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CANADIAN ARMY TROPHY ANALYSIS

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CPT(P) Steven J. Mains

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This study provides a method to measure the effect of improving tank accuracy, firing speed, and detection on score during the CAT competition. This study uses a custom stochastic computer model designed to replicate the CAT gunnery battle run and score the results. Ph, Pd and firing times were varied to determine the payoff of improving each.

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CPT(P) Steven J. Mains	(502) 624-3776	ATSB-CDC

CANADIAN ARMY TROPHY (CAT) ANALYSIS

1. Purpose. To determine the most cost-effective doctrine, training, and materiel strategy to pursue in CAT '91 to produce winning teams.

2. Study Summary. The factors that provided the largest score changes with the least cost are probability of detection and time to fire the first round. Ph provided only limited payoff and is expensive to improve. Time to fire subsequent rounds (reengagements) had little effect on the score. If probability of detection is improved by 5% and time to fire improved by two seconds, the average US platoon will score within 300 points of the winning 1989 score and 1000 points higher than the average 1989 Leopard II platoon score.

3. Background.

a. CAT measures the ability of a tank platoon to negotiate a timed gunnery course consisting of 32 targets. The targets are tank turrets and frontals (see Figure 1). The targets may be either moving or stationary. The firing tanks fire while moving and from stationary positions. The platoons start with a total of 48 main gun rounds. The targets are exposed for a total of 40 seconds each.

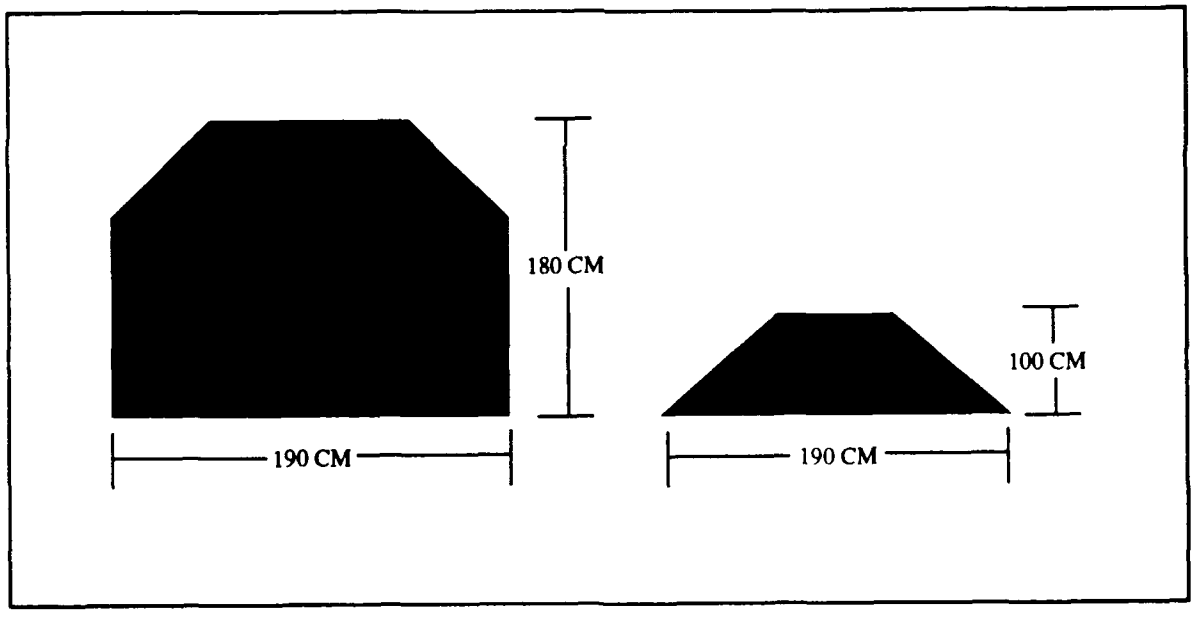

Figure 1. CAT Targets

b. A great deal of analysis has gone into determining what can be done to improve the 1991 CAT performance. The analysis focused on "post mortem" lessons learned and subject matter expert assessment of the results. There has been, however, no way to determine the benefits of improving specific aspects of the "gunnery system." The improvement of the score caused by decreasing the round-to-round dispersion on the bullet (thereby improving probability of hit or "Ph"), for instance, could not be weighed against the cost of the improvement. A way to measure score improvement was required.

c. This study provides the means to measure score improvement by using a computer simulation. The simulation measures the effects of the three primary factors in the CAT gunnery system. They are:

(1) Probability of Detection (Pd) of a target.

(2) Time to fire (TTF) at the target (two inputs really, time to fire the initial shot and time to reengage missed targets).

(3) Probability of Hitting the target (Ph).

A detailed explanation of the model and methodology is at Appendix A.

d. For comparison, the average American and winning Dutch team (4-41 Tank Battalion) results from 1989 are shown in Table 1. This study will examine the effect of each input on the score. It will then propose solutions that will raise the mean American score to equal the 1989 winning score. This goal is chosen so that the United States will not merely win the competition, but dominate it by placing one-half of our teams at or above the previous winner's score.

Table 1. Comparison of Winning Team and American Teams

		4-41 Tank Bn	American Averages
Pd		.97	.87
Time To Fire	Initial Shot	9.13	11.50
	Subsequent Shot	16.00	15.88
Ph		.83	.75
Score		18147	14180

4. Essential Elements of Analysis.

a. How much impact does Pd, TTF, and Ph have on the outcome of CAT?

b. Which factors provide the most payoff for the lowest cost?

c. What mix of solutions must be implemented to bring the mean 1991 US score up to equal the winning 1989 score?

5. Discussion. The three input variables, Pd, TTF and Ph were varied individually. The contribution of each and possible solutions will be evaluated in turn.

a. Probability of Detection.

(1) The Pd of the M1A1 teams was .87, the Leopard II's Pd was .98. Since the gunner's primary sights (GPS) are very similar (10x vs 12x), the improved Pd must be attributed to training and the Leopard II's Commander's Independent Viewer (CIV). The impact of this improved Pd is shown in Figure 2. Improving Pd from .87 to .98 improves the mean score from 14,941 points to about 16,750. Not enough to win, but much closer.

Pd has large effect on score.

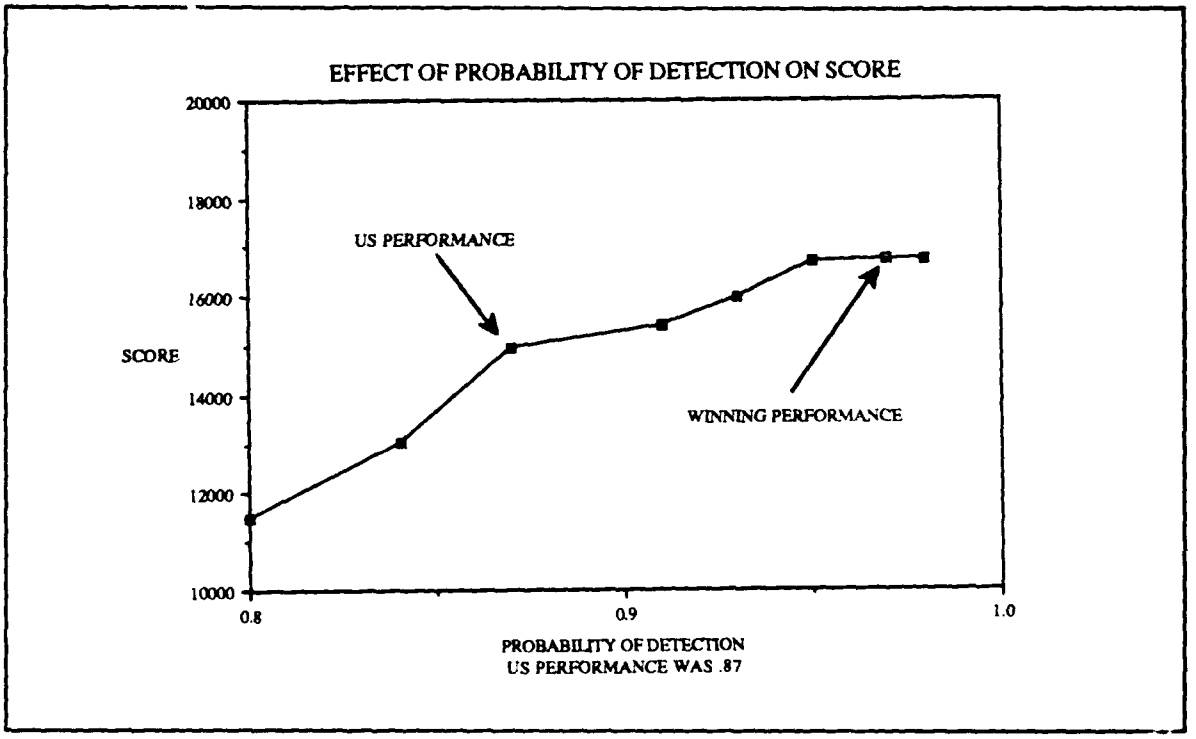

Figure 2. Effect of Improved Pd on Score

(2) Training Solutions. Detection drills and improved range knowledge may improve the score with little or no cost. Detection drills could, for instance, use reduced size targets presented for short periods of time to improve the crews' visual acuity. Detailed knowledge of the range (to include range deadspace) can also improve Pd. CAT '89 participants and observers say they were surprised when targets appeared in positions masked to certain tanks. The platoons need to know where the dead space is and be prepared to fire using either cross or frontal techniques as required.

(3) Materiel Solutions. Fielding the M1A2 with the Commander's Independent Thermal Viewer (CITV) would provide American tank commanders with a target acquisition capability similar to the German CIV. The decision to delay production of the M1A2 (except in very limited quantities), however, makes this solution wholly inadequate. Other means must be found to mitigate the CIV advantage. The use of variable zoom binoculars or stabilized 10x binoculars may improve the tank commanders' ability to find targets. 1989 after-action reports indicate that Germans used the CIV to confirm target hits rather than identify subsequent targets. It must be assumed, however, that the CIV aided finding the initial target. The advantage of providing improved binoculars should be tested to determine how much they improve Pd. Using these binoculars carries a cost, however, because CAT rules state that only standard Army equipment can be used. The rest of the Army would have to be similarly equipped to follow the CAT rules. If improved binoculars improve the CAT Pd, they should also improve a tank commander's Pd against targets in combat. Testing will determine their utility to the force so an informed decision can be made on fielding them.

CITV will not be available by 1991. Better binos may help.

(4) Disregarding possible binocular improvements, training alone should improve the American Pd. By assuming an equal contribution from training and the CIV (to be conservative), training could raise Pd to .92. Doing so would raise the mean US score to about 15,900 points.

b. Time to Fire.

(1) The score is very sensitive to initial TTF. As shown in Figure 3, improving the initial TTF by just two seconds (from 11.5s to 9.5s) improves the mean score to 17,500 points, very close to the goal.

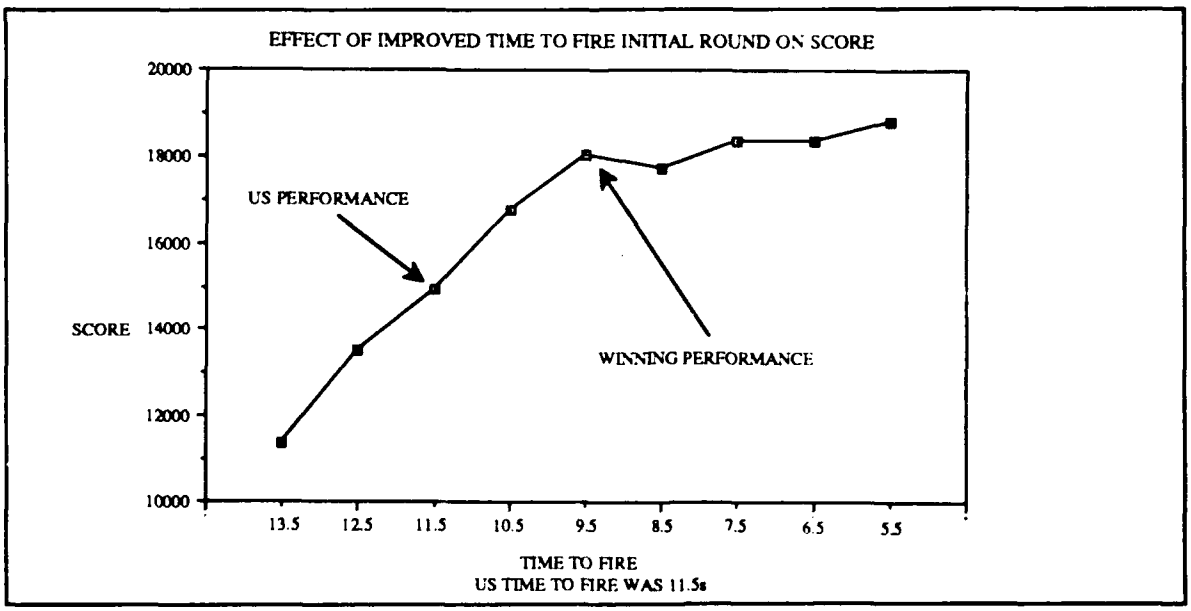

Figure 3. Effect of Improved TTF on Score

(2) Training Solutions.

(a) Training the crews to fire faster may be difficult without a concurrent change to the CAT gunnery procedures. The crews in 1989 were highly trained but still slower than the 1987 M1 firing times and the 1987 and 1989 Leopard II firing times. Since the main gun round is loaded prior to the start of each engagement, the first round firing times are not apparently affected by the change from 105mm to 120mm systems. According to participants in 1989, CAT platoons counted the targets, confirmed the count, then fired. By eliminating this step, crews could fire at targets upon presentation, reducing the TTF by two seconds (estimating conservatively). Eliminating the fire command carries with it the possibility of lessened control by the platoon leader during the engagement. This can be made up for by training the platoon to distribute fires automatically without a command from the platoon leader. This requires extensive range knowledge and training by each platoon. It is apparent that other teams trade control for the benefits of faster first rounds because many Leopard II engagements occurred in 1-3 seconds.

(b) This gunnery strategy has the drawback of possibly implying that platoon fire commands are not important. They are, of course, important but, as (then) MG Ulmer wrote in the CAT '81 After Action Review, "we must recognize that standard US gunnery techniques will not suffice...and amend as necessary."

(c) The speed of the crews themselves may be improved by using quick-fire drills. For instance, MILES equipped targets can be presented for 9.5 seconds to get crews used to firing to this standard. This may improve firing times even more than the two seconds required.

(3) The score (as shown in Figure 4) proved to be insensitive to improvement of the time to fire subsequent rounds. For this reason, no solution set was developed for improving the TTF subsequent rounds.

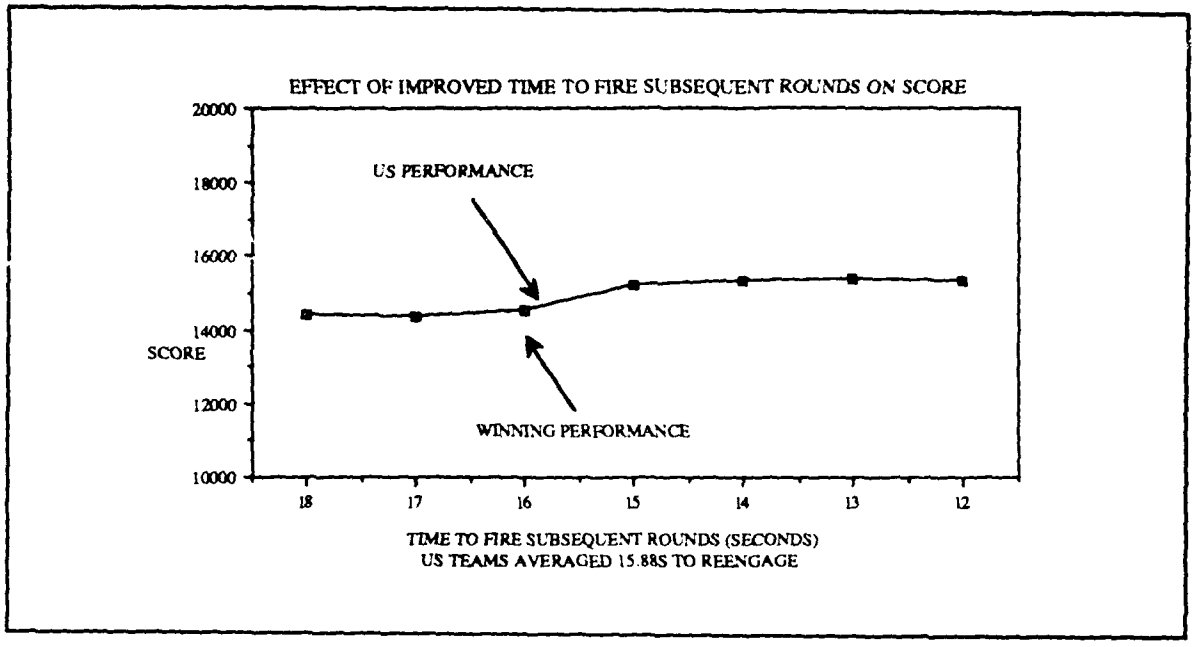

Figure 4. Effect of TTF Subsequent Rounds on Score

c. Probability of Hit. Improving Ph, surprisingly, has relatively little effect on the results, as shown in Figure 5. Improving the American Ph by .1 across all engagements only improves the expected score to about 15,790 points. Improving Ph, however, is problematic. According to analysis done by the TEXCOM Armor and Engineer Board, the Ph that the teams attained in 1989 is very close to the M1A1's expected Ph. In other words, the crews' superb gunnery training virtually eliminated gunner error as a cause of target misses. No amount of training could improve the displayed Ph. Any improvement would have to come from modifications to the tank or the bullet fired. Both of these are, by their nature, very expensive (remember that they must be done across the entire force to conform with CAT rules). No solutions to improve Ph are proposed.

Score is relatively insensitive to improved Ph.

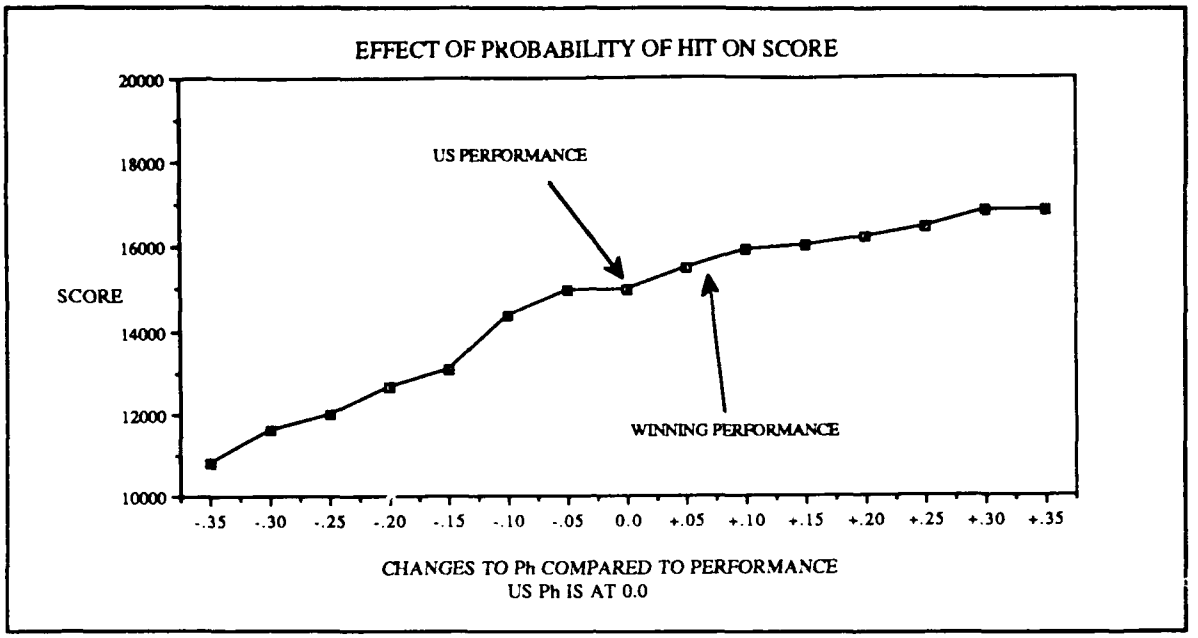

Figure 5. Effect of Ph on Score

d. Conclusion.

(1) The recommended solutions are:

(a) Eliminate platoons counting targets when they come up.

(b) Train to improve Pd.

(c) Train to improve reaction time.

(d) Evaluate impact of improved binoculars on the force; include in CAT if warranted.

Implicit in this solution set is that Ph will remain at 1989 level.

(2) Implementation of this solution set will raise the average American score to about 17,900 points with a standard deviation of 1100 points. This means that the nine American platoons will have six platoons scoring between 19,000 points and 16,800 points with the remaining three platoons spread slightly above and below these scores. The Leopard II scores, adjusted like the American scores with full machine gun points and no penalties, averaged 17,039 points with a standard deviation of 990 points.

If Pd improves to .92 and TTF to 9.5s, the average score will equal 17,900 points.

(3) Winning CAT is well within the capabilities of the M1A1 and our crews. Our training needs to focus on the factors that provide the leverage to get the most out of the scoring system. This means concentrating on Pd and TTF in addition to the current concentration on Ph. This is

not meant to minimize the training challenge of producing world-class teams. Ph must remain very high and the teams must be ready to compete at the international level. It is only meant to provide a reasoned cost/benefit analysis in order to get the most from the precious precompetition training time and resources. In this way, the United States can have the best chance of dominating the competition in 1991.

(4) Further development of the model CATMOD will continue. Its use may assist preparation of future teams by evaluating their results at intermediate points. The value of training to improve specific areas of the gunnery process can then be weighed against the availability of remaining training time.

6. POC for this analysis is CPT Mains, Directorate of Combat Developments, USAARMS, AV 464-3776/1347.

Annex A: Methodology.

1. A computer simulation, called CATMOD, was written to model the CAT competition. Actual Pd, TTF and Ph inputs from 1989 were used as well as an actual CAT scenario. The input variables were then varied individually to determine how each improved the score and the point of diminishing returns. The model was set to run 50 iterations of the CAT Battle Run to determine a mean score and standard deviation. Because the model draws randomly from a uniform distribution to determine hits and a normal distribution to determine TTF and detection, the measured mean approximates the true mean. The measured mean must be viewed as a range rather than a point value. This fact is important because it results in the output graphs not being smooth. In one case, the score appears to decline despite improved TTF. The TTF curve, in fact, flattened out and the measured mean score was slightly below the true mean.

The CAT competition was modeled using actual Pd, TTF, and Ph and a scenario from the 1989 competition.

2. Once the "leverage" variables were determined, the benefits of specific solutions were evaluated against their cost and/or burdens. Solutions were proposed in training, doctrine, leader development then materiel areas until the mean American score reached the 1989 winning score.

3. For the purpose of this analysis it is assumed that the teams received all available machine gun points. This is because machine guns account for only 10% of the overall score and the majority of the teams got all or nearly all the points.

4. It is also assumed that no crew errors (and resultant penalty points) will occur. This is because the teams should be familiar with the CAT rules and the focus of this study is tank gunnery, not range procedures. The result of these assumptions is that the American average score was "normalized" to 14,941. This score was used as the baseline to compare all improvements. All allied scores used for comparison in this analysis were similarly normalized.

5. An initial assumption that CATMOD is a good predictor of actual gunnery results was validated by inputting actual data and comparing the results to the attained scores.