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Measuring the "Will to Fight" in Simulation

A limited excursion into JWARS "Soft Factors" with an emphasis on Morale and Cohesion

By

Paul J. Bross

Lockheed Martin Corporation

Relationship Between Pol-Mil Plan, EBP/O, ONA & Simulation Tools

Crisis

POL-MIL Plan
- Developed by NSC-PCC
- Frames crisis response and identifies end-state
- Guidance to relevant elements of national power (DIME) to achieve strategic objectives
- Provides: **Strategic Objectives & Policy Aims**

[CPG* simulates Coalition policy decisions]

Effects Based Plan (EBP)
- Developed by SJFHQ and RCC Staff with JIACG* as advisory element
- ONA links DIME Actions to relevant PMESII* Nodes to achieve desired Effects

Operational Net assessment (ONA)
- Developed by SJFHQ Includes:

Linked:
- 27 Desired Effects
- 52 potential DIME Actions
- 1200 Nodes

•Assig

DImE COA Analysis

SEAS
Agent-based DImE Campaign
- Models ONA Actions on PMESII Nodes
  - •interactions, synergy, and muting
- Quantifies Impacts of DIE Actions

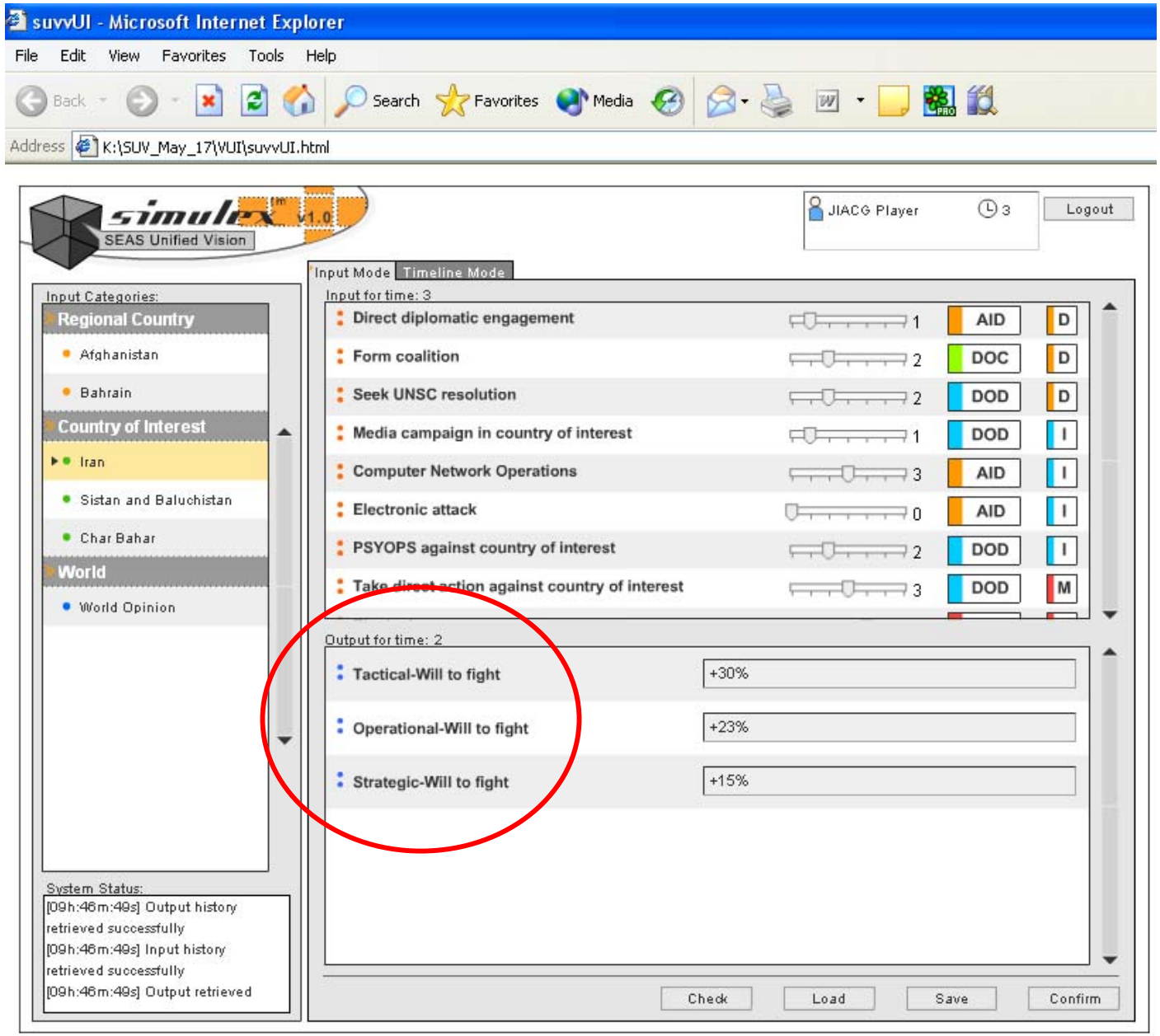
JWARS
Military Campaign
- Models Blue and Red combat
- Quantifies Impacts of Mil Actions

- **Execute Operations**
- **Conduct Effects Assessment**

*CPG: Coalition Planning Group
*JIACG: Joint Inter-Agency Coordination Group
*PMESII: political, military, economic, social, information, and infrastructure

Synthetic Environment for Analysis and Simulation (SEAS)

Input Screen
DIME Actions
Iran



Information Provided
Iran
Will to Fight for prior period

Analytical Tasking

Will to Fight

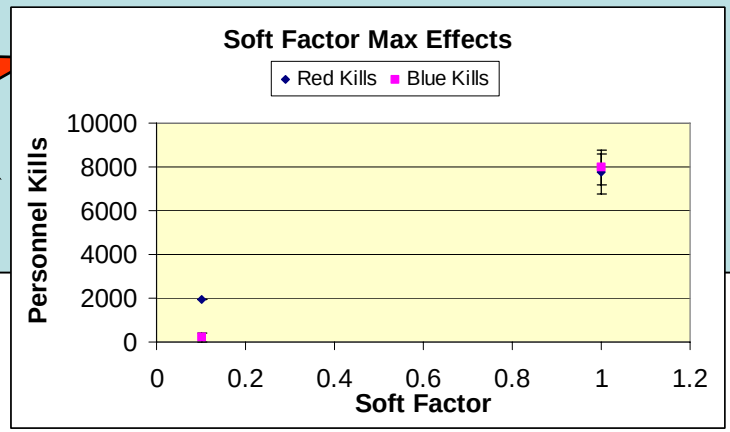
NGIC Factors
Ability to Assimilate
Air Defense
Battle Command
Combat Experience
Combat Service Support
Combined Arms Operations
Fire Support
Intelligence
Joint and Combined Operations
Leadership
Maneuver
Mobility and Survivability
Morale and Cohesion
Power Projection
Readiness
Training

Behaviors
Breakpoints
Rate of Direct Fire
Speed of Maneuver
Suppression of Direct Fire
Suppression of Maneuver Speed
Comms Delay
Planning Delay
Time to Clear Obstacles

Unit Function
Combat
Combat Support
Combat Service

Ranking
Elite
Standard
Militia

Combat



- What is the impact of the “Will to Fight” on the combat outcomes?
- How sensitive is JWARS to the NGIC Morale and Cohesion Soft Factor?
- Determine if it will be worthwhile to pursue linkages between JWARS and SEAS to represent sociological effects on combat units and vice versa

AT

Analytical Approach

- Step 1
  - Examine the foundation for the Soft Factors with emphasis on Morale and Cohesion
- Step 2
  - Determine if any elements could be addressed without simulation
- Step 3
  - Design and conduct appropriate simulation experiments

Soft Factor Fundamentals (1)

NGIC Factors

Ability to Assimilate
Air Defense
Battle Command
Combat Experience
Combat Service Support
Combined Arms Operations
Fire Support
Intelligence
Joint and Combined Operations
Leadership
Maneuver
Mobility and Survivability
Morale and Cohesion
Power Projection
Readiness
Training

- **National Ground Intelligence Center (NGIC) rates foreign countries on 16 factors**
- **NGIC does not rate US forces**
- **Methodology is Unclassified but Results are Classified**
- **NGIC rates for current, near future, far future time frames**
- **Each factor comprised of sub-components for scoring**

Soft Factor Fundamentals (2)

Unit Function
Combat
Combat Support
Combat Service

No difference for RED and BLUE

Ranking
Elite
Standard
Militia

- **Unit Function based on role in combat**
- **Combat units rated at 1.0**
- **All other units rated below 1.0**
- **In general: CBT = 1.0 > CS > CSS**
- **No data source other than the analyst**

- **Unit Ranking based on expertise**
- **Elite units ranked at 1.0**
- **All other units rated below 1.0**
- **In general: E = 1.0 > S > M**
- **No data source other than the analyst**

Soft Factor Fundamentals (3)

NGIC Factors
Ability to Assimilate
Air Defense
Battle Command
Combat Experience
Combat Service Support
Combined Arms Operations
Fire Support
Intelligence
Joint and Combined Operations
Leadership
Maneuver
Mobility and Survivability
Morale and Cohesion
Power Projection
Readiness
Training

Ranking
Elite
Standard
Militia

Unit Function
Combat
Combat Support
Combat Service

Behaviors
Breakpoints
Rate of Direct Fire
Speed of Maneuver
Suppression of Direct Fire
Suppression of Maneuver Speed

$$SF_{Behavior} = \left(1-\left(N_{\%} * \left(1-N\right)\right)\right) * \left(1-\left(R_{\%} * \left(1+R\right)\right)\right) * \left(1-\left(F_{\%} * \left(1-F\right)\right)\right)$$

Soft Factor Equation

$$SF_{Behavior} = \left(1-\left(N_{\%} * \left(1-N\right)\right)\right) * \left(1-\left(R_{\%} * \left(1-R\right)\right)\right) * \left(1-\left(F_{\%} * \left(1-F\right)\right)\right)$$

SF = Soft Factor Value, $0 \leq SF \leq 1$

where 0 = Totally Ineffective and 1 = Totally Effective

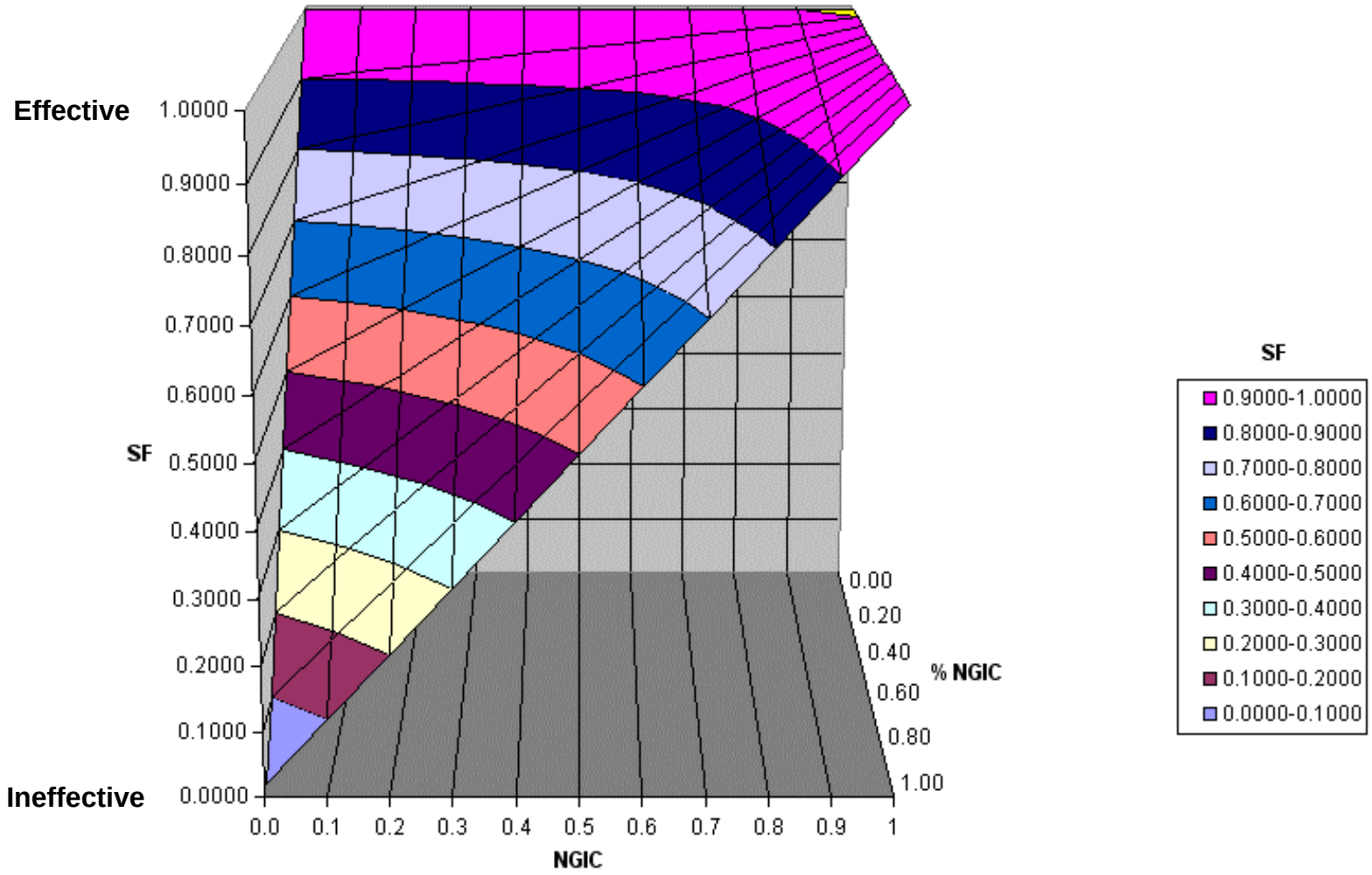
- $N_{\%}$ = amount of composite NGIC score applied, $0 \leq N_{\%} \leq 1$
- N = normalized composite NGIC score, $0 \leq N \leq 1$
- $R_{\%}$ = amount of Ranking Factor applied, $0 \leq R_{\%} \leq 1$
- R = Ranking Factor , $0 \leq R \leq 1$
- $F_{\%}$ = amount of Combat Function score applied, $0 \leq F_{\%} \leq 1$
- F = normalized Combat Function score, $0 \leq F \leq 1$

Soft Factor for Elite Combat Units

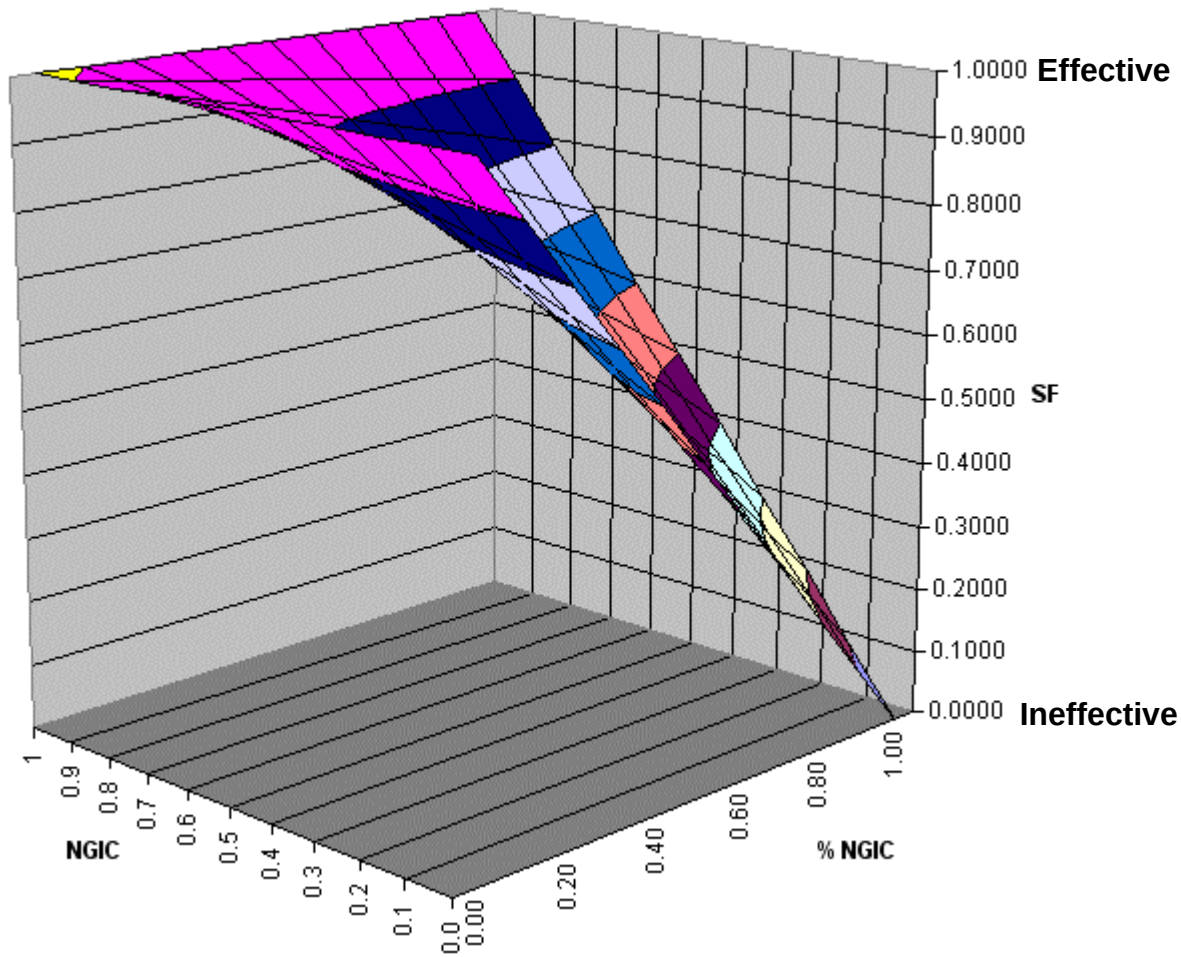
$$SF_{Behavior} = \left(1-\left(N_{\%} * \left(1-N\right)\right)\right) * \left(1-\left(R_{\%} * \left(1-R\right)\right)\right) * \left(1-\left(F_{\%} * \left(1-F\right)\right)\right)$$

N	$N_{\%}$ 0.0000	0.1000	0.2000	0.3000	0.4000	0.5000	0.6000	0.7000	0.8000	0.9000	1.0000
0.0000	1.0000	0.9000	0.8000	0.7000	0.6000	0.5000	0.4000	0.3000	0.2000	0.1000	0.0000
0.1000	1.0000	0.9100	0.8200	0.7300	0.6400	0.5500	0.4600	0.3700	0.2800	0.1900	0.1000
0.2000	1.0000	0.9200	0.8400	0.7600	0.6800	0.6000	0.5200	0.4400	0.3600	0.2800	0.2000
0.3000	1.0000	0.9300	0.8600	0.7900	0.7200	0.6500	0.5800	0.5100	0.4400	0.3700	0.3000
0.4000	1.0000	0.9400	0.8800	0.8200	0.7600	0.7000	0.6400	0.5800	0.5200	0.4600	0.4000
0.5000	1.0000	0.9500	0.9000	0.8500	0.8000	0.7500	0.7000	0.6500	0.6000	0.5500	0.5000
0.6000	1.0000	0.9600	0.9200	0.8800	0.8400	0.8000	0.7600	0.7200	0.6800	0.6400	0.6000
0.7000	1.0000	0.9700	0.9400	0.9100	0.8800	0.8500	0.8200	0.7900	0.7600	0.7300	0.7000
0.8000	1.0000	0.9800	0.9600	0.9400	0.9200	0.9000	0.8800	0.8600	0.8400	0.8200	0.8000
0.9000	1.0000	0.9900	0.9800	0.9700	0.9600	0.9500	0.9400	0.9300	0.9200	0.9100	0.9000
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Soft Factor affected by NGIC and %NGIC Score

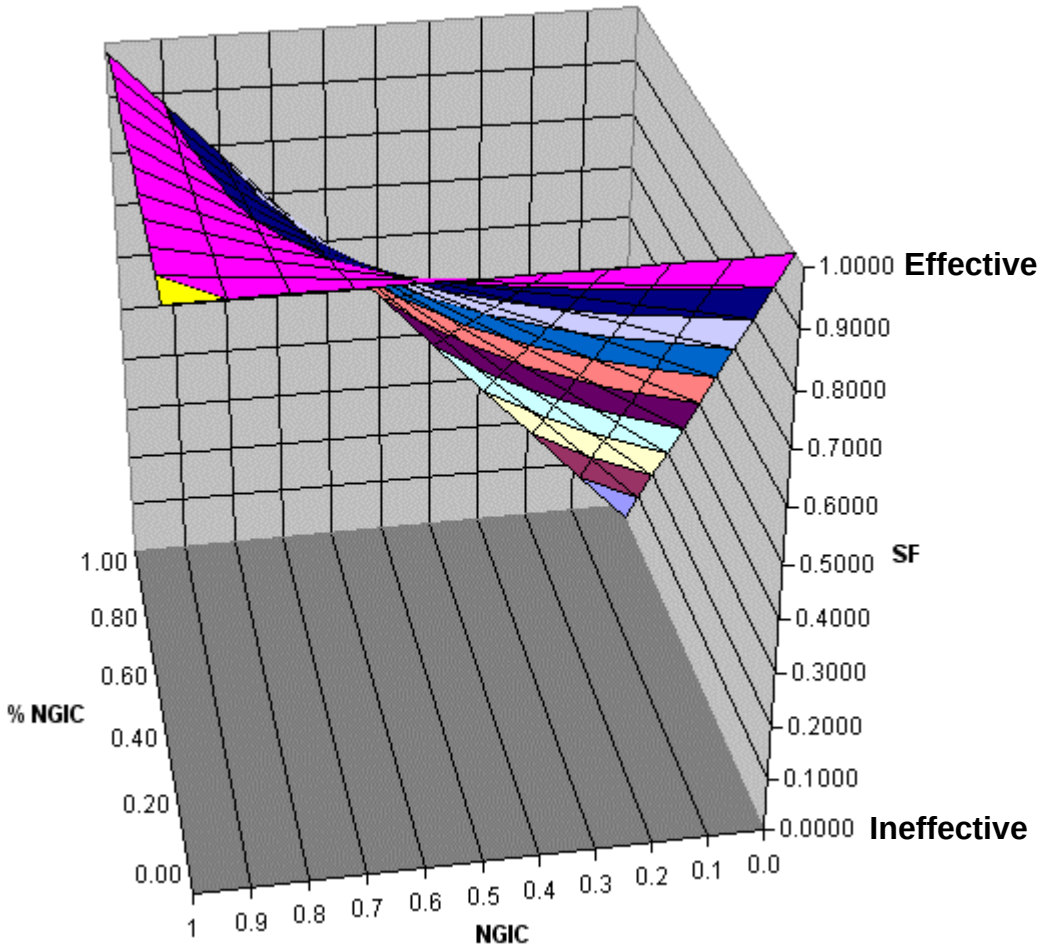


Soft Factor affected by NGIC and %NGIC Score



315° Rotated View

Soft Factor affected by NGIC and %NGIC Score



260° Rotated View, 30° Elevation

Soft Factor Settings

Most Effective

	Combat	Combat Support	Combat Service Support
Elite	1.000	0.600	0.300
Standard	0.700	0.420	0.210
Militia	0.400	0.240	0.120

	Combat	Combat Support	Combat Service Support
Elite	0.500	0.300	0.150
Standard	0.350	0.210	0.105
Militia	0.200	0.120	0.060

	Combat	Combat Support	Combat Service Support
Elite	0.900	0.540	0.270
Standard	0.630	0.378	0.189
Militia	0.360	0.216	0.108

	Combat	Combat Support	Combat Service Support
Elite	0.400	0.240	0.120
Standard	0.280	0.168	0.084
Militia	0.160	0.096	0.048

	Combat	Combat Support	Combat Service Support
Elite	0.800	0.480	0.240
Standard	0.560	0.336	0.168
Militia	0.320	0.192	0.096

	Combat	Combat Support	Combat Service Support
Elite	0.300	0.180	0.090
Standard	0.210	0.126	0.063
Militia	0.120	0.072	0.036

	Combat	Combat Support	Combat Service Support
Elite	0.700	0.420	0.210
Standard	0.490	0.294	0.147
Militia	0.280	0.168	0.084

	Combat	Combat Support	Combat Service Support
Elite	0.200	0.120	0.060
Standard	0.140	0.084	0.042
Militia	0.080	0.048	0.024

	Combat	Combat Support	Combat Service Support
Elite	0.600	0.360	0.180
Standard	0.420	0.252	0.126
Militia	0.240	0.144	0.072

	Combat	Combat Support	Combat Service Support
Elite	0.100	0.060	0.030
Standard	0.070	0.042	0.021
Militia	0.040	0.024	0.012

Most Ineffective

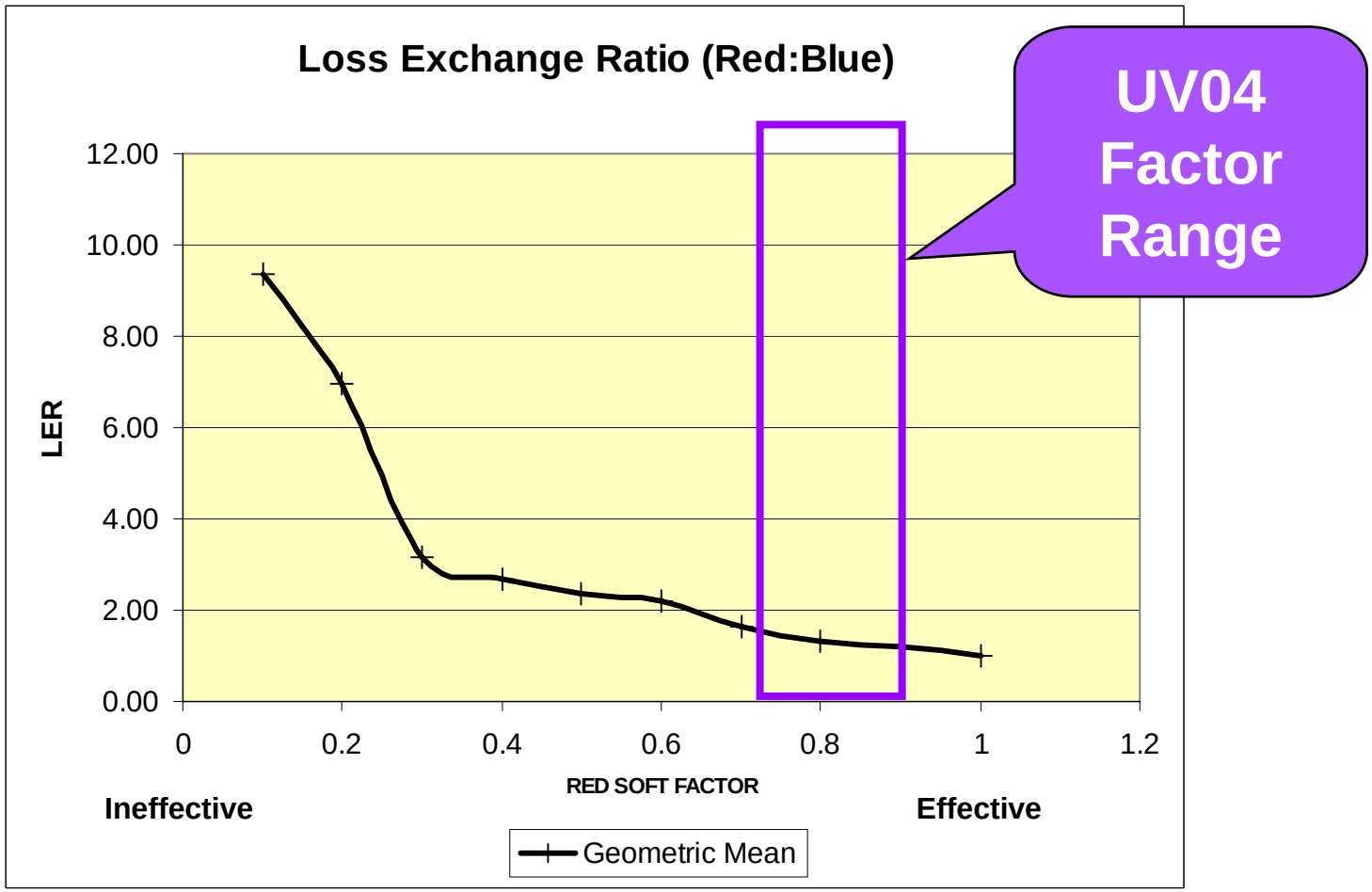
Simulation Experiments (a)

- Screen for Soft Factor Effects
  - Run opposite ends of spectrum (RED: SF = 0.1, SF = 1.0)
  - If first pairing shows major difference, complete the Soft Factor response curve (SF = 0.2, 0.3 …. 0.9)
- Use UV04 Baseline Four 8-23-04 Scenario
  - Final UV04 baseline
  - Focus on RED and BLUE Troop Losses
  - Run 5 replications for each SF setting (n = 5)
- Determine succeeding steps after analyzing results of screening

Loss Exchange Ratio

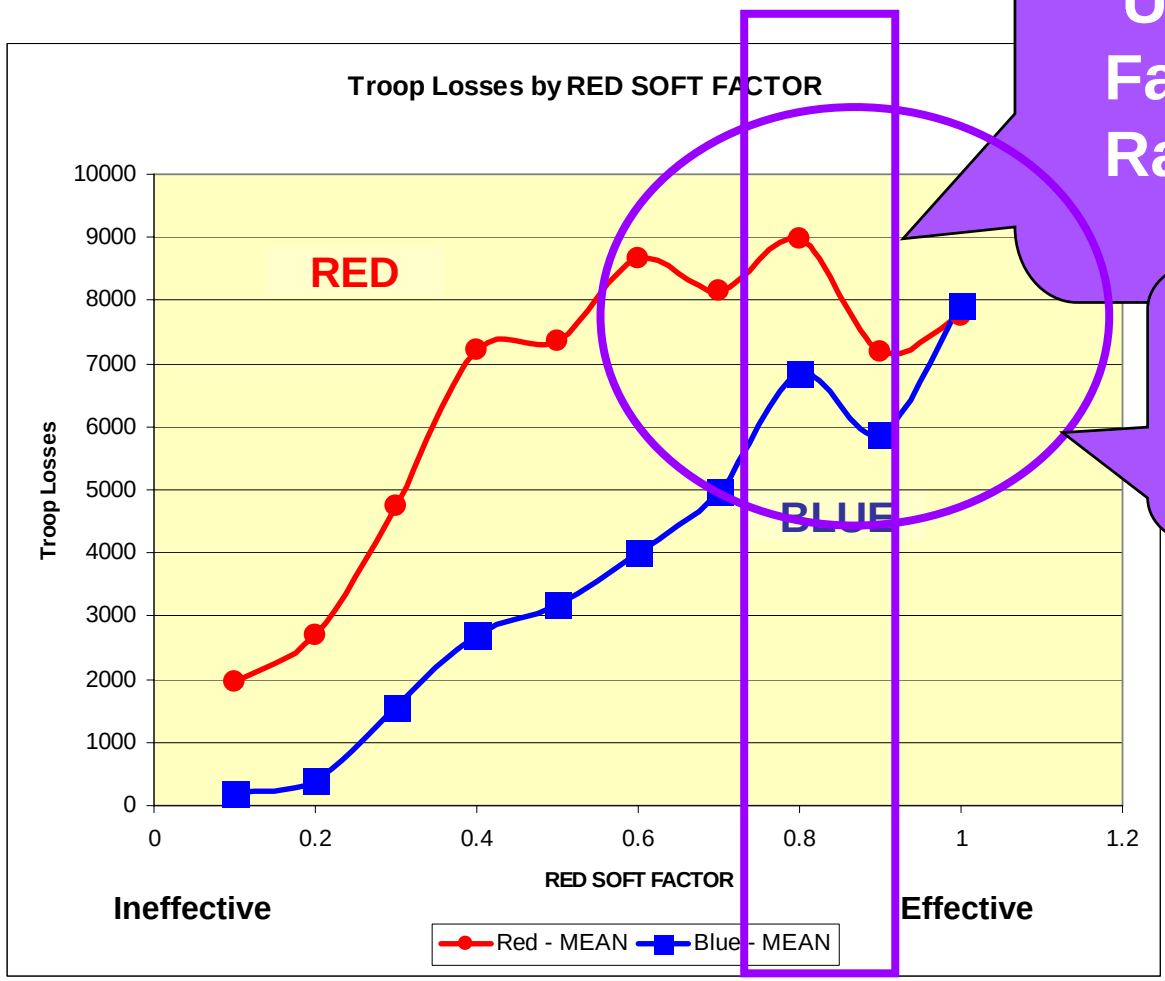
$$LER = \frac{Loss_{RED}}{Loss_{BLUE}}$$

- LER > 1 favors **BLUE**
- LER < 1 favors **RED**



S3a

Personnel Losses



UV04 Factor Range

What is happening here?

S3a

Simulation Experiments (b)

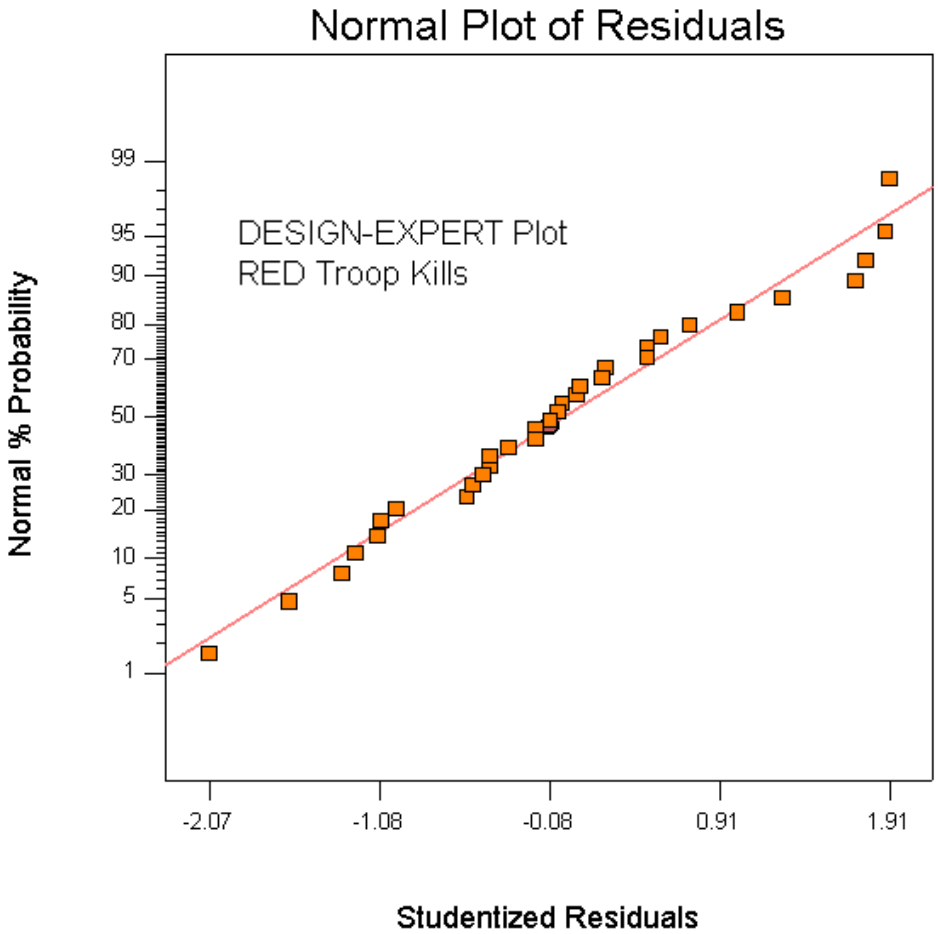
- Investigate the “ripple” effect in the casualty measure as the Soft Factor varies at the upper end of the spectrum
  - Short screening experiment to determine if the five implemented behaviors are the cause
    - Breakpoints
    - Rate of Direct Fire
    - Suppression of Direct Fire
    - Maneuver Speed
    - Suppression of Maneuver Speed
  - Use a one-half replicate of a full factorial design = 16 reps
  - Identify primary behavior influence
  - Identify interaction effects (note: second- and third-order interactions are confounded in this design)
- Graduate to full factorial design (32 points) if time permits

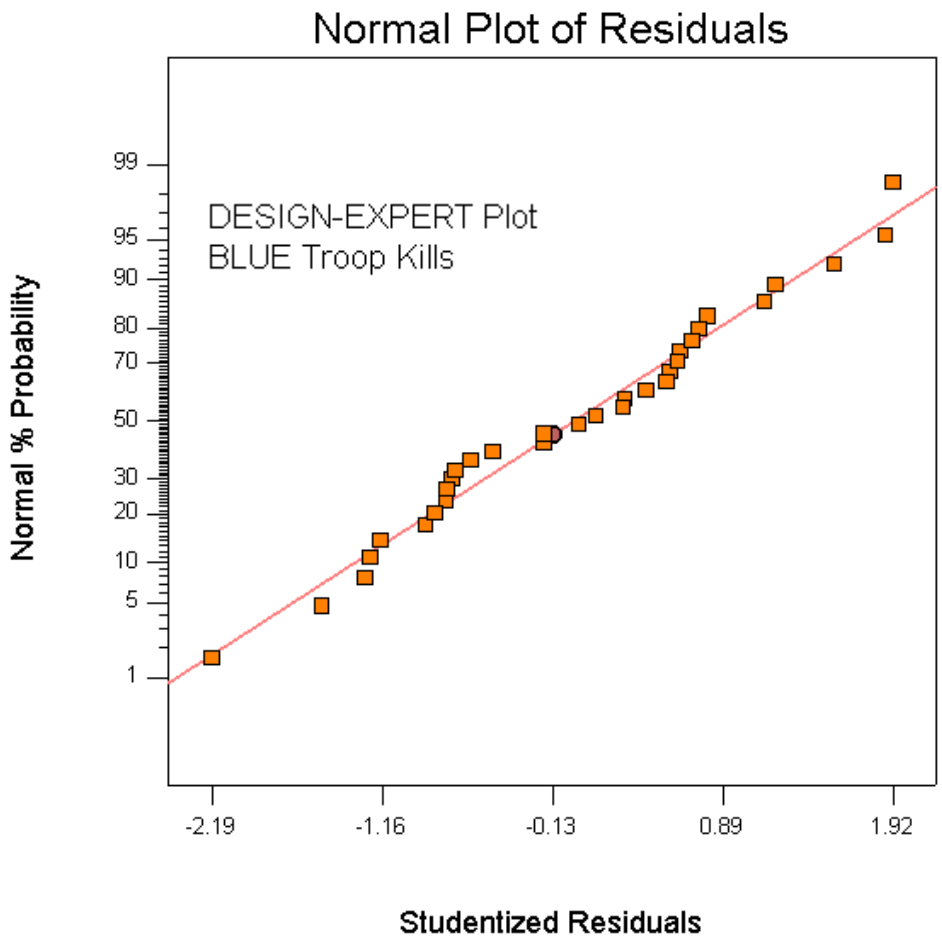
Time permitted!

Design Matrix and Run Results

Behavior Design			Breakpoint	Rate-DF	Spd-Man	Sup-DF	Sup-ManSp	Troop	Kills
STD	RUN		A	B	C	D	E	RED	BLUE
8	1	Block 1	1	1	1	-1	-1	7515	6250
10	2	Block 1	1	-1	-1	1	1	10490	6203
5	3	Block 1	-1	-1	1	-1	-1	7316	5945
2	4	Block 1	1	-1	-1	-1	-1	10256	5788
7	5	Block 1	-1	1	1	-1	1	6135	5792
3	6	Block 1	-1	1	-1	-1	-1	8528	5715
1	7	Block 1	-1	-1	-1	-1	1	8763	5882
9	8	Block 1	-1	-1	-1	1	-1	8481	5609
13	9	Block 1	-1	-1	1	1	1	6439	4836
4	10	Block 1	1	1	-1	-1	1	10615	6078
11	11	Block 1	-1	1	-1	1	1	8736	6488
15	12	Block 1	-1	1	1	1	-1	7221	6483
14	13	Block 1	1	-1	1	1	-1	7501	6257
6	14	Block 1	1	-1	1	-1	1	8636	6203
12	15	Block 1	1	1	-1	1	-1	9732	6049
16	16	Block 1	1	1	1	1	1	8524	5789
21	17	Block 1	1	1	-1	1	1	10028	6115
20	18	Block 1	-1	-1	1	1	-1	7721	5781
31	19	Block 1	1	-1	-1	-1	1	10430	5795
30	20	Block 1	-1	1	-1	-1	1	8850	5786
17	21	Block 1	1	1	1	1	-1	7857	6537
32	22	Block 1	-1	-1	-1	-1	-1	8573	5510
24	23	Block 1	-1	-1	-1	1	1	8708	5751
19	24	Block 1	1	-1	1	1	1	8530	5184
18	25	Block 1	-1	1	1	1	1	6127	6133
28	26	Block 1	-1	-1	1	-1	1	5860	5959
29	27	Block 1	1	1	-1	-1	-1	9736	5206
27	28	Block 1	1	-1	1	-1	-1	8037	6836
25	29	Block 1	1	1	1	-1	1	8801	5673
26	30	Block 1	-1	1	1	-1	-1	7309	5812
23	31	Block 1	1	-1	-1	1	-1	9966	5127
22	32	Block 1	-1	1	-1	1	-1	8642	5853

Normal Plot of Residuals

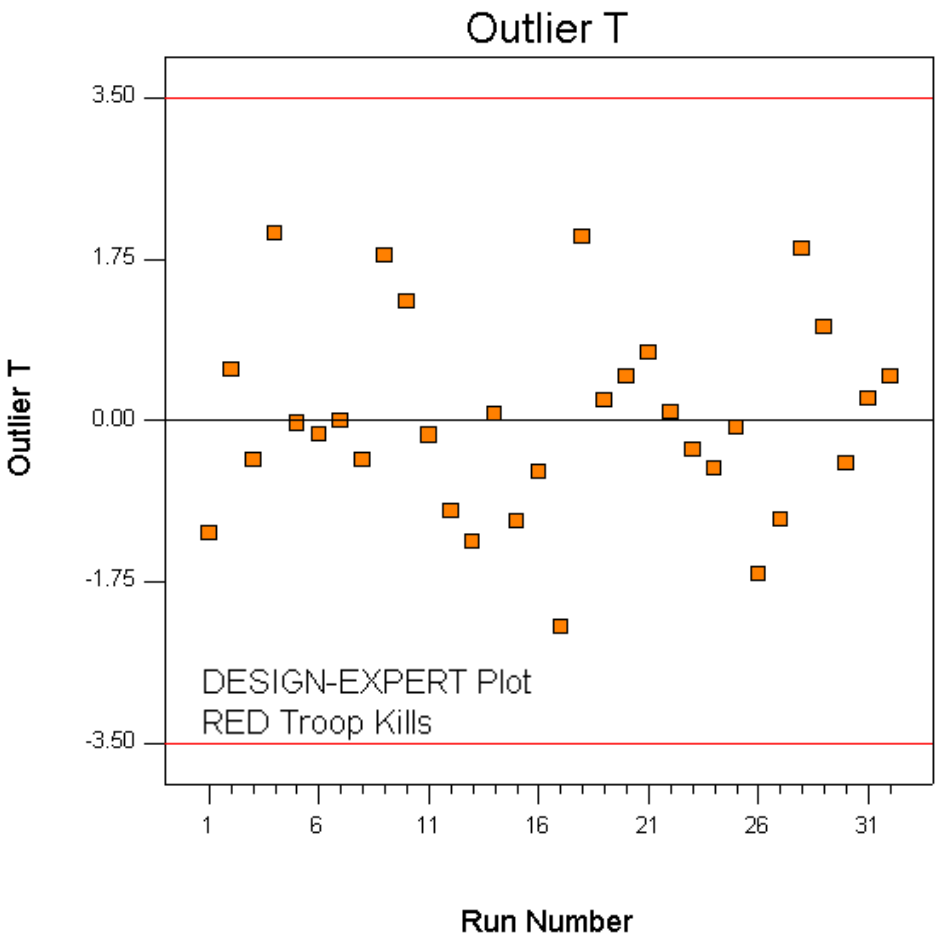




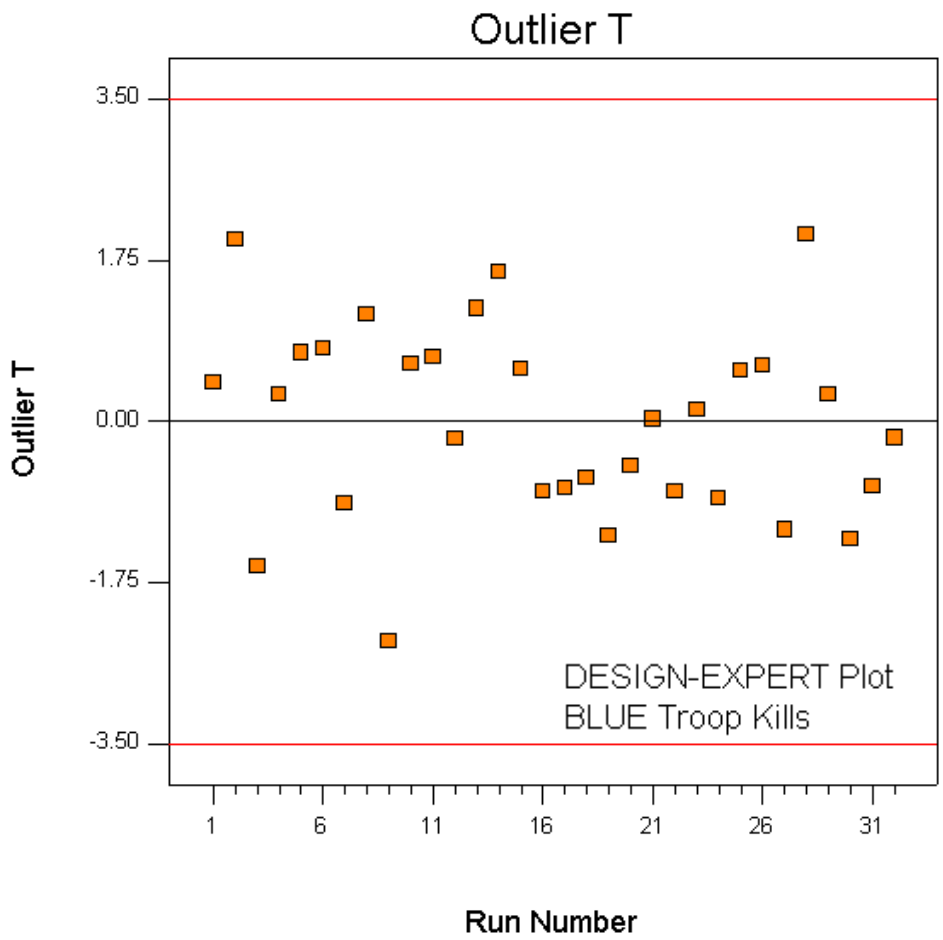
RED

BLUE

Outlier T

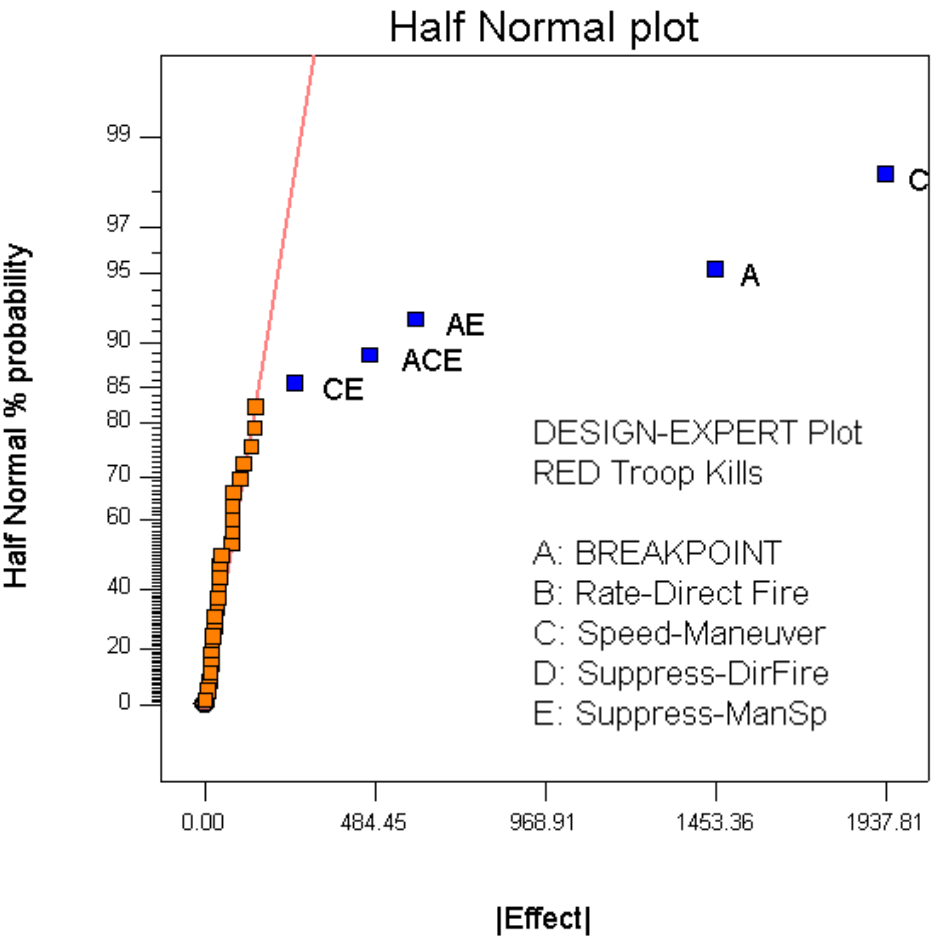


RED

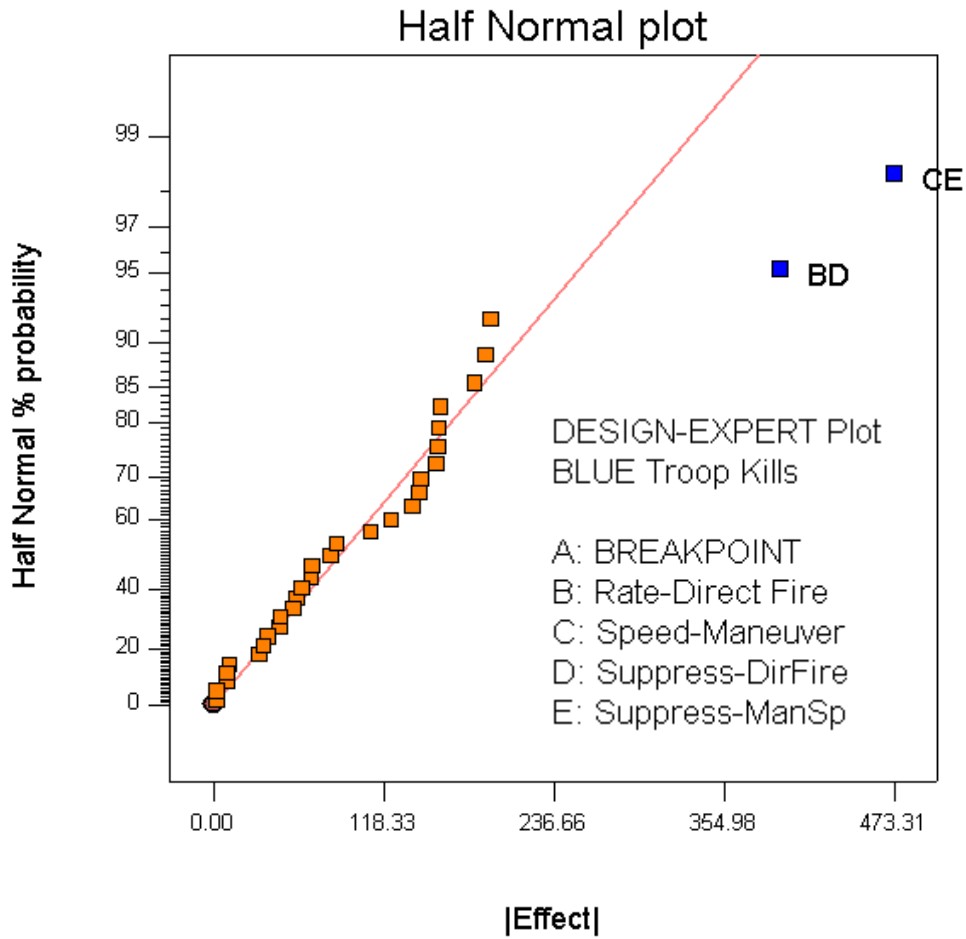


BLUE

Significant Effects



RED



BLUE

RED Soft Factor Response

ANOVA for Selected Factorial Model

Analysis of variance table [Partial sum of squares]

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	52202222.22	7	7457460.32	182.57	< 0.0001	significant
A	16885313.28	1	16885313.28	413.38	< 0.0001	
C	30040938.28	1	30040938.28	735.45	< 0.0001	
E	51280.03	1	51280.03	1.26	0.2736	
AC	15268.78	1	15268.78	0.37	0.5467	
AE	2896222.78	1	2896222.78	70.90	< 0.0001	
CE	533286.28	1	533286.28	13.06	0.0014	
ACE	1779912.78	1	1779912.78	43.58	< 0.0001	
Residual	980327.75	24	40846.99			
Cor Total	53182549.97	31				

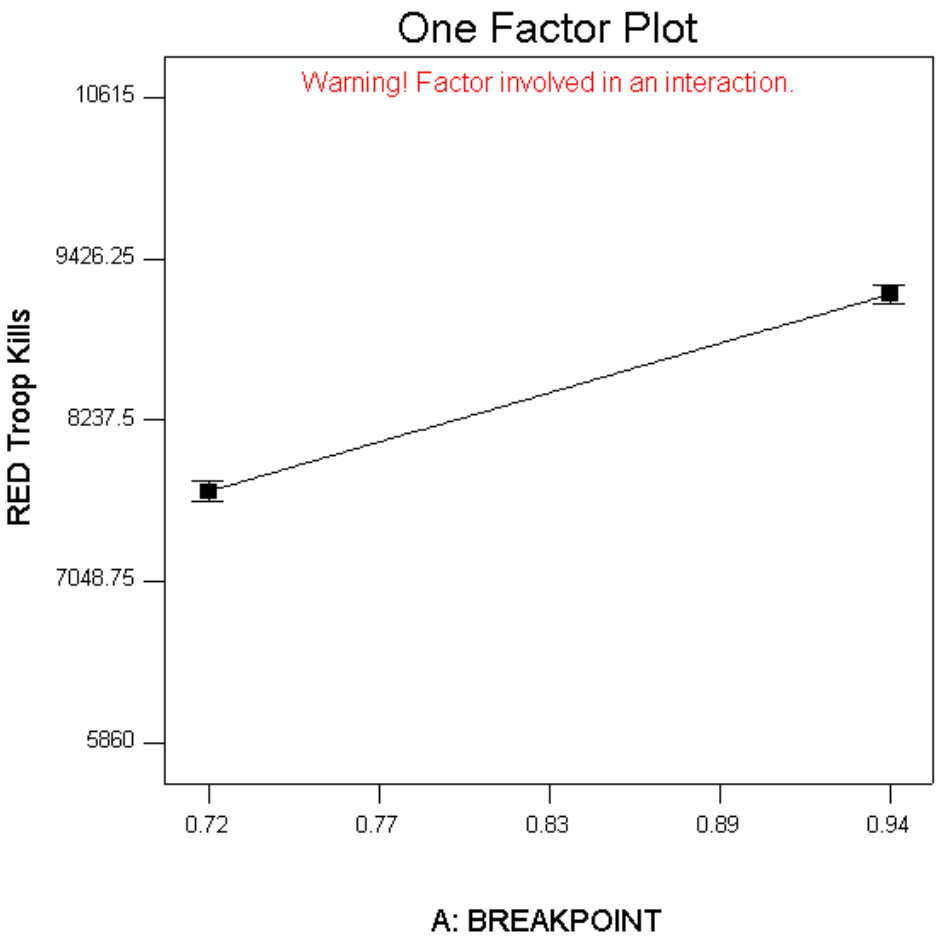
DESIGN-EXPERT
RED Troop Kills

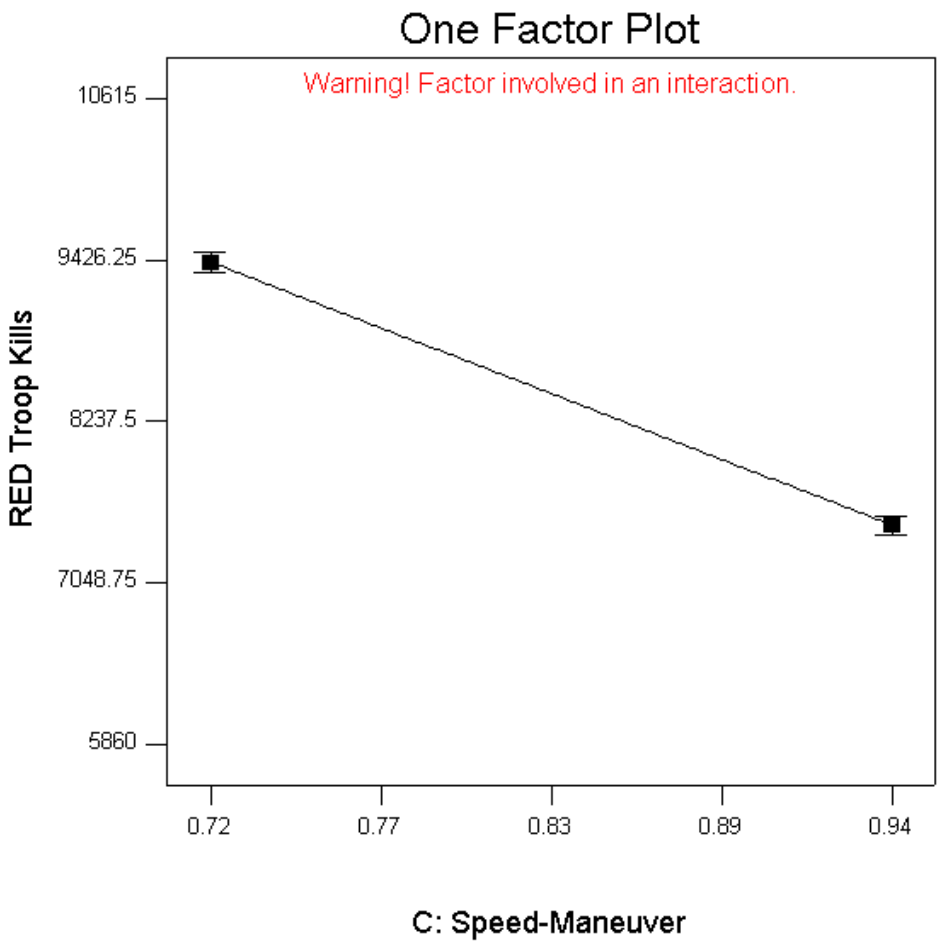
A: BREAKPOINT
B: Rate-Direct Fire
C: Speed-Maneuver
D: Suppress-DirFire
E: Suppress-ManSp

Preliminary Findings

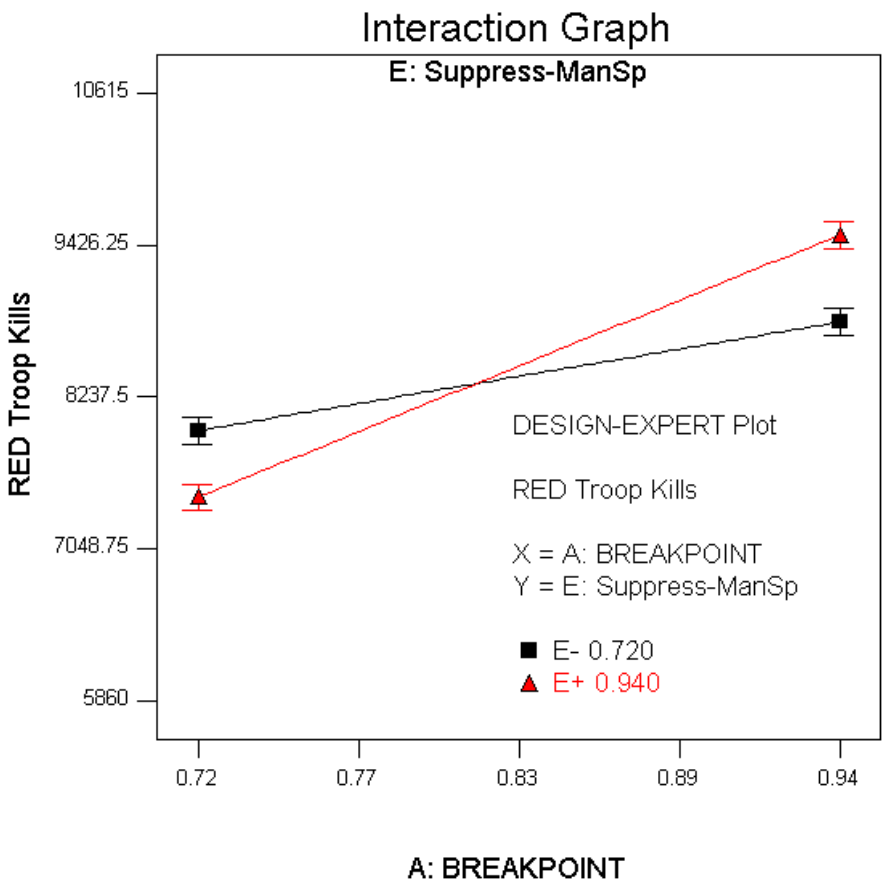
- Some element of each behavior has significance but not the same for RED and BLUE
- Most behaviors are significant at the interaction level rather than the pure behavior level
- Next step – examine details

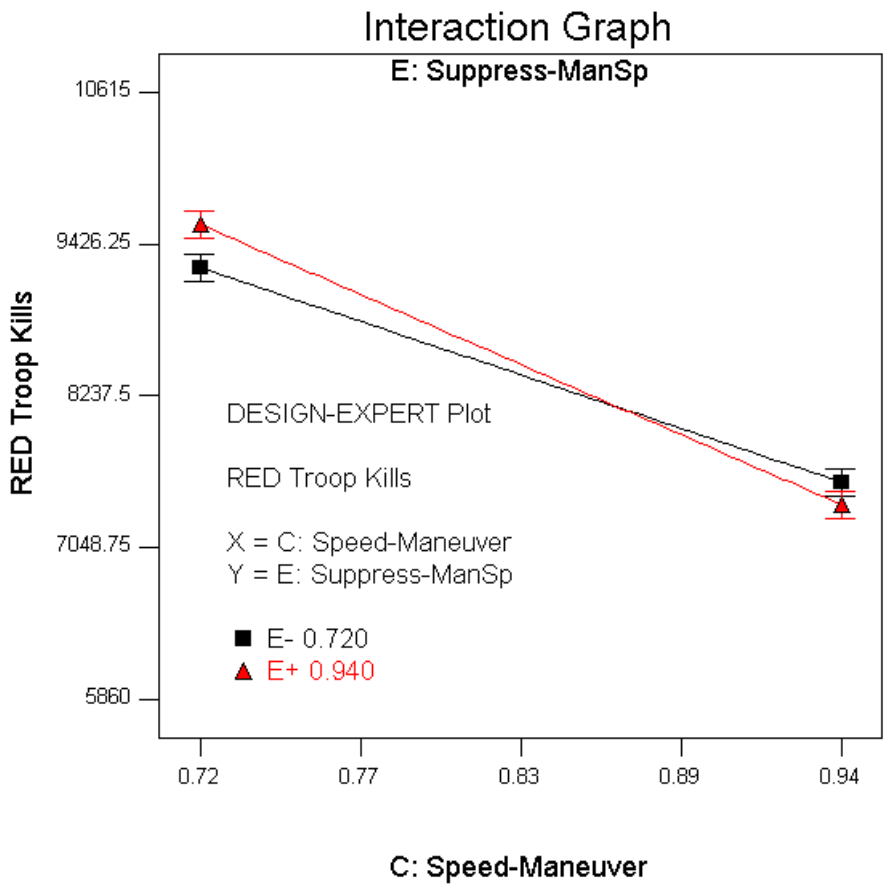
RED Single Factors





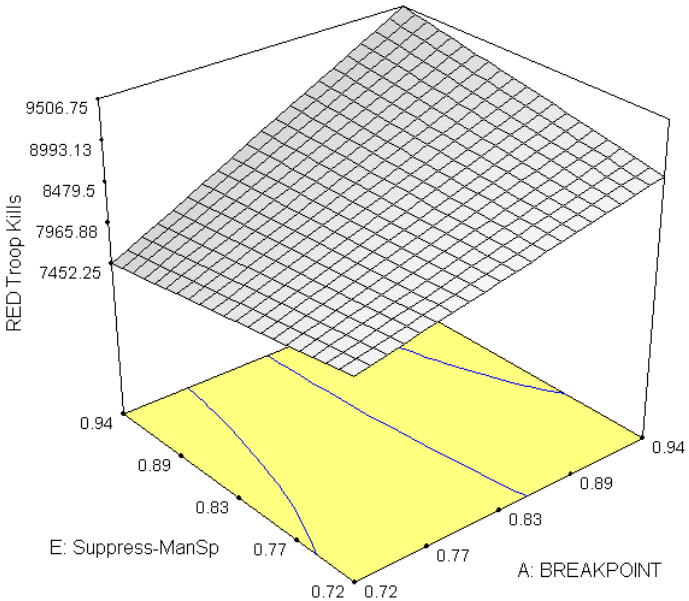
RED Interactions

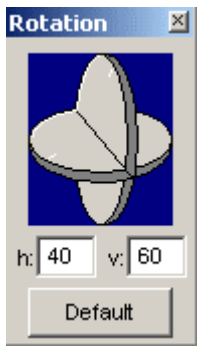




RED Breakpoint x Suppression of Maneuver Speed

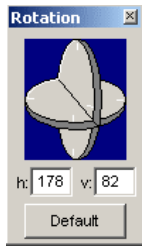
Standard View

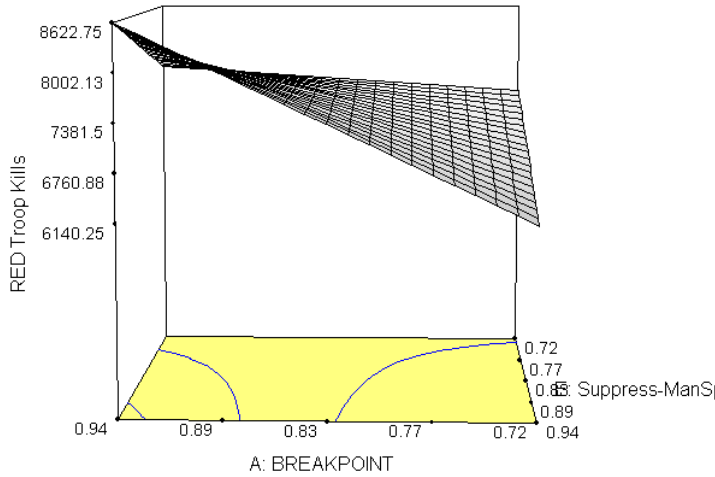




RED Troop Kills
X = A: BREAKPOINT
Y = E: Suppress-ManSp

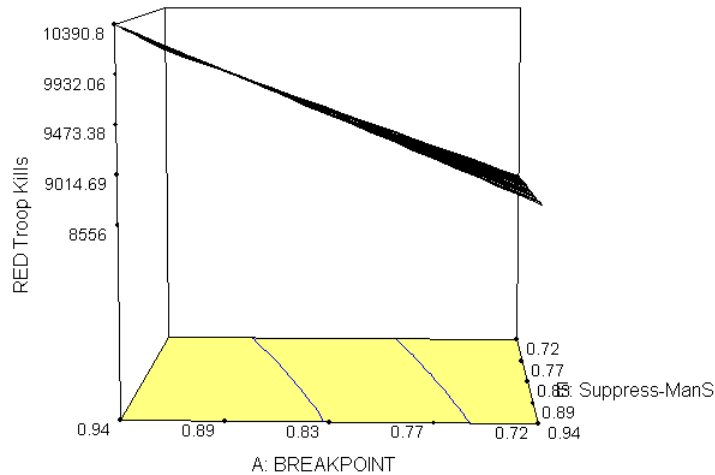
Actual Factors
B: Rate-Direct Fire = 0.94
C: Speed-Maneuver = 0.94
D: Suppress-DirFire = 0.94





RED Troop Kills
X = A: BREAKPOINT
Y = E: Suppress-ManSp

Actual Factors
B: Rate-Direct Fire = 0.72
C: Speed-Maneuver = 0.72
D: Suppress-DirFire = 0.72



S3b

Analytical Tasking - Answers

- What is the impact of the “Will to Fight” on the combat outcomes?
  - Behavior effects are significant
  - Behavior effects are extremely non-linear
  - Behaviors reveal themselves mostly in interactions rather than in pure effects
- How sensitive is JWARS to the NGIC Morale and Cohesion (M&C) Soft Factor?
  - Experiment over the design space shows JWARS very sensitive to the M&C component
- Determine if it will be worthwhile to pursue linkages between JWARS and SEAS to represent sociological effects on combat units and vice versa
  - Based on NGIC criteria, it appears that a one-way JWARS-to-SEAS relationship may be appropriate

Recommendations

- Determine reasonable, defensible settings for:
  - Unit Ranking benchmarks (Elite, Standard, Militia)
  - Unit Function benchmarks (Combat, Combat Support, Combat Service Support)
  - Weights for each Behavior