



United States Army ⁽²⁾ Recruiting Command

RESEARCH MEMORANDUM 82-1

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THE GIDEON CRITERION: THE EFFECTS OF SELECTION CRITERIA ON SOLDIER CAPABILITIES AND BATTLE RESULTS

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By

J. R. WALLACE

January 1982

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This paper addresses the relationship between individual tank crewman mental aptitude and tank crew performance in gunnery skills. Additionally, the study uses combat simulation to establish correlations between battle results and individual tank crewmen mental aptitude. The findings clearly suggest a relationship between soldier mental aptitude and battle results and highlight the crucial need for the U. S. Army to recruit high-quality personnel.		

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ABSTRACT

This paper addresses the relationship between mental aptitude of individual tank crewmen and tank crew gunnery performance. Additionally, the study uses combat simulation to establish correlations between battle results and individual tank crewmen mental aptitude. The findings suggest a strong relationship between soldier mental aptitude and battle results and highlight the need for the U.S. Army to recruit high-quality personnel.



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DIVISION	

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"The Lord said to Gideon: 'The people who are with you are too many for me to give Midian into their hands'... 'whoever is afraid and trembling, let him return and depart'... "then the Lord said to Gideon: 'the people are still too many. Bring them down to the water and I will test them for you there'... 'I will deliver you with the 300 men'... 'and will give the Midianites into your hand."

Judges 7:1-7 (RSV)

THE GIDEON CRITERION: THE EFFECTS OF SELECTION CRITERIA ON SOLDIER CAPABILITIES AND BATTLE RESULTS

THE PROBLEM

The relationship between soldier aptitude as measured by paper/pencil tests and weapons performance/battle results is the subject of considerable research and controversy. With the revelation that the U.S. Army inducted almost 50 percent mental category (MC) IV (eligible applicants who score less than 31 on the Armed Forces Qualification Test) recruits in FY 80, there has been increased concern about the effects that this large number of MC IV personnel will have on the combat performance of U.S. units. There have been many complex combat simulations performed that clearly establish that battle outcomes can be affected by changes in weapons system performance. To date, however, links between weapon system performance and soldier aptitudes have been less clearly defined.

The objective of this study is to determine if a statistically significant correlation between battle results and soldier aptitude exists. First, the correlation between mental aptitudes of soldiers (tank crewmen) and weapon system (tank) performance is determined. Then, using combat simulations, the effect of soldier aptitudes on battle results is demonstrated. This memorandum provides information on the study data, the analytical methodologies used in the study, and presents the results and conclusions derived from the analysis and combat simulations.

THE DATA

The data used in this analysis are the firing results from the 1981 Canadian Army Trophy (CAT) Competition held at Grafenwoehr, FRG in June 1981. The competition involved six NATO nations competing for a tank gunnery trophy donated by the Canadian Army in 1963. Each nation sent teams selected from operational tank battalions stationed in central Europe. Each national team consisted of five three-tank platoons that were required to negotiate a difficult battle run course.

The major reason USAREC selected the CAT competition as a source for study data was to avoid a classic problem in behavioral research, that is, restriction in the range of the test variables. Armed Forces Qualification Test (AFQT) percentile scores of participating crewmen ranged from 14 (MC V) to 93 (MC I), and crew performance ranged from poor to outstanding. With these ranges in the data, it was possible to establish valid correlations between individual crewman aptitude and crew performance.

Additionally, all crewmen had been intensely trained and were highly motivated. They were scored and judged under a rigid, uniform standard. Also, each nation was restricted in the amount of time and ammunition that could be expended in training each platoon. No main gun practice was allowed after 8 May 1981. As the competition took place June 15-19, 1981, the study is, in some ways, a measure of the retention of crew gunnery skills, also a valid concern in battle circumstances.

Finally, the competition provides a large data base. If all nations support the research, 90 sets of crew data would be available. Some problems do exist in attempting to correlate the other NATO participants' aptitude test scores to our AFQT score. Since this memorandum is concerned only with the performance of U.S. crews, those problems will not be addressed until the final study report is published. The advantages of the large data set are obvious, however.

THE ANALYSIS

Introduction

This section covers the disaggregation of firing results into data that could be analyzed, lists the relationships that were explored, and provides the results of relationships found to be significant.

The U.S. Seventh Army Training Command (7ATC) was responsible for hosting the CAT competition at Grafenwoehr Training Area. As part of their efforts to support the competition, six video tapes were made of each platoon battle run. Four cameras covered the downrange target area and two covered the firing tanks. USAREC obtained from 7ATC a set of the tapes and scoring sheets for each platoon.

The CAT scoring is aggregated into platoon results; no record is made of individual tank efforts. However, using the official scoresheets and the video tapes, it was possible to produce an accurate record of each crew's performance. The 21 performance variables computed for each tank crew are listed in table 1.

Table 1. Tank performance variables and abbreviations

<u>Variable</u>	<u>Abbreviation</u>
1. Percentage 1st round hits	PlR
2. Percentage 2d round hits	P2R
3. Percentage 3d round hits	P3R
4. Percentage total hits	PT
5. Percentage 1st round hits on moving targets	PlMT
6. Percentage total hits on moving targets	PMT
7. Percentage 1st round hits fired on the move	PlRS
8. Percentage total hits fired on the move	PS
9. Percentage 1st round hits at range $\geq$ 1600 m	PlR16
10. Percentage 2d round hits at range $\geq$ 1600	P2R16
11. Percentage total hits at ranges $\geq$ 1600 m	PT16
12. Percentage 1st round hits at ranges $<$ 1600 m	PlLT16
13. Percentage 2d round hits at ranges $<$ 1600 m	P2LT16
14. Mean time to fire 1st round	MT1R
15. Mean time between rounds	MTBR
16. Minimum opening time	MINOT
17. Maximum opening time	MAXOP
18. Minimum time between targets	MINBT
19. Maximum time between targets	MAXBT
20. Total hits	TOTHIT
21. Point score	SCORE

Other data obtained for this analysis were the U.S. Army Enlisted Master File (EMF) entries and the results of the pre-competition physical examinations administered to the U.S. team.

Objective

The objective of the analysis was to correlate the AFQT scores and physical exam findings (color blindness, vision acuity, etc.) of individual crewmen to tank performance. The AFQT composite was chosen because other NATO nations can produce a similar composite for their crewmen. Renormed AFQT scores* were used for all enlisted U.S. crewmen (officer AFQT scores are not available). All AFQT scores and physical results are, of course, restricted, but crew performance summaries can be found in appendix A.

A further explanation of the SCORE variable is required. As stated earlier, only platoon scores were computed during the competition. However, using the crew firing results compiled from the TV tapes, the scoring rules for the CAT competition could be applied to each tank. The scoring procedure awards 500 points for each main gun hit and 0 to 500 points for "time to hit", on a scale from 1 to 40 seconds (1 second = 500 points; 40 = 0 points). This scoring method was applied to each crew. Because the SCORE variable represents an accurate appraisal of total crew performance, (i.e., it measures the crew's ability to hit targets quickly), it seems appropriate to begin investigating relationships between the variables using SCORE as the response variable.

Results

To better understand the relationships between the variables, it is best to begin with a look at the plot of tank commander's (TC) AFQT versus SCORE. The original hypothesis was that the TC and gunner's (GR) AFQT score would correlate the highest with SCORE. A plot of TC AFQT and SCORE is shown in figure 1.

A linear relationship exists and it can be observed that all crews with TC AFQT's greater than 65 scored high, while those with TC AFQT below 30 scored low. Crews with TC AFQT percentiles between these ranges had mixed results. Table 2 contains the results of a linear regression of the 15 data points.

Table 2. TC AFQT regressed against SCORE (15 observations)

<u>Slope</u>	<u>Intercept</u>	<u>Correlation</u>	<u>R²</u>	<u>MSE</u>	<u>F Test</u>
					<u>Significance (—)</u>
35.59	1704.25	.59	.35	1729070	6.89 (.01)

* Because the people tested with the Armed Services Vocational Aptitude Battery tests 5, 6, and 7 administered between 1976 and 1980 were found to score higher than people with same aptitudes scored on previous versions of the tests, the results were subsequently renormed to provide correct scores. In all cases the renorming lowered the original AFQT score and therefore, the assigned mental category of soldiers who took ASVAB 5, 6, and 7.

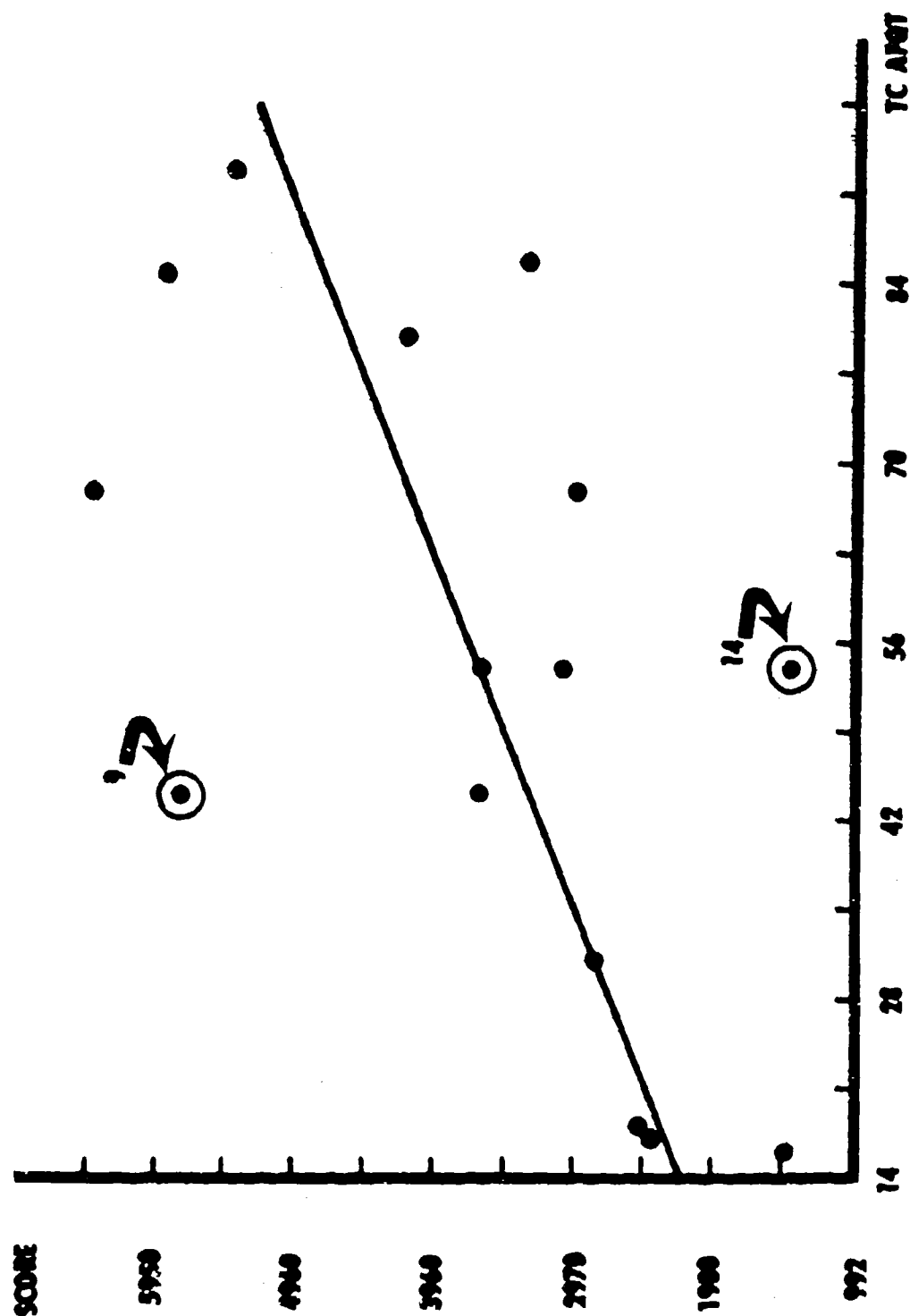


Figure 1. Tank commander APQT versus SCORE

There are two observations with fairly large residuals; 9 and 14. These observations are in the middle range (MC III) of the AFQT data. A regression with these points deleted shows that, while the intercept and slope of the regression line hardly change, the MSE of the equation is reduced by 40 percent and the R^2 is increased by 57 percent. These statistics indicate that these two points contribute heavily to the variance within the data. There are, as well, reasons to believe that these points are atypical observations (discussed in appendix B). A third regression was run using only nine data points, the three below AFQT 30 and the six above AFQT 65.

The regression line from these points almost duplicates the second equation, indicating that the relationship between variables is most strongly influenced by these nine observations.

Therefore, while analysis was conducted on both the 15 and 13 observation data sets (plus some smaller subsets), the 13 observations are believed to provide better estimates of the functional relationships between the variables. Table 3 shows that when using the smaller data set, only the precision (confidence intervals) of the estimates of the variable SCORE are improved, while only a minor change takes place in the coefficient values.

Table 3. TC AFQT regressed against SCORE (15, 13 and 9 observations)

No. of Obsv	Slope	Intercept	Correlation	R2	MSE	F Test Significance (α)
15	35.59	1704.25	.59	.35	1729070	6.89 (.01)
13	38.25	1535.63	.74	.55	1029954	13.23 (.001)
9	38.9	1508.66	.74	.54	1545963	8.27 (.05)

The correlation matrices for TC, GR and loader (LR) AFQT scores with all 21 variables are in appendix C. With one exception, the only significant relationships found to exist were with TC AFQT scores. The GR AFQT was found to be correlated with variables PS and PIRS. Otherwise, the TC AFQT dominates the variance between crew performance.

The eight variables found to have the highest correlations with TC AFQT are listed in table 4.

Table 4. Variables highly correlated with TC AFQT

Variable	Slope	Intercept	Correlation	F Test Significance (α)
P1R	.3839	36.83	.61	6.46 (.05)
P2R	.84	- 6.78	.48	2.65 (.10)
PT	.4963	28.27	.67	9.31 (.01)
P1R16	.6476	4.81	.44	2.66 (.10)
MINBT	-.0911	12.85	-.47	3.14 (.10)
P1LT16	.2015	54.93	.44	2.65 (.10)
TOTHIT	.0522	2.05	.77	15.92 (.001)
SCORE	38.28	1535.63	.74	13.23 (.001)

Other combinations of crew AFQT scores were explored to see if stronger correlations existed. Regression equations using independent variables both TC and GR AFQT scores, the mean of the GR and TC AFQT, and a weighted average of their scores failed to produce results better than those in table 4. However, a log-linear equation of the TC AFQT did produce superior results for some variables. Those are listed in table 5.

Table 5. Variables highly correlated with TC AFQT, log-linear form (13 observations)

Variable	Slope	Intercept	Correlation	F Test	
				Significance (<)	
ln (PIR)	.2918	2.89	.61	6.59	(.05)
ln (PT)	.4245	2.31	.68	9.66	(.05)
ln (TOTHIT)	.5171	-.4658	.82	23.29	(.001)
ln (SCORE)	.5019	6.19	.80	20.23	(.001)

This result indicates that the relationships for some variables may be slightly non-linear. This possibility needs to be explored with larger data sets. TC age and ability to bench press his body weight (taken from the physical exam data) were found to be insignificant predictors.

Conclusions of the Analysis

The conclusions can be simply stated. The tank commander dominated the performance of his tank in the NATO 1981 CAT tank gunnery competitions. His ability, as measured by AFQT, provided an accurate, statistically significant predictor of the gunnery performance of his tank. TC with high aptitude compensated (apparently) for GR with low aptitude while GR with high aptitude could not compensate for TC with low aptitude. The conclusion is intuitively appealing; the performance of a crew is highly correlated to the aptitude of their leader. However, it is acknowledged that the strength of the conclusion is weakened by the small sample size.

This finding should not be interpreted to mean that no relationships exist between the mental ability of the other crew members and the combat effectiveness of the tank. When considering the total tank combat effectiveness, (maintenance, communications, tactics) statistically significant relationships could exist between the aptitude of all crew members and tank performance.

TANK BATTLE SIMULATION (BATTLE SIM)

Introduction

Although the analysis shows a relationship between TC AFQT and tank gunnery performance, it is necessary to demonstrate the effect of aptitude differences on combat effectiveness of the tank crews. As previously stated, many skills in addition to tank gunnery contribute to the combat effectiveness of tanks. In this study, combat effectiveness will be measured by the number of opposing vehicles killed by the crew in a combat simulation. Also, it is assumed that the crews perform their jobs at the standard effectiveness levels used in most of our war games and analyses, with one exception: for each simulation, tanks are commanded by soldiers with either high, standard, or low aptitude as measured by AFQT. Therefore, the simulation results provide an estimate of the differences in battle results attributable to the TC mental aptitude and provide insights and answers to the following questions:

- o Is there a significant difference in combat effectiveness of a tank platoon with all MC II tank commanders and a tank platoon with all MC IV tank commanders?
- o What increases in effectiveness can be expected by increasing the TC aptitudes to CAT MC I?

o Is the relationship between aptitude and battle results linear or non-linear?

o In short, should there be a "Gideon Criterion", that is, a practical selection criterion based on AFQT score for U.S. tank commanders?

Simulation Experimental Design

To answer these questions, a simple combat simulation was constructed using the General Purpose Simulation System (GPSS). The major assumptions incorporated in this model are discussed in appendix D. The GPSS code is listed in appendix E.

Essentially, the simulation portrays a Blue platoon of 5 tanks defending against a Red motorized rifle battalion (reinforced). Only direct-fire weapons are simulated; no artillery or infantry action is included. The simulation allows the Blue tanks to engage with main guns and the Red, in turn, to engage the Blue tanks with main guns and BMP-mounted Sagger anti-tank missiles.

To conduct the simulation, the levels of Blue and Red performance had to be established. From the previous analysis, it was determined that a Blue TC must have an AFQT score of 83 (MC II) for the Blue tanks to perform at the standard level of effectiveness used in our war games and simulations. This level of Blue performance was considered "base level" or "specification" (SPEC). Performance levels for TC with AFQT of 95 () and 25 (LOW) were the other two Blue levels of performance used in the analysis. Additionally, two levels of Red performance were assumed, one at specification (SPEC) and another at a level equivalent to our MC IV TC performance. The Red levels were included to test the effect of degradation of Red performance on the battle outcomes. There is no data to support the two Red levels. However, it is possible we may be overestimating the abilities of crewmen in Red tank forces. Of course, the level of Red aptitudes is a factor we cannot control, and estimates of Red performance should continue to be based on best available intelligence data. Three repetitions of the simulation were run for each combination of factors, making for a total of 18 repetitions.

Results of the Tank Battles

Table 6 contains the results of the number of mobility/firepower kills achieved by a Blue platoon (BMP and tank kills combined) and the results of the number of Blue tanks killed by the Red. Notice that when the Blue platoon is at SPEC (TC = MC II), the exchange ratio is 7.45 Red to 1 Blue. If the Blue platoon is at LOW (TC = MC IV), the mean exchange ratio is only 1.33 to 1, an 82 percent degradation in performance, as shown in figure 2. If the Red level is reduced to LOW while the Blue is maintained at SPEC, the exchange ratio is 11.5 Red to 1 U.S. Table 7 displays the ANOVA for the Blue kills while table 8 displays the results of Tukey's pairwise comparison of cell means. The results in tables 7 and 8 show that the most

significant factor in affecting the battle outcome is Blue performance. While there is no statistical difference between the HI and SPEC levels of Blue performance, the difference between these levels and LOW is dramatic. Table 9 shows that the number of Red kills on the Blue platoon is independent of both Red and Blue performance levels. Figure 3 shows a plot of TC AFQT against the mean M/F kills (3 simulations) for 6 TC AFQT level. The plot demonstrates a nonlinear relationship between these variables and that a diminishing returns effect is probably occurring around an AFQT score of 65 (MC II).

Discussion of the Battle Results

The results indicate that, under the conditions assumed in the simulation, tank platoons with MC I and MC II tank commanders stand a good chance of destroying, or at least decimating, an attacking Soviet MR battalion; tank platoons with CAT IV commanders will likely be destroyed, leaving the Soviet formation intact. While BATTLE SIM results show no advantage from increasing TC aptitude from MC II to MC I, they demonstrate an astounding increase in effectiveness that can be expected when MC IV commanders are replaced by MC II commanders. The results suggest that the outcome of tank battles could hinge more on the quality of people than on material, and that efforts to recruit high aptitude soldiers may have a greater return in combat effectiveness than equivalent resources spent on hardware.

Persons who would argue that more or better training can make up for aptitude deficiencies are reminded that the crews participating in the CAT competition were probably the most intensively trained tank crews in the U.S. Army in 1981. No tank battalion under normal circumstances can begin to approach the intensity and thoroughness of training given these crewmen: time, range, and ammunition resources are just not there. We must consider these crews, then, to represent the upper range of U.S. tank crew performance (at the current time) and, therefore, the results of the battle simulations a "best" case.

Conclusions

This study has demonstrated that a significant relationship exists between tank commander AFQT and the performance of his tank. Additionally, a significant relationship between TC AFQT and expected battle results has been established. It suggests that a "Gideon Criterion," (perhaps an AFQT score equal to or greater than 65) for tank commanders could dramatically improve the combat effectiveness of the tank force. As a minimum, it is apparent that MC IV tank commanders can cause serious degradation of the effectiveness of tank units. Although the cost and difficulty of recruiting personnel with higher mental aptitude is significant, the consequences of not recruiting them could be more significant. If our efforts "to train to fight and win outnumbered" are to be taken seriously, the manpower quality of our tank force must be improved.

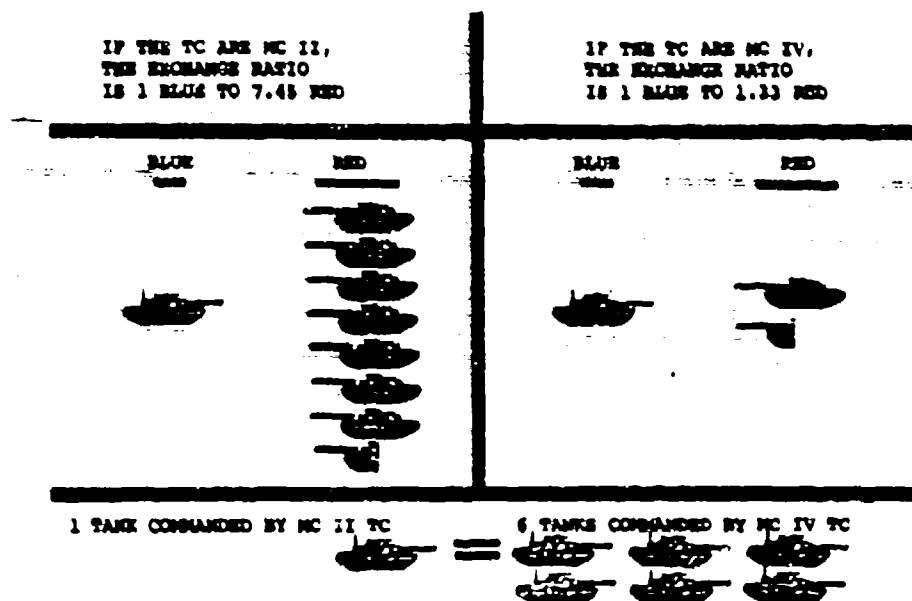


FIGURE 2. COMPARISON OF SIMULATED BATTLE RESULTS OF BLUE TANKS WITH MC II VERSUS MC IV TANK COMMANDERS

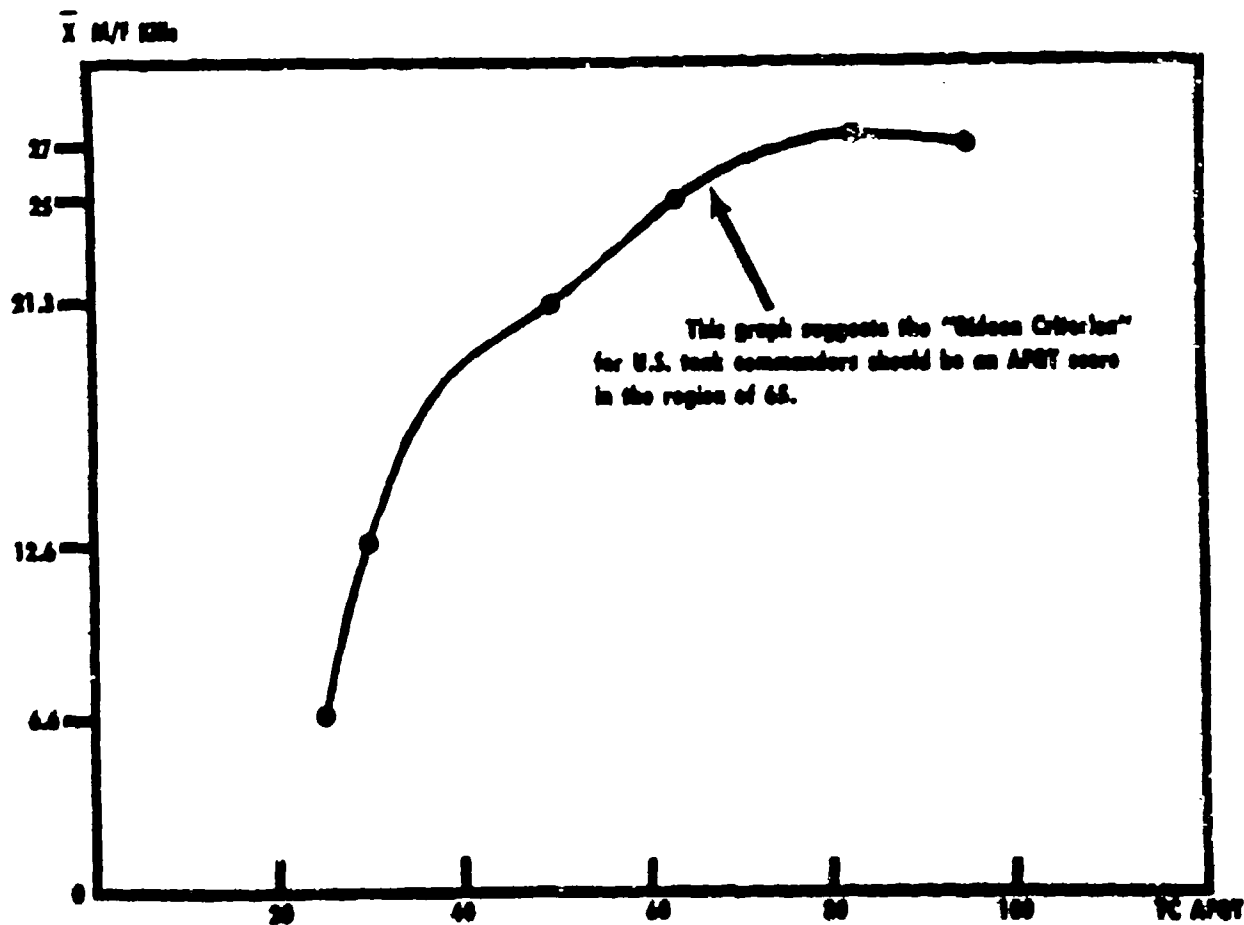


FIGURE 3. TC APQT VERSUS MEAN NUMBER OF M/F KILLS PER PLATOON

Table 6. Results of the battle simulations

Blue M/F* Kills on Attacking Red					Red M/F Kills on Defending Blue				
Red	Blue					Blue			
	SPEC	HI	LOW	Y...		SPEC	HI	LOW	Y...
SPEC	17	31	2	183		5	4	5	39
	24(82)	33(81)	9(20)			5(11)	4(13)	5(15)	
	41	17	9			1	5	5	
LOW	37	37	30	298		3	3	4	32
	26(104)	26(96)	34(98)			5(9)	5(13)	3(10)	
	41	33	34			1	5	3	
Y..j	186	177	118	481		20	26	25	71
				=Y...					=Y...

* Mobility/Firepower

Table 7. Analysis of variance for blue kills

Source	DF	SS	MS	F ₀
Blue	2	454.78	227.39	6.93*
Red	1	738.72	734.72	22.39*
Blue(Red)	2	394.44	198.72	6.06***
Error	12	393.67	32.8	
TOTAL:	17			

* Significant at .01 level.

*** Significant at .05 level.

Table 8. Pairwise comparison of cell means, $\alpha = .01^{**}$

	<u>spec/-*</u>	<u>-/-</u>	<u>+ /-</u>	<u>spec/spec</u>	<u>+ /spec</u>	<u>- /spec</u>
spec/-	-	2	2.6	7.3	7.6	28**
-/-		-	0.6	5.3	5.6	26**
+/-			-	4.7	5	25.4**
spec/spec				-	.3	20.7**
+ /spec					-	20.4**
- /spec						-

* HIGH = +
LOW = -

Table 9. Analysis of variance for Red kills

<u>Source</u>	<u>DF</u>	<u>SS</u>	<u>MS</u>	<u>F₀</u>
Blue	2	3.445	1.772	.911
Red	1	2.722	2.722	1.44
Blue(Red)	2	2.111	1.055	.558
Error	12	22.667	1.889	
Total:	17			

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APPENDIX A - DATA SUMMARIES

Table A-1. Summary of 1981 U.S. CAT crew performance

NATION	PLATFORM	CREW	PERCENT FIRST ROUND HITS	PERCENT SECOND ROUND HITS	PERCENT THIRD ROUND HITS	PERCENT TOTAL	PERCENT HITTING TARGETS	PERCENT FIRST ROUND HITTING TARGETS	PERCENT STAB
US	1	A	43	0	9999	30	20	33	100
US	1	B	29	0	9999	22	9999	9999	100
US	1	C	44	0	9999	40	9999	9999	100
US	2	A	35	0	9999	33	0	0	0
US	2	B	30	0	9999	44	33	30	50
US	2	C	62	100	9999	66	100	100	9999
US	3	A	57	33	9999	50	100	100	100
US	3	B	44	100	9999	50	50	50	0
US	3	C	77	100	9999	80	0	0	100
US	4	A	60	9999	9999	60	0	0	9999
US	4	B	57	0	9999	30	0	0	0
US	4	C	89	9999	9999	88	9999	9999	100
US	5	A	75	100	9999	78	100	100	50
US	5	B	28	0	9999	20	0	0	0
US	5	C	88	100	9999	89	100	100	0

PERCENT FIRST ROUND STAB	PERCENT FIRST ROUND => 1600 METERS	PERCENT SECOND ROUND => 1600 METERS	PERCENT TOTAL ROUNDS => 1600 METERS	MEAN TIME FIRST ROUND	MEAN TIME BETWEEN ROUNDS	MINIMUM OPENING TIME	MAXIMUM OPENING TIME	MINIMUM TIME BETWEEN ROUNDS
100	25	0	17	10	11	6	15	9
100	0	0	0	19	23	8	35	5
100	0	0	0	17	15	7	37	9
0	0	9999	0	13	23	7	27	2
50	30	0	33	13	9	4	31	5
9999	33	100	50	10	12	5	17	3
100	0	9999	0	11	9	7	16	23
0	0	9999	0	7	8	5	5	6
100	100	100	100	15	11	4	33	1
9999	50	9999	50	8	9999	7	10	11
0	67	9999	67	9	7	5	13	11
100	100	9999	100	8	9999	5	10	6
50	100	9999	100	15	9	6	38	4
0	25	0	20	13	13	7	20	1
0	100	9999	100	14	10	5	31	8

MAXIMUM TIME BETWEEN ROUNDS	PERCENT FIRST ROUND < 1600 METERS	PERCENT SECOND ROUND < 1600 METERS	TYPE TANK	TOTAL HITS	SCORE
11	67	0	1	3	2476
16	50	9999	1	2	1445
19	67	9999	1	4	2934
12	63	0	1	5	3284
9	50	9999	1	4	3613
13	80	9999	1	6	4130
23	66	33	1	5	2789
16	57	100	1	5	3632
12	67	9999	1	8	5753
17	67	9999	1	3	2393
12	50	0	1	4	3029
9	88	9999	1	8	4372
10	67	100	1	7	5353
7	33	0	1	2	1410
21	86	100	1	8	5847

Table A-2. Summary of U.S. statistics, 15 observations

VARIABLE	MEAN	STANDARD DEV	CASES
AFBT	54.1333	25.9281	15
NATION	.0001	0.	15
PLATOON	3.0000	1.4639	15
CREW	.0000	.0000	15
JOB	.0000	0.	15
PIR	57.2000	18.8119	15
P2R	41.0000	49.3592	13
PT	54.0000	22.2075	15
PRT	41.9167	45.6318	12
PINT	44.4167	45.1411	12
PS	53.0442	47.7037	13
PIRS	53.0442	47.7037	13
PIR16	43.3333	41.1108	15
P2R16	28.5714	48.7950	7
PT16	42.4447	41.5896	15
MTIR	12.1333	3.5227	15
MTBR	12.3077	5.2023	13
MINOT	5.8667	1.2459	15
MAXOP	22.5333	11.1026	15
MINOT	6.9333	5.5352	15
MAXBT	13.0000	4.6935	15
PILT16	63.8667	14.5498	15
P2LT16	41.6250	49.6097	8
TOTHIT	4.9333	2.0862	15
SCORE	3630.6447	1567.4575	15

Table A-3. Summary of U.S. statistics, 13 observations

variable	mean	standard dev	cases
afbt	54.9231	27.8402	13
nation	.0001	0.	13
platoon	2.8462	1.4632	13
crew	.0000	.0000	13
job	.0000	0.	13
pir	57.9231	17.5664	13
p2r	39.3636	49.0352	11
pt	55.5385	20.5167	13
pwt	50.3000	45.5681	10
piat	53.3000	44.3222	10
ps	54.5435	47.1940	11
pirs	54.5435	47.1940	11
pir16	40.3846	40.8259	13
p2r16	20.0000	44.7214	5
pt16	39.7692	41.1363	13
mtir	11.8462	3.6934	13
mtbr	12.3636	5.6793	11
minot	5.9231	1.1875	13
maxop	21.9231	11.5648	13
minot	7.8462	5.3828	13
maxbt	14.4615	4.9738	13
pilt16	66.0000	12.7214	13
p2lt16	47.5714	50.4112	7
tothit	4.9231	1.8913	13
score	3638.2308	1442.2335	13

APPENDIX B

DISCUSSION OF OBSERVATIONS 9 AND 14

The deletion of data points 9 and 14 is supported in this discussion. Observation 14 represents a crew commanded by an officer. Since AFQT scores do not exist for officers, the mean TC AFQT score of the Blue crews was substituted for the officer scores. Therefore, exact placement of this observation cannot be made. Additionally, the extremely poor performance of the tank (all misses were "short-line") creates suspicion that the tank had some undetected mechanical error or had been improperly zeroed. Of course, the observation may be valid and, if it is, could say a lot about the proficiency of Blue officer tank commanders. In fact, none of the Blue officer crews excelled in the competition. Therefore, factors may be at work among officer performance that are not apparent in the other observations. The most appealing consideration is that the officer's were relatively young and inexperienced, although age was found to be an insignificant factor. For these reasons, observation 14 was considered to be atypical.

Observation 9 is the opposite case. This individual represented an NCO whose AFQT was a low 38. Additionally, his gunner had a low AFQT. It was interesting to read in the CAT team captain's after action report, that he observed a relationship between GT score and performance in training (see appendix F). He noted that, with one exception, TC with a low GT score had less interest in, motivation for and grasp of the CAT gunnery requirements than their higher scoring counterparts. I suspect, but cannot prove, that observation 9 was this TC and that he is atypical of his AFQT percentile. In a very small sample size, it is disadvantageous to include observations that are atypical and could, therefore, produce erroneous analysis conclusions. For these reasons, however, observation 9 was deleted from the further analysis.

APPENDIX C

CORRELATION MATRICES

Table C-1. TC correlation matrix, 13 observations

	afet	nation	platoon	crew	job	plr	p2r	pt	rat	plnt	ps	plrs
afet	13.	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
nation	99.00000	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
platoon	.36995	99.00000	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
crew	.44231	99.00000	.02821	13.	13.	13.	11.	13.	10.	10.	11.	11.
job	99.00000	99.00000	99.00000	99.00000	13.	13.	11.	13.	10.	10.	11.	11.
plr	.60848	99.00000	.80678	.37280	99.00000	13.	11.	13.	10.	10.	11.	11.
p2r	.47700	99.00000	.62131	.30705	99.00000	.62909	11.	11.	9.	9.	10.	10.
pt	.67353	99.00000	.81632	.39461	99.00000	.97079	.76411	13.	10.	10.	11.	11.
rat	.42213	99.00000	.31442	.44905	99.00000	.54594	.78624	.56497	10.	10.	8.	8.
plnt	.38740	99.00000	.23911	.46129	99.00000	.51522	.73790	.51622	.99026	10.	8.	8.
ps	-.48931	99.00000	-.44985	.06932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	11.	11.
plrs	-.48931	99.00000	-.44985	.06932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	1.00000	11.
plr16	.44162	99.00000	.78785	.26450	99.00000	.84016	.43644	.77803	.25988	.26062	-.19541	-.19541
p2r16	.63069	99.00000	.61237	.58333	99.00000	.76585	1.00000	.85707	.98847	.96976	99.00000	99.00000
pt16	.49195	99.00000	.80235	.33277	99.00000	.87112	.53601	.82927	.34365	.32292	-.20795	-.20795
ratr	.16358	99.00000	-.32856	.09473	99.00000	-.26865	-.26668	-.28365	.40781	.43902	.27041	.27041
ratr	-.04507	99.00000	-.55755	-.03840	99.00000	-.42281	-.41526	-.37289	-.32870	-.36249	.19691	.19691
minot	-.37828	99.00000	-.34308	-.36515	99.00000	-.43174	-.38020	-.43253	-.14984	-.21322	.44173	.44173
maxop	.38440	99.00000	-.16819	.10098	99.00000	-.07797	-.14544	-.08937	.35466	.39100	.12074	.12074
minbt	-.47164	99.00000	.12371	-.24442	99.00000	-.03010	-.17177	-.13954	.12632	.11381	.32142	.32142
maxbt	-.22189	99.00000	.03624	.10619	99.00000	-.08524	.16759	-.06563	.39985	.33884	.05648	.05648
plr16	.44094	99.00000	.36710	.57405	99.00000	.77229	.60226	.75894	.61214	.57759	.14008	.14008
p2r16	.40933	99.00000	.67372	.48177	99.00000	.53676	1.00000	.70698	.75007	.72628	-.24976	-.24976
totht	.76906	99.00000	.65785	.48201	99.00000	.89528	.80403	.92033	.78691	.74301	-.27174	-.27174
score	.73899	99.00000	.66078	.50441	99.00000	.89911	.76451	.91116	.67913	.66368	-.24268	-.24268

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	plr16	p2r16	pt16	ratr	ratr	minot	maxop	minbt	maxbt	plr16	p2r16	totht
afet	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
nation	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
platoon	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
crew	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
job	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
plr	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
p2r	11.	5.	11.	11.	11.	11.	11.	11.	11.	11.	7.	11.
pt	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
rat	10.	3.	10.	10.	9.	10.	10.	10.	10.	10.	7.	10.
plnt	10.	3.	10.	10.	9.	10.	10.	10.	10.	10.	7.	10.
ps	11.	4.	11.	11.	10.	11.	11.	11.	11.	11.	7.	11.
plrs	11.	4.	11.	11.	10.	11.	11.	11.	11.	11.	7.	11.
plr16	13.	5.	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
p2r16	.79386	5.	5.	5.	5.	5.	5.	5.	5.	5.	1.	5.
pt16	.98422	.77398	13.	13.	11.	13.	13.	13.	13.	13.	7.	13.
ratr	-.13819	-.51982	-.17687	13.	11.	13.	13.	13.	13.	13.	7.	13.
ratr	-.58991	-.28412	-.47355	.61254	11.	11.	11.	11.	11.	11.	7.	11.
minot	-.53218	-.35335	-.50021	.47207	.72627	13.	13.	13.	13.	13.	7.	13.
maxop	.04366	-.54297	.01135	.94399	.43710	.26652	13.	13.	13.	13.	7.	13.
minbt	-.17376	-.64467	-.18872	-.19830	-.38635	.24549	-.29739	13.	13.	13.	7.	13.
maxbt	-.34850	-.08436	-.30367	.18626	.01171	.54477	.03994	.63669	13.	13.	7.	13.
plr16	.47574	.74922	.55209	-.19845	-.11517	-.17652	-.12008	-.03529	.12121	13.	7.	13.
p2r16	.43503	99.00000	.45648	.22597	-.40426	-.43885	.29396	-.21048	.29707	.44136	7.	7.
totht	.65445	.82916	.70241	-.14886	-.38123	-.48520	.00733	-.15679	-.06272	.75161	.78536	13.
score	.77638	.65129	.79992	-.18142	-.45337	-.59884	.02368	-.28082	-.24298	.70932	.80617	.96182

Table C-2. TC correlation matrix, 15 observations

	AFOT	NATION	PLATOON	CREW	JOB	PIR	P2R	PT	PMT	PINT	PS	PIRS
AFOT	15.	15.	15.	15.	15.	15.	13.	15.	12.	12.	13.	13.
NATION	99.00000	15.	15.	15.	15.	15.	13.	15.	12.	12.	13.	13.
PLATOON	.33687	99.00000	15.	15.	15.	15.	13.	15.	12.	12.	13.	13.
CREW	.37201	99.00000	0.	15.	15.	15.	13.	15.	12.	12.	13.	13.
JOB	99.00000	99.00000	99.00000	99.00000	15.	15.	13.	15.	12.	12.	13.	13.
PIR	.49521	99.00000	.49024	.42352	99.00000	15.	13.	15.	12.	12.	13.	13.
P2R	.38517	99.00000	.42453	.40903	99.00000	.69924	13.	13.	11.	11.	12.	12.
PT	.54253	99.00000	.48998	.44597	99.00000	.97810	.80182	15.	12.	12.	13.	13.
PMT	.42370	99.00000	.14867	.22183	99.00000	.45327	.60484	.46188	12.	12.	10.	10.
PINT	.39006	99.00000	.07533	.19907	99.00000	.41760	.95132	.41287	.99161	12.	10.	10.
PS	-.46926	99.00000	-.51463	.18803	99.00000	.04480	-.13277	-.02780	.13777	.19172	13.	13.
PIRS	-.46926	99.00000	-.51463	.18803	99.00000	.04480	-.13277	-.02780	.13777	.19172	1.00000	13.
PIR16	.36329	99.00000	.63381	.36921	99.00000	.81831	.52804	.77127	.12280	.11377	-.02095	-.02095
P2R16	.48784	99.00000	.16667	.70065	99.00000	.85502	1.00000	.90511	.42930	.29471	.29277	.29277
PT16	.60758	99.00000	.63355	.42660	99.00000	.85122	.61371	.82011	.19728	.17090	-.02205	-.02205
MTIR	.13274	99.00000	-.26318	.16230	99.00000	-.19445	-.17310	-.19959	.14279	.14880	.28212	.28212
MTBR	-.03499	99.00000	-.48911	-.06700	99.00000	-.39129	-.40988	-.34984	-.33410	-.35890	.14040	.14040
MINDT	-.28906	99.00000	-.19582	-.45887	99.00000	-.54123	-.50740	-.54831	-.08339	-.12615	.14686	.14686
MAXOP	.34091	99.00000	-.16701	.18405	99.00000	.02921	-.01742	.02654	.19993	.21890	.20285	.20285
MIMBT	-.38715	99.00000	-.01763	-.29654	99.00000	.02072	-.17545	-.06927	.29791	.29854	.27454	.27454
MAXBT	-.18466	99.00000	-.12476	.07073	99.00000	.07006	.18977	.08457	.49217	.45069	.14719	.14719
PILT16	.35374	99.00000	.05366	.48168	99.00000	.79710	.60238	.78491	.59323	.57649	.31424	.31424
P2LT16	.40492	99.00000	.44474	.41799	99.00000	.60747	1.00000	.73761	.78212	.76233	-.13241	-.13241
TOTHIT	.60100	99.00000	.37422	.53925	99.00000	.91584	.83163	.93707	.53731	.49883	.04043	.04043
SCORE	.58865	99.00000	.38218	.55149	99.00000	.92119	.80431	.93236	.46913	.45173	.04663	.04663

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	PIR16	P2R16	PT16	MTIR	MTBR	MINDT	MAXOP	MIMBT	MAXBT	PILT16	P2LT16	TOTHIT
AFOT	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
NATION	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
PLATOON	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
CREW	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
JOB	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
PIR	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
P2R	13.	7.	13.	13.	13.	13.	13.	13.	13.	13.	8.	13.
PT	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
PMT	12.	5.	12.	12.	11.	12.	12.	12.	12.	12.	8.	12.
PINT	12.	5.	12.	12.	11.	12.	12.	12.	12.	12.	8.	12.
PS	13.	6.	13.	13.	12.	13.	13.	13.	13.	13.	8.	13.
PIRS	13.	6.	13.	13.	12.	13.	13.	13.	13.	13.	8.	13.
PIR16	15.	7.	15.	15.	13.	15.	15.	15.	15.	15.	8.	13.
P2R16	.66036	7.	7.	7.	7.	7.	7.	7.	7.	7.	2.	7.
PT16	.98637	.84963	15.	15.	13.	15.	15.	15.	15.	15.	8.	15.
MTIR	-.06346	-.27367	-.08139	15.	13.	15.	15.	15.	15.	15.	8.	15.
MTBR	-.48491	-.28554	-.45739	.58378	13.	13.	13.	13.	13.	13.	8.	13.
MINDT	-.61125	-.58916	-.59006	.32982	.67043	15.	15.	15.	15.	15.	8.	15.
MAXOP	.14264	-.13776	.11529	.93860	.39850	.10878	15.	15.	15.	15.	8.	15.
MIMBT	-.22621	-.35311	-.23008	-.26693	-.33613	.24719	-.32134	15.	15.	15.	8.	15.
MAXBT	-.29124	.01197	-.24264	.10541	.00438	.30048	.02550	.68132	15.	15.	8.	15.
PILT16	.43308	.62641	.50353	-.19195	-.11889	-.28080	-.05215	.14268	.32174	15.	8.	15.
P2LT16	.45163	99.00000	.47946	.14105	-.42371	-.51943	.28445	-.04338	.41316	.53006	8.	8.
TOTHIT	.69485	.88999	.73965	-.07646	-.34860	-.60621	.12808	-.12412	.05620	.74564	.79529	15.
SCORE	.78618	.80891	.80904	-.09657	-.40576	-.68689	.13347	-.20983	-.07740	.72528	.81619	.97209

Table C-3. GR correlation matrix, 13 observations

	afet	nation	plateau	crew	job	plr	p2r	pt	put	plnt	ps	plrs
afet	13.	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
nation	99.00000	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
plateau	.04404	99.00000	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
crew	.15971	99.00000	.02021	13.	13.	13.	11.	13.	10.	10.	11.	11.
job	99.00000	99.00000	99.00000	99.00000	13.	13.	11.	13.	10.	10.	11.	11.
plr	.18385	99.00000	.80678	.37280	99.00000	13.	11.	13.	10.	10.	11.	11.
p2r	-.28158	99.00000	.62131	.30705	99.00000	.62909	11.	11.	9.	9.	10.	10.
pt	.14107	99.00000	.81632	.39461	99.00000	.97079	.76411	13.	10.	10.	11.	11.
put	.00823	99.00000	.31442	.46905	99.00000	.56584	.78624	.58497	10.	10.	8.	8.
plnt	.02640	99.00000	.23911	.46129	99.00000	.51522	.73790	.51622	.99026	10.	8.	8.
ps	.50727	99.00000	-.46985	.06932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	11.	11.
plrs	.50727	99.00000	-.46985	.06932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	1.00000	11.
plr16	.08848	99.00000	.78785	.26450	99.00000	.84016	.43644	.77803	.25988	.26062	-.19541	-.19541
p2r16	-.39658	99.00000	.61237	.58333	99.00000	.76585	1.00000	.85707	.98647	.96976	99.00000	99.00000
pt16	.04839	99.00000	.80235	.33277	99.00000	.87112	.53601	.82927	.34365	.32292	-.20795	-.20795
put16	.10927	99.00000	-.32856	.09473	99.00000	-.26865	-.26668	-.28365	.40781	.43902	.27041	.27041
plnt16	-.07437	99.00000	-.55735	-.03840	99.00000	-.42281	-.41526	-.37289	-.32870	-.36249	.19691	.19691
ps16	.13352	99.00000	-.34308	-.36515	99.00000	-.43174	-.38020	-.43253	-.14984	-.21322	.44173	.44173
maxop	.17609	99.00000	-.16819	.10098	99.00000	-.07797	-.14544	-.08937	.35466	.39100	.12074	.12074
maxbt	.27538	99.00000	.12371	-.24442	99.00000	-.03010	-.17177	-.13954	.12832	.11381	.32142	.32142
maxht	.05445	99.00000	.03624	.10619	99.00000	-.08524	.16759	-.06563	.39985	.33884	.05648	.05648
plnt16	.15418	99.00000	.36710	.57405	99.00000	.77229	.60226	.75894	.61214	.57759	.14008	.14008
p2ht16	.05498	99.00000	.67372	.48177	99.00000	.53676	1.00000	.70698	.75007	.72628	-.24976	-.24976
totht	.11318	99.00000	.65785	.48201	99.00000	.89528	.80403	.92033	.78691	.74301	-.27174	-.27174
score	.13563	99.00000	.66078	.50441	99.00000	.89911	.76651	.91116	.67913	.66368	-.24268	-.24268

13 ideon scatterplots 1

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2d matrix identical to table C-1.

Table C-4. LR correlation matrix, 13 observations

	afet	nation	platoon	crew	job	plr	p2r	pt	ret	plot	ps	plrs
afet	13.	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
nation	99.00000	13.	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
platoon	.18523	99.00000	13.	13.	13.	13.	11.	13.	10.	10.	11.	11.
crew	-.22814	99.00000	.02021	13.	13.	13.	11.	13.	10.	10.	11.	11.
job	99.00000	99.00000	99.00000	99.00000	13.	13.	11.	13.	10.	10.	11.	11.
plr	-.01697	99.00000	.80678	.37280	99.00000	13.	11.	13.	10.	10.	11.	11.
p2r	-.31883	99.00000	.62131	.30705	99.00000	.62909	11.	11.	9.	9.	10.	10.
pt	-.04757	99.00000	.81632	.39461	99.00000	.97079	.76411	13.	10.	10.	11.	11.
ret	-.33468	99.00000	.31442	.44905	99.00000	.56584	.78624	.58497	10.	10.	8.	8.
plot	-.39765	99.00000	.23911	.44129	99.00000	.51522	.73790	.51622	.99026	10.	8.	8.
ps	-.23463	99.00000	-.44985	.04932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	11.	11.
plrs	-.23463	99.00000	-.44985	.04932	99.00000	-.21744	-.41750	-.32627	.25786	.34591	1.00000	11.
plr16	.03059	99.00000	.78785	.26650	99.00000	.84016	.43644	.77803	.25988	.26062	-.19541	-.19541
p2r16	-.36051	99.00000	.61237	.58333	99.00000	.76585	1.00000	.85707	.98847	.96976	99.00000	99.00000
pt16	.03390	99.00000	.80235	.33277	99.00000	.87112	.53601	.82927	.34365	.32292	-.20795	-.20795
plr1r	.11647	99.00000	-.32856	.09473	99.00000	-.26865	-.26668	-.28365	.80781	.43902	.27041	.27041
plr	-.05498	99.00000	-.35755	-.03840	99.00000	-.42281	-.41526	-.37289	-.32870	-.36249	.19691	.19691
minet	.20654	99.00000	-.34308	-.36515	99.00000	-.43174	-.38020	-.43253	-.14984	-.21322	.44173	.44173
maxop	.17307	99.00000	-.16819	.10098	99.00000	-.07797	-.14544	-.08937	.35446	.39100	.12074	.12074
minbt	.19105	99.00000	.12371	-.24442	99.00000	-.03010	-.17177	-.13954	.12832	.11381	.32142	.32142
maxbt	-.02527	99.00000	.03624	.10619	99.00000	-.08524	.16759	-.06563	.39985	.33884	.05648	.05648
pl1116	-.31493	99.00000	.36710	.57485	99.00000	.77229	.60226	.75894	.61214	.57759	.14008	.14008
p21116	-.41430	99.00000	.67372	.48177	99.00000	.53676	1.00000	.70698	.75807	.72628	-.24976	-.24976
totht	-.08795	99.00000	.65785	.48201	99.00000	.89528	.80403	.92033	.70691	.74301	-.27174	-.27174
score	-.12719	99.00000	.66078	.50441	99.00000	.89911	.76651	.91116	.67913	.66368	-.24268	-.24268

13x13 scatterplots 1

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2d matrix identical to table C-1.

APPENDIX D

ASSUMPTIONS USED IN THE COMBAT SIMULATION

This appendix describes the combat conditions assumed to exist during the simulation. Almost all of the assumptions/conditions have been incorporated into the model so that they may be easily changed or modified. Therefore, the effect of these assumptions/conditions can be tested.

The Blue tank platoon is assumed to occupy its assigned general defensive position (GDP). The position is prepared with several hull defilade firing points for each tank. All Blue engagements take place from hull defilade positions. Each tank carries a basic load of 60 Armor Piercing Fin Stabilized Discarding Sabot (APFSDS) rounds. All weapon systems are functioning to specifications. Visibility exists to 2,000 meters. Engagement sequences begin at 2,000 m for both Red and Blue forces. Terrain is considered typical of that in the Fulda Gap region of the West German border.

Tank gun fire and Red anti-tank (AT) missiles are the only weapons simulated. The Blue platoon has no infantry support nor any TOW AT missiles. Red BMP 73 mm gun, Blue .50 cal M85 machine gun, small arms and artillery fire are not simulated. Once Red vehicles close within 500 meters of the Blue position, they are terminated from the model as having succeeded in assaulting the position.

The Blue platoon is confronted with a major Red breakthrough attempt. Reconnaissance forces are ignored. The Red battalion is configured to be attacking with two BMP companies in the 1st echelon. Each company is preceded by a platoon of four attached Red main battle tanks. The 2nd echelon is comprised of the 3rd BMP company with attached tank platoon. Two ZSU-23/4's are attached. Two battalion command vehicles and the tank company commander comprise the command group. The entire attacking force consists of 13 MBT's, 30 BMP's, 2 ZSU-23/24's, and 2 battalion command vehicles for a total of 47 AFV's (Armored Fighting Vehicles).

The initial rate of advance of the Red battalion is 12 km/hr. This rate slows down as the unit closes on the Blue position. At 1,500 m the rate is 8 km/hr and at 1,000 meters becomes 4.8 km/hr. At any given time, the Red force is considered to be comprised of 50 percent moving targets. However, all Red engagements are fired from the halt. The Red are assumed to have a .6 probability of acquiring a Blue tank ONCE it has fired its main gun.

Engagements occur every 100 meters. That is, every 100 meters beginning at 2,000 meters, each Red vehicle is potentially engaged and, as well, has the opportunity to engage a Blue tank. If, however, a Red tank is not engaged within 20 seconds after acquisition, it automatically moves to the next 100 meter interval.

Each Blue tank will fire a maximum of three rounds/target. If a Red target is hit on the 1st, 2nd or 3d Rd, the Blue tank immediately relays to another Red target. If all rounds miss, the Blue tank ends the engagement of the Red target and proceeds to the next Red target. The Red vehicle advances to the next 100 meter interval where it is again placed in jeopardy. However, at each 100 meter interval it also has the opportunity to fire at the Blue tanks.

Blue tanks are exposed for only the "X" seconds and are then made unavailable for "Y" seconds. The heavy and light sections are initially staggered so that some portion of the platoon is always engaging. Blue priority is given to the closest Red MBT or ZSU-23/4. If no MBT or ZSU is available, BMP's will be engaged.

APPENDIX E

BATTLE SIM GPSS CODE

```

1      SIMULATE
2      RMULT      3991
3      FUNCTIONS
4
5      1 FUNCTION      RN1.D2      MOVER-1, STATIONARY-2
6      .7,1/1.2
7
8
9      EXP FUNCTION      RN1.C24
10     0.0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69
11     .8,.915/.7,1.2/.75,1.38/.8,1.6/.84,1.83/.88,2.12
12     .9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2/.97,3.5
13     .93,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9997,8
14
15
16
17
18
19
20     ACC FUNCTION      PH1.C7      PROBABILITY OF TGT ACQUISITION BY US TANK
21     0.700/30,750/60,800/90,850/120,900/150,950/300,999
22
23
24     ENG FUNCTION      PH1.C5      PROBABILITY OF US ENGAGING THE TARGET
25     0.300/90,800/120,900/150,950/300,999
26
27
28     TGTYP FUNCTION      PH3.D5
29     1.TYP1/2,TYP2/3,TYP1/4,TYP1/5,TYP2
30
31
32     MTST1 FUNCTION      PH2.D2      DIFFERENTIATES BETWEEN MOVING AND STA TARGET
33     1.MOV1/2,STA1
34
35
36     PH51 FUNCTION      PH1.C4      /
37     0.183/150,512/375,688/800,849
38
39
40     PHM1 FUNCTION      PH1.C4
41     0.137/150,472/375,864/800,999
42
43
44     MTST2 FUNCTION      PH2.D2      AS MTST1
45     1.MOV2/2,STA2
46
47
48     PH52 FUNCTION      PH1.C4      /
49     0.193/150,527/375,706/800,883
50
51
52     PHM2 FUNCTION      PH1.C4
53     0.191/150,434/375,649/800,794
54
55
56     ROF FUNCTION      PH1.C4      ADJUSTS RATE OF FIRE
57     0.5/150,5/375,5/800,3
58
59
60     RWGE FUNCTION      PH1.D4      RATE OF ADVANCE IN SECONDS
61     0.30/150,30/375,45/800,75
62

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63	•		
64	•	COREL FUNCTION PH4.D5	ASSIGNS FACILITIES TO STORAGES
65	•	1.6/2.7/3.8/4.9/5.10	
66	•		
67	•		
68	•	CHAIN FUNCTION PH4.D5	ASSIGNS FACILITIES TO IMP CHAINS
69	•	1.11/2.12/3.13/4.14/5.15	
70	•		
71	•		
72	•	THENG FUNCTION PH1.C3	PROBABILITY OF SOVIET ENGAGING US TANK
73	•	0.950/150.975/300.999	
74	•		
75	•		
76	•	SPH FUNCTION PH1.C4	
77	•	0.147/150.235/375.380/300.573	
78	•		
79	•		
80	•	BMPSG FUNCTION PH1.C4	PROBABILITY OF BMP ENGAGING US TANK
81	•	0.950/120.975/375.999/300.500	
82	•		
83	•		
84	•	TOF FUNCTION PH1.C4	TIME OF FLIGHT FOR SAGGER MISSILE
85	•	0.19/150.15/375.10/300.6	
86	•		
87	•		
88	•	PHSAG FUNCTION PH1.C4	
89	•	0.295/150.296/375.297/300.172	
90	•		
91	•		
92	•	RELAY FUNCTION PH1.C4	TIME REQUIRED TO RELAY FROM TARGET TO TARGET
93	•	0.5/150.5/375.5/300.4	
94	•		
95	•		
96	•	BALK FUNCTION PH3.D5	ASSIGNS BALK XAC TO CORRECT USER CHAIN
97	•	1.BBB/2.CCC/3.BBB/4.BBB/5.CCC	
98	•		
99	•		
100	•	BASIC LOAD OF AMMO PER US TANK:	
101	•		
102	•	INITIAL XH1-XH5.60	
103	•	INITIAL XF1-XF4.0	
104	•		
105	•		
106	•	GENERATION OF SOVIET MR BATTALION REINFORCED	
107	•	-----	
108	•		
109	•	GENERATE 5.4.18.1	1ST COMPANY T-62
110	•	ASSIGN 1.0.PH	ASSIGNS INITIAL RANGE
111	•	ASSIGN 2.FN1.PH	" MOVING/STA TGT MODE
112	•	ASSIGN 3.1.PH	" TGT TYPE (1/T62)
113	•	ASSIGN 12.40.PH	" BASIC LOAD OF AMMO (40 RDS-TANK)
114	•	JOIN TANK	PLACES TARGET IN GROUP TANK
115	•	SPLIT 1.BATL2	CNTRPART GOES TO SVT TNC COUNTERFIRE SEGMENT
116	•	TRANSFER .BATL	ENTER THE BATTLE
117	•		
118	•		
119	•	GENERATION OF 2 BMP COMPANIES	
120	•		
121	•	GENERATE 5.4.90.20.2	2 COMPANIES BMPs
122	•	ASSIGN 1.0.PH	
123	•	ASSIGN 2.FN1.PH	
124	•	ASSIGN 3.2.PH	TGT TYPE(2/BMP)
125	•	ASSIGN 12.4.PH	ASSIGNS BASIC LOAD OF MISSILES (4-BMP)
126	•	JOIN BMP	

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125 SPLIT 1.BATL3 CNTRPART GOES TO BMP COUNTERFIRE SEGMENT
126 TRANSFER .BATL
127
128 *
129 * GENERATE ADA SECTION OF 2 7SU/23-45
130 *
131 GENERATE ..120.2.1 2 7SU/23-4
132 ASSIGN 1.0.PH
133 ASSIGN 2.FN1.PH
134 ASSIGN 3.3.PH TGT TYPE (3/250)
135 JOIN BMP
136 TRANSFER .BATL
137
138 *
139 * GENERATION OF TANK CO CMND TANK
140 *
141 GENERATE ..120.1.1 CO CMND TANK
142 ASSIGN 1.0.PH
143 ASSIGN 2.2.PH STA TGT MODE
144 ASSIGN 3.4.PH TGT TYPE (4/CMND VEHICLE)
145 JOIN TANK
146 TRANSFER .BATL
147
148 *
149 * GENERATION OF BN CMND VEHICLES
150 *
151 GENERATE ..120.2.3 BN CMND VEH
152 ASSIGN 1.0.PH
153 ASSIGN 2.2.PH STA TGT MODE
154 ASSIGN 3.5.PH TGT TYPE (5/BN CMND VEH)
155 JOIN BMP
156 TRANSFER .BATL
157
158 *
159 * GENERATION OF LAST T-62 FLT
160 *
161 GENERATE 5.4.390.4.1 LAST T-62 FLT
162 ASSIGN 1.0.PH
163 ASSIGN 2.FN1.PH
164 ASSIGN 3.1.PH
165 ASSIGN 12.40.PH
166 JOIN TANK
167 SPLIT 1.BATL2
168 TRANSFER .BATL
169
170 *
171 * GENERATION OF 3RD BMP COMPANY
172 *
173 GENERATE 5.4.420.10.2 LAST BMP COMPANY
174 ASSIGN 1.0.PH
175 ASSIGN 2.FN1.PH
176 ASSIGN 3.2.PH
177 ASSIGN 12.4.PH
178 SPLIT 1.BATL3
179 JOIN BMP
180
181 *
182 * SIMULATION OF DIRECT FIRE TANK GUN ENGAGEMENTS BY US FORCES.
183 *
184 -----
185 BATL ASSIGN 7.3.PH INCREMENTS NUMBER OF INC. FIRED PER TARGET
186 TRANSFER .FN1ACO.MTCH1.ENG ACQUIRE TARGET?
187 ENG TRANSFER .FN1ENG.MTCH1.ELL ENGAGE TARGET?
188 SEL SELECT MIN 4PH.1.5.1.0 SELECT US FIRING TANK
189 QUEUE PH4 ENTER FIRING TANKS QUEUE
190 ASSIGN 5.FN1CHAIN.PH
191
192 *
193 * ENGAGEMENT DECISIONS BY EACH TANK CMNDR FOLLOWED BY

```

187	•	ACTUAL ENGAGEMENT SEQUENCE.		
188	•			
189	•			
192		MARK	SPH	BALK PROGRAM, SEE SEGMENT "REMAINDER OF BALK P
194		SPLIT	1,AAA	
195		EXAMINE	TANK1,BMP1	IS TARGET IN TANK GROUP?
196		LINK	PH4,1PH,TN1	PLACE TARGET ON TANK TARGET CHAIN, IF YES
197	BMP1	LINK	PH5,1PH,TN1	PLACE TARGET ON BMP TARGET CHAIN, IF NO
198	TNK1	SEIZE	PH4	NOTE: RANGE IS THE ORDERING PARAMETER
199		DEPART	PH4	
200	•	ING PARAMETER.		
201	SHT	TRANSFER	FN,TGTYP	DETERMINE TARGET TYPE.
202	TYPE1	TRANSFER	FN,MTST1	" IF TGT IS MOVING OR STATIONARY
203	STA1	TRANSFER	.FN5PH1,RLD,HIT1	" PH FOR STA TGT
204	MOV1	TRANSFER	.FN5PH1,RLD,HIT1	" PH FOR MOV TGT
205	HIT1	RELEASE	PH4	TGT HIT AND DESTROYED
206		SAVEVALUE	PH4-.1,XH	REDUCE FIRING TANK AMMO BY ONE RD
207		ADVANCE	FN\$RELAY	RELAY GUN TO NEXT TARGET
208		UNLINK	PH4,TN1,1,1,BACK,BMP3	UNLINK CLOSEST TANK IF AVAILABLE
209		PRIORITY	PR,BUFFER	HOLD UNLINKING XAC
210		TEST LE	PH3,2,TER1	TEST FOR DMP OR TANK
211		TRANSFER	.MTCH5	WAIT FOR COUNTERPART FIRING AT US TANKS
212	BMP3	UNLINK	PH5,TNK1,1,1,BACK	UNLINK DMP IF TANK NOT AVAILABLE
213		PRIORITY	PR,BUFFER	
214		TEST LE	PH3,2,TER1	
215	MTCH5	MATCH	MTCH5	WAIT FOR COUNTERPART MATCH MTCH5
216	TER1	TERMINATE		TERMINATE CMD VOPS IF HIT
217	•			
218	TYPE2	TRANSFER	FN,MTST2	DETERMINE IF TARGET IS MOV OR STA
219	STA2	TRANSFER	.FN5PH2,RLD,HIT2	" PH FOR STA TGT
220	MOV2	TRANSFER	.FN5PH2,RLD,HIT2	" PH FOR MOV TGT
221	HIT2	RELEASE	PH4	BMP HIT AND DESTROYED
222		SAVEVALUE	PH4-.1,XH	REDUCE FIRING TANK AMMO BY 1 ROUND
223		ADVANCE	FN\$RELAY	
224		UNLINK	PH4,TN1,1,1,BACK,BMP4	
225		PRIORITY	PR,BUFFER	
226		TEST LE	PH3,2,TER2	
227		TRANSFER	.MTCH7	
228	BMP4	UNLINK	PH5,TNK1,1,1,BACK	
229		PRIORITY	PR,BUFFER	
230		TEST LE	PH3,2,TER2	
231	MTCH7	MATCH	MTCH7	
232	TER2	TERMINATE		
233	•			
234	RLD	SAVEVALUE	PH4-.1,XH	REDUCE AMMO BY ONE
235		ASSIGN	PH5,PH,PH	EVALUATE RLDWD TIM
236		ADVANCE	PH7	RELOAD
237		ASSIGN	7-.1,PH	REDUCE FIRING REPR
238		TEST E	PH2,1,NXT	TEST FOR MOVING TARGET
239		ASSIGN	1+.PH,PH	ADD RANGE TO MOVING WHILE RLDWD
240	NXT	TEST E	PH7,0,SHT	DOES US TANK RE-ENGAGE
241		RELEASE	PH4	IF NO, RELEASE FIRING TANK
242		ADVANCE	FN\$RELAY	RELAY TO NEXT TARGET
243	•			
244	•			
245		UNLINK	PH4,TNK1,1,1,BACK,BMP2	UNLINK TANK TARGET FIRST
246		PRIORITY	PR,BUFFER	
247		TEST LE	PH3,2,ADV	
248		TRANSFER	.MTCH1	ADVANCE TO THE NEXT ENG RANGE
249	BMP2	UNLINK	PH5,TNK1,1,1,BACK	UNLINK BMP TARGET
250		PRIORITY	PR,BUFFER	
251	MTCH1	TEST LE	PH3,2,ADV	

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202 MTCH3 MATCH MTCH3
203 ADV ASSIGN 10.FN$RNGE.PH EVALUATE RATE OF ADVANCE
204 ASSIGN 1+.PH10.PH UPDATE RANGE PARAMETER
205 ADVANCE PH10 ADVANCE TIME
206 TEST GE PH11.750.BATL MAY TARGET REACHED APPROX 500 METERS
207 TEST LE PH3.2.TER3
208 MTCH3 MATCH MTCH3 EMP 5 AND TANKS WAIT FOR ENTPART
209 TER3 TERMINATE
210
211 REMAINDER OF BALI PROGRAM
212
213 AAA ADVANCE 20 TARGET WAITS 20 SECONDS TO BE ENGAGED
214 TRANSFER FN.BALK IF NOT ENGAGED TARGET GOES TO USER CHA
215 BBB UNLINK PH4.MTCH1.1.SPH
216 PRIORITY PR.BUFFER
217 TERMINATE
218 CCC UNLINK PH5.MTCH1.1.SPH
219 PRIORITY PR.BUFFER
220 TERMINATE
221
222 EXPOSE FIRING TANK FOR ONLY 'X' SECONDS
223
224 COUNT GENERATE ...5 GENERATE 5 CONTROL XACS
225 ASSIGN 1.N$COUNT.PH
226 FUNAVAIL PH1.CO,...RE.MTCH1 INITIALLY ALL US TANKS UNAVAIL
227 TEST LE PH1.3.222 TEST FOR TANKS 4 & 5
228 RET ADVANCE 10.FN$EXP EXPOSE TANKS 1,2,3.
229 FAVAIL PH1
230 XXX GATE FV PH1
231 ADVANCE 30.3 REMAIN EXPOSED
232 FUNAVAIL PH1.CO,...RE.MTCH1 GO INTO HIDE: CANNOT FIRE
233 ADVANCE 40.4 REMAIN HIDDEN
234 GATE LS PH1.XXY CHECK TO DETERM US TANK NOT HIT
235 TERMINATE
236 XXX FAVAIL PH1
237 TRANSFER ,XXX
238 222 ADVANCE 20.FN$EXP DELAY EXPOSURE OF TANKS 4 & 5.
239 TRANSFER ,RET
240
241 AMMUNITION CONTROL FOR US TANKS
242
243 COUN GENERATE ...5
244 ASSIGN 1.N$COUN.PH
245 TEST E XH$PH1.0
246 FUNAVAIL PH1.RE.MTCH1,...RE.MTCH1
247 LOGIC S PH1
248 TERMINATE
249
250
251
252
253
254
255
256 RETURN FIRE SECTION BY SOVIET MAIN BATTLE TANKS
257
258 BATL2 TEST E PH3.1.BATL2 IS FIRING VEH A TANK OR EMP?
259 SELECT FV 4PH1.1.5..F.EXIT1 SELECT FIRST AVAILABLE US TANK
260 ASSIGN 5.FN$COREL.PH
261 QUEUE PH5
262 ENTER PH5
263 DEPART PH5
264 TRANSFER .4.CONTO.SVTEG ACQUIRED TARGET (US)?
265 SVTEG TRANSFER .FN$THENG.CONTO.SSHIT ENGAGES TARGET?

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317	SSHIT TEST E	PH2,2,LNGAC	LONG ACQ TIME FOR MOVING TANK
318	ADVANCE	10	SHORT ACQ TIME FOR STA TANK
319	TRANSFER	.SSHIT	
320	LNGAC ADVANCE	15	LONG TIME + STOP TANK AND LAY GUN
321	SSHIT TRANSFER	.FN\$PH,SSHIT	FIRE 1ST ROUND
322	ASSIGN	12-.1,PH	REDUCE AMMO BY ONE RD
323	ADVANCE	17	RELOAD
324	GATE IV	PH4,CONTU	IS TARGET STILL EXPOSED
325	TRANSFER	.FN\$PH,FIRE1,SSHIT	YES,FIRE 2ND ROUND
326	USHT LEAVE	PH5	US TANK HIT
327	ASSIGN	12-.1,PH	
328	FUNAVAIL	PH4	US TANK OUT OF ACTION
329	LOGIC S	PH4	SET CORRECT LOGIC SWITCH
330	TRANSFER	.MTCH2	
331	CONTU LEAVE	PH5	
332	NEXT TEST LE	PH12,0,MTCH2	IS SOVIET OUT OF AMMO? YES: TERMINATE
333	TRANSFER	.MTCH9	
334	MTCH2 TEST E	PH3,1,OTHER	IS XAC A TANK? NO: GO TO OTHER
335	GATE M	MTCH5,CHCK2	HAS CNTRPART BEEN HIT?
336	TRANSFER	.MTCH5	IF YES GO TO MTCH5 AND LINK-UP
337	OTHER GATE M	MTCH7,CHCK2	SAME SEQUENCE FOR BMP
338	TRANSFER	.MTCH7	
339	CHCK2 GATE M	MTCH9,MTCH8	HAS CNTRPART REACHED 500 METERS
340	TRANSFER	.MTCH9	
341	TERMINATE		
342	MTCH8 MATCH	MTCH3	WAIT ON CNTRPART IF IT HAS NOT BEEN HIT
343	ASSIGN	10,FN\$RNGE,PH	ADVANCE WITH COUNTERPART
344	ASSIGN	1+.PH10,PH	
345	ADVANCE	PH10	
346	TEST GE	PH1,750,BATL2	
347	TRANSFER	.MTCH9	
348	TERMINATE		
349			
350	FIRE1 LEAVE	PH5	
351	ASSIGN	12-.1,PH	
352	TRANSFER	.NEXT	
353	EXIT1 TRANSFER	.MTCH2	
354			
355	STORAGE	S6-S10,5	
356			
357			
358			
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400			

COUNTERFIRE BY SOVIET INFANTRY PERSONNEL CARRIERS, ARMED WITH SAGGER AT-3 MISSILES.

BATL2 SELECT FV	4PH,1,5,.F,EXIT2	
ASSIGN	5,FN\$COREL,PH	
QUEUE	PH5	
ENTER	PH5	
DEPART	PH5	
TRANSFER	.4,ENDEG,UMPHEN	DOES BMP ACQUIRE TARGET?
BMPEN TRANSFER	.FN\$BMP\$G,ENDEG,SSHIT	DOES BMP ENGAGE TARGET?
SSHIT TEST E	PH2,2,LNGAC	IS BMP MOVING? IF YES, GO TO LNGAC
ADVANCE	7	
TRANSFER	.TOF	
LNGAC ADVANCE	15	LONG ACQUISITION TIME
TOF ADVANCE	FN\$TOF	TIME OF FLIGHT FOR AT MISSILE
GATE FV	PH4,ENDEG	IS US TANK STILL EXPOSED
TRANSFER	.FN\$PH\$G,SSHIT	PH FOR AT MISSILE HIT
ASSIGN	12-.1,PH	REDUCE MISSILE LOAD BY 1.

300	LEAVE	PH5	
301	TEST LE	PH12.0.MTCH2	
302	TRANSFER	.MTCH9	
303	SACHT LEAVE	PH5	US TANK HIT
304	ASSIGN	12-.1.PI	
305	FUNAVAIL	PH4	US TANK OUT OF ACTION
306	LOGIC S	PH4	
307	TEST LE	PH12.0.MTCH2	
308	TRANSFER	.MTCH9	
309	ENDEG LEAVE	PH5	
310	TEST LE	PH12.0.MTCH2	
311	TRANSFER	.MTCH9	
312	EXIT2 TRANSFER	.MTCH2	
313	.		
314	.		
315	.		
316	.		
317	.		
318	GENERATE	60	
319	TERMINATE	1	
320	START	20	
400	END		
401			

APPENDIX F

OBSERVATIONS ON INTELLIGENCE AND EDUCATION LEVELS OF U.S. TANK COMMANDERS AND GUNNERS VERSUS PERFORMANCE MADE BY CAT 1981 TEAM LEADER DURING THE TRAINING PERIOD JANUARY TO JUNE 1981 AND MAJOR GENERAL W. F. ULMER, COMMANDER, 3RD ARMORED DIVISION.

Comments by 1981 CAT Team Captain

Establishment of an Attack SOP for a CAT Battle Run:

After the first draft was developed, it was fielded to the NCO's for comment/recommendation. The response was proportional to the education/intelligence level of the NCO's. Those on the lower end of the scale had no comments or recommendations, either because they did not understand the concepts involved and did not want to publicize their lack of knowledge, or (hopefully not), they just did not care enough to get involved. This observation held true throughout the remainder of the training. Recommendations for SOP changes came from the "smarter" crewmen. These were the ones with enough perception to recognize shortcomings in our plan and tell us how to improve upon the SOP. Additionally, it was obvious throughout the training that those who understood the concepts involved and assisted in the SOP development mastered it more quickly and used it more effectively.

Boresight and Zero Procedures:

Again, the level of proficiency attained could be correlated to the intelligence/education levels of the tank commanders involved. We repeatedly had problems with the same tank commanders making procedural errors during the exercise. These tank commanders, again, were our less educated/intelligent NCO's.

Conduct of Fire:

To accomplish this (conduct of fire) quickly and accurately requires keen thought and decision making ability on the part of the tank commanders. We had some tank commanders who could not handle this, especially under the 40 second time limit of target presentation imposed by the competition.

Conclusions:

I feel experience and intelligence are the primary prerequisites to train soldiers to fight tanks effectively and to optimize the capability afforded them by their sophisticated equipment. Based on the CAT experience, if I have a choice between experience and low GT and inexperience and high GT score, I would take the latter.

A lack of education or lower intelligence scores can be overcome by a strong desire to excel and self study coupled with long hours of extra training to make up for these shortcomings. We had one TC who fell in that category and he sacrificed and worked hard to overcome his deficiencies. In my experience, he was the exception.* Rarely are these types motivated enough to sacrifice to excel. Unfortunately, they generally tend to accept their station and plod through. As systems become more complex, we must man them with people who can not only learn "how" but have the ability to understand "why."

*Underlining done by author.

COMMENTS BY MAJOR GENERAL ULMER:

Intelligence more than anything else (seniority, experience, time in service, crew stability) is the discriminator between good and outstanding tank gunnery performance where multiple target engagements under the stress of time are the primary concern. (I would be very reluctant to enter a crew into the final training phase for CAT '83 where the combined GT score of TC and gunner was less than 220).* Screening of individual crewman for intelligence, visual acuity, and hand-eye coordination should be the first step in forming the CAT team.

*Requires an average of MC II for the gunner and tank commander.