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Def Sci J, Vol 36, No 1, January 1986, pp 35-44

Computer Modelling of a Tank Rattle with Helicopter Support

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Received 5 January 1985

Abstract. The paper attempts to model a tank versus tank battle scenario in which the &fender is provided an armed helicopter unit support, against surprise advance of the attacker towards an important place. The stochastic and dynamic nature of the battle system has been handled by means of Monte Carlo simulation. In that activities like move, search, fire, hit and kill are simulated and their effects generated in the model. The game has been repeated for parameters relating to (i) fire power (ii) mobility (iii) intervisibility (iv) blind shooting (v) defender/attacker force ratio and (vi) helicopter unit support with the defender. Then, average numerical effects in each case have been analysed.

Although the results are based on tentative data, the. trend seems to suggest that a battalion of Centurion tanks or 2 coys with a helicopter unit support stand fairly good chance to defeat the attack by M-47148 tanks equivalent to 4 coys. Nevertheless, the methodology provides an effective basis to systematically approach realistic situations and quantitatively assess weapon systems effectiveness under tactical alternatives and battle field environments.

1. Introduction

The problems in the area of military strategy, tactics, communication, command and control, etc., present considerable difficulties in their recognition, formulation and solution by usual scientific methods. The main difficulty in deriving scientific means from experiences in warfare stems from the very nature of battle themselves. Battles are non-repetitive, destructive experiments and are not adequately observed and recorded. Trials/exercises cannot be repeated over the whole battle system. The problems in this area have, therefore, been attempted recently through wargames on computers. Leak reports a parametric version of their basic armoured warfare model. This model steps in time frames with deterministic information on some parameters and stochastic on others relating to the battle system. The stochastic information is drawn from the models, giving the line of sight and duration of exposures, reaction time to fire the first round, probabilities of hit and kill depending upon the state of the target-moving, stationary or hull down, and the aspect-head-on, side-on or tail-on, etc. With such inputs the model generates casualties of both attacker and defender at various ranges. However, basic information on modelling and input parameters is not available and therefore the outcome cannot be interpreted objectively.

Here, we have attempted computer simulation methodology which can be made to approach the reality (wherever lacking) through gradual improvements. To start with, an attempt has been made to model a tank versus tank battle situation in which the defender is provided an armed helicopter unit support. As an illustration casualties of both attacker (M-47/48) and defender (Centurion tanks) have been generated by the model.

2. Scenario

Goline is an obstacle along the boundary of two countries and has its tactical importance. The enemy sacrifices its artillery support to achieve surprise offensive to capture it. The armour start advancing towards the objective. The defender have had no time but to deploy its tank coys and an armed helicopter unit, to intercept and destroy/delay the enemy before reaching the Goline. In this context the model assumes the following sequence of operations.

On the battle field RED and BLUE forces move forward and/or laterally towards the Goline from their initial line formations. The move takes place by bounds, the distance between bounds depending upon the natural and/or artificial obstacles. The movements between'bounds is covered by fire from other tanks of the unit. Each unit moves and searches for the target in its area of tire. If and when a target is sighted within the effective gun range it acquires the target and fire r rounds and immediately moves to change its position, provided it survives. If one or more rounds have hit the target and it is a casualty, all other units cancel their activities with respect to this unit. Otherwise, the target moves from its current position and searches for an enemy unit. In this way each unit moves, manoeuvres; searches for the target, acquires the target and fires. This activity continue till either side has reached the Goline or reduced to a non-fighting strength, whichever state is reached earlier.

At the same time the helicopter unit equipped with a number of missiles, moves towards the enemy area in search of enemy units. When a target is sighted, it releases a missile and turns back toward its own side and searches for a next target. It returns to its base at a time when either all its missiles are fired or maximum flight time is completed or battle is terminated whichever occurs earlier.

The state and outcome of the battle will thus depend upon the relative merit of equipment and weapons of both sides, tactics, terrain and the multiple interactions of these parameters. The interactions in the battle system are shown in Fig I.

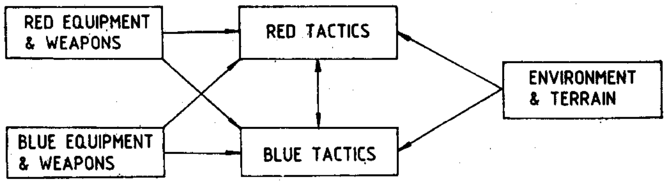


Figure 1. Interactions of the battle system.

3. Mathematical Modelling

The overall **survivability** of a force is generally assumed a function of such parameters as fired power (F), protection (P), mobility (M) terrain (θ) and tactics (ϕ). Mathematically, this can be expressed as

$$\dot{N}_i = f_i (F_1, P_1, M_1, \theta_1, \phi_1; F_2, P_2, M_2, \theta_2, \phi_2), (i = 1, 2) \quad (1)$$

where N_i is the number of units on the ith side at time t. Each of the factors on the right side of Eqn. (I) is dependent on a number of other factors. For example, fire power is a function of the accuracy, lethality and rate of fire of a combat unit, i. e.,

$$\dot{F}_i = f_i (P_h, P_d, r, N_i) \quad (2)$$

where P_h and P_d are probabilities of hit and of damage, respectively, and are dependent on the range, aspect and state of the target. At a given range, the probability of hit is well known to follow the bivariate normal law

$$P (x, y) = (2\pi \sigma_L \sigma_R)^{-1} \text{ Exp} \left[-\frac{1}{2}\left(\left(\frac{x}{\sigma_L}\right)^2 + \left(\frac{y}{\sigma_R}\right)^2\right)\right] \quad (3)$$

where σ_L and σ_R denote standard deviation of the line and range errors about the aim point. If A is the projected area of the target, the probability of hit/given the line of sight, is given by

$$P_h/\text{LOS} = \iint_A P (x, y)\, dx\, dy. \quad (4)$$

However, single shot hit probabilities for various gun-ammunition and sighting systems have been reported in the literature[2]. Pooling such results, single shot hit probabilities of a Centurion versus au M-47 or M-48 tank (stationary) with, their optical range finder, may be assessed approximately as given in Table 1.

In practice the probability of hit decreases on a moving target and increases substantially with each successive round fired after correction. The chances of survival of the tank which fire first are, therefore, more than those of its opponent. During Indo-Pak

Table 1. SSHP of a centurion versus M-47148 tank

Gun	Range (m)				
	500	1000	1500	2000	2500
105 mm	0.94	0.75	0.53	0.34	0.23
90 mm	0,89	0.68	0.47	0.28	0.17

wars it was often found[3] that before a M-47148 could open fire against a Centurion, the latter could knock it out employing a blind shooting technique. This suggests lesser response time of a Centurion than a M-47/48 tank. Similarly, if P_d is the probability of lethal damage due to a hit, the probability of kill is given as

$$P_k = P_h \times P_d \tag{5}$$

4. Line of Sight Model

It is noticed that the probability of hit depends upon the availability of the line of sight. In a real situation obstacles appear randomly in the line of sight. Generally, longer the range larger will be the number of obstacles and hence smaller will be the chance of sighting a target. Thus, the probability of sighting a target at a range R may be given by the relation,

$$P_R = e^{-\theta R} \tag{6}$$

where θ is a constant determined by the average width and the number of obstacles/ unit area. For typical values of θ, P_R is graphically shown in Fig. 2. Olson[4] observes a similar exponential trend for a typical terrain data.

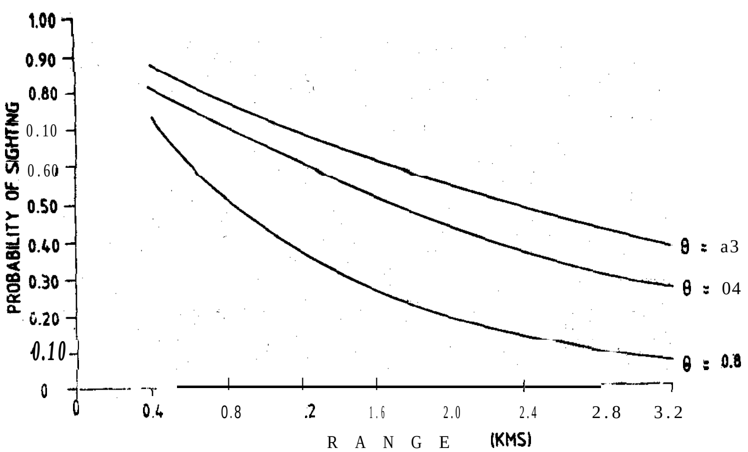


Figure 2. The variation of visibility with range and obstacles density.

However, system of equations of the type (1) to (6) cannot be solved analytically. Therefore, simulation approach has been attempted to integrate the component models involving probabilistic and deterministic events and decisions as dictated by the battle scenario, Here, probabilistic events are decided with the help of Monte Carlo technique. An event whose probability of happening is p will occur if a random number drawn from rectangular population (0,1) does not exceed p, that is, a target at a range R will be considered sighted if and only if random number does not exceed P_R. All probabilistic events are decided similarly.

5. Computer Modules

The model has been programmed in FORTRAN IV and has been executed on PRIME-750 system. It contains a main programme and the following subroutines to be used by the main programme as and when required :

(i) Main Programme

(ii) Random Number Generator

(iti) Movement — Red

(iv) Movement — Blue

(v) Search — Red

(vi) Search — Blue

(vii) Fire Sequencing -- Red

(viii) Fire Sequencing — Blue

(ix) Helicopter unit

(x) Hit/Kill Generation

(xi) Analysis

The activities-move and search, target acquisition and fire; and dead units are distinguished by three states 1, 2 and 0, respectively. Initially, all combat units are assigned state 1 and later this state is updated to 2, 1 or 0 whichever occurs earlier. The computer keeps a track of all combat units and maintains, state and time registers in the common block of its memory.

6. Input Data

The input data sooner or later becomes critical element in a simulation study. In the case of weapon systems it can be said almost universally, that most data are biased and not representative of the field conditions. Most direct fire studies involve tests which are conducted at a proving ground under better than average visibility and climatic environments, against fully visible targets, engaged by fairly well trained gunners who are hardly representative of men in combat. Nevertheless, such inputs in a simulation study can lead to some quantitative insight. In the present context, the primary interest is an adequate system model. The model operates and steps in time with deterministic information on some parameters and sampling information from component models discussed earlier. Without loss of generality, the following input configuration has been assumed to make it operational as dictated by the scenario. The tanks characteristics data are taken close to those of Centurion and a M-47/48.

Battle Field and Terrain

Depth — 4000 metres
Width — 6000 metres
Goline — Middle of Depth
Max. atmospheric visibility — 3000 metres
LOS model parameter, θ = 0.4 for defender
= 0.5 for attacker

Tactical Decision Rules

Initial deployment — line formations about 2 kms from Goline.

Average distance between bounds	— 50 metresj
Chord of fire	— 1000 metres
Fire opening range	— 2000 metres
No. of rds fired from a position	— 3
Time to covering fire	— 1 minute
Casualty level, for defensive moves	— 40%
Casualty level for game to end	— 60%

Weapons & Characteristics

	BLUE (Attacker)	RED (Defender)
No. of tanks	36	27
	36	18
	36	27 + H
	36	18 +H
	27	18 + H

Actual rate of fire (rds/min)	4	4
SSHP	As given in Table (I)	
3rd round hit prob	Lower range zone value	
Speed of forward moves (Kms/hr)	15	20
Speed lateral moves	10	15
Gun laying/acquisition time (min)	0.5	0.35
Prob of a hit killing the target	0.5	0.5

Helicopter Unit

Base (X, Y)	= (- 10, 1)
No. of missiles carried	- 4
Average speed	— 80 Kms/hr
LOS parameter θ	— 0.2
Depth of penetration from Goline	— 6Kms
Prob. of kill	— 80%
Flight endurance	— 1 hr

7. Results

When interpreting the results produced by simulation, it is to be realized that they are not produced by a process of optimisation. Simulation may be considered valid if it faithfully replicates activities as they would infact be implemented in practice. The results generated at any time t, may differ from game to game due to various causes. Analysis of variations can be done by usual statistical tests.

Let C,, C,, ... C_n be the differences in the casualities of the two sides, and $\bar{C}$ be the mean difference of n repetitions, then for large n

$$Z = \sqrt{n}\, \bar{C} / \sqrt{\Sigma\, (C_i - \bar{C})^2 / n} \rightarrow N(0,1)$$

If there is no difference between the two sides the value of Z has to be less than some critical value.

Fifty engagements have been conducted over the same inputs to both Red and Blue side. Battle statistics, such as percentage survivals, average number of casualties and their standardized difference, average number of rounds fired and hit achieved and the probabilities of hit, have been calculated and recorded in Table 2. As it should happen, the differences in the number of rounds fired and casualties inflicted by the two sides, are found statistically insignificant for the case when both sides assume the same parameters. Further, the estimates of SSHP agree closely with the input values.

Table 2. Comparative effects of fire power, mobility, intervisibility, force ratio and helicopter unit support on the battle outcome
(Analysis based on 50 games for each case)

Force	Percentage Survival Time (min) 00-20	20-24	24-28	28-32	32-36	Casualty/ Game	Test of Diff z	Rds fired	Hit Score	SSHP
36 : 36	Same Parameters on Both Sides									
R	98.8	84.3	56.4	46.2	46.0	19		113	44	0.39
B	98.7	86.1	58.9	49.8	48.8	18	-1.3	121	45	0.38
	Red with Better Hit Prob. Guns									
R	99.2	86.2	61.9	51.1	50.8	18		127	48	0.38
B	98.6	85.9	56.8	44.3	44.7	20	2.2	129	41	0.32
	Red More Mobile									
R	99.2	86.3	63.9	58.1	57.8	15		134	51	0.38
B	'96.6	79.4	50.7	43.2	42.8	21	4.9	113	36	0.32
27 : 36	CENTURIONS AGAINST M-47/48 LOS Better for Defender									
D	99.2	87.3	59.6	50.4	50.3	13		127	50	0.39
A	96.9	78.5	53.7	44.8	44.3	20	7.4	92	29	0.32
	Tactical Firing by Defender									
D	99.0	87.3	63.5	58.1	58.0	11		116	50	0.43
A	95.8	76.6	49.3	43.0	42.8	21	9.3	80	25	0.32
18: 36										
D	99.3	86.0	55.3	45.2	44.2	10		88	37	0.43
A	96.8	81.2	63.5	57,6	57.4	15	5.1	71	24	0.34
27 + H : 36	Helicopter Unit with Defender									
D	99.6	90.4	70.5	68.4	68.4	9		104	45	0.43
A	94.7	67.8	43.2	39.7	39.7	22	19.9	65	20	0.34
18 + H : 36										
D	99.7	89.1	61.6	52.6	51.3	9		87	37	0.43
A	95.7	74.1	53.4	48.5	48.1	19	10.3	64	21	0.34
18 + H : 27										
D	99.3	90.0	13.9	68.0	67.0	6		76	32	0.42
A	95.0	70,5	44.1	40.4	39.5	16	16.1	46	14	0.32

Similarly, to execute the scenario characteristics of both sides, relevant input parameters have been changed successively in the following order :

(i) Red with better hit prob. gun

(ii) Red more mobile

Defender (Centurions) against M-47/48 tanks

(iii) LOS prob. better for Defender

(iv) Blind shooting by Defender

(v) Force ratio (18:36)

Defender with Helicopter Unit

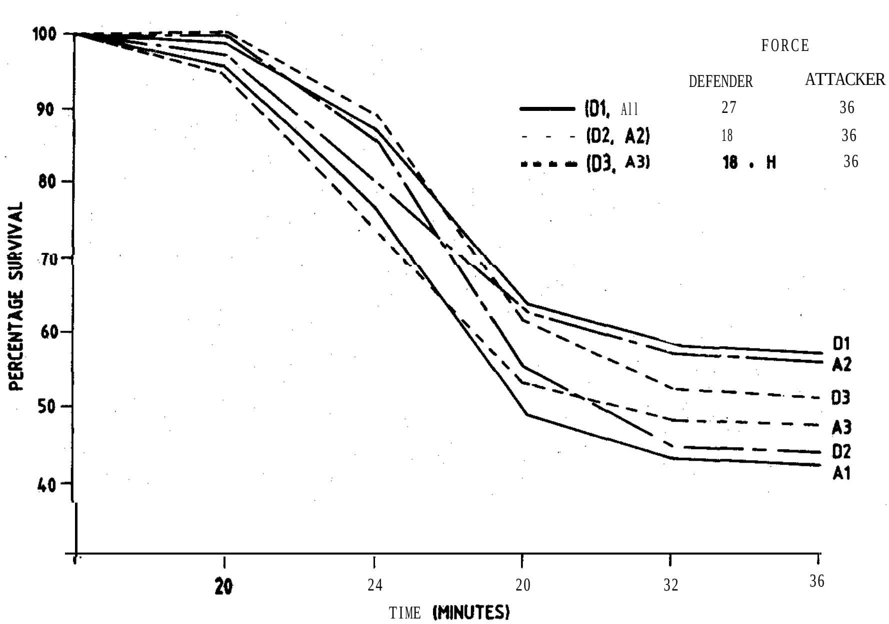
(vi) Force Ratio (27 : 36)

(vii) Force Ratio (18 : 36)

(viii) Force Ratio (18 : 27)

In each case fifty engagements have been repeated and the average effects analysed and reported in Table 2.

Apart from the accuracy and the speed of movements, better performance of the Centurions seem to be more due to its gun stabilizer which permits accurate blind



Pigure 3. Effects of force ratio on survivability of centurions **(defence)** against M-47/4% (attack).

shooting, particularly at lower ranges where APDS rounds take almost a flat trajectory. In the present case the firing ranges being greater than 1500 m, the gain is more due to lesser reaction time as compared to M-47/48.

Although the results are based on tentative data, the trend seems to suggest that a battalion of Centurions or 2 coys with a helicopter unit support stand fairly good chance to defeat the attack by M-47/48 tanks equivalent to 4 coys. (Fig. 3).

8. Conclusions

Simulation methodology of a war game has been developed and programmed on PRIME-750. Effects due to various battle parameters have been demonstrated. The model provides a basis to systematically approach realistic situations and quantitatively assess weapon system effectiveness under tactical alternatives and battlefield environments.

Acknowledgement

The author is grateful to Dr. N. K. Jaiswal, Director, fnstitute for Systems Studies & Analyses Delhi for his valuable advice and suggestions. Thanks are also due to, Mr. Chandra Prakash for computation assistance, the DRDO Computer Centre for help in errors diagnosis.

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