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

MOVES Open House
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MAJ Simon R. Goerger, USA
srgoerge@nps.navy.mil
(831) 656 - 3733

Dr. Niki C. Goerger, ERDC
niki.goerger@trac.nps.navy.mil
(831) 656 - 3751

Mr. David Durda, TRAC
durda@trac.wsmr.army.mil
(505) 678 - 3217

Agenda

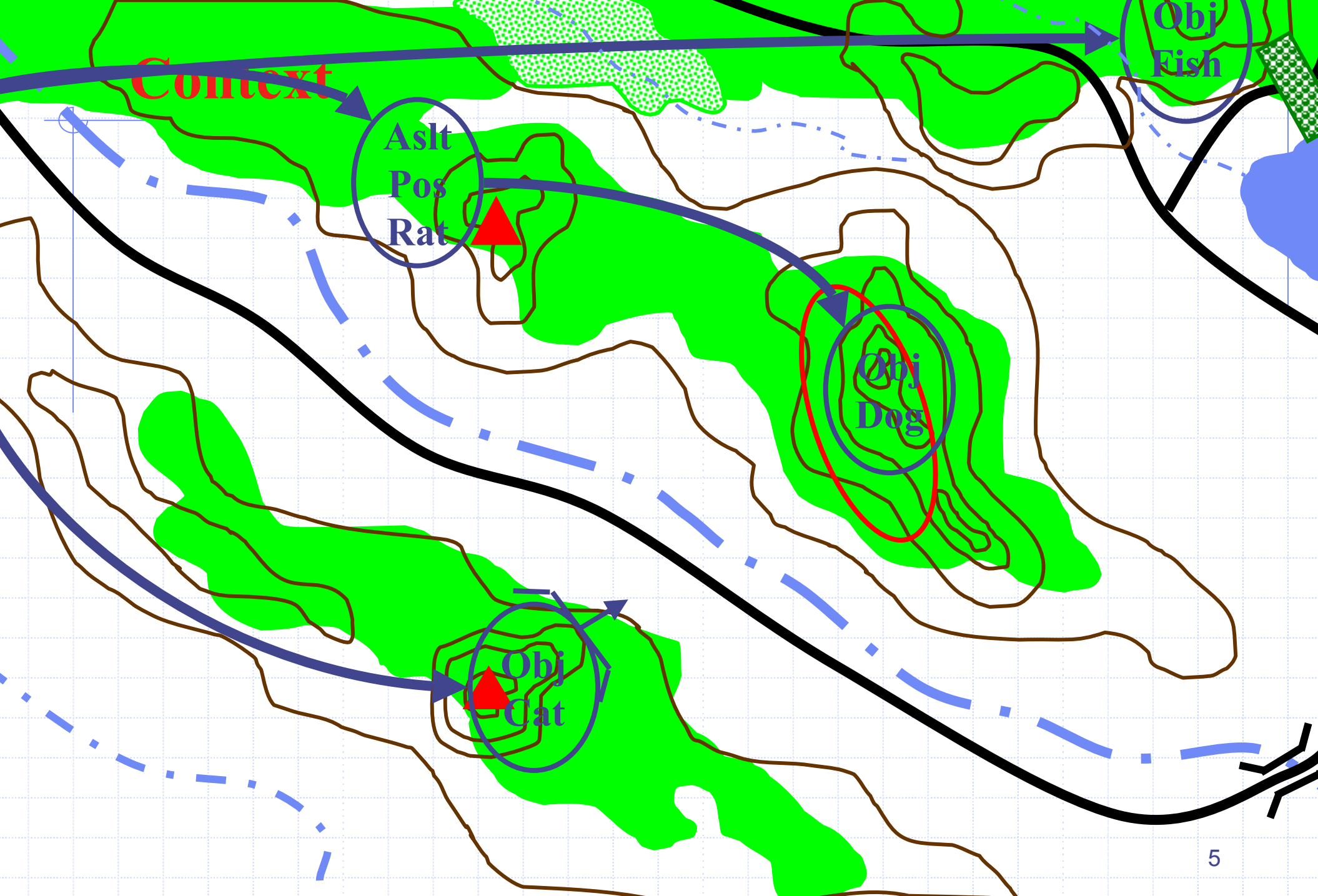
- Issues
- Goal & Payoffs
- Context
- Objectives and Scope
- Study Questions
- Study Methodology
- Analysis
- Summary
- Recommendations

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

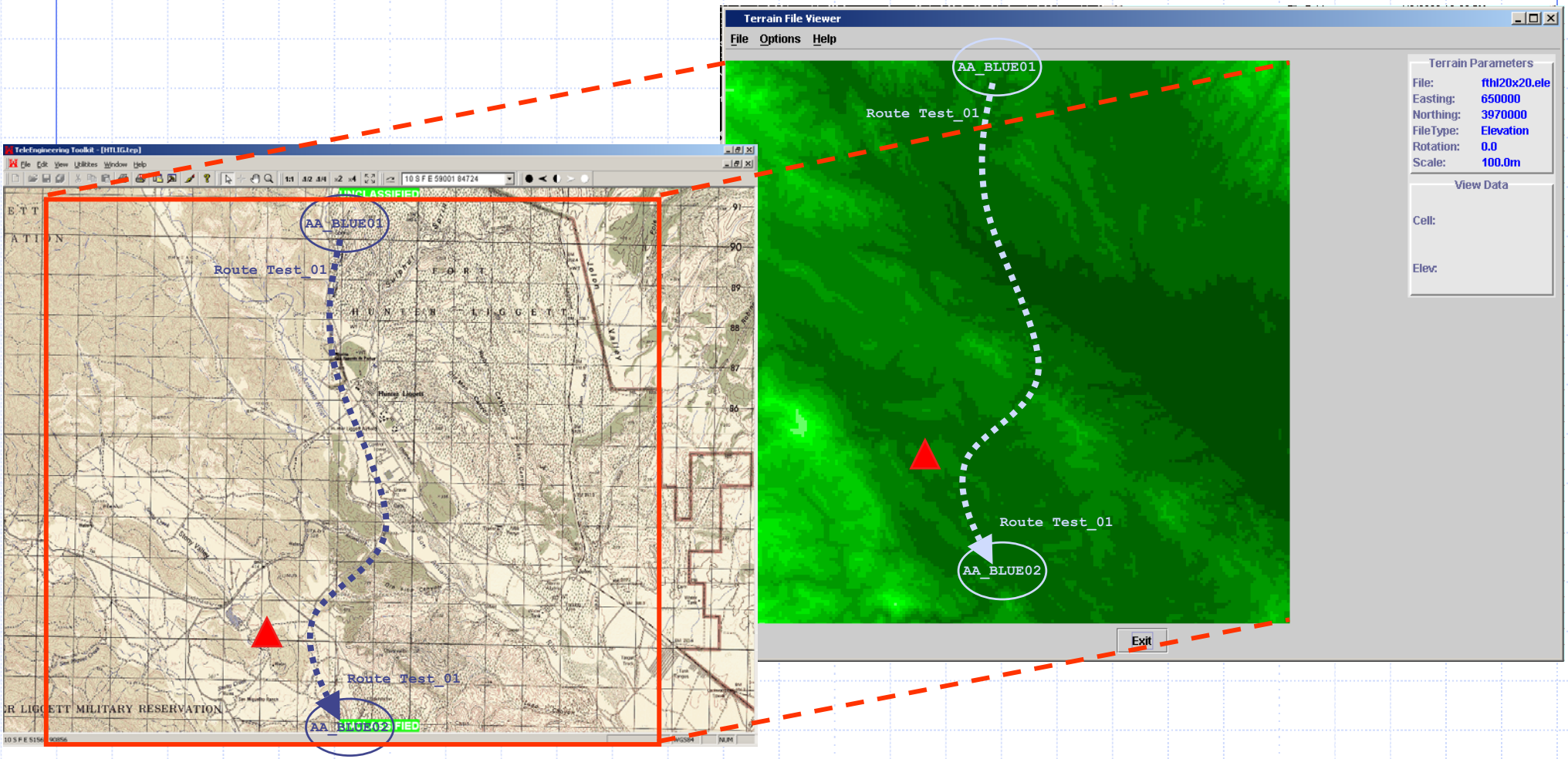
- Established focus questions and MOEs to address study questions
- Developed corresponding hypothesis tests
- Selected variables to use to investigate study question(s)
  - Terrain (elevation, soils, vegetation, weather condition)
  - Vehicles
  - Command ordered speeds
- Developed experimental design 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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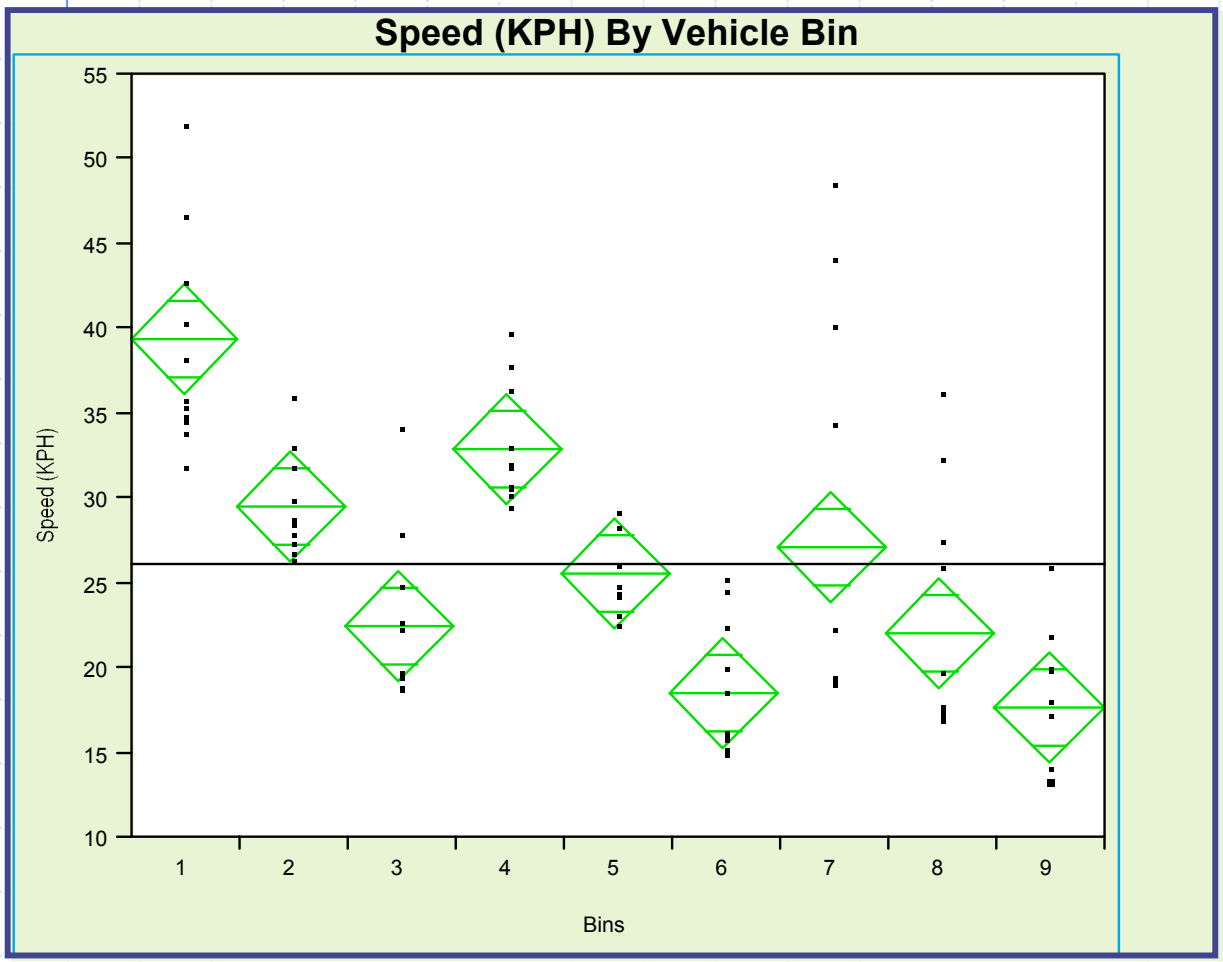
Analysis



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

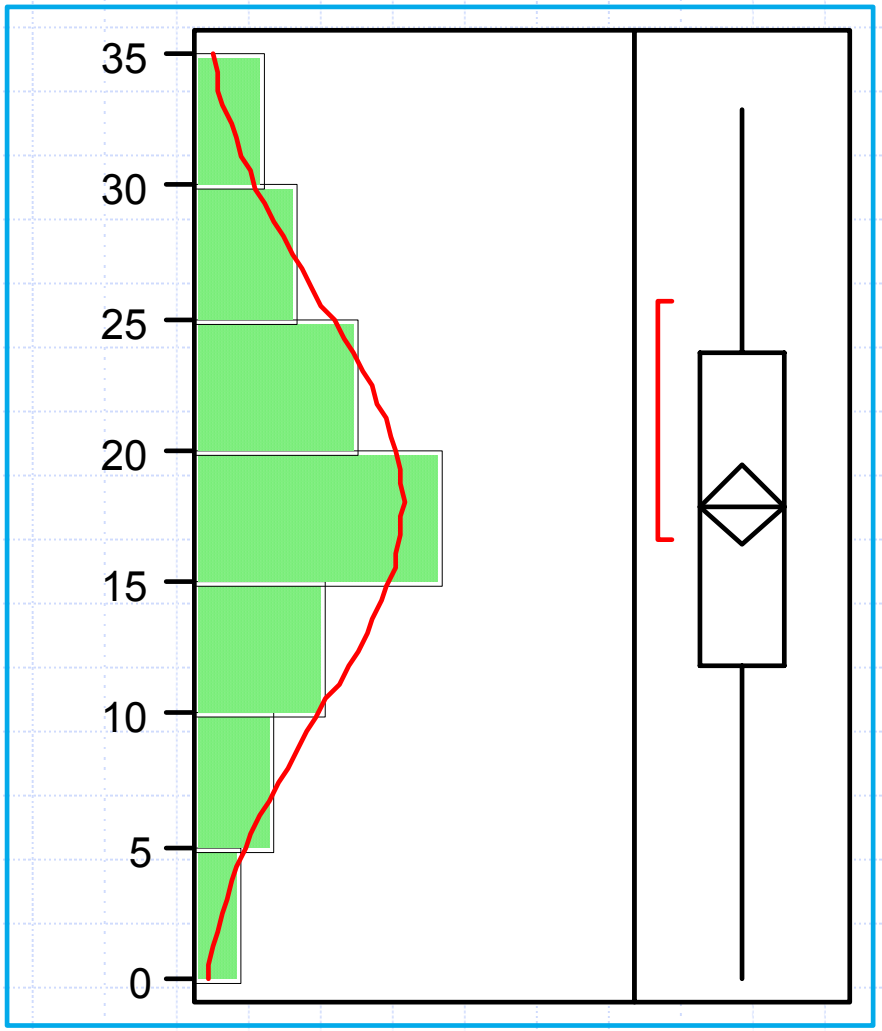
Test Mean = value
Hypothesized Value = 0 KPH
Actual Estimate = 17.9943 KPH

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

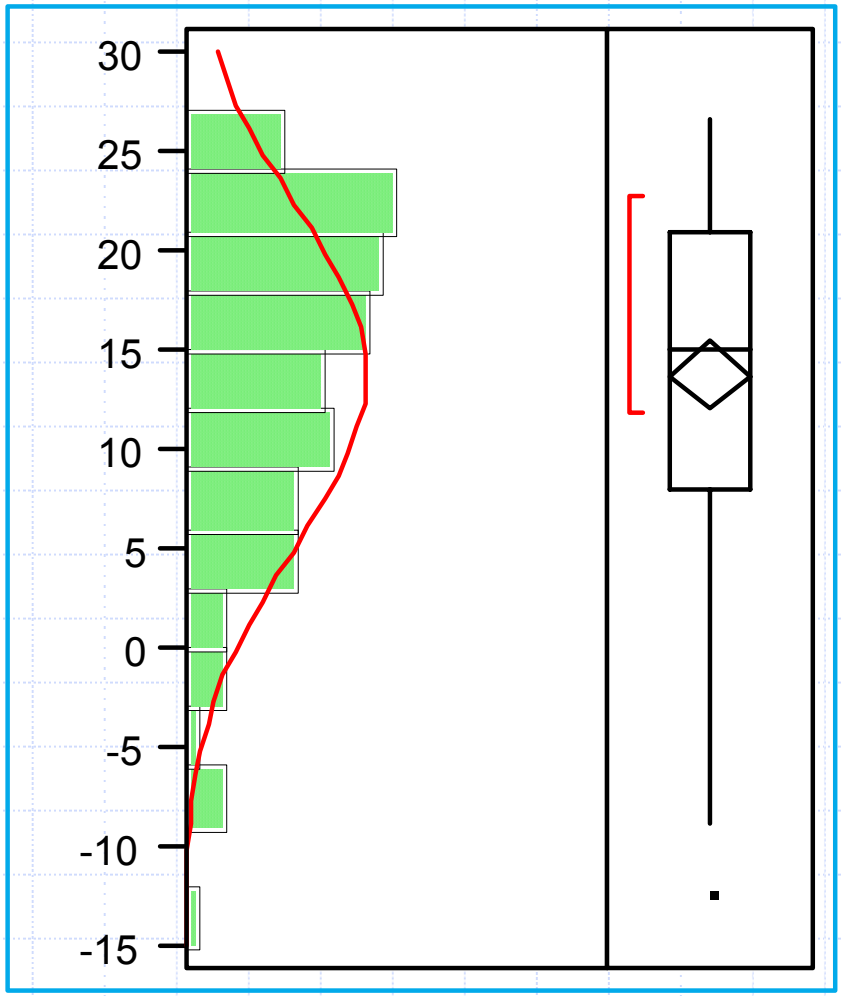
Test Mean = value
Hypothesized Value = 0
Actual Estimate = 13.8548

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

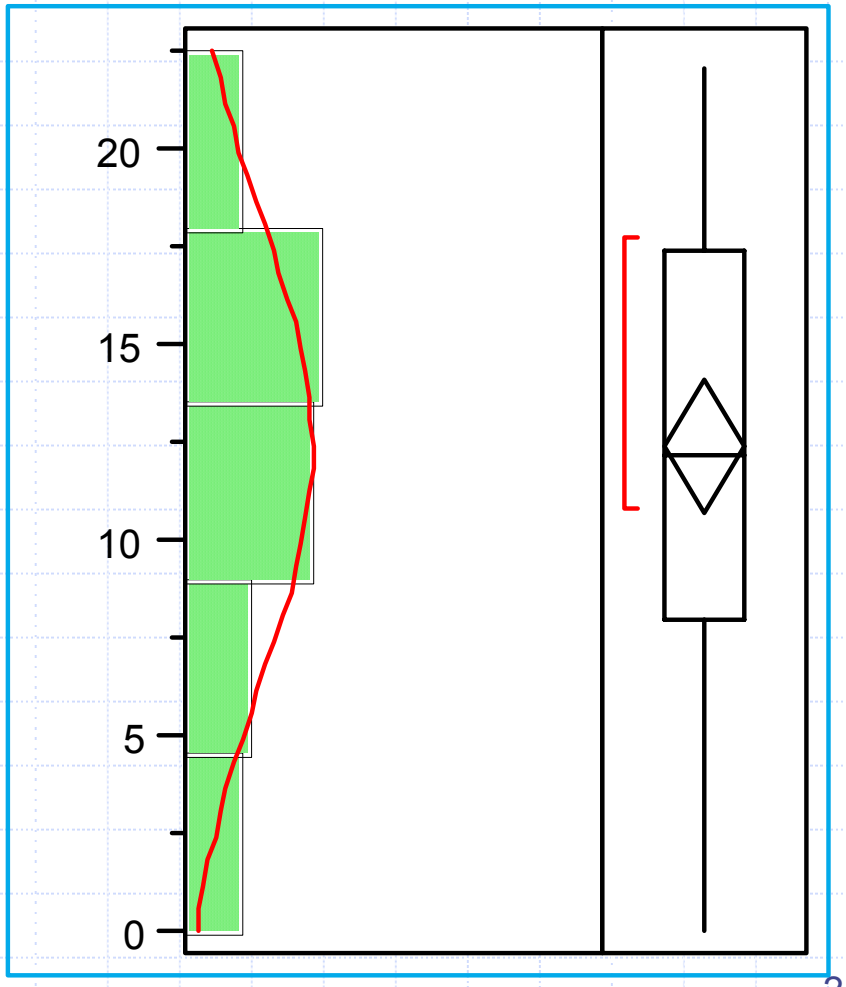
Test Mean=value
Hypothesized Value = 0
Actual Estimate = 12.4038 KPH

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

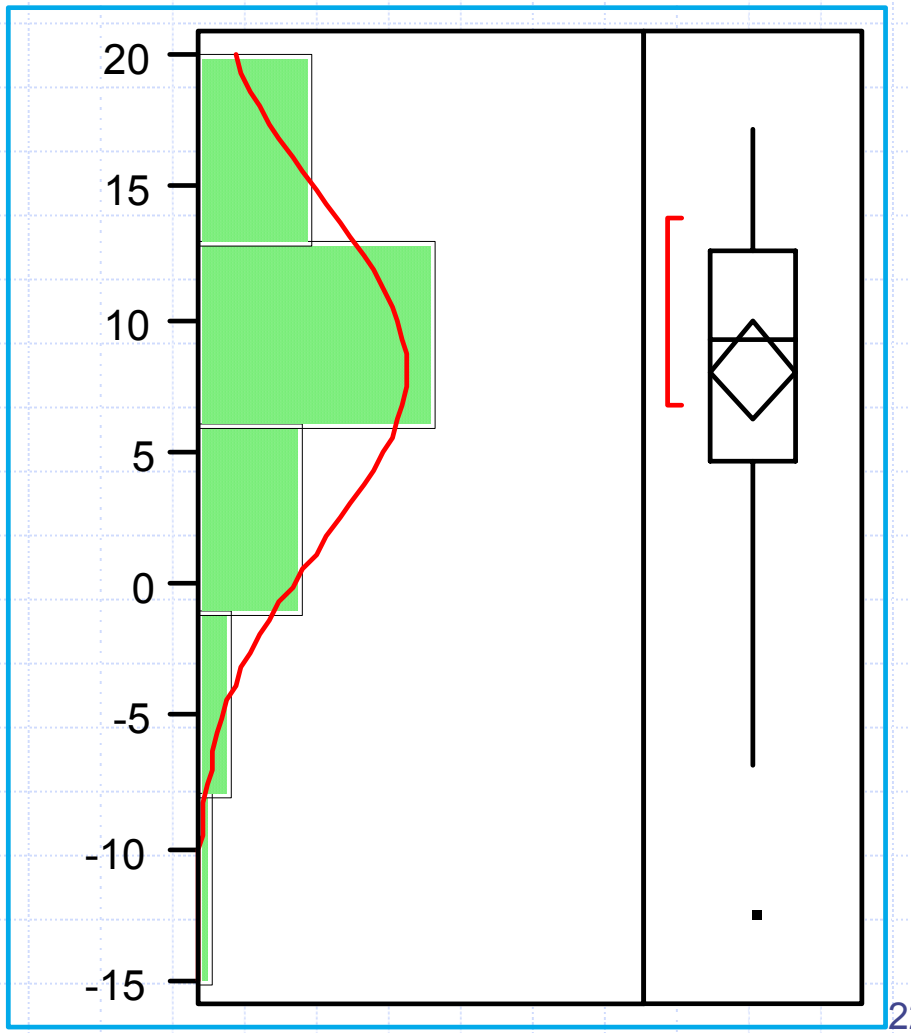
Test Mean = value
Hypothesized Value = 0 KPH
Actual Estimate = 8.12454 KPH

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

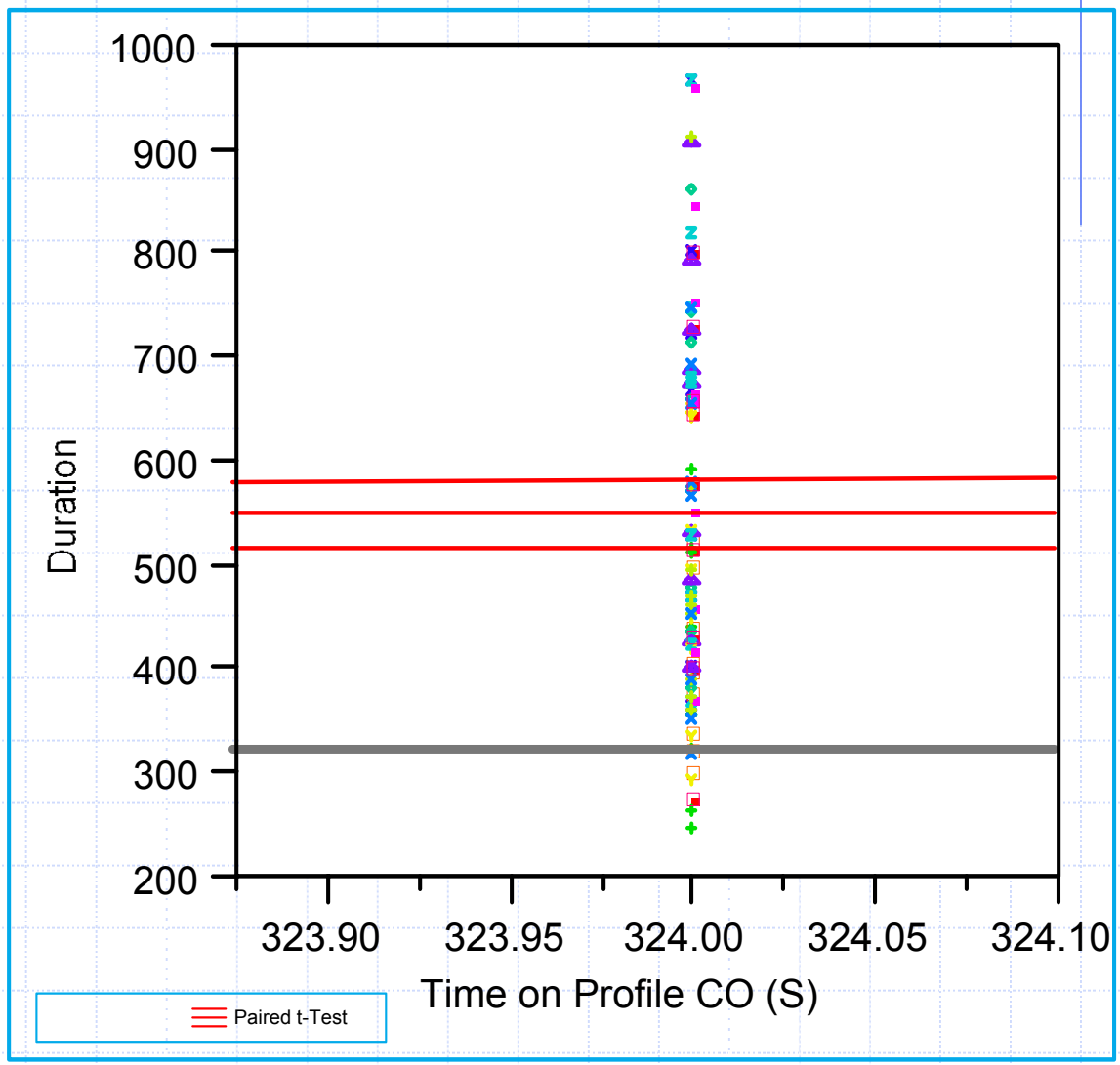
Analysis

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



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?