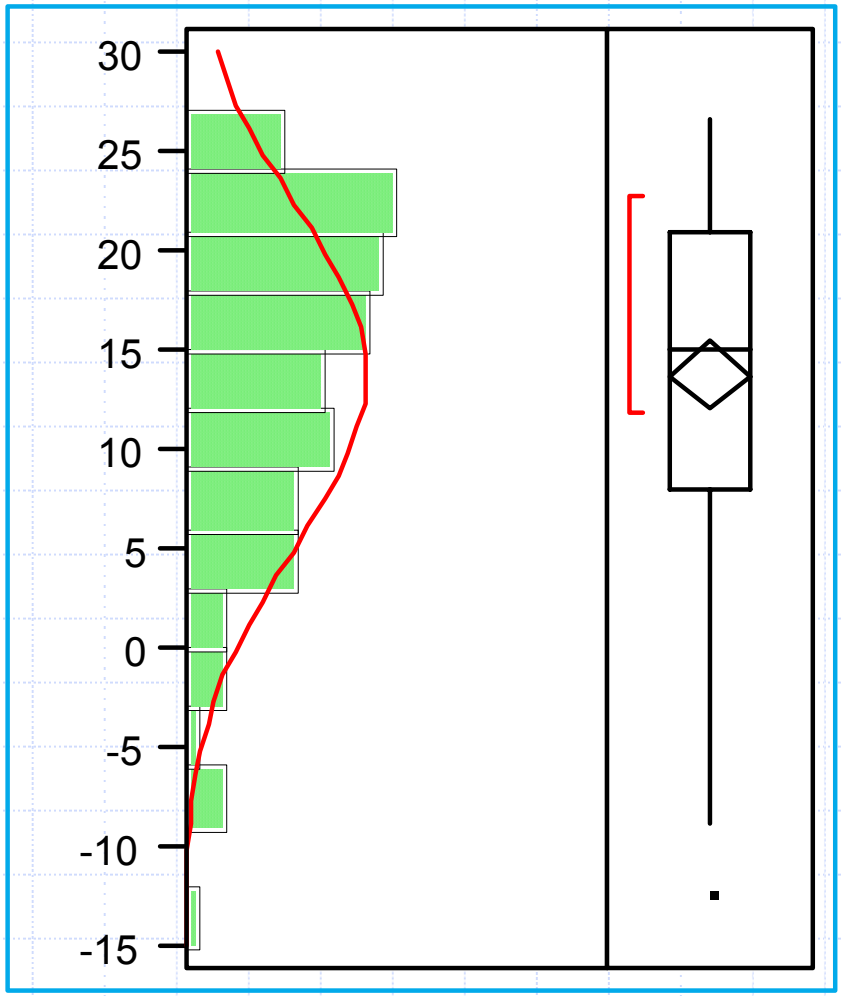
Test Mean = value
Hypothesized Value = 0
Actual Estimate = 13.8548

t Test
Test Statistic = 16.6687
Prob > |t| <.0001
Prob > t <.0001
Prob < t 1.0000

Result: Reject null hypothesis and conclude there is a statistically significant difference between Command Ordered (CO) speed and Terrain Limited (TL) speed.

CO speed = 40 KPH; 9 vehicle bins

Distribution of Difference in Speed (KPH)
Command Ordered – Terrain Limited



Analysis

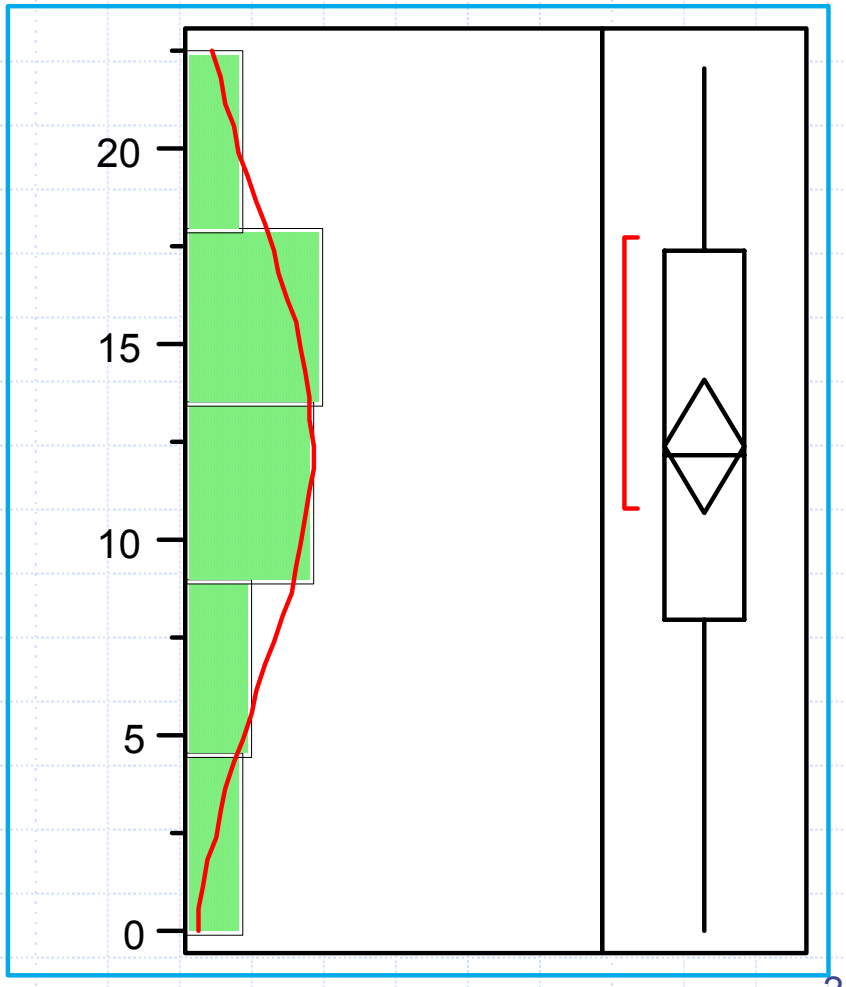
Test Mean=value
Hypothesized Value = 0
Actual Estimate = 12.4038 KPH

t Test
Test Statistic= 14.5228
Prob > |t| <.0001
Prob > t <.0001
Prob < t 1.0000

Result: Reject null hypothesis and conclude there is a statistically significant difference between Command Ordered (CO) speed and Terrain Limited (TL) speed.

CO speed = 40 KPH; bin 1, 2, 4, 5

Distribution of Difference in Speed (KPH)
Command Ordered – MIN(CO, Terrain Limited)
(Combat Vehicles)



Analysis

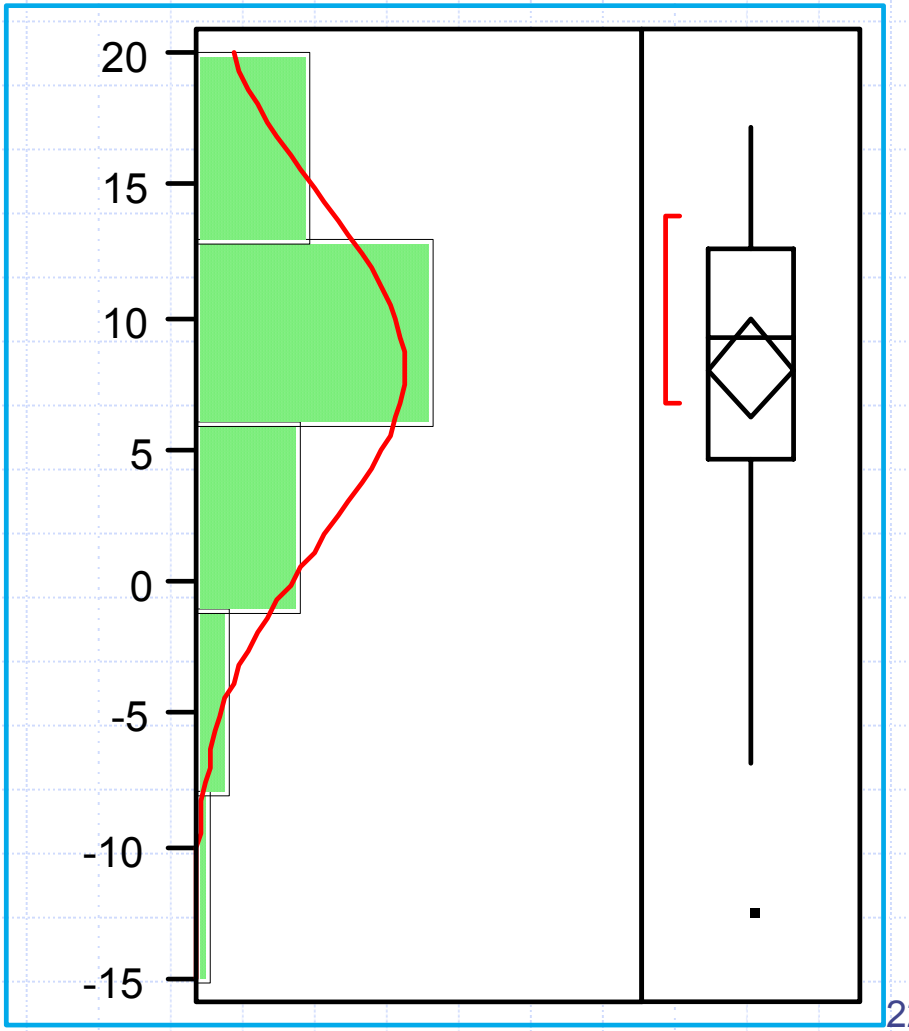
Test Mean = value
Hypothesized Value = 0 KPH
Actual Estimate = 8.12454 KPH

t Test
Test Statistic = 8.7032
Prob > |t| <.0001
Prob > t <.0001
Prob < t 1.0000

Result: Reject null hypothesis and conclude there is a statistically significant difference between Command Ordered (CO) speed and Terrain Limited (TL) speed.

CO speed = 40 KPH; bin 1, 2, 4, 5

Distribution of Difference in Speed (KPH)
Command Ordered – Terrain Limited
(Combat Vehicles)



Analysis

Response: _Stacked_CO,MIN(CO,TL))(KPH)

Summary of Fit

RSquare	0.821186
RSquare Adj	0.813374
Root Mean Square Error	4.567922
Mean of Response	31.00284
Observations (or Sum Wgts)	216

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Movement Method	1	1	17484.959	837.9677	<.0001
Bins	8	8	2254.898	13.5083	<.0001

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	9	19739.856	2193.32	105.1149
Error	206	4298.377	20.87	Prob>F
C Total	215	24038.234		<.0001

Result: Conclude there is a statistically significant difference in using Command Ordered versus Terrain Limited speeds. Conclude blocking on vehicle bins was successful in partitioning variability

Analysis

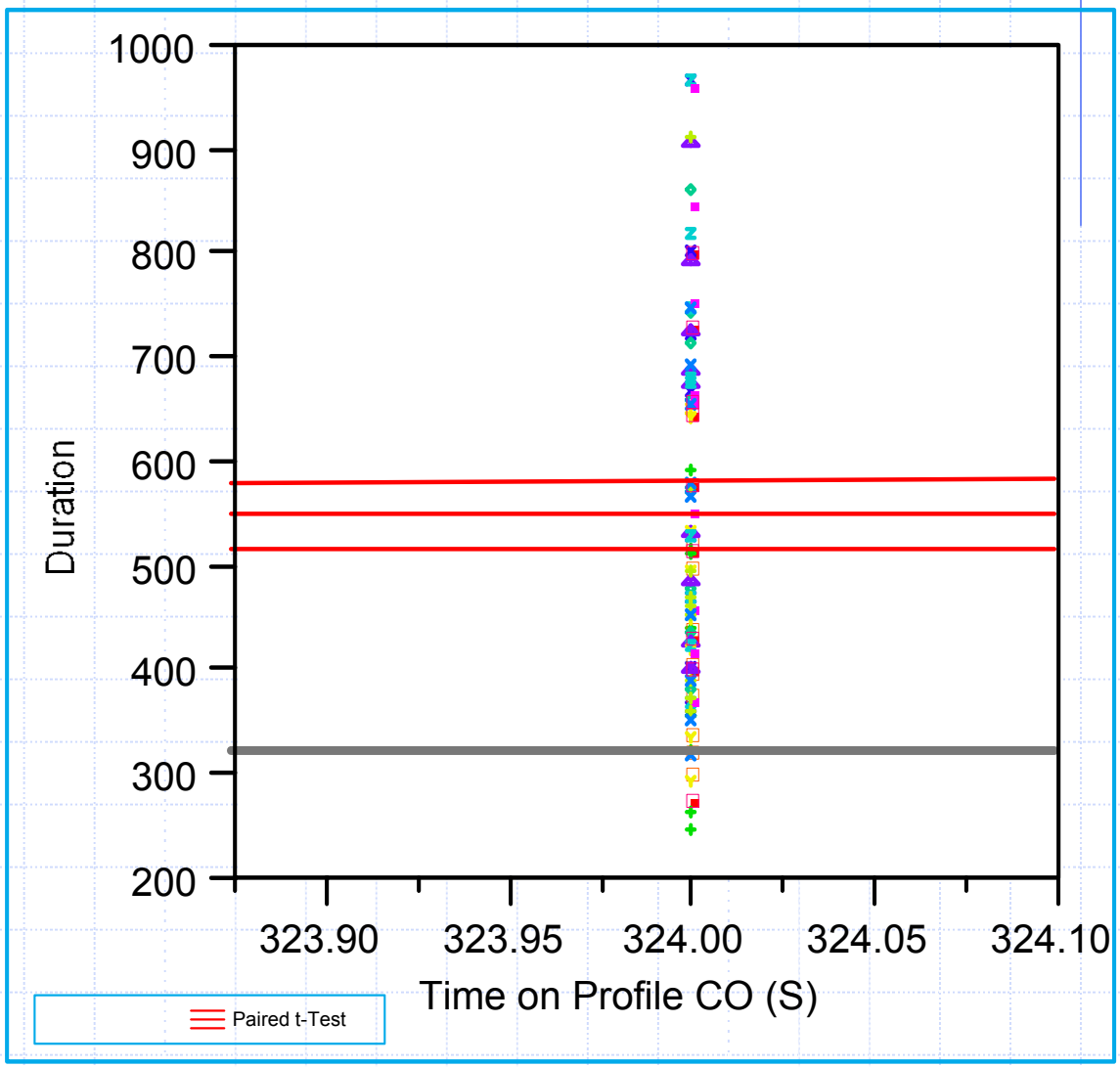
Paired t-Test
Time on Profile CO (S) - Duration

Mean Difference	-225.722	
	Prob > |t|	<.0001
Std Error	16.8978	Prob > t1.0000
t-Ratio	-13.3581	Prob < t<.0001
DF	107	

Result: Reject null hypothesis and conclude there is a statistically significant difference in time to reach objective in Command Ordered (CO) speed versus Terrain Limited (TL) speed. (Takes longer to reach objective using TL).

CO speed = 40 KPH; 9 vehicle bins
Distance to objective = 3600 m

Time to Reach Objective (s)
Terrain Limited versus Command Ordered



Summary

Emerging results indicate that mobility models such as the Standard Mobility API can effect the performance of vehicles and units in an analytical model (COMBAT^{XXI}) thus, providing a richer study environment to analyze the effects of doctrine, vehicle capabilities, and information processing.

Recommendations

- Develop additional levels to the Standard Mobility API
- Establish a set of criteria to implement in current/legacy M&S for improved analysis based on movement and maneuver of ground vehicles
- Continue further investigation of study questions
- Implement studies in more extensive vignettes/scenarios to address the “bigger picture” questions of force synchronization and effects on C4ISR

Questions?