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EFFECT OF MOVING TARGET ON TERMINALLY-GUIDED WEAPON

- AN ILLUSTRATIVE EXAMPLE -

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One class of terminal guidance systems is that which homes passively by correlating target scene information supplied by a radar sensor or television sensor with a stored picture which was taken earlier on a reconnaissance mission. Since the guidance system is capable of achieving very high accuracy with respect to the target scene, the target element within the scene is usually a small hard target which by nature requires almost a direct hit for a kill. The target element must then be located relative to the target scene and this information supplied to the guidance system. Obviously, if the target element can move within the scene, an error is introduced in the system accuracy.

Consider the following illustrative example: Let an anti-tank weapon (warhead) have a lethal radius of 60 ft. and the carrier missile have a terminal seeker which is a correlator of some kind (i.e., it does not home on the target element directly, but rather on the target scene). Assume that the target element can be located within the scene to a five foot standard deviation in a circular normal p.d.f. If t_D is the time delay from last target acquisition system to seeker update and warhead detonation, and if the target moves randomly with parameter 20 ft/sec/ from a Rayleigh distribution, the probability of single shot kill P_K is

$$P_K = 1 - \exp\left\{ \frac{-1800}{\left[\frac{\text{cep}^2}{1.1774^2} + 25 + 400\, t_D^2 \right]} \right\}$$

Where CEP is the circular probable error of the seeker about the designated target location within the scene.

Figure 1 shows P_K vs. CEP for several values of t_D. Note that as t_D gets large, the P_K becomes somewhat insensitive to variations in CEP, implying that this type of optical correlator with high accuracy may be inefficient against a moving target.

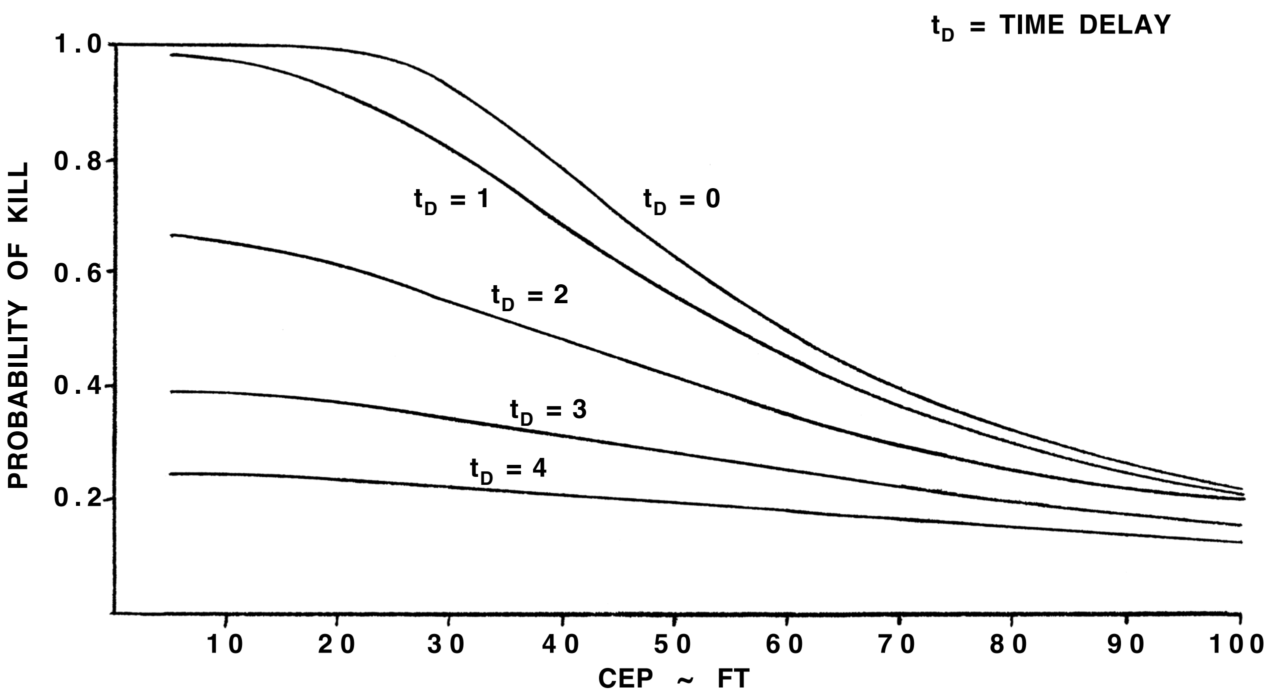


Figure 1 - Single Shot Probability of Kill vs CEP

The actual utility of the weapon system is measured by its contribution to the productivity of the total friendly force mix. This productivity is quantifiable and mathematically equal to the force combat potential divided by the input manpower effort expended. For this illustrative example, the following assumptions are made simply to provide ease in calculations:

1) Input effort is partly a function of CEP as shown in Figure 2. This implies that the more accurate guidance system (with CEP's less than say 20 feet) require more and more effort to provide the necessary data base and maintenance.

2) Total input effort is equal to the number of missiles required for a target kill times the corresponding guidance system input effort which is shown in Figure 2.

3) Combat potential is equal to the P_K as shown in Figure 1.

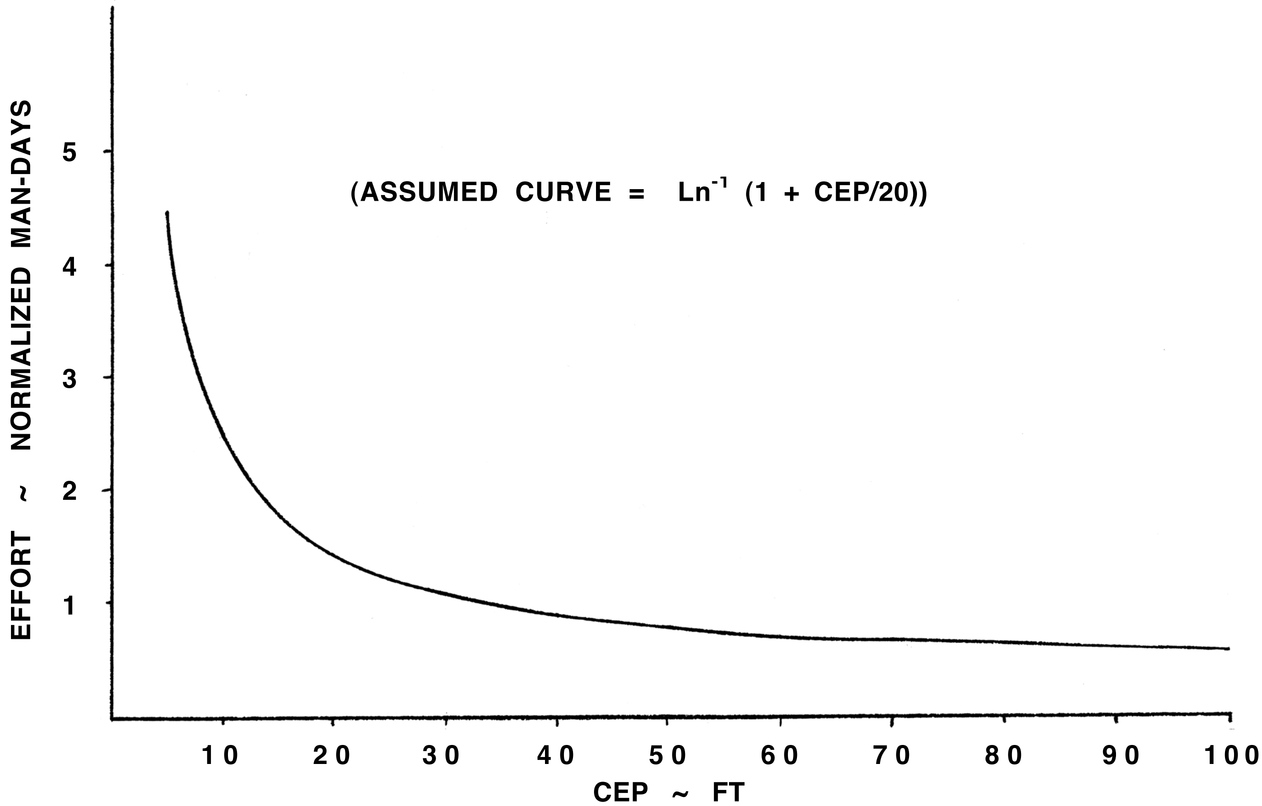


Figure 2 - Guidance System Input Effort vs CEP

Of course, these assumptions are far too restrictive for a complete analysis; however, they do provide the required amplification needed to show the gap which may result from improper treatment of moving targets.

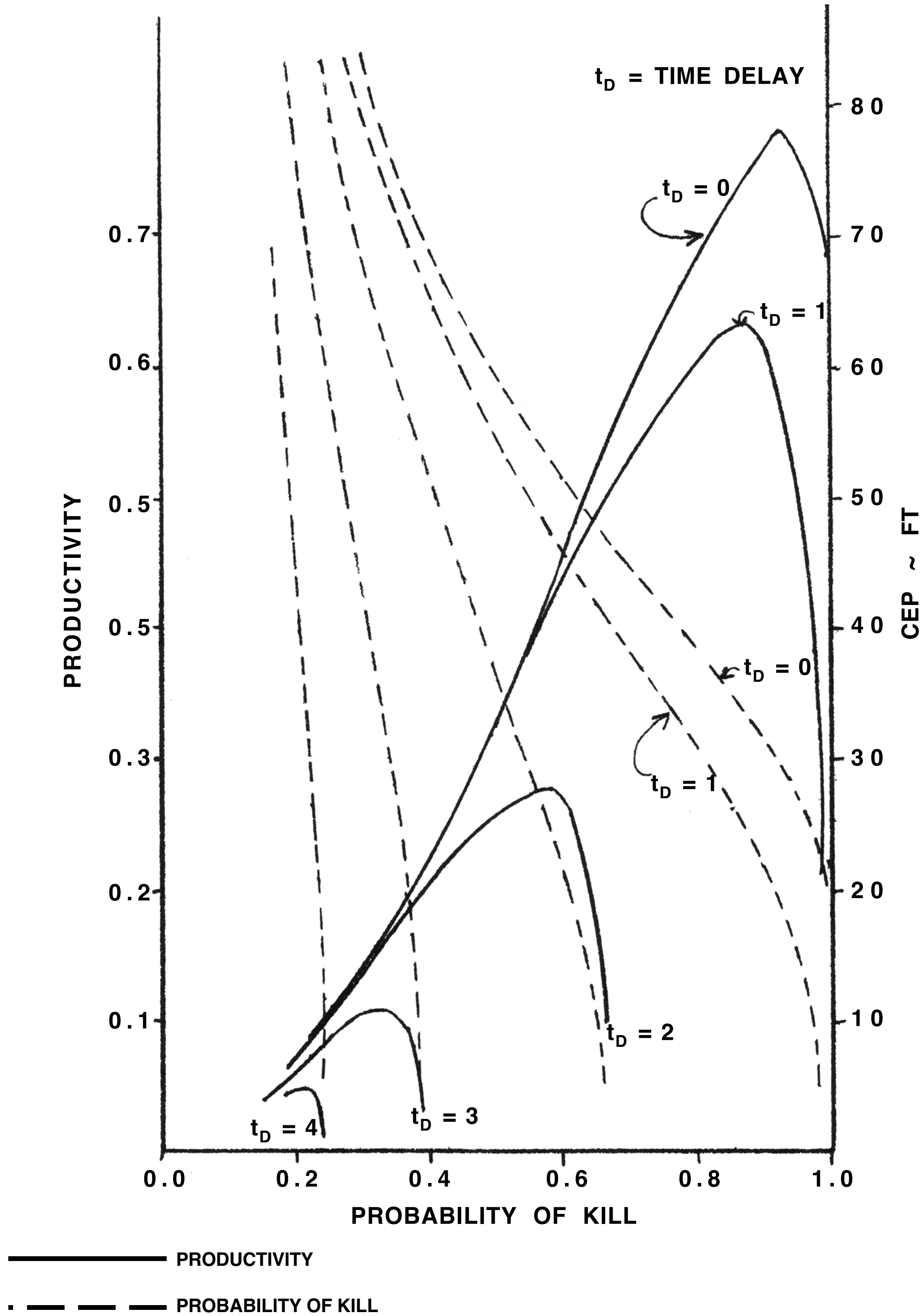
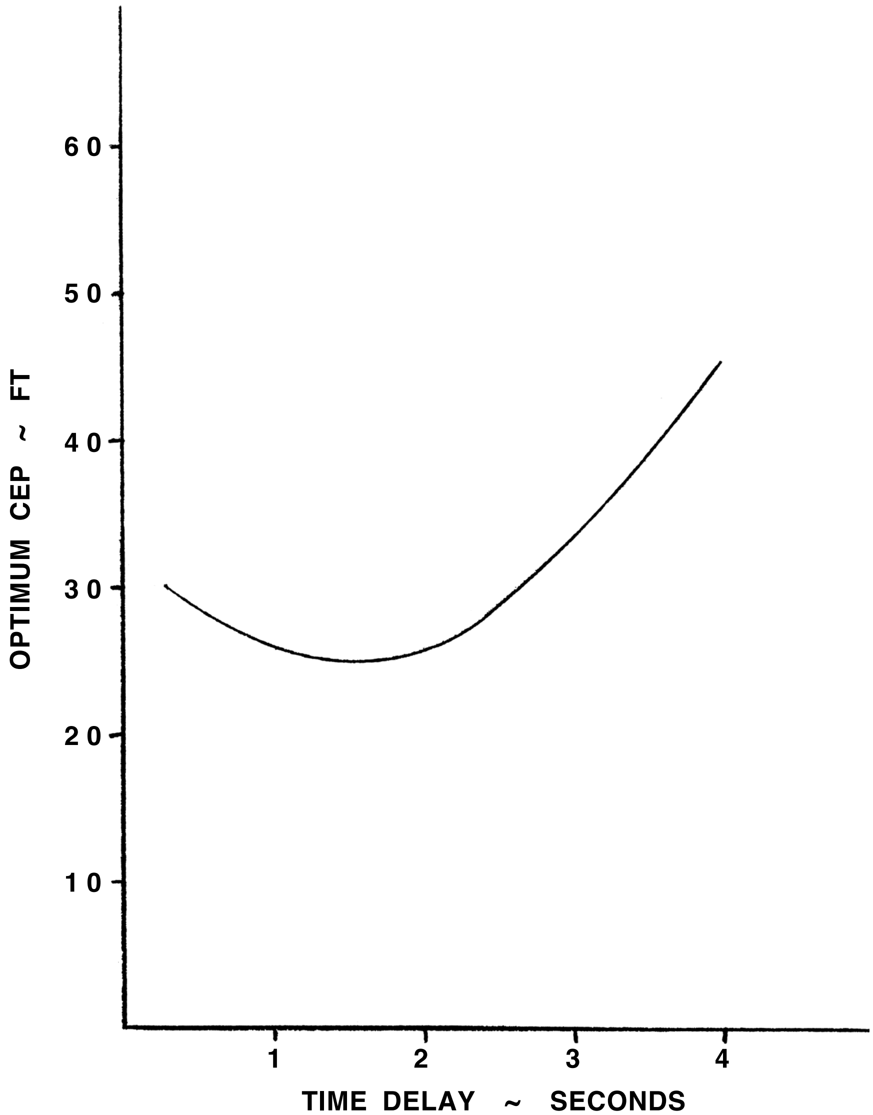


Figure 3 - Weapon System Productivity

Figure 3 show productivity vs. P_K and CEP vs. P_K for several values of t_D which, when combined, result in the curve shown in Figure 4 which is the optimum CEP (that which yields maximum productivity) vs. the time delay. Note that for large time delays a 10 or 20 ft. CEP is far from optimum. Also note from Figure 3 that the greatest danger is too small a CEP because, for a given time delay, this places one on the steepest portion of the productivity curve.



* DEFINED AS MAXIMUM PRODUCTIVITY

Figure 4 - Optimum CEP vs Time Delay*

Appendix C