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A PRELIMINARY ANALYSIS OF NATIONAL TRAINING CENTER
FORCE-ON-FORCE PERFORMANCE

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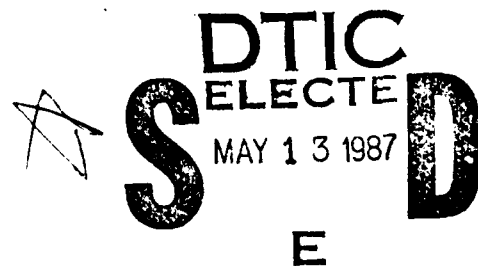


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and across missions.

2) Generally, the task forces suffered very high casualty rates themselves, while inflicting relatively low casualty rates on the opposing forces (OPFOR). This seemed to be the case for all task forces, and was seemingly unrelated to the MTOE (modification table of organization and equipment) of the task force. In order to understand task force performance, it will be necessary to have a full complement of data, rather than the partial complement available in the take home packages.

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A PRELIMINARY ANALYSIS OF NTC FORCE-ON-FORCE PERFORMANCE

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A PRELIMINARY ANALYSIS OF NTC FORCE-ON-FORCE PERFORMANCE

EXECUTIVE SUMMARY

Requirement:

To assess the Task Force Performance in Force-on-Force Simulation at the NTC.

Procedure:

Using the data available in 64 Take Home Packages for battalions training at the NTC during the period of February 1982 to January 1985, an exploratory analysis (Tukey, 1977; Hartwig and Dearing, 1979) of performance in force-on-force simulations was conducted. This analysis focused on the relative contribution of task force type (Armor vs. Mechanized Infantry) and task force MTOE organization (H-series vs J-series) to mission performance. Two measures of performance were used in the analyses: percentage of task force vehicles lost and casualty exchange ratio.

Findings:

- o Substantial performance variation was found across battalions and missions.

- o Performance differed for type of task forces (Armor vs. Mechanized Infantry). This difference was greatest for Offensive missions.

- o Performance was not consistently related to the new MTOE organization, though J-series task forces lost a lower percentage of their force while simultaneously having a higher casualty exchange ratio.

- o The results show that:
 - The battalions suffered very high casualty rates while correspondingly inflicting a lower casualty rate upon the OPFOR.

- Battalion TFs are rendered combat ineffective by mission's end as a result of their casualties.

- Battalion TFs suffered very heavy tank casualties with an average loss of two-thirds of the available tanks.

- The above results hold true for all types of Task Forces

Military Implications:

- o The force multiplier effects of reorganization under the J-series MTOE cannot be determined from these results and will need to be investigated with the full complement of data.

- o The OPFOR performs better than the battalion task forces by achieving a much higher kill ratio on both offense and defense. This suggests basic weaknesses in battalion training. As a result, careful examination should be given to home-station factors and NTC performance, particularly to identify areas for improved Army-wide training.

A Preliminary Analysis of NTC Force-on-Force Performance

INTRODUCTION

U.S. Army battalions have been training at the National Training Center (NTC) at Ft. Irwin, California since 1981. The objective of NTC training is to provide a facility where units can undergo essential combined arms training that cannot be accomplished at home stations due to physical limitations and the prohibitive cost of providing a realistic training environment. A secondary objective of NTC training is to gather information which can be used to contribute to the improvement of doctrine, tactics, training systems, equipment and procedures in the U.S. Army.

In support of the NTC information-gathering objective, the Army Research Institute (ARI) has developed a research program which includes as a technical objective the collection, organization, and analysis of NTC data in order to assess those training benefits which may be accrued by the units training at the NTC. This report is an exploratory investigation (Tukey, 1977; Hartwig and Dearing, 1979) of the force-on-force data that are contained in the Take Home Packages (THPs) which are compiled and issued to the training units at the end of each NTC rotation. The objectives of this study was two-fold. First, it was designed to provide a description of the overall force-on-force performance at the NTC. Second, it investigated whether this performance was related to the task force type (Armor vs. Mechanized Infantry) and/or to task force organization (H- vs. J-MTOE series organization).

BACKGROUND

The NTC concept is geared to the training of the battalion task force (TF). Each battalion task force participates in approximately six force-on-force exercises during a two-week rotation period at the NTC. These exercises usually are more or less evenly divided between offensive and defensive operations using laser-based engagement simulation instrumentation to provide real-time casualty assessment. The simulator, the Multiple Integrated Laser Engagement System (MILES), is used on all principal weapons and casualties are assessed when a weapon fires and the MILES laser hits a target. In addition to force-on-force training, units also perform three missions on the live fire range during their rotation (see Figure 1). A separate investigation of live-fire performance has been conducted and is reported in Forsythe and Doherty (1985).

Missions Conducted

TF_____ conducted the following missions during their NTC training period:

DATE	MISSION
	Deliberate Day Attack
	Defend in Sector
	Delay in Sector
	Defend Battle Position (Day) (LFX)
	Defend Battle Position (Night) LFX)
	Movement to Contact (LFX)
	Movement to Contact
	Deliberate Night Attack
	Defend Battle Position

Figure 1. Typical Mission Schedule for an NTC Rotation.

The scenario dictates the force ratios of the combatants. While terrain and scenario options are limited, no two scenarios are exactly the same. When the TF conducts defensive missions they are always attacked by an OPFOR that replicates a Motorized Rifle Regiment. When TFs conduct offensive operations, they originally encountered a defending Motorized Rifle Company. However, in the summer 1984, the force ratio was changed to deploy a defending Motorized Rifle Battalion (-).

SCOPE

Sample

The source of the data analyzed in this report is the Take Home Package (THP) prepared at the end of each rotation. Data from 64 THPs covering the period February 1982 through January 1985 are represented in this analysis. The 64 THPs represent the rotations of 64 battalions from six divisions and two separate brigades located in the Continental United States (CONUS) that underwent training at the NTC during the above time period. The 64 battalions included 32 Armor and 32 Mechanized Infantry units which were cross reinforced to form 64 combined arms task forces (i.e., 32 Armor heavy and 32 Mech heavy TFs). Two rotations by the opposing force (OPFOR) -- i.e., two MTOE battalions permanently stationed at Ft. Irwin -- were also included in the sample. The OPFOR battalions did not undergo the standard rotation series of exercises but rather performed a mini-ARTEP. However, the

data extracted for the two missions performed by the OPFOR battalions (i.e., movement to contact and defend in sector) were not substantially different from the data of the rest of the sample and so were included in the analysis.

Data Sources

As previously mentioned, Take Home Packages (THPs) are prepared and issued to the training units at the termination of each NTC rotation. Separate packages are prepared for the respective Armor and Mechanized Infantry task forces. The THP is an overall description of unit performance during the rotation and includes statements of performance trends during the 14-day rotation period. The THP is the final compilation of all after action review scripts and encompasses an assessment of all seven operating systems, live fire gunnery data, and TF and opposing force (OPFOR) aggregate losses.

The force-on-force results are reported in the THPs in several formats and include the following data:

- TF and OPFOR vehicle loss summaries for Offensive Engagement Simulation (OES) operations
- TF and OPFOR vehicle loss summaries for Defensive Engagement Simulation (DES) operations
- Numbers of TF vehicles started and killed for each mission
- Numbers of OPFOR vehicles killed for each mission

Offensive and defensive operations summary data were extracted from the 64 THPs. Mission-specific data for the six most commonly performed missions (i.e., movement to contact/meeting engagement, deliberate day attack, deliberate night attack, defend in sector, delay in sector, and defend from a battle position) were also extracted from the THPs and combined with the summary data to construct the data base for this analysis. Each individual task force was coded to preserve anonymity and the data were then subjected to a number of statistical operations.

Data Analysis

The task force was designated as the unit of measurement and the data were divided into groups in order to identify differences in task force performance at the NTC during the period that force modernization was taking place. Task forces that were organized as H-MTOE series rotations occurring between February 1982 and January 1985 were identified as one analytic group while another

group was identified to include all J-MTOE series rotations occurring during the same time period. The two groups were further identified as Mechanized Infantry and Armor TFs within the H- and J-series categories. This provided a 2x2 analytic design for inferential investigation of performance differences.

The limited scope of force-on-force data available in the THPs severely constrained the analysis in several areas. For example, information on the numbers of OPFOR tanks and APCs starting each mission was not available in the THP thus prohibiting the derivation of percent of enemy vehicles killed during an exercise. Although the force strengths for Motorized Rifle Regiment and Motorized Rifle Company are available in FM 71-2, The Tank and Mechanized Infantry Battalion Task Force, Appendix H, this does not allow for instances of vehicle breakdown in the field, numbers of vehicles actually available to the OPFOR during specific individual missions, and so forth. For the purposes of this report, which is a preliminary exploration of the data available in the Take Home Packages only, it was decided that assumption of consistent standards for OPFOR strengths would not be made.

Of those data available in the THP (see Appendix A), two measures were selected as meaningful indicators of differences in TF performance. The first indicator, "%Lost", represents the percentage of TF vehicles lost on the NTC battlefield -- i.e., numbers of TF vehicles killed at each mission / numbers of TF vehicles started at each mission. The %Lost indicator was available for each TF vehicle type killed (i.e., APCs to include TOWs, and tanks) as well as an aggregate value ("Total Vehicles Lost") that combined all vehicle types. ITV/TOW data were extracted from the THPs for the six missions analyzed in the study. Results of ITV/TOW analyses revealed that losses were not obviously different from APC losses and so ITV/TOW data were incorporated into the APC data to produce the APC/TOW category. This indicator was investigated for overall offensive and defensive performance summaries. Because of the small number of cases for individual missions this indicator was not analyzed at the mission level.

The second type of measure "Casualty Exchange Ratio", consisted of the ratio of vehicle casualties for the two forces -- i.e., numbers of TF vehicles killed / number of OPFOR vehicles killed -- and was calculated for both specific vehicle types (i.e., APC/TOW and tanks) and across vehicle types. This indicator was used for both overall summary and mission level analyses.

RESULTS

The results of the investigation for the two types of performance measures are reported below. The discussion has been organized into two parts. The first part reports the results of simple descriptive analyses which portray the overall performance of the TF. The second part presents the results of the analyses of two factors (i.e. type of task force and task force organization) which might relate to variation in TF performance. In both sections, separate results are reported for offensive and defensive summary performance. Casualty exchange ratio results are also presented for six individual missions in the Appendix.

Analysis of Task Force Performance

%lost Performance Measure

Table 1 shows the percentage of TF vehicles by type that were lost across offensive and defensive missions. As seen in the table, TFs experience serious losses as evidenced by both the offensive and defensive mission summaries. In the offense, the TF lost over 45% of their combat vehicles on the average. A high loss pattern of results is found when the specific type of vehicle is examined. Almost two-thirds (64.8%) of the TF tanks are lost on the average offensive mission. At the same time, the TF loses an average of over a third (36.3%) of its APC's in the offense.

Table 1

Percentage of Task Force Vehicles Lost in All Force-on-Force Exercise

Offense Missions	%TANK LOST	%APC LOST	COMBINED VEHICLES
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs (N=31)	67.3 (17.4)	35.8 (14.3)	42.5 (12.0)
Armor TFs (N=31)	62.3 (14.2)	36.7 (12.9)	48.1 (12.1)
All TFs	64.8 (14.7)	36.3 (12.6)	45.3 (12.7)
Defense Missions	%TANK LOST	%APC LOST	COMBINED VEHICLES
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs (N=31)	74.6 (16.8)	45.9 (18.0)	52.0 (16.0)
Armor TFs (N=30)	72.0 (16.7)	45.7 (13.5)	56.9 (13.3)
All TFs	73.3 (15.9)	45.8 (14.3)	54.4 (13.7)

The summary performance results for defensive missions show greater TF losses than for offense at the NTC. On the average, the TF's lose more than half their vehicles (54.4%). The loss is greatest for tanks. The TF average almost three-quarters of their tanks as casualties. The APC loss averages slightly less than 50% (45.8%). Thus, the average TF at the NTC loses more than half of all their vehicles: three quarters of their tanks, and about half of their APCs.

Table 1 also shows the offensive and defensive results for the Mechanized Infantry and Armor task forces. These results indicate that the Armor task force experiences somewhat higher overall vehicle losses than the Mechanized Infantry in both the

offensive and defensive missions. Examination of the results by vehicle type, shows very similar percentage losses in the defensive area for the two TF types, and a cross-over pattern in the offensive area. That is, the Armor loses a lower percentage of its tanks but a slightly higher percentage of its APCs. The Mechanized Infantry experiences the reverse of this pattern.

Table 2

Casualty Exchange Ratio For TF in All Force-on-Force Exercises

Offense Missions

	TF Tanks Per OPFOR Kill	TF APC/TOWs Per OPFOR Kill	TF Combined Per OPFOR Kill
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs (N=31)	4.45 (4.98)	2.94 (2.12)	3.34 (2.70)
Armor TFs (N=32)	4.69 (3.41)	1.58 (0.98)	2.39 (1.28)
All TFs	4.57 (4.23)	2.26 (1.40)	2.87 (2.07)

Defense Missions

	TF Tanks Per OPFOR Kill	TF APC/TOWs Per OPFOR Kill	TF Combined Per OPFOR Kill
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs (N=31)	.45 (.25)	.62 (.28)	.55 (.21)
Armor TFs (N=30)	.70 (.37)	.34 (.14)	.47 (.14)
All TFs	.58 (.22)	.48 (0.17)	.51 (.15)

Casualty Exchange Ratios

Table 2 presents the offensive and defensive summary results for the casualty exchange ratio measure. This measure is expressed in terms of the number of TF vehicles killed for each OPFOR vehicle killed. Thus, values greater than one indicate greater numbers of TF vehicles lost per OPFOR vehicle lost.

For offensive missions the TF lose slightly less than three vehicles for each OPFOR vehicle killed. An examination of the losses by vehicle type show that greater losses are experienced for tanks than for APCs. The results indicate that over four tanks are lost per OPFOR tank loss in offensive missions. This rate of loss appears to be extremely high in light of the relative size of the two opposing forces at the NTC.

The offensive results for Armor and Mechanized Infantry TFs shown in Table 2 follow the same pattern as the combined results, i.e. a greater loss for tanks than APC/TOWs. It is interesting to note that the Armor TF had a combined vehicle casualty exchange ratio about two-thirds as large as that for the Mechanized Infantry TF. The Armor TFs show a casualty exchange ratio in the number of APCs of almost half that for the Mechanized Infantry. The Mechanized Infantry shows about the same losses in number of tanks as the Armor TFs.

The results for the individual missions, contained in the Appendix, show that the largest fluctuations in tank and APC/TOW exchange ratios occur in the Movement to Contact mission for all TF types (i.e., All TF, Mechanized Infantry TF, and Armor TF). The results for the remaining offensive missions display less variation in performance.

The summary results for the defensive missions are also presented in Table 2. As one can see, the offensive missions show a much higher casualty exchange ratio than found for defensive missions. This finding is particularly interesting in light of the Table 1 results, where the Task Forces lost a greater percentage of the vehicles in the defense than in the offense. Thus, it should be stressed that the average casualty exchange ratios are not sufficient for the TFs to offset the numerical superiority of the OPFOR when the TFs are on the defense.

Analysis of the individual defensive mission results, presented in the Appendix, shows that the largest fluctuations in tank exchange ratios across defensive missions occur in the H-series groups with the largest occurrences in the Mechanized Infantry TF category. H-series Armor TFs have the lowest exchange ratios for both tanks and APC/TOW vehicles at the Delay in Sector mission. Armor TFs killed on the average of 2 OPFOR tanks for each tank they lost and slightly more than 3 OPFOR APC/TOW vehicles for each TF APC/TOW vehicle lost. Both Defend in Sector and Defend a Battle Position show H-series Armor TFs with the highest tank exchange ratios of the three task force categories.

although the ratio of exchange is less than 1 TF tank lost per OPFOR tank kill. Generally, Armor TFs showed higher tank exchange ratios for both H- and J-series groups at each mission.

The results of the analyses on the casualty exchange ratio reinforce the finding for the percentage lost measure. The TFs experience losses at a rate which would not allow them to stop an enemy at the current OPFOR strength level. The loss is particularly high for tanks, a result which both TF types experience.

Analysis of Task Force Type and Task Force Organization

The previous results presented a picture of the performance at the NTC on force-on-force missions. The results were displayed in terms of combined performance and by TF type. This section specifically examines the question of whether the performance variation reported above is related to two factors: TF type (Armor vs. Mechanized Infantry) and TF organization (H-series to J-series MTOE). To address this issue, a two factor multivariate analysis of variance (MANOVA) was performed separately on each of the two performance indicators. For each analysis, the dependent variable set included APC and tank average mission losses* for both offensive and defensive missions (this produced a total of four dependent measures in each analysis). The results of the MANOVA for the two performance indicators are presented separately below.

%Lost Measures

Tables 3 and 4 show the mean values for the %Lost measures across three offensive and three defensive missions. Data are displayed for task force type categories (i.e., Mech TFs, and Armor TFs) and are separated into H- and J-MTOE series organizational groups.

Offensive Operations. The results of the MANOVA for the %lost measure indicated a significant overall effect for the TF organization (H- vs. J-series MTOE: $F=4.89$, $p<.01$, $df=4.53$) but not for the TF type (Armor vs. Mechanized Infantry) or the interaction term. Examination of the univariate results showed that the only significant difference occurred on the APC loss measure for offensive missions ($F=20.10$, $p<.01$, $df=1.56$). These findings were further explored by examining the cell means.

* The average mission casualty exchange ratio should not be confused with the OES and DES casualty exchange ratios reported in the first section. The earlier results include all missions, partial and completed, performed during a rotation. The average mission casualty exchange ratio includes performance on specific complete missions: Movement to Contact, Deliberate Day Attack, Deliberate Night Attack, Defend in Sector, and Defend from a Battle Position. The use of the average mission results insured a more constant performance sample for comparing the different battalions and thus was selected for this analysis.

The largest differences between H- and J-series groups occur within the Mechanized Infantry task forces. J-series APC/TOW losses are significantly different from the corresponding losses in the H-series group (H-series APC/TOW losses=43%, J-series APC/TOW losses=25% at $p<.01$). J-series TFs also incur 7% fewer tank losses than TFs in the H-series group (H-series tank losses=70%, J-series tank losses=63%). This 7% difference is slightly more than 1/2 tank over all in absolute numbers.

Table 3

Average Percentage of Task Force Vehicles Lost in Selected Offensive Engagement Simulation Force-On-Force Exercises

MTOE Organization				
	H-series		J-series	
	% Tanks Lost	% APCs/TOWs Lost	% Tanks Lost	% APCs/TOWs Lost
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs	70% (17%)	43%** (12%)	63% (17%)	25%** (10%)
	N=19		N=12	
Armor TFs	64% (11%)	40%* (15%)	62% (18%)	32%* (06%)
	N=19		N=12	

* Univariate F-Test significant $p<.01$

** Univariate F-Test significant $p<.05$

Although the Armor TF category shows smaller differences between H- and J-series TFs than the Mechanized Infantry TF category shows, the overall pattern of significantly lower APC/TOW losses is also found in the Armor TFs. J-series TFs average 8% fewer APC/TOW losses (significant at $p < .05$) than H-series TFs.

Defensive Operations. The multivariate analysis indicated the presence of no statistically significant differences in performance on the defensive missions due to either TF type or TF organization.

The results in Table 4 for Mechanized Infantry and Armor task forces show very small differences between the percentage of combat vehicles lost by H- and J-series TFs on the NTC battlefield. Additionally, there is no substantial difference between the Mechanized Infantry and Armor TFs when organizational group is not considered.

Table 4

Average Percentage of Task Force Vehicles Lost in Selected Defensive Engagement Simulation Force-On-Force Exercises

Defensive Engagement Simulation				
	H-series		J-series	
	%Tanks Lost	%APC/TOWs Lost	%Tanks Lost	%APC/TOWs Lost
	\bar{X}	\bar{X}	\bar{X}	\bar{X}
	(SD)	(SD)	(SD)	(SD)
Mechanized Infantry TF	75% (21%)	46% (19%)	74% (09%)	46% (18%)
	N=19		N=12	
Armor TFs	75% (16%)	47% (12%)	67% (17%)	44% (14%)
	N=19		N=12	

Casualty Exchange Ratios

A parallel analysis to that performed on the "%lost" measure was conducted on the casualty exchange ratio. For purposes of analysis, the average casualty exchange ratio was calculated across three offensive missions and three defensive missions for each vehicle type. The use of the average mission casualty exchange ratio was required by the variation in missions which TFs performed at the NTC.* This produced a dependent variable set that consisted of four separate indicators (offensive APCs, offensive tanks, defensive APCs, and defensive tanks).

The results of the MANOVA on the average mission casualty exchange ratios indicates an overall significant difference due to TF type ($F=13.84$, $p < .01$, $df=4,56$). Also, there were statistical differences across the comparison groups formed on the basis of combining TF type and TF organization (TF Type x TF Organization; $F=4.15$, $p < .01$, $df=4,56$). Examination of the univariate results shows statistically significant differences for offensive APCs, defensive tanks, and defensive APCs. There was a significant ($p < .01$) difference due to TF type for all three variables (the respective results were: $F=6.45$, $F=12.25$, $F=16.50$; $df=1,59$). The remaining significant result on the defensive tank loss indicator, is for the combined effect of TF type and TF organization which reached the .05 significance level ($F=5.55$, $df=1, 59$). Interpretation of these differences was accomplished through the results of specific comparisons on the means as described below.

Tables 5 and 6 show the mean casualty exchange ratios for offensive and defensive missions. As indicated above, casualty exchange ratios were calculated by dividing the numbers of TF tanks and/or APCs (to include TOWs) killed by the numbers of corresponding type OPFOR vehicles killed thus yielding the numbers of TF vehicles lost per one (1) OPFOR loss.

Offensive Operations. As is shown in Table 5, the Mechanized Infantry has a larger tank exchange ratios for TFs in the J-series group than for H-series. A comparison of Mechanized Infantry and Armor TFs shows significantly higher APC/TOW exchange ratios for the Mechanized Infantry than for Armor TFs in the H-series group for all offensive missions.

* The average mission casualty exchange ratio should not be confused with the OES and DES casualty exchange ratios reported in the first section. The earlier results include all missions, partial and completed, performed during a rotation. The average mission casualty exchange ratio includes performance on specific complete missions: Movement to Contact, Deliberate Day Attack, Deliberate Night Attack, Defend in Sector, and Defend from a Battle Position. The use of the average mission results insured a more constant performance sample for comparing the different

battalions and thus was selected for this analysis.

Armor TFs show higher tank exchange ratios than the Mechanized Infantry TF categories in the H-series group although generally, tank exchange ratios for Armor TFs show more consistency between the H- and J-series groups than for the Mechanized Infantry TFs. H-series APC/TOW exchange ratios are substantially and significantly ($p < .05$) smaller for the Armor TF than for the Mechanized Infantry TF.

Table 5

Average Mission Casualty Exchange Ratios for Selected Offensive Engagement Simulation Force-On-Force Exercises

Offensive Engagement Simulation				
	H-series		J-series	
	TF Tanks Per 1 OPFOR Kill	TF APC/TOWs Per 1 OPFOR Kill	TF Tanks Per 1 OPFOR Kill	TF APC/TOWs Per 1 OPFOR Kill
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs	2.77 (2.82)	2.77[*] (2.22)	4.09 (3.02)	1.84 (1.33)
	n=19		n=12	
Armor TFs	4.47 (2.73)	1.21[*] (0.64)	4.38 (4.21)	1.75 (1.14)
	n=18		n=12	

[*] Univariate F-Test between Mechanized Infantry and Armor TFs
- $p < .05$.

Defensive Operations. As indicated at the start of this section the MANOVA analysis indicated significant differences due to TF type for the defensive mission summaries. This result occurs for both tank casualty exchange ratios and APC casualty exchange ratios. In addition, for the tank casualty exchange ratio there was a significant interaction term indicating that performance depended both on TF type and TF organization.

Table 6 presents the summary values for tank and APC casualty exchange ratios for TF type and TF organization. As can be seen from that table, the Armor TFs had higher casualty exchange ratios than the Mechanized Infantry for the tank variable. On the other hand, the Mechanized Infantry had higher ratios for the APC variable. The cause of these performance differences are not totally clear, though the direction of the differences may indicate that they may be a result of the relative vehicle constitution of the TF. That is, since the Armor TF has more tanks available to it there is a greater opportunity for loss in this area. The reverse is true for APCs. Thus, these results may not reflect a true difference in performance as much as be an artifact of the numbers.

The presence of the interaction effect is reflected by the improvement of the casualty exchange ratio for tanks for J-series vs. H-series in the Armor TFs while the opposite occurs in the Mechanized Infantry TFs. Alternatively the Armor TF performance for the APC/TOWs is worse for J-series than H-series, while the Mechanized Infantry experiences the exact opposite result. This can be seen from an inspection of the cell means in Table 6.

Table 6

Average Mission Casualty Exchange Ratios for Selected Defensive Engagement Simulation Force-On-Force Exercises

Defensive Engagement
Simulation

	H-series		J-series	
	TF Tanks Per 1 OPFOR Kill	TF APC/TOWs Per 1 OPFOR Kill	TF Tanks Per 1 OPFOR Kill	TF APC/TOWs Per 1 OPFOR Kill
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
Mechanized Infantry TFs	.38[*] (.12)	.65[*] (.31) N=19	.54 (.34) N=12	.55 (.21)
Armor TFs	.75[*] (.28)	.31[*] (.15) N=19	.61 (.22) N=12	.41 (.15)

[*] Univariate F-Test between Mechanized Infantry and Armor TFs
- $p < .05$.

DISCUSSION

The results of the analyses indicate that the determinants of force-on-force performance are more complex than the current information from the Take Home Packages allow us to investigate. Considerable variation in battalion task force performance was found in the results reported above. Yet, only a small portion of that variation seemed to be related to differences in the organization of the task force (H-series vs J-series) or to the type of task force (Armor vs Mechanized Infantry). Further, the differences in performance along these dimensions were not consistent either in terms of the type of mission (offensive or defensive) or the type of performance measure (percentage lost or casualty exchange ratio). This lack of systematic results provides considerable evidence that force-on-force performance can only be understood in the full context in which that performance took place. To accomplish that end it will be necessary to employ the full range of NTC digital data as well as supporting data such as the commo tapes.

Despite the limitations of the results, several findings are of note. There was considerable variation in performance of the task forces measured either in terms of percentage of vehicles lost or by the casualty exchange ratio. Variation in performance was greater for offensive missions than defensive missions. This suggests either that the causal mechanisms for offensive performance are more complex than for their defensive counterparts or that training in the elements of defense are more standardized. Alternatively, there might possibly be differential impact on the two types of missions by home station resources. That is, resource constraints at home station may preclude training on offensive missions to the same degree as on defensive missions. Thus, greater training would occur on the elements of the defense than on the offensive elements.

The results also show that the loss rates experienced at the NTC have considerable implications for survivability against a numerically greater foe. In both the offensive and defensive scenarios, the BLUEFOR task forces are being reduced to combat ineffectiveness by their OPFOR counterparts. This trend is consistent even for the J-series task forces which have greater numbers of vehicles available to them.

The results also show that performance is different for the type of task force and the way in which it is organized (i.e., H- or J-series). The manifestation of these differences is greatest between type of task force and is most noticable for the offensive missions. The cause of this difference can only be speculated on here as there was no empirical information available for an analysis of this issue. This is clearly a topic to be pursued in the more detailed and comprehensive analyses to be conducted in the future.

Another finding of note is that performance variation was least visible in the loss of tanks. Differences between type of task force and task force organization, when tested on the percentage of tanks lost or in the casualty exchange ratio for tanks, failed to produce any significant differences. As tanks constitute the primary weapon system on the NTC battlefield, performance characteristics in this area are particularly important. The high level of loss in this area and the lack of relationship to the analysis variables studied here indicate a more generic cause for the performance. The nature of this cause needs to be identified and studied.

The last significant finding from these results concerns the performance of the reorganized task forces (J-series). Since performance for these task forces was not found to be consistently better than their earlier counterpart (H-series), it is important to determine why this should be the case. One possibility is that the addition of the new assets independent of sufficient training in the deployment of those assets may result in their inefficient and ineffective use. That is, the new assets may in fact be consumed at a higher rate than the previous assets (under the prior organization) because the task force commander is unable to incorporate them into the scheme of maneuver. Whether this hypothesis is true or whether some other causes are at work can only be determined by the more comprehensive analyses to be performed in the future.

As indicated at the start of this section the analysis of the force-on-force performance data was necessarily limited by the type and level of information available for analysis. While recognizing those limitations, it was felt that considerable could be gained in exploring performance variations to determine the extent of their existence and whether they were related to the macro-level variables available in the THPs. The results of the analysis have accomplished these objectives. They have demonstrated that variation does exist and that the macro-level variables, while related, do not account for all of the observed differences in performance. Further, the analyses have pointed to be pursued in more comprehensive analyses conducted with be conducted with the NTC digital data. Thus, the results reported here represent the anticipated initial step of a multi-step research effort.

APPENDIX A

This appendix contains both raw data that has been extracted from the force-on-force exercise wrap-ups in the Take Home Packages and statistics derived from the raw data.

Table A-1

Kill Ratios by Mission for Mech and Armor TFs
(TF losses per one OPFOR loss)

	Mission 1		Mission 2		Mission 3	
	Mech	Armor	Mech	Armor	Mech	Armor
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
OES	n=25	n=30	n=27	n=29	n=27	n=29
Tanks	5.1 (6.4)	6.1 (8.8)	6.6 (6.3)	8.4 (8.8)	6.2 (5.4)	7.2 (5.3)
APCs	3.9 (3.8)	2.5 (3.1)	4.3* (3.6)	2.5* (2.3)	2.6 (2.6)	1.9 (3.4)
Combined	3.8 (3.6)	2.9 (3.0)	4.4 (3.0)	3.7 (3.7)	3.5 (3.2)	2.7 (1.7)
<hr/>						
	Mission 4		Mission 5		Mission 6	
	Mech	Armor	Mech	Armor	Mech	Armor
	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)
DES	n=28	n=29	n=16	n=15	n=24	n=28
Tanks	.45** (.22)	.80** (.41)	.51 (.55)	1.30 (2.0)	.61 (.69)	.80 (.80)
APCs	.79* (.86)	.40* (.24)	1.10* (1.10)	.32* (.24)	.63 (.38)	.45 (.56)
Combined	.61 (.45)	.55 (.27)	.75 (.73)	.52 (.25)	.58 (.33)	.59 (.63)

* $p < .05$

** $p < .01$

a. Mission 1=Movement to Contact, Mission 2=Deliberate Day Attack, Mission 3=Deliberate Night Attack, Mission 4=Defend in Sector, Mission 5=Delay in Sector, and Mission 6=Defend From a Battle Position.

Table A-2

^a
 \bar{X} Numbers of Vehicles Killed Across OES Missions

	Mission1		Mission2		Mission3	
	Armor	Mech	Armor	Mech	Armor	Mech
<hr/>						
(TFs)						
Tanks	12.5**	24.4**	16.1	20.3	9.5**	16.4**
APCs	28.3**	18.7**	28.5**	16.6**	11.6	9.3
Comb	40.8	43.1	44.6	36.9	21.1	25.8
<hr/>						
(OPFOR)						
Tanks	12.4	9.0	4.0	4.1	3.2	2.5
APCs	16.1	13.7	11.0	10.5	8.3	6.7
Comb	28.4	22.7	15.0	14.6	11.4	9.2

^a
 \bar{X} Numbers of Vehicles Killed Across DES Missions

	Mission4		Mission5		Mission6	
	Armor	Mech	Armor	Mech	Armor	Mech
<hr/>						
(TFs)						
Tanks	13.5**	21.5**	10.8**	20.4**	12.8**	19.9**
APCs	32.9**	18.7**	23.1**	12.7**	25.9*	16.6*
Comb	46.3	40.2	33.9	33.1	38.7	36.5
<hr/>						
(OPFOR)						
Tanks	31.8	33.2	26.3	28.8	37.3	29.0
APCs	53.7	52.3	44.5	41.4	52.3	45.4
Comb	85.5	85.5	70.8	70.3	89.6	74.4

* $p < .05$

** $p < .01$

- a. Mission 1=Movement to Contact, Mission 2=Deliberate Day Attack, Mission 3 =Deliberate Night Attack, Mission 4=Defend in Sector, Mission 5 = Delay in Sector, and Mission 6 = Defend a Battle Position.

Table A-3

Casualty Exchange Ratios for Three OES Missions
(TF vehicles killed per 1 OPFOR kill)

	OES Missions					
	Movement to Contact		Deliberate Day Attack		Deliberate Night Attack	
	Tank	APC/TOW	Tank	APC/TOW	Tank	APC/TOW
	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}
<hr/>						
All TFs						
H-series	4.90 (n=38)	2.73 (n=38)	5.96 (n=29)	2.62 (n=33)	5.48 (n=30)	1.35* (n=32)
J-series	7.12 (n=12)	4.25 (n=16)	7.48 (n=22)	3.63 (n=23)	7.36 (n=23)	2.70* (n=23)
<hr/>						
Mech TFs						
H-series	3.02 (n=19)	3.95[*] (n=19)	4.73 (n=14)	5.06[*] (n=16)	4.11 (n=15)	1.69[*] (n=16)
J-series	11.71 (n=4)	3.85 (n=6)	7.67 (n=10)	3.09 (n=11)	7.46 (n=10)	3.88 (n=11)
<hr/>						
Armor TFs						
H-series	6.77 (n=19)	1.51[*] (n=19)	7.11 (n=15)	2.28[*] (n=17)	6.86 (n=15)	1.00[*] (n=16)
J-series	5.29 (n=10)	4.49 (n=10)	7.32 (n=12)	2.20 (n=12)	7.28 (n=13)	1.62 (n=12)

* Ttest comparison between H- and J-series TFs ($p < .05$).

[*] Ttest comparison between Mechanized Infantry and Armor TFs ($p < .05$).

Table A-4

Casualty Exchange Ratios for Three DES Missions
(TF vehicles killed per 1 OPFOR kill)

	DES Missions					
	Defend in Sector		Delay in Sector		Defend a Battle Position	
	Tank	APC/TOW	Tank	APC/TOW	Tank	APC/TOW
	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}	\bar{X}
<hr/>						
All TFs						
H-series	.64 (n=35)	.67 (n=35)	1.00 (n=23)	.81 (n=23)	.79 (n=29)	.58 (n=29)
J-series	.60 (n=22)	.54 (n=22)	.58 (n=08)	.42 (n=08)	.62 (n=23)	.48 (n=23)
<hr/>						
Mech TFs						
H-series	.41[*] (n=17)	.70 (n=17)	1.51 (n=12)	1.30[*] (n=12)	.64 (n=13)	.73 (n=13)
J-series	.50 (n=11)	.92 (n=11)	.42 (n=04)	.42 (n=04)	.57 (n=11)	.50 (n=11)
<hr/>						
Armor TFs						
H-series	.86[*] (n=18)	.39[*] (n=18)	.54 (n=11)	.27[*] (n=11)	.91 (n=16)	.45 (n=16)
J-series	.71 (n=11)	.42 (n=11)	.74 (n=04)	.43 (n=04)	.66 (n=12)	.45 (n=12)
<hr/>						

[*] Ttest comparison between Mechanized Infantry and Armor TFs
(p<.05).

Table A-5

DES Summary Data for All Rotations

BN	TM	TF Tanks Killed	TF APCs Killed	OPFOR Tanks Killed	OPFOR APCs Killed	% TF Vehicles Killed
231	T	58	37	80	187	.
232	M	18	32	54	66	09.30
241	T	56	51	57	75	89.17
242	M	34	107	51	83	65.54
251	T	52	23	32	75	63.16
252	M	21	70	52	99	58.02
261	T	60	28	69	128	45.13
262	M	10	16	24	31	24.30
271	T	68	36	100	140	63.80
272	M	21	55	33	67	53.15
281	T	26	22	33	43	53.33
282	M	26	100	83	102	82.89
311	T	54	28	86	118	50.62
312	M	24	72	94	103	64.00
321	T	45	25	53	93	59.83
322	M	23	36	77	98	46.09
331	T	75	24	71	97	68.28
332	M	20	46	39	82	61.11
341	T	78	49	91	104	72.57
342	M	27	80	91	112	53.50
351	T	75	53	94	90	71.58
352	M	25	109	71	78	61.09
361	T	59	46	99	165	58.33
362	M	19	50	74	141	53.49
371	T	64	39	197	222	60.48
372	M	27	102	95	143	70.11
381	T	7	5	11	30	38.71
382	M	7	7	13	27	34.15
391	T	30	20	69	98	47.17
392	M	35	91	111	162	56.00
401	T	55	52	109	147	58.47
402	M	23	45	63	122	40.48
411	T	74	43	109	168	55.98
412	M	21	77	93	177	.
421	T	79	47	104	214	68.07
422	M	24	47	61	88	46.98
431	T	48	92	103	134	66.16
432	M	36	81	115	131	48.55
441	T	39	35	88	144	55.64
442	M	22	32	51	118	40.30
451	T	37	60	73	145	61.78
452	M	46	103	92	143	57.09

Table A-5 (Cont'd)

DES Summary Data for All Rotations Continued

BN	TM	TF Tanks Killed	TF APCs Killed	OPFOR Tanks Killed	OPFOR APCs Killed	% TF Vehicles Killed
461	T	34	30	72	112	36.78
462	M	52	67	105	166	45.77
471	T	50	71	58	127	74.48
472	M	64	105	106	154	80.95
481	T	18	30	77	125	28.92
482	M	25	55	77	122	43.24
491	T	50	70	51	114	70.59
492	M	19	71	50	141	59.74
501	T	45	49	81	157	54.34
502	M	33	41	73	149	45.40
503	T	43	27	57	88	.
504	M	18	66	54	74	58.74
505	T	32	39	35	72	46.41
506	M	31	60	66	92	48.66
511	T	00	00	00	00	.
512	M	69	89	65	130	52.14
521	T	28	49	72	139	42.54
522	M	34	63	25	63	80.56
531	T	50	43	86	122	41.70
532	M	29	35	105	133	34.41
541	T	55	42	78	116	44.91
542	M	18	47	76	125	34.39

Table A-6

OES Summary Data For All Rotations

BN	TM	TF Tanks Killed	TF APCs Killed	OPFOR Tanks Killed	OPFOR APCs Killed	% TF Vehicles Killed
231	T	71	53	18	53	70.54
232	M	62	42	19	45	57.07
241	T	72	52	32	58	56.83
242	M	13	50	24	29	30.29
251	T	31	14	13	16	78.05
252	M	16	62	15	38	63.93
261	T	75	37	28	52	53.85
262	M	48	71	23	40	38.51
271	T	39	29	26	28	59.65
272	M	27	59	12	34	50.33
281	T	68	44	32	35	54.37
282	M	15	50	34	28	52.00
311	T	52	36	25	20	57.05
312	M	28	68	26	22	55.49
321	T	86	51	25	27	54.37
322	M	51	118	22	29	55.59
331	T	75	34	21	39	51.87
332	M	44	74	14	13	54.63
341	T	51	22	15	33	41.48
342	M	30	83	14	38	43.63
351	T	76	55	32	54	54.13
352	M	27	68	2	7	54.29
361	T	59	29	5	14	51.46
362	M	37	19	29	52	62.64
371	T	33	12	4	25	32.87
372	M	23	56	5	9	39.70
381	T	15	8	4	10	58.67
382	M	10	23	4	11	64.71
391	T	58	31	7	28	30.80
392	M	36	52	7	14	42.23
401	T	44	42	7	13	56.57
402	M	33	96	9	32	36.99
411	T	65	49	13	34	30.29
412	M	34	59	19	46	
421	T	57	32	8	24	45.64
422	M	23	80	23	40	34.45
431	T	52	55	25	55	38.63
432	M	26	31	7	16	23.50
441	T	104	46	20	42	48.08
442	M	40	66	25	51	40.93
451	T	82	72	22	48	54.49
452	M	45	32	5	13	27.38

Table A-6 (Cont'd)

OES Summary Data For All Rotations Continued

BN	TM	TF Tanks Killed	TF APCs Killed	OPFOR Tanks Killed	OPFOR APC s Killed	% TF Vehicles Killed
461	T	64	34	8	15	44.83
462	M	41	28	10	30	28.24
471	T	74	12	77	28	46.56
472	M	66	11	66	34	34.81
481	T	64	85	38	33	47.15
482	M	60	59	6	13	31.96
491	T	64	68	12	39	39.13
492	M	35	80	21	40	48.31
501	T	79	70	57	129	41.56
502	M	77	106	28	75	45.76
503	T	58	25	13	27	25.63
504	M	32	53	16	41	31.16
505	T	40	34	8	25	27.66
506	M	47	27	7	23	25.25
511	T	54	63	39	13	.
512	M	28	6	38	17	27.21
521	T	41	56	11	33	34.07
522	M	14	31	3	20	38.10
531	T	61	58	29	62	56.40
532	M	46	71	23	54	36.24
541	T	83	40	5	17	49.40
542	M	28	117	10	28	44.32

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