WEAPON FIREPOWER POTENTIAL

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THESIS

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ABSTRACT

Methods are proposed for measuring the combat effectiveness of the main armament of tank and antitank weapons using firepower potential scores. A comparison of these scores can be used as a simplified screening process to decrease the number of candidate options that must be evaluated by simulation or detailed analysis.

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I. INTRODUCTION AND SCOPE

Measuring combat effectiveness is one of the most difficult problems encountered in any military analysis. The purpose of this paper is to enrich the methodology of measuring and evaluating combat effectiveness by using firepower potential scores to quantify the more important parameters of weapon systems. These potential scores can then be used to compare or rank the effectiveness of weapons or units.

There are three general problem areas where operations research and system analysis techniques are directly related to measuring and quantifying combat effectiveness: Force Planning Analysis, Systems Design Analysis, and Wargaming. Personnel working in these areas are frequently confronted with attempting to evaluate numerous options that can satisfy specific requirements. For example, the Force Planner is confronted with the problem to determine the size and composition of a force to meet a given threat. There are almost unlimited possibilities that could be tried and in fact should be tried in an attempt to obtain a proper mix and size force that meets stated limitations. For example, TATAWS III, completed by the Armor Agency of the Combat Developments Command in March 1969, had to evaluate 3420 possible alternatives that could be obtained by cross-attaching tank and mechanized infantry forces in an attempt to find the "best" size and equipment for Armor units against a given threat. [7]

The Systems Designer must evaluate designs to determine which are feasible and which are the most effective. This is the type analysis done by the Combat Developments Command in their "K" Tank Study which compared the design parameters of several candidate tanks. [12]

Wargaming personnel also use measures of combat effectiveness to evaluate and determine attrition of forces for different scenarios, weapons, and tactics in computer and manual simulations. The Research Analysis Corporation has devised "Quick Game" and "THEATERSPIEL" as two simulations that use measures of combat effectiveness to determine attrition. [5]

In all these cases, it might be possible to evaluate completely each and every option using computer simulation but usually monetary and time constraints have limited the analyst's ability to test all possible options. The procedure then is to limit detailed evaluation to only those options that appear to be feasible. While some of the options can be eliminated quickly and easily by using judgement or visually noticing that a constraint will be violated, the remaining set of options is many times still too large to handle and thus further screening is required.

This paper suggests that firepower potentials can be used to quickly evaluate these remaining options and select for detailed evaluation and simulation those options that will be the most fruitful. A methodology of firepower potential exists and is presently in use,

but as will be pointed out, possesses some shortcomings which may prevent it from being an accurate screening tool.

Since the USSR and its satellite nations are known to possess more than 40,000 tanks of many different makes and models, sure and effective measures must be taken to insure that the U. S. capability to defeat armor in any area of confrontation is sufficient to meet this threat. Because of the magnitude of the armor threat, this paper will deal only with the methodology used to compute the firepower potential of the main armament on tank and antitank weapons. The factors that affect the success of a tank in battle will be evaluated to find the most important quantifiable parameters that can be used to define potential. And finally, these factors will be combined in a manner that is mathematically correct and heuristically appealing to obtain models that can be used to quickly and efficiently limit all possible options to those that are both feasible and effective.

II. WHAT IS POTENTIAL?

Webster's dictionary defines "potential" as existing in possibility and capable of development into actuality. To apply this definition to the capabilities of a tank in combat would not provide a sufficient description of what a tank adds to the combat situation. What is needed is a more specific definition which can be quantified in some manner so that it can be measured or ranked in comparisons. The influence that a tank or a tank unit has on the combat situation depends on many factors, but if potential is defined as the worth, value, gain, or return it can be quantified and used to signify the effectiveness of the tank. For the purposes of this paper potential will be synonymous with worth and will be expressed as a firepower score. Clearly the term "worth" is not sufficient to cover all situations in combat because a tank by itself may have very little or possibly no worth. The worth depends upon having a target for the tank to shoot at, ammunition to fire, personnel to operate the tank and many other factors. These factors imply that the potential of a tank depends on the situation in which it is employed. It can therefore be concluded that the definition of potential as worth, must be supplemented with other terms to describe the situation to be evaluated.

The technique of operationally defining a term is ideally suited for potential because an operational definition completely specifies the situation and describes how potential should be measured. Since

this paper is advocating the use of firepower potential as a screening measure it is desirable to standardize the manner in which the potential is measured. Before and during the battle, evaluations cannot in general produce a quantative computation of worth because of the uncertainty involved. Evaluation of "after battle" statistics can produce a true quantitative measure of a tank's success such as "our tank is twice as good as theirs because each of our tanks killed two of theirs." This paper therefore will use the firepower score to represent the worth of a tank before and during a battle. The score will in no way represent the quantitative worth but can be used to obtain relative rankings of the worth of future participants in a conflict.

Potential can now be operationally defined as the ability of a tank to attrit the weapon systems of an opposing force and the gain to the friendly force from the attrition. This ability will be measured by the firepower score.

The problem now is to find the factors that affect a tank's success in battle and then determine how to measure these factors in order to compute a firepower score that will represent the effectiveness of a tank. The list of possible factors is extensive but the most significant are firepower, mobility, survivability, maintainability, sustainability, enemy capability, and interaction with other friendly weapons.

III. SELECTION OF FACTORS WHICH INFLUENCE POTENTIAL

While the seven factors just described are very general and interrelated, each has several basic components which can influence the outcome of a battle. A selection from these areas must be made to determine which specific component contributes to a tank's potential and also state the parameters on which it depends.

A. FIREPOWER

Since this paper is only concerned with the main armament of a tank, the components in this factor are the gun, the ammunition and the necessary fire control equipment to aim and fire. In general all weapons are designed so that they have specific hitting and killing ability for each type round against various targets. When these design parameters are combined with operational data [acquisition time, identification of target, time to load weapon, and various errors in aiming and trajectory] a value representing the probability of obtaining a mobility or firepower kill (M or F kill) on a specific target with a single round is obtained. This single shot kill probability (Pssk) is the first factor to be used in the models to compute the weapon's potential. Pssk is dependent on the range to the target, weapon, type of target and type of ammunition fired.

The second factor to be used in potential computations is the quantity of ammunition available by type. This input data can be

based on historical usage rates, basic load carrying capabilities or some other resupply rate. The quantity of ammunition used is dependent upon the posture of the weapon and the duration of the battle.

Other factors in the firepower area that were considered but not selected for inclusion in potential were: parallax resolution problems, super-elevation correction factors, tube wear, difference in ammunition propellants and speed of flight. These factors could adversely affect the worth but are considered to be insignificant or have already been partially included in the Pssk factor.

B. MOBILITY

Tanks are designed for general mobility across country. The design parameters are based on terrain, trafficability of the soil, obstacles both man-made and natural, and weather. All these factors are in turn interrelated and in addition, the enemy posture, strength and capability can influence mobility. [The mobility considered here is tactical mobility not strategic mobility.] All of these factors can be quantified into a variable called rate of movement. This rate is the relative rate of movement, relative in that it depends upon both the friendly and the enemy rate.

C. ENEMY CAPABILITIES

The enemy's capability to defend himself using armor protection has already been included in the Pssk factor. What remains is to account for the enemy's offensive capability; the enemy Pssk against

the friendly weapon systems. To account for this capability a factor called utility will represent the gain received by the friendly force for killing an enemy target and destroying its offensive capability. Utility will be the product of the enemy ammunition and the Pssk of the enemy weapon against the friendly force. It is clearly range dependent in an inverse manner. That is, a friendly force gets more utility for killing an enemy weapon system earlier in the battle because the friendly force is not subjected to the enemy weapons' kill rate for the remainder of the battle. This utility is therefore dependent on the quantity of enemy ammunition, the Pssk of the enemy weapon against the friendly force and the range separating the two forces.

D. MAINTAINABILITY

Maintainability is the ability of the tank to remain in working order and hence available to fight when called to do so. The factors in this area are: reliability of the gun, engines, tracks, communication and fire control equipment. Since potential is worth, this paper assumes that maintainability factors of a well designed tank can be disregarded. This means that the tank is always available for combat with probability one. While this may be somewhat unrealistic, the only other alternative would be to assign a worth of zero to any tank which is inoperative. This is essentially the same as a tank that has sustained an M or F kill in combat.

E. SUSTAINABILITY

Sustainability is the ability of the tank to remain in the combat area. The factors involved are all the classes of supply: POL so the tank can move, ammunition so it can shoot and food so the crewmen can eat. Since ammunition and mobility have already been accounted for, other factors in this area can be disregarded by assuming that they are present in sufficient quantity so as not to degrade the tank's worth.

F. SURVIVABILITY

Survivability reflects the ability of a tank to survive combat on the battlefield. Most of this area can be considered to interact with other areas already covered such as mobility and enemy capabilities. These other areas sufficiently cover survivability so no factor from this area is selected for inclusion in firepower computation.

G. INTERACTION WITH OTHER WEAPONS

This area includes the general need for close in support provided by Infantry-type forces and the interaction between individual tanks in the same unit as well as interaction with the fires of other supporting weapons. This area is generally unexplored as far as quantifying how much more effective a platoon of five tanks is than just five individual independently operated tanks.

This paper assumes that the interaction capability is not degraded by assuming independent operation. While this assumption leads to

less potential for a given organic unit it can be justified by the fact that enemy potential will be computed under the same assumption. The assumption results in a great deal of needed simplification. Consider a U. S. antitank force consisting of two teams of two guns per team. Since U. S. doctrine recommends that AT weapons be employed in pairs, this assumption can handle a case where one AT gun is knocked out and the "mate" joins with the full team to become a force with three AT guns.

By the above selection process the potential of a weapon or unit can be represented by combining and measuring the following factors:

1. Pssk - which represents the ability of the weapon system to shoot or launch a projectile the required distance to a target and once there get a mobility or firepower kill.
2. Quantity of ammunition - which represents the ability of the weapons system to bring a certain amount of fire on the enemy.
3. Rate of movement - which represents the relative rate of movement of the two forces.
4. Utility - which represents the gain received by killing an enemy target early in the battle.

These factors all depend upon the distance between the two forces and can be used to mathematically quantify the worth of a tank in combat.

IV. MODELS TO COMPUTE POTENTIAL

A. GENERAL

Weapon Firepower Potential can be computed by using two different methodologies: static or dynamic. In general, the static potential methodology considers the potential available at a specific moment in time, without regard to any past or future data or worth. This approach is typified by its ease of computation and generalization of the combat situation. Dynamic methods are generally more complicated and are based on considerations from higher mathematics but account for past potential and consider the interaction of the forces over a period of time.

While both dynamic and static computations could be made for any given scenario, the methodology used depends upon the resolution that is required. A high resolution requirement means that the analyst is interested in the detailed effect of each weapon system on the outcome. Usually only a small number of weapons are involved which insures that a valid movement rate for each weapon can be obtained. Requirements for low resolution results are used in cases where large forces are involved and the effect of varying the size of the forces is required. The static methodology should be used in most of these cases because of the difficulty in quantifying movement rates and the effect of interaction between units.

A unit tank-antitank potential is computed by summing the firepower potentials of the weapons organic to the unit. If the dynamic potentials are summed, then the result is a dynamic unit potential. Likewise, the static weapon potentials yield static unit potentials.

B. PRESENT FIREPOWER POTENTIAL

The Combat Operations Research Group (CORG) in the mid 1960's developed a Firepower Potential computation that is still in use. [11] This model to compute tank and antitank weapon potential is

$$FP = A \, \overline{P}_{kill} \, W \quad ;$$

where A is the ammo available based on historical data for eleven different combat postures of friendly and enemy forces; $\overline{P}_{kill}$ is the average probability of killing an enemy main battle tank at an opening range of 1500 meters; and W is a range factor based on how far the friendly weapon can fire.

This model is "good" for situations where extremely low resolution is required but has the following shortcomings that may detract from its effectiveness as a screening tool for evaluation of tank designs or tank and antitank combat situations.

1. $\overline{P}_{kill}$ is not range dependent and cannot be easily adjusted to account for terrain where the opening range is in excess of or less than 1500 meters.

2. $\overline{P}_{kill}$ is based on the ability of a system to kill an enemy main battle tank. This factor cannot be changed to portray the difference

in capability due to targets other than main battle tanks which may be present on the battlefield.

3. "W" the range factor is a simple weighting device that gives added weight to weapons that have longer maximum ranges. This factor is a substitute for a term which quantifies the utility gained by killing targets at long range before they become effective against the firer.

C. EXTENSION I

One assumption of the present CORG model is that historically tank battles occur at ranges less than 1500 meters. This fact does not reflect the capabilities of present weapons in combat and questions why the United States is still designing weapons systems with a maximum effective range in excess of 1500 meters. In fact, if this assumption is relaxed and the range to the target is included as a parameter, a more discerning measure results.

Weiss' [13] concept of force separation will be used as the measure of the range to the target. Force separation is defined as the distance between the centers of mass of the opposing forces. Since force separation is a relative measure, it is independent of the postures of the two forces but can account for increases or decreases in range produced by different tactical movements. The force separation at the start of the battle can be designated as the opening range (Ro) and the separation at the end of battle as the final range (Rf). Depending

on the tactical movements as specified by the scenario Rf is the maximum or the minimum range of the weapon.

For a battle in which the force separation is decreasing, the model is:

$$FP = \frac{A \quad W}{Ro - Rf} \int_{Rf}^{Ro} Pssk\ (r)\ dr.$$

Pssk (r) is the single shot kill probability as a function of range. If the scenario to be screened using firepower potential scores provides information on terrain, a valid opening range can be computed by a terrain analysis to determine an average intervisibility distance. For example, if the scenario included tank forces operating in the Sinai desert an opening range of 3000 meters would be feasible. For tank operations in Viet Nam, Ro could be less than 1000 meters; the Rhine Valley, Germany, would have a different Ro factor. As long as a valid average opening range can be obtained, this model will yield good results. For larger theaters such as Europe where an average Ro would be difficult to obtain or invalid, this model may not be acceptable.

D. EXTENSION II

Since heavy tanks are generally harder to kill than main battle tanks, it is readily apparent that the value of Pssk vs an enemy main battle tank is overrating a weapon's capability if an enemy heavy tank is encountered. Extension I can be modified to account for the different

killing ability of a weapon system facing targets other than main battle tanks. By estimating the percentage of each type target that will be encountered on the battlefield, a weighted average for a systems Pssk can be included in the model.

$$FP = \frac{A \cdot W}{Ro - Rf} \sum_{i=1}^{n} Pi \int_{Rf}^{Ro} Pssk_i(r)\, dr$$

where n = number of different type targets

i = type target

Pi = percentage of targets of type i and

$Pssk_i(r)$ = probability of killing a target of type i as a function of range.

Pssk of all United States weapons vs any weapon in the enemy inventory is available and can be obtained. The parameter Pi is situation dependent and requires additional specific scenario information. In a force planning scenario Pi can easily be obtained from the threat analysis and enemy troop lists. In most situations the threat analysis will provide the force and equipment that makes up the threat. As an example, if the threat analysis in Southeast Asia rules out any employment of enemy main battle tanks this model will account for that fact. Similarly the Sinai Desert threat may show a predominance of heavy tanks. It is well known that threat analysis involving satellite nations of Russia do not include the employment of new main battle tanks. These satellite nations are assumed to have a predominance of older

more easily killed tanks. [4] All these factors serve to point out that the Pi value could be validly obtained and in fact, for low resolution applications, the value of Pi could be based upon the known ratio of equipment in a whole theater of operations. The CORG model could seriously over or underrate the potential in these specific situations.

E. EXTENSION III

Up to now the historical ammunition expenditure factor has not been modified in any of the models. While historical data may not be extremely accurate it is realistic for U. S. forces and its allies. The problem is to obtain realistic data for all possible adversaries. In past conflicts the USSR has always reported expending large amounts of tank ammunition. This may have occurred because their tanks lacked the accuracy or because their supply lines were so short that they did not have to constrain their expenditure rates. In the case of some possible adversaries these expenditure rates can only be estimated. Since the ammunition factor used to compute potential is so important, accurate expenditure rates are a necessity.

This paper proposes an alternate to using expenditure rates; that is to use the basic load carrying capability of the weapon system. Potential is, in effect, evaluating a battle of short duration. This implies that in most cases ammunition would not be resupplied but will be expended according to the amount that can be carried with the weapon systems. Using basic load expenditure rates seems heuristically

correct. Because of the nature of the tank and its configutation the rated basic load cannot safely be exceeded and resupply is a long and tedious process by which the ammunition must be loaded one round at a time through a hatch on the turret. If resupply is attempted it must take place outside the combat area and essentially the tank is out of service. By substituting A_b for basic load of ammunition into Extension II, Extension III is:

$$FP = \frac{A_b W}{Ro - Rf} \sum_{i=1}^{n} Pi \int_{Rf}^{Ro} Pssk_i(r)dr.$$

This substitution could also be made into the CORG model for situations where expenditure rates are not known or cannot be accurately estimated.

F. EXTENSION IV

In Extension I the CORG model was made range dependent but the CORG range factor "W" was left in the model as a representation of the worth of killing a target. This factor initially seems to be double weighting the weapon's ability to kill at long ranges. In actuality the range factor expresses the desire of commanders to kill targets as far away as possible. To alleviate any possible double counting it is proposed that the worth of killing a target be directly included in the computation as utility. The utility gained by killing a target depends upon the target killed. For example, more is gained by killing a heavy tank than by killing an antitank gun.

Utility can be evaluated by ranking the enemy weapons according to their destructive ability against the friendly force and then assign a number to each ranking. If Wi is the ranking of the utility gained by killing a target of type i, Extension IV (a) becomes

$$FP = \frac{A}{Ro - Rf} \sum_{i=1}^{n} Pi\ Wi \int_{Rf}^{Ro} Pssk_i(r)dr.$$

Utility can also be considered as proportional to the enemy's kill rate against friendly systems. This kill rate is range dependent and is the product of the enemy ammunition expenditure rate times the single shot kill probability of the enemy weapon against the friendly weapon. If wi (r) represents the range dependent kill rate of target i against the friendly weapon, then Extension IV(b) is

$$FP = \frac{A}{Ro - Rf} \sum_{i=1}^{n} Pi \int_{Rf}^{Ro} Pssk_i(r)\ wi(r)dr.$$

The concept that utility is proportional to kill rate is widely used in Lanchester-type equations and has been explored by Taylor [9].

While this model seems appealing because it contains all the elements of potential that are important, it does fail to evaluate a situation in which each force has only one type weapon. In this case the model, because of the definition of utility, is symmetric and the potential for each side will be dependent only upon the numbers of weapons on each side. This of course is not a true evaluation and must be recognized as a limitation to the use of this model.

G. EXTENSION V

In all of the preceding extensions the static firepower potential methodology has been used to construct the models. Extension IV(b) provides an average kill potential over the range that separates the two forces; but when one or both forces is moving, this average kill potential changes at the rate that the separation between the two forces is increasing or decreasing. The dynamic potential methodology is needed to account for this change in potential during the future course of the battle. A value for the velocity of the range separation included in the computations, will make it possible to determine for how long a period of time a given kill rate is in effect and what is the utility of the targets killed during that time period.

At the same time that velocity is included, it is also possible to revise the utility of killing a target to account for the "multiplying effect" attributed to the dynamics of combat. This "multiplying effect" accounts for the fact that a weapon lost early in the battle decreases the potential for the loss at that time and in addition decreases the potential because the killing capability for the rest of the battle has also been lost. If an assumption is made that the utility gained from a target killed at R min (minimum range) is the actual kill rate of the target against the friendly force at that range, then it is possible to integrate backwards from the minimum range and find the utility gained by killing the target on the first firing at the opening range (Ro). Taylor [8] has accomplished this mathematically for kill rates that vary

with the range to the target. By making these changes to Extension IV, Extension V becomes

$$FP = \sum_{i=1}^{n} \frac{Pi \quad A}{Ro - R\ min} \int_{R\ min}^{Ro} Pssk_i(r)\ Wi(r)dr.$$

Wi(r) is the utility gained by killing a target of type i as a function of velocity of the force separation and can be obtained from a backward integration in the manner described by Taylor [10]. The actual velocity of the force separation depends on many parameters and would require additional study effort to validate. If a constant velocity is assumed, this model may be used to compute potential after it has been modified to be a function of time rather than range. In reality the rate of movement is not constant. It clearly depends upon the amount and accuracy of fire the attacking force is receiving and on the posture of the defending or delaying force. In addition, as the force separation decreases, the acquisition of targets becomes easier and the tank must stop in firing positions more frequently thus slowing the rate of force separation. When a range is reached where a final assault is possible the tank would speed up in order to close with and destroy the enemy.

The dynamic model has the added property that it is <u>not</u> symmetric. That is, any two weapon systems will have a different potential unless they have exactly the same characteristics. This model could be further evaluated to determine the change in potential that would result from changes in velocity of the force separation.

V. EVALUATION OF THE MODELS

A. SCENARIO

To evaluate the models of Chapter IV, a scenario that required high resolution was written. The hypothetical terrain situation included a velocity of the change of force separation and a maximum opening range of 3000 meters. Each force had a fixed quantity and mix of tank and antitank weapons and each weapon had a hypothetical set of the following specified characteristics:

1. range dependent single shot probability of killing each type target;
2. historical ammunition expenditure rates;
3. basic load carrying capability;
4. maximum effective range.

The complete scenario is attached as Appendix A.

Each of the static models was tested in the scenario so that the results could be compared. The dynamic model was, for ease of computation, tested by using only one type weapon of each force. Computations were also made using different opening ranges to check the sensitivity of each model.

B. COMPUTATION RESULTS

All of the models yielded results which were consistent with the logic used to construct the model. In all cases the Red force had higher potential than the Blue force which essentially means that the

Blue force probably could not win the confrontation because they were "outgunned." The most notable difference in potential occurred in the computations for Extension III, where the different ammunition rates were used. This was as expected and again serves to point out the criticality of a valid ammunition expenditure rate when using any firepower potential model.

When the computations were compared by determining the percentage of unit potential contributed by the weapons of a certain type, it was found that the present CORG system continually overrated the weapons that had a maximum effective range of less than the opening range. As the opening range was decreased the results indicated that the percentage of potential contributed by these weapons increased. Heuristically this seems correct because these weapons are involved in the battle earlier and the potentials of the longer range weapons have decreased because the differential of their range advantage is not as great.

A strict mathematical comparison of the different models was not conducted because of the validation problem (see Section D). A sample of the results of the computations can be found in Appendix B.

C. COMPLEXITY

There is a definite order of complexity and ease of computation associated with these models. Although the sample computations were made on a desk calculator, all models could be programmed for a digital

computer where the compiler time would be proportional to the complexity of the model. The CORG model is the least complex followed closely by Extension I which accounts for range dependence. Complexity increases through Extension II, Extension IV(a) and Extension IV(b) with the most complex being the dynamic model Extension V. Extension III is classed with Extension IV(b) and in fact the ammunition factor employed in Extension III could be applied to any of the models presented.

If an extremely high resolution requirement exists then the model may be so detailed and complex that a point will be reached where the potential computation exceeds the cost and time required to perform a simulation of all the options. At such a point weapon firepower potential scores will not be an effective screening tool.

D. VALIDITY

How effective or efficiently any of these models are at screening options can only be surmised at this time. For a model to be effective it must be validated and this was not feasible because of the security classification of weapon characteristics. The models presented in this paper could be validated by computing the actual potential of all the options evaluated in the TATAWS study.

This potential could then be compared with the performance of the option in the TATAWS computer simulation. At the same time that validation is taking place the models can be evaluated for their screening

ability and some measure of effectiveness can be assigned to each model based on the ability to select "good" candidates by using firepower potential scores.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. RECOMMENDATIONS

Weapon Firepower Potential is a relatively new area of research; much is left to be accomplished. While this paper has only dealt with the main armament of tank and antitank weapons, each weapon in the inventory of the United States and its possible adversaries has been evaluated under the CORG potential. Some of these potentials accurately evaluate their weapons while others are based on rather weak assumptions and require extended modification.

While many organizations and individuals have attempted potential evaluations of whole systems, this work has generally fragmented itself to assessing the individual weapons of the system and continued to ignore the interaction of a system within itself and between or with other systems. In these days of advanced technology it seems incredulous that it has not been possible to quantify the gain in potential when two tanks are operating together. Apparently work in this area has either failed or has not been pursued to a satisfactory conclusion.

Continued validation of the CORG System is sorely needed and while it would not be a simple project, it is essentially required if the potential scores are to be used for any critical purpose.

The effect of mobility on the outcome of battles has been studied extensively by Bonder [2,3] while the Combat Operations Research Group [11] has attempted to quantify mobility into potential. Both of

these efforts could possibly be expanded to produce valid measures of the effect on firepower potentials directly attributed to the dynamics of combat. All of the topics in this section are recommended as extremely fruitful problems for future projects or theses in the area of Weapon Firepower Potential.

B. CONCLUSIONS

The firepower potential of tank weapons systems is a situation dependent evaluation of the system's capability to perform in future combat. Once a scenario has been established and the degree of resolution specified, a model can be selected to determine the potential of the force. This force potential then can be used as a screening device to modify weapon systems, composition of force, or quantity of systems until parity of potential is obtained between the two forces.

All options that achieve parity or near-parity with the opposing force can then be further evaluated by computer simulation, detailed analysis, or field test. The screening done by the force potential scores should considerably reduce the cost and time required to evaluate designs, war games, or force plans.

Weapon firepower potential is needed to solve the problems initially presented in this paper. Potential models, once they are validated, can be used to screen many options and allow the analyst to devote his skill and time to solving the basic problems of how much force is needed? what should be the composition of the force? and what design factors influence the combat situation?

APPENDIX A

SCENARIO

The following scenario is devised to test models that could possibly be used to compute weapon and unit firepower potentials. This scenario lacks some realism in that the organic units do not possess the same type weapon system. This was done to ascertain the sensitivity of the models to differentiate between systems with different characteristics.

Two forces, Red and Blue, are engaged in a conflict. The terrain has a maximum line of sight of 3000 meters with the Red and Blue forces both on high ground. Once a battle starts there is no problem with intervisibility but because of fog and weather conditions the opening range (separation) can vary from a minimum of 500 meters to the maximum range of 3000 meters. Red or Blue may attack with the opposition being considered as occupying a deliberate defensive position.

The Red force has the following equipment:

3 - JS-3 type heavy tanks maximum effective range 5000 meters
*10 - T-62 type medium tanks maximum effective range 4000 meters
4 - T-55 type medium tanks maximum effective range 3000 meters
3 - T-54 type medium tanks maximum effective range 3000 meters

1 - 115 mm Antitank gun (SP) heavy maximum effective range 2500 meters
2 - 85 mm Antitank gun medium maximum effective range 1500 meters
2 - 76 mm Antitank gun light maximum effective range 750 meters

5 - "SWAT" AT Rocket Launchers maximum effective range 1500 meters
5 - "SAGR" AT Rocket Launchers maximum effective range 500 meters

The Blue force has the following equipment:

5 - MBT-70 Tanks maximum effective range 4500 meters
*17 - M60 A1E2 Tanks maximum effective range 3500 meters
3 - M60 A1 Tanks maximum effective range 3500 meters

3 - 106 mm Recoilless rifles maximum effective range 2000 meters
3 - MAW-AT missiles maximum effective range 1000 meters

*Denotes Main Battle Tank for CORG Computation

Each weapon in the scenario had a graph of single shot kill probability vs range for each type target of the opposing force. Ninety of these linear Pssk functions were used to represent all possible weapon-target combinations. In addition, each of the fourteen different weapons evaluated had a set of basic load and historical ammunition usage rates for offensive and defensive situations.

All the numbers used in the scenario are artificial but their relative magnitude has been kept consistent with generally known capabilities. For example, at a given range there is more probability that an MBT-70 will kill a T-54 tank than a JS-3 because the T-54 has a different silhouette, less armor plate and different slope to the frontal armor.

APPENDIX B

SAMPLE COMPUTATIONS

When the static models of Chapter IV are applied to the scenario the following results are obtained:

A. CORG PRESENT SYSTEM

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	21.00	105.00
M60A1E2	18.36	282.12
M60A1	18.36	55.08
106RR	5.62	16.86
MAW	1.50	4.50
Total unit potential		463.56
Red		
JS 3	49.44	148.32
T-62	26.10	261.00
T-55	42.66	170.64
T-54	34.92	104.76
115mm AT gun	57.75	57.75
85mm AT gun	49.50	99.00
76mm AT gun	11.56	23.12
SWAT	6.51	32.55
SAGR	2.38	11.88
Total unit potential		909.02

B. EXTENSION I

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	18.00	90.00
M60A1E2	15.90	270.30
M60A1	15.90	47.70
106RR	3.45	10.40
MAW	.68	2.00
Total unit potential		420.40

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Red		
JS3	48.00	144.00
T-62	25.20	252.00
T-55	40.20	160.80
T-54	30.00	90.00
115mm AT gun	46.20	46.20
85mm AT gun	24.30	48.60
76mm AT gun	2.80	5.60
SWAT	2.60	12.80
SAGR	.40	2.00
Total unit potential		762.00

C. EXTENSION II

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	20.25	101.30
M60A1E2	17.62	299.50
M60A1	18.32	55.00
106RR	4.23	13.90
MAW	.86	2.60
Total unit potential		472.20
Red		
JS3	47.96	143.89
T-62	24.90	249.00
T-55	38.25	153.00
T-54	29.02	87.05
115mm AT gun	42.85	42.85
85mm AT gun	24.36	48.72
76mm AT gun	3.70	7.41
SWAT	3.16	15.81
SAGR	.395	1.98
Total unit potential		749.70

D. EXTENSION III

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	440.47	2202.33
M60A1E2	432.06	7345.01
M60A1	565.25	1695.75
106RR	86.84	260.52
MAW	48.21	144.62
Total unit potential		11648.23
Red		
JS-3	519.34	1558.03
T-62	602.60	6026.04
T-55	688.25	2752.99
T-54	477.58	1432.74
115mm AT gun	240.12	240.12
85mm AT gun	130.74	261.49
76mm AT gun	120.50	240.99
SWAT	92.31	461.55
SAGR	41.40	207.02
Total unit potential		13180.47

E. EXTENSION IV

(a) Rankings of worth

Blue Ranks	JS-3	9	Red Ranks	MBT-70	9
	T-62	8		M60A1E2	8
	T-55	7		M60A1	7
	T-54	6		106RR	5
	115mm	5		MAW	3
	85 mm	4			
	76mm	3			
	SWAT	2			
	SAGR	1			

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	34.00	170.00
M60A1E2	29.62	503.57
M60A1	30.34	91.03
106RR	7.25	21.75
MAW	1.96	5.88
Total unit potential		792.23
Red		
JS-3	115.25	345.77
T-62	60.04	600.37
T-55	91.11	364.44
T-54	69.03	207.11
115mm AT gun	102.16	102.16
85mm AT gun	58.23	116.46
76mm AT gun	12.50	25.00
SWAT	7.40	37.00
SAGR	2.77	13.87
Total unit potential		1812.18

(b) Worth as a function of target kill rate

Force Weapon	Firepower Potential of each type weapon	Total contribution by these weapon types to the unit firepower potential
Blue		
MBT-70	37.54	187.71
M60A1E2	40.86	694.55
M60A1	39.17	117.50
106RR	10.91	32.94
MAW	2.88	8.63
Total unit potential		1041.13
Red		
JS-3	53.78	161.35
T-62	37.17	371.66
T-55	64.38	257.53
T-54	51.57	154.72
115mm AT gun	78.57	78.57
85mm AT gun	44.85	89.71
76mm AT gun	10.03	20.07
SWAT	6.33	31.67
SAGR	2.13	10.64
Total unit potential		1175.92

F. PERCENTAGE OF UNIT POTENTIAL CONTRIBUTED BY WEAPON TYPE

MODEL / WEAPON	CORG	EXT I	EXT II	EXT III	EXT IVa	EXT IVb	XXX
MBT-70	22.65	21.41	21.45	18.90	21.46	18.03	16.1
M60A1E2	60.86	64.30	63.42	63.06	63.56	66.71	54.8
M60A1	11.88	11.35	11.63	14.55	11.49	11.29	9.7
106RR	3.64	2.48	2.94	2.23	2.75	3.14	9.7
MAW	.97	.48	.55	1.23	.74	.83	9.7
JS-3	16.32	18.89	19.19	11.82	19.08	13.72	8.5
T-62	28.71	33.07	33.21	45.72	33.13	31.61	28.5
T-55	18.77	21.10	20.41	20.88	20.11	21.90	11.4
T-54	11.52	11.81	11.61	10.86	11.43	13.16	8.5
115mm	6.35	6.06	5.71	1.82	5.64	6.68	2.9
85mm	10.89	6.38	6.50	1.98	6.43	7.63	5.8
76mm	2.54	.73	.99	1.82	1.38	1.71	5.8
SWAT	3.58	1.68	2.11	3.50	2.04	2.69	14.3
SAGR	1.31	.26	.26	1.57	.77	.90	14.3

XXX This is the percentage of this type weapon in the force

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13. ABSTRACT

Methods are proposed for measuring the combat effectiveness of the main armament of tank and antitank weapons using firepower potential scores. A comparison of these scores can be used as a simplified screening process to decrease the number of candidate options that must be evaluated by simulation or detailed analysis.

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