Chapter 8.4

THE VALUE OF MINE WARFARE

1.0 Deployment Modes

The military value of mine warfare has been difficult, if not impossible, to justify because of the inability to establish a measure of worth. Why is that so? Because mine destructive effects are delayed in time, and sometimes contingent on appropriate response of the intended target, their utility is down-graded by analyses which place stress only on attrition of enemy assets. Unless the combat value of Delay and Disruption of enemy plans can be established, which proves to be greater in at least some situations than the value of attrition, mines in whatever method of distribution are not recognizable as an important weapon capability. Yet mines and booby-traps have been included in the armament of most military forces for many years. Surely this represents a deficiency in modern-day analysis, rather than persistently wrong-headed military thinking.

Warheads can be broadly divided into unitary or cluster types, either of which can be delayed in action, i.e. *Mines*. There are three basic advantages of cluster munitions. For any given weight of munition we can package only a certain amount of explosive power, which provides a certain fund of lethality (L) to be distributed over an area surrounding the point of detonation (or the center of the distribution pattern of a cluster).

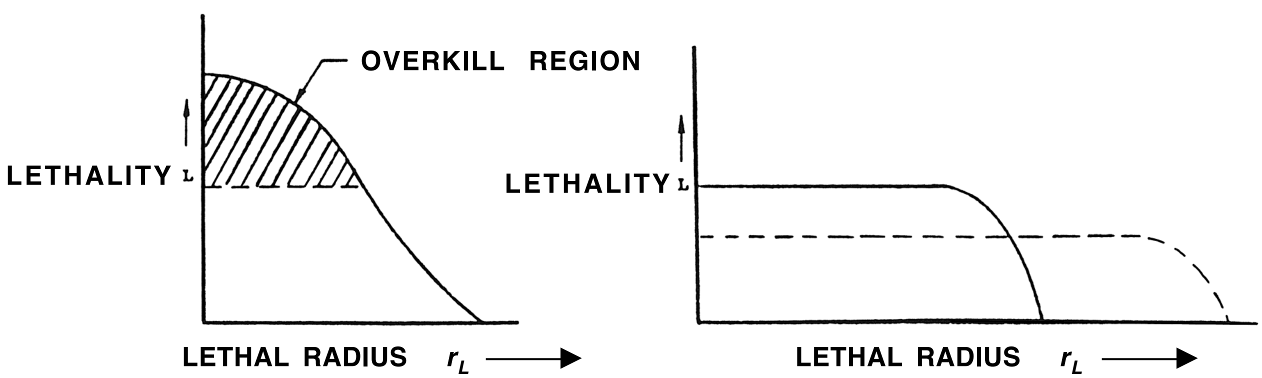

Figure 8.4-1 - Distribution of Warhead Lethality, (L).

Figure 8.4-1 represents the probability of kill of some target element situated within a distance r_L from this central point given weapon detonation. Lethality is a probability density function dependent on detonation at a specified point; the probability of detonating at that point is determined by accuracy, reliability, etc.

For a unitary munition, L varies inversely with some value between $r_{L,2}$ and $r_{L,3}$. Relatively high accuracy is required, but for many targets a near-direct hit results in over-kill, obliteration of the target. While this is not undesirable, it does represent some waste of explosive power.

A cluster munition, because of packaging problems, has a smaller fund of L than an equal-weight unitary munition. However, this can be distributed reasonably uniformly to provide a greater lethal radius r_L shown by the solid line in Figure 8.4-1(b). Thus the cluster munition has greater capability against mobile and/or dispersed targets. It also can be used against fixed targets without imposing as great a requirement for accuracy. Of course, to evaluate the relative utility, the analysis must bring out the relative importance (value) of mobile and fixed targets.

The second advantage of cluster munitions is illustrated by the dotted line of Figure 8.4-1(b); by varying the packaging and distribution pattern, one can trade off Lethality for r_L (Lethal Radius). Assuming some fairly uniform density of target elements, the same kill is achieved, but over a wide area. When analyzed from a *percent destroyed* point of view, this capability appears at best immaterial. However, against complex functioning organizations, widespread damage may be more productive of delay and disruption - the value of such effects must be reflected in the analysis.

Various levels of *Kill* should be recognized. *Kill* really means to prevent the functioning of the target or of some of its elements. As an example, suppose that in Figure 1b the solid line represents *K-kill* against trucks, the dotted line represents a more temporary mobility kill, *M-kill*. *K*-kill may be preferable for trucks far behind the FEBA, where they are easily replaceable and their utility is not highly time-dependent. On the other hand, for a key reinforcement or supply convoy, *M*-kill over a wider area may be sufficient to accomplish the purpose of denial to the front lines at a critical time of the convoy's contents.

A third advantage of Cluster Munitions is the possibility, albeit with some packaging and delivery difficulties, of combining multiple effects in one munition. To present the target with several different problems (anti-personnel and anti-materiel) enhances the delay effect and multiplies the repair/replacement problem. In addition, the cluster can include both immediate and delayed effects (mines or booby-traps), a very significant contribution to the delay imposed on the target.

The true value of cluster munitions (or, in fact unitary munitions) can be brought out only if the importance (value) of delay, disruption, and attacks on mobile and dispersed targets is given appropriate weight as compared to mere attrition of enemy assets. Combat must be regarded as a dynamic, time-dependent interplay of the adversary functions of Fire, Maneuver, and Intelligence controlled by the Command function.

2.0 Evaluation Process

The analysis of mine warfare requires: 1) Analytic tools, 2) Definitions, 3) Lethality, 4) Output value, and 5) Input effort. Since analysis is the objective, let us exclude technology. In the use of Analytic Tools, one needs: 1) Descriptive Model, 2) Problem Definition, 3) Input Data, and 4) Computational models. The Descriptive Model is being presented herein. Problem Definition includes scenarios, and special questions (for later discussion). Input Data can be handled parametrically in the early stages of analysis without wasting time on technological detail. Computational models (e.g., CAPMOD) are available except for terrain detail in an Engagement model.

A mine is an explosive device, detonated after emplacement and fused by 1) Command, 2) Influence, or 3) Time. It can be deployed on land or at sea. It can be a planted or sown (by air delivery or artillery), fixed in place or drifting (at sea), and defended or undefended. Our illustrative example is Land, Influence Fused, Sown, and Defended. Others choices can be handled..

Kill probability assessment is straightforward, but detailed and laborious. First we must Define Kill, then we must calculate lethality (given detonation). Kill can be destructive K-kill or mobility M-kill as described above. Lethality (L) can be calculated by a probability of kill (P_K) given detonation (D).

$$L = P_{K|D}$$

The mine can be command or time fused and P_K is computed as

$$P_K = \int \Pr(v_D) \cdot L(v_D)\, dv$$

where (v_D) is the state given detonation. If the mine is Influence fused, then P_K is calculated as

$$P_K(\Delta t) = P_D(\Delta t) \cdot L(\bar{v})$$

where P_D is the probability of detonation. The target action triggers detonation of influence mines as indicated in Figure 8.4-2.

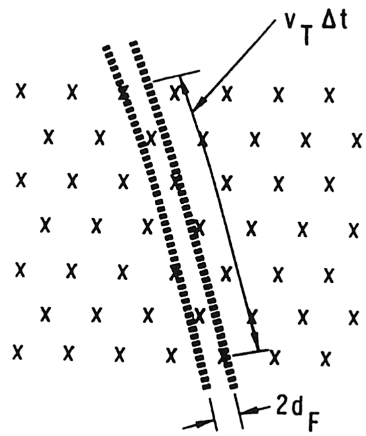

Figure 8.4-2 - Target Action Triggers Detonation of Influence Mines.

where $P_D(\Delta t) = 1 - \exp(-2\rho \, \mathrm{d}_F \mathrm{v}_T \Delta t)$

and ρ = Density of Mines

v_T = Speed of Target

d_F = Fuzing Distance

The output value of mines lies in damage, delay and disruption of enemy plans. Quantification will be explained later. The drawing in Figure 8.4-3 represents a leading tank element entering a terrain

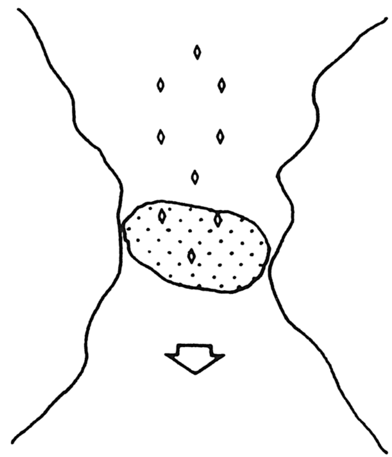

Figure 8.4-3 - Mine Payoff is Damage and Delay.

bottle-neck. Aerial mines sown on top. Some tanks are damaged before they can stop. The whole tank column incurs delay - affecting higher echelon plans and objective function value. In addition, if follow-on strikes are available, tanks are in an emergency situation requiring hurried planning and reaction.

The input effort of mining includes: 1) Procurement, 2) Transportation, 3) Supply, and 4) Emplacement. The theory of military element value and quantification is treated in Chapter 5 where the Objective Function expectation is the key to value theory. Command continuously plans and triggers functional performance as shown in Figure 3-9 in Chapter 3. Value theory is closely correlated with the picture of the Command Function, because the Commander's Estimation is an Analysis. However, the analyst can be cognizant of the *real* (not an estimation) value, since he can see both sides. The quality of the Commander's evaluation depends upon the state of his input information, his skill in estimation, and generalship. The reader is referred back to Section 3 of Chapter 5 for a refresher on military value theory and quantification.

Returning to the subject of Mine warfare in Figure 8.4-3, the quantified value of the tank column entering a mine field is measured in terms of damage, delay and disruption of enemy plans. Damage to the Red tank column is calculated by $\sum_j P_{R_j} V_{R_j}$. Delay is quantified by $Q(\Delta t_d)$, where (Δt_d) is the resulting time delay. To calculate the value of disruption to enemy plans refer to the matrix of Blue versus Red possible Courses of Action (C/A) shown in Figure 8.4-4. This shows 5 possible Courses of Action (C/A) for Blue and three for Red. The only difference between Red's C/A II and II* is the introduction of Blue's minefield. Blue's realized value (or payoff) from introducing the minefield is $(A* - A)$ if Red persists on moving through the mined area. This incremental value is the sum of damage plus delay to Red.[1] However, should Red find out in advance about the mine field, he could shift to C/A III, under which circumstance Blue's value is B and his realized payoff is $(B - A)$ due to disruption to Red's plan. On intelligence information that Red has changed to C/A III, Blue could switch to his C/A 5 and his realized value is then $(B' - A)$, but the decision to do so is limited by $(A'* - A)$.

B \ R	I	II	II*	III
1				
2				
3		A	A*	B
4				
5		A'	A'*	B'

*WITH MINES

Figure 8.4-4 - Mine Payoff Includes Disruption of Enemy Plans.

As pointed out in Chapter 3, the battle is decided by functional performance of Combat and Support functions, linked by Command. Each function has various measures in that CAPABILITY in some defined, idealized situation is modified by the actual situation to a POTENTIAL, which is further modified by Command to be actual PERFORMANCE. As the analyst backs off from specific performance forecasts, he has to work in terms of some modified POTENTIAL. As time extends and space expands, the analyst has to move more and more toward a generalized CAPABILITY (times some Δt), perhaps modified by experience.

This brings us full circle to the fact (see Chapter 5, Section 3.6) that the battle is decided by functional performance of combat and support functions and for generalization the analyst needs a *Combat* function - measured by Objective Function expectations.

[1] The analyst must include consideration of the emergency situation of the tank column caught in the mine field, where hasty Red planning and decision based on inadequate information will probably enhance Blue's realized value.

In summary, the military worth of mines, or any other fire means for that matter, depends upon three factors: a) Output Value, b) Input Effort, and c) Lethality. The major points made herein are:

1. Initial Mine Warfare study should be broad and parametric - with detail added later.

2. Damage alone will not justify the input effort of Mining

3. Theory of value includes Damage, Delay, and Disruption of enemy plans.

4. Generalization can lessen the degree of scenario dependence

and, finally,

5. That the study of Mine Warfare is amenable to the Anatomy of Combat methodology because it allows quantification of delay and disruption of enemy plans.

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