UNCLASSIFIED 000762 C. 1

SC 1004-A (3-55)

[redacted]

[redacted]

~~THIS MEMORAND[redacted] NOT TO BE RE-PRODUCED WITHOUT THE EXPRESS WRITTEN PERMISSION OF SANDIA CORPORATION.~~

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

1st Review Date: 10-10-96	Determination (Circle Numbers):
Authority: [illegible]	1. Classification Retained
Name: W Layne	2. Classification Changed to: U
2nd Review Date: 10/30/96	3. Contains No DOE Classified Information
Authority: ADD	4. Coordinate With:
Name: R.T. Duff	5. Contains UCAI: NO-UCAI
	6. Comments: UNLIMITED RELEASE

SCTM-124-57-51

SOME ASPECTS OF WEAPON KILL VERSUS CARRIER KILL

W. F. Roherty - 5121

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

Emelda Selph 11-25-96	R.T. Duff
W C Layne 11-20-96	97SN037
PERSON VERIFYING MARKING & DATE	DATED: 10/30/96

ABSTRACT

Some aspects of a local air-defense engagement in which the offense possesses a dead-man switch are explored.

Work performed under AEC Contract AT-(29-1)-789.

[redacted]

Case No. 417.02

May 16, 1957

UNCLASSIFIED

[redacted]

DISTRIBUTION:
S. C. Hight, 5100
W. W. Bledsoe, 5120
D. C. Kleinecke, 1811
M. J. Norris, 5121
W. F. Roherty, 5121
J. W. Weihe, 5122
C. R. Carlson, 1261-3
J. McMinn, 1832-3
R. K. Smeltzer, 7221-3
L. F. Parman, 7223 (6)

[redacted]

SOME ASPECTS OF WEAPON KILL VERSUS CARRIER KILL

THE PROBLEM

To gain some insight into the problem of aircraft-plus-bomb versus aircraft-only kill, an exploratory study of the following assumed situation was made.

An attack by a given number of bombers is made against a defended target, it being essential to the offense that the defenses are penetrated. Each attacking aircraft carries a weapon having a completely reliable dead-man switch which produces an off-target surface burst if the defense scores an aircraft-only kill. Every aircraft surviving the defenses drops its weapon upon the target (all weapons having the same yield), surface-burst fuzing being used

The defense is capable of firing a given number of "shots" during the attack at individual aircraft (no multiple kills are possible). All shots have the same guidance errors and yield, fuzing errors being negligible. Furthermore, the fuzing system is such that the per-shot aircraft kill probability, which is the sum of the per-shot aircraft-plus-bomb and aircraft-only kill probabilities, can be made to take on any prescribed value (fixed throughout the engagement) between the aircraft-plus-bomb kill probability (fixed by the yield and guidance errors) and unity (before inclusion of reliability degradations). In other words, by dudding all shots that do not come close enough to the aircraft, the defense can set the aircraft-only kill probability at any value it chooses between zero and one minus the aircraft-plus-bomb kill probability. The objective of the defense is to minimize the total expected population loss on and off target by an appropriate choice of the aircraft-only kill probability.

PROCEDURE

If the population losses resulting from a given engagement are divided into two categories, on-target and off-target, the following assumptions are made:

1. Off-target losses are directly proportional to the number of surface bursts which occur.

2. The target population is lost entirely if either one or more penetrations of the defenses occur or the number of off-target surface bursts exceeds a given number.

If it is assumed, in addition, that penetration to the target cannot occur until the defense has launched a prescribed number of shots, then the expected population loss in an engagement can be written* as

*The probability relations contained in this memorandum are primarily the work of G. P. Steck, 5125.

[redacted]

[redacted]

$$\overline{V} = B\left[A - \frac{P_B}{P}\sum_{K=0}^{N} \min(K, A)\binom{N}{K}p^K(1-p)^{N-K}\right] + 1 - \left[\sum_{m=A}^{N}\binom{N}{m}p^m(1-p)^{N-m}\right]\left[\sum_{K=0}^{C-1}\binom{A}{K}\frac{P_{AO}^K P_B^{A-K}}{p^A}\right], \quad (1)$$

where the notation used is

$\overline{V}$ = expected population loss normalized on target population,

B = ratio of off-target population loss per surface burst to target population,

A = number of attacking aircraft,

P_B = one-shot bomb-plus-aircraft kill probability,

P_{AO} = one-shot aircraft-only kill probability,

$P = P_B + P_{AO}$ = per-shot aircraft kill probability,

N = number of shots the defense can launch, and

C = number of off-target surface bursts required to destroy the target population.

Evaluation of $\overline{V}$ was made for all combinations of the following:

B: 0.05, 0.1, and 0.2;

A: 5, 10, and 15;

P_B: 0.14, 0.35, 0.56, and 0.70 (including a reliability of 0.7);

P_{AO}: as required to find a minimum $\overline{V}$ but always in the interval from zero to $(0.7 - P_B)$;

N: 20; and

C: 1, 2, and 5.

Plots of $\overline{V}$ versus P_{AO} are given in Figs. 1-9 for various values of A, B, C, and P_B. Although no optimization of P_{AO} is involved, $\overline{V}$ versus A and B at $P_B = 0.7$ is illustrated in Fig. 10 to complete the description of $\overline{V}$ versus P_B.

Maximizing the probability of no penetrations might be considered as an alternative objective to minimizing the expected population loss (the two objectives could be identical in the absence of a dead-man switch). Figure 11 is therefore included to illustrate the probability of no penetrations versus the per-shot aircraft kill probability.

[redacted]

EXTENSIONS

If it were desired to include in $\overline{V}$ the physical (nonpersonnel) losses on target, then the term

$$D\left[1 - \sum_{m=A}^{N} \binom{N}{m} P^m (1 - P)^{N-m}\right]$$

would be added to the right side of Equation 1. It is assumed here that one penetration is adequate to destroy the complete physical value, D, where D is this physical value normalized on the value of the target population. The effect of including this term in $\overline{V}$ would be both to increase $\overline{V}$ generally and to increase the optimum value of P_{AO}.

To permit the estimation of $\overline{V}$ in an attack by bombers and decoys (assuming that the defense cannot distinguish between the two), Equation 1 takes the form

$$B \sum_{h=0}^{A} hP_h + 1 - \left[\sum_{k=0}^{c-1} \binom{A}{k} \frac{P_{AO}^{k} P_B^{A-k}}{P^B}\right] \cdot \left[\sum_{m=A}^{F} \binom{F-A}{m-A} P_m \Big/ \binom{F}{m}\right],$$

where

$$P_h = \sum_{k=A-h}^{A} \binom{k}{A-h} P_B^{A-h} P_{AO}^{k-A+h} \cdot R_k / P^k,$$

$$R_k = \sum_{m=k}^{F} \binom{A}{k} \binom{F-A}{m-k} P_m \Big/ \binom{A}{k},$$

$$P_m = \binom{N}{m} P^m (1 - P)^{N-m} \qquad F > m$$

$$= \sum_{k=F}^{N} \binom{k-1}{F-1} P^F (1 - P)^{k-F}, \qquad N > F,\ m = F$$

and F - A is the initial number of decoys. It is expected that when the attacking force is large and is composed of several times as many decoys as bombers, $\overline{V}$ would be minimized by large values of P_{AO}.

CONCLUSIONS

For most of the situations assumed (as illustrated in Figs. 1-9), minimum casualties among the defended occur when the defense duds all, or nearly all, defensive missiles which cannot achieve a weapon kill.

The reverse situation exists if either the attacking force is large and the population well protected from fallout or the offense does not employ a dead-man switch (Fig. 11).

W. F. ROHERTY - 5121

Case No. 417.02
May 16, 1957

A = number of attacking aircraft

B = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

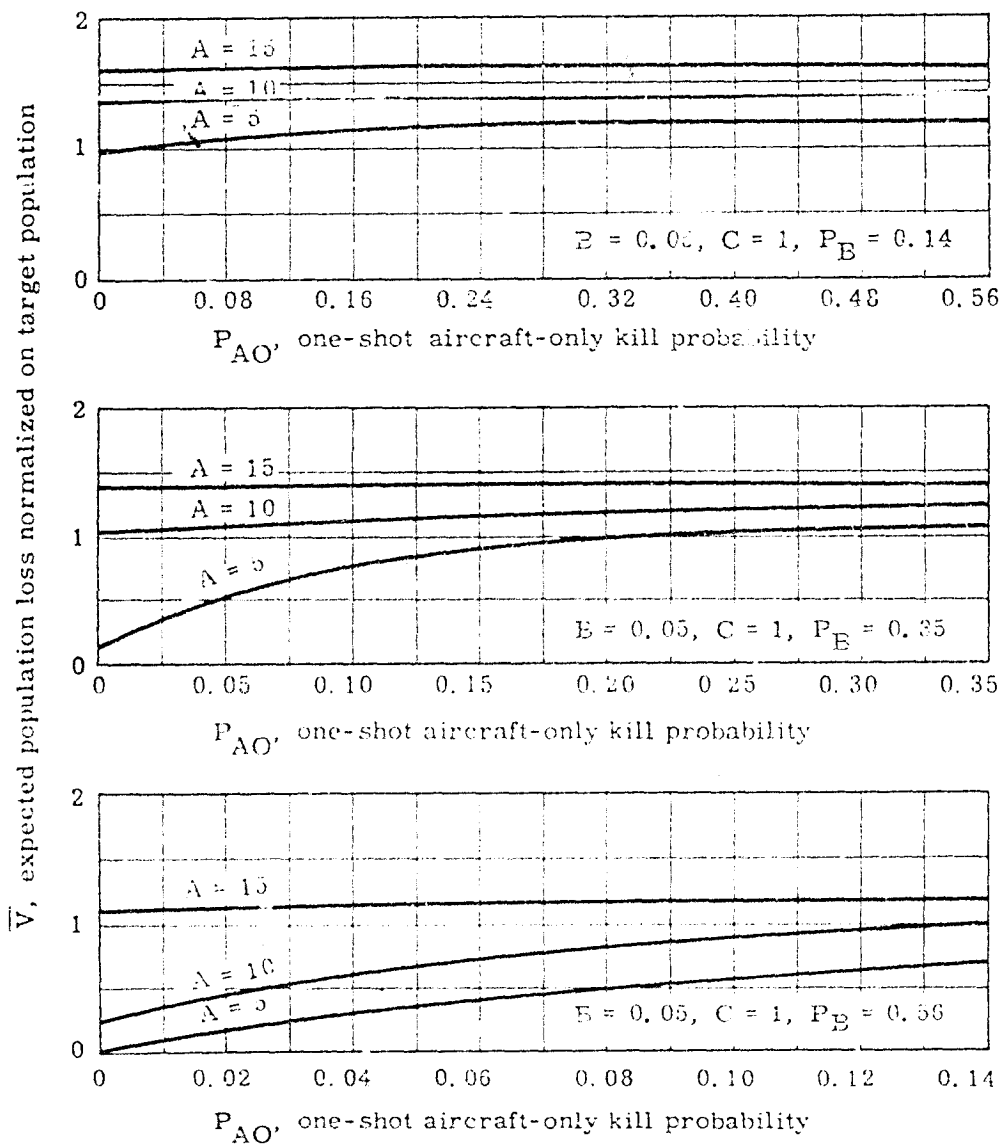

Fig. 1 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.05 and C = 1

[redacted]

A = number of attacking aircraft

B = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

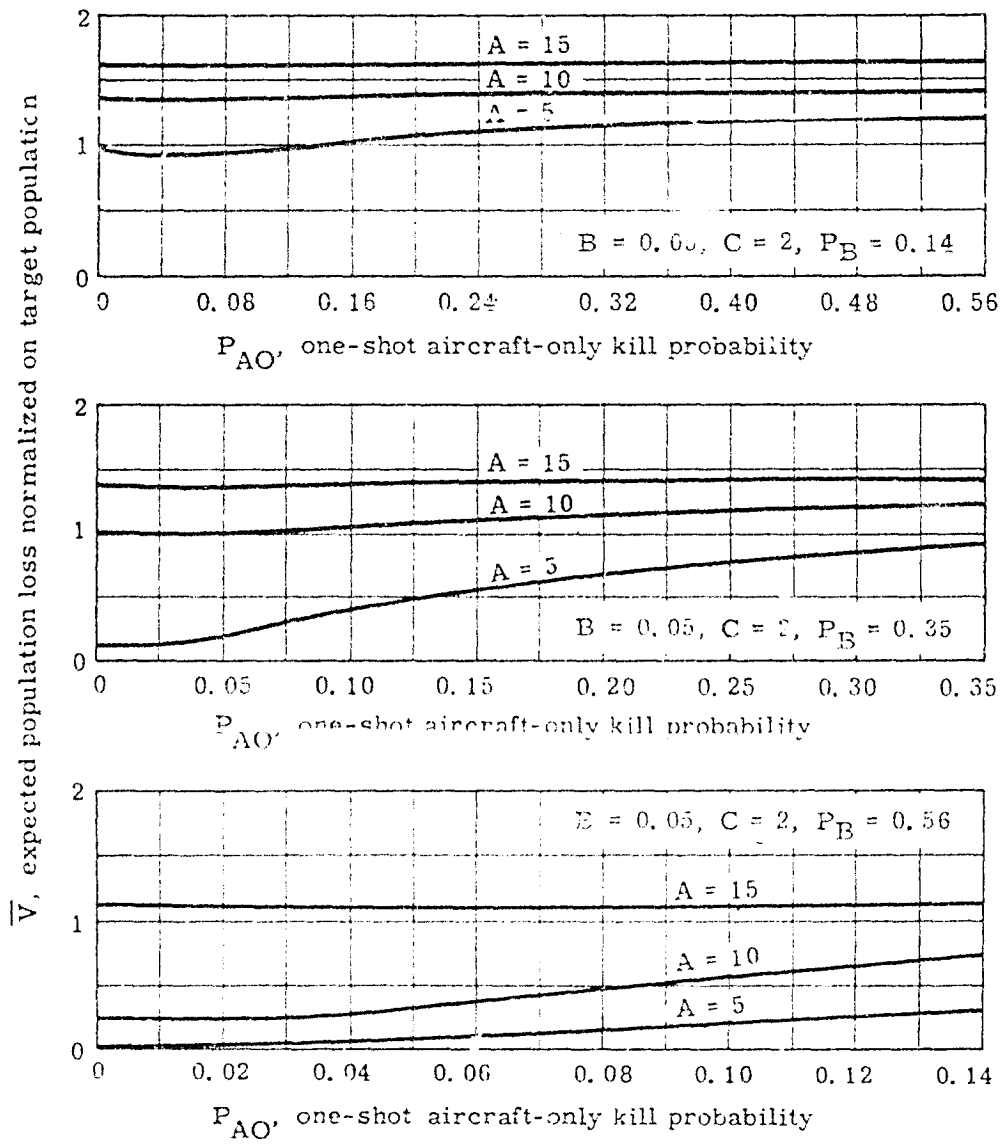

Fig. 2 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.05 and C = 2

[redacted]

A = number of attacking aircraft

E = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

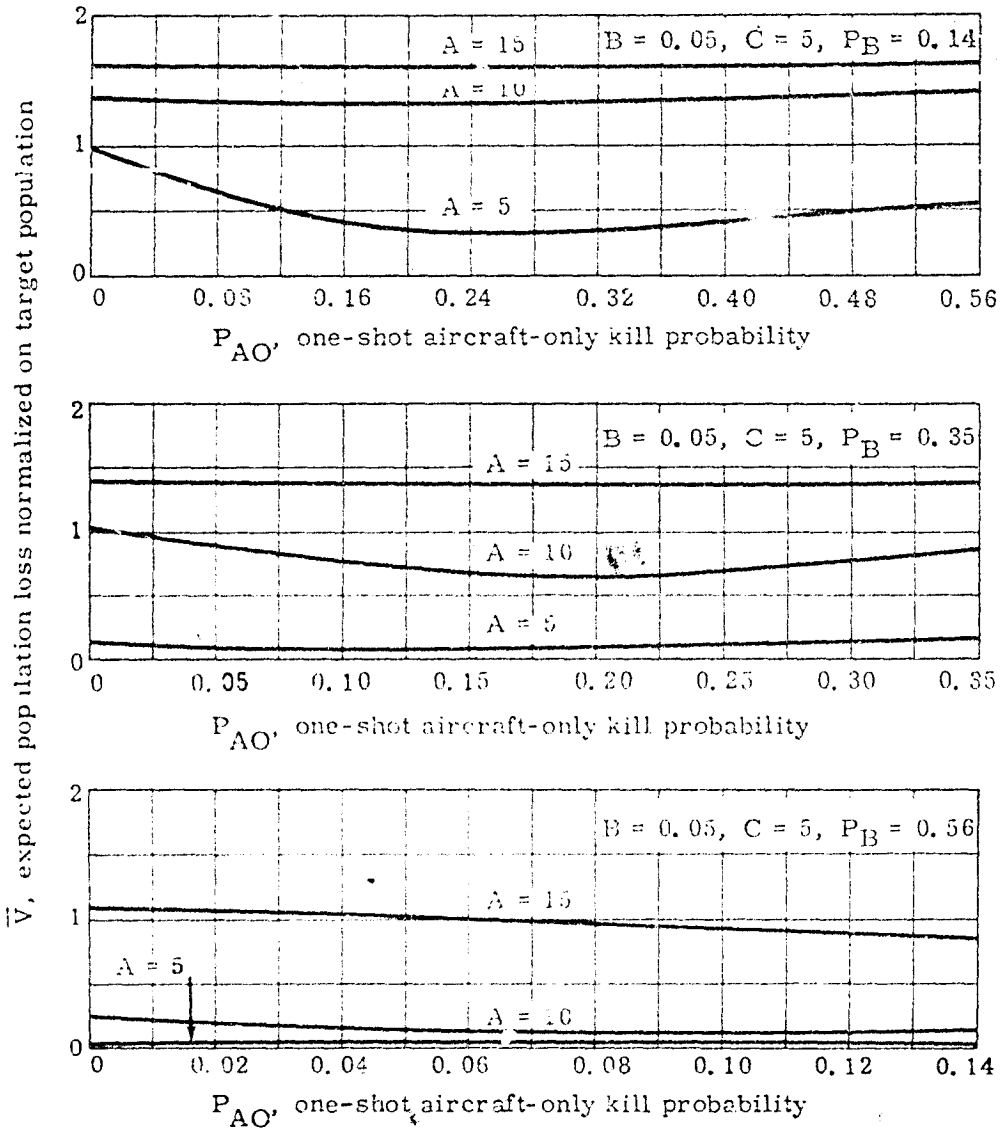

Fig. 3 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.05 and C = 5

A = number of attacking aircraft

B = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

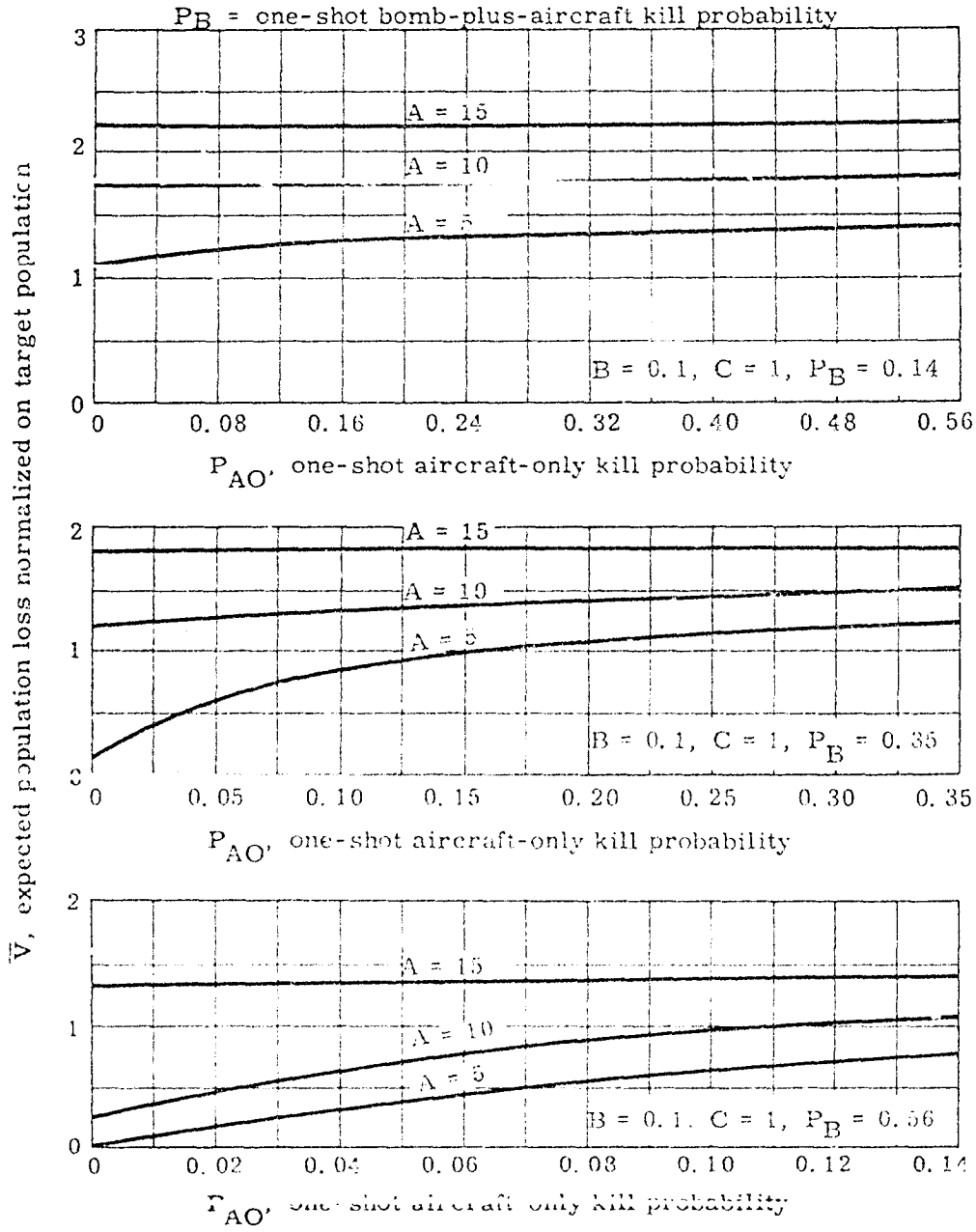

Fig. 4 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.1 and C = 1

[redacted]

A = number of attacking aircraft

B = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

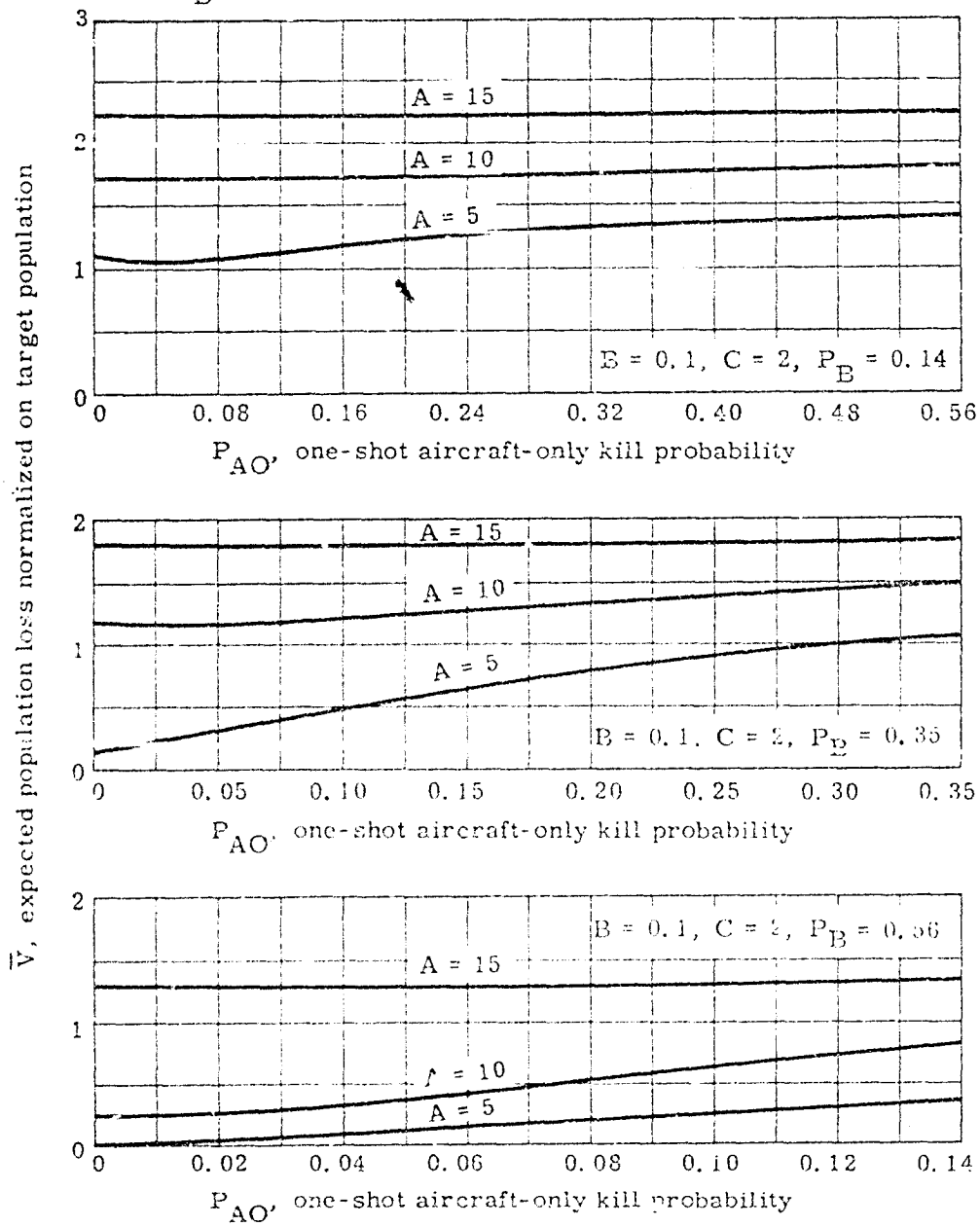

Fig. 5 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.1 and C = 2

[redacted]

[redacted]

A = number of attacking aircraft

B = ratio of off-target population loss per surface burst to target population

C = number of off-target surface bursts required to destroy target population

P_B = one-shot bomb-plus-aircraft kill probability

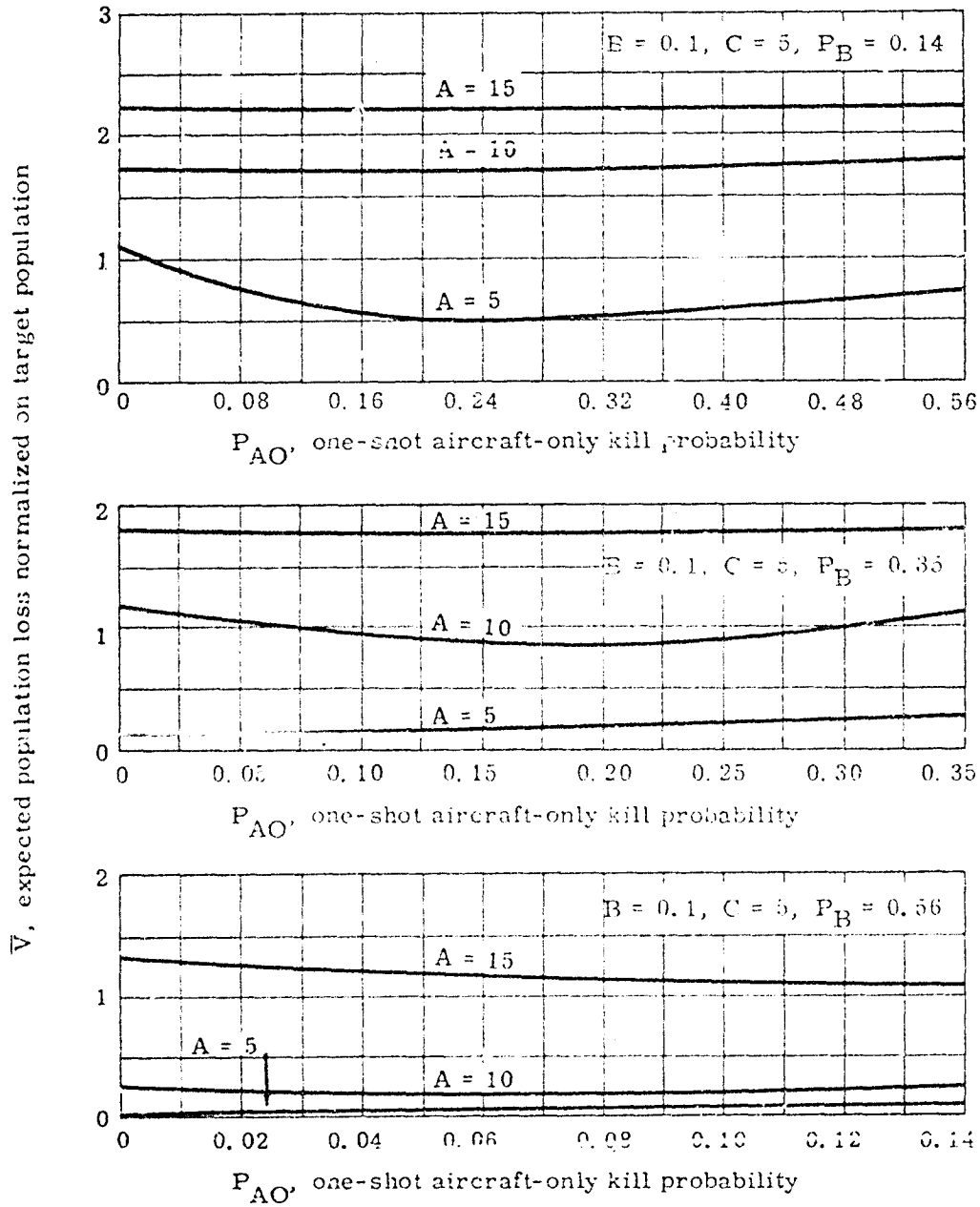

Fig. 6 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.1 and C = 5

[redacted]

A = number of attacking aircraft
B = ratio of off-target population loss per surface burst to target population
C = number of off-target surface bursts required to destroy target population
P_B = one-shot bomb-plus-aircraft kill probability

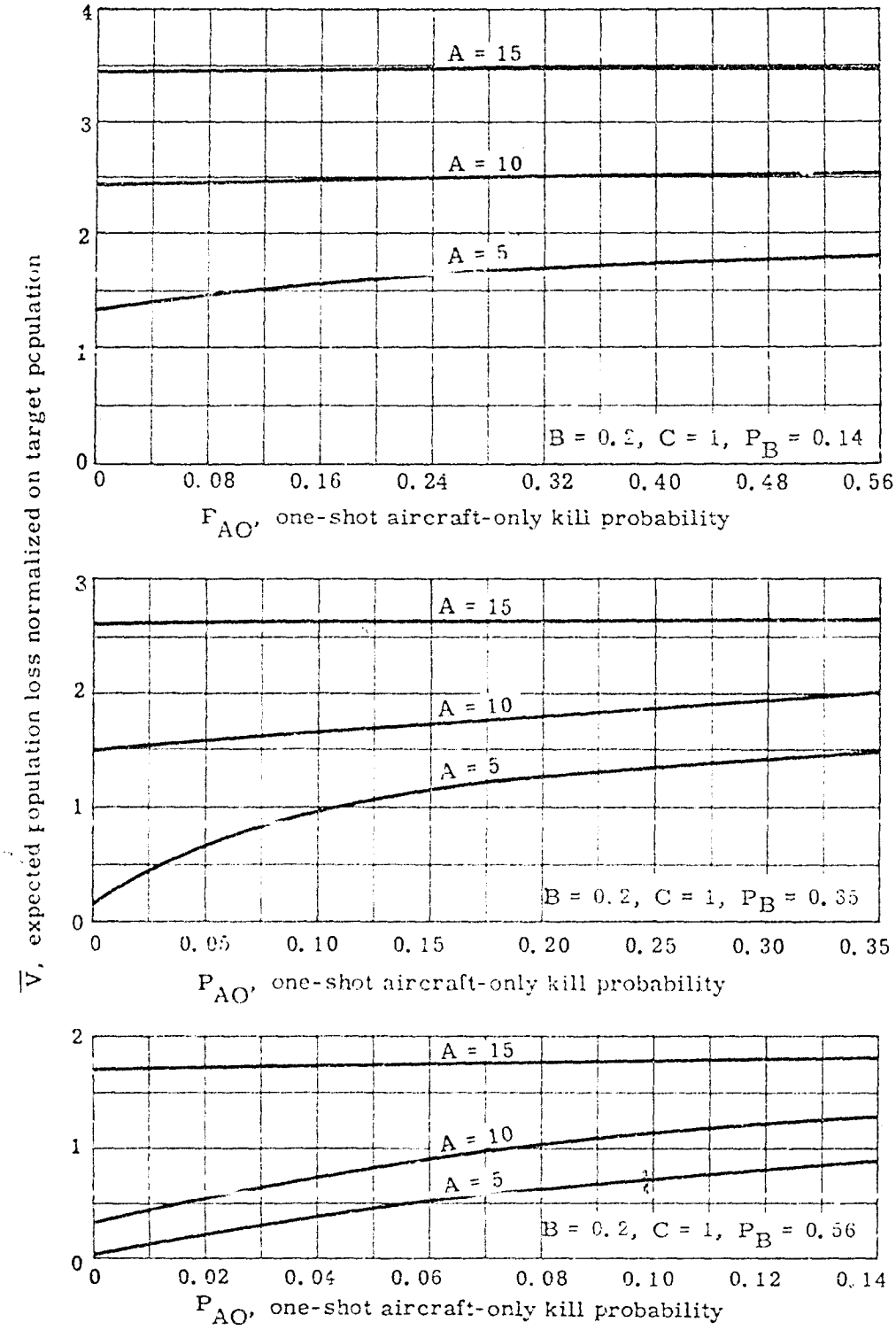

Fig. 7 -- Plots of $\bar{V}$ versus P_{AO} for B = 0.2 and C = 1

[redacted]

A = number of attacking aircraft
B = ratio of off-target population loss per surface burst to target population
C = number of off-target surface bursts required to destroy target population
P_B = one-shot bomb-plus-aircraft kill probability

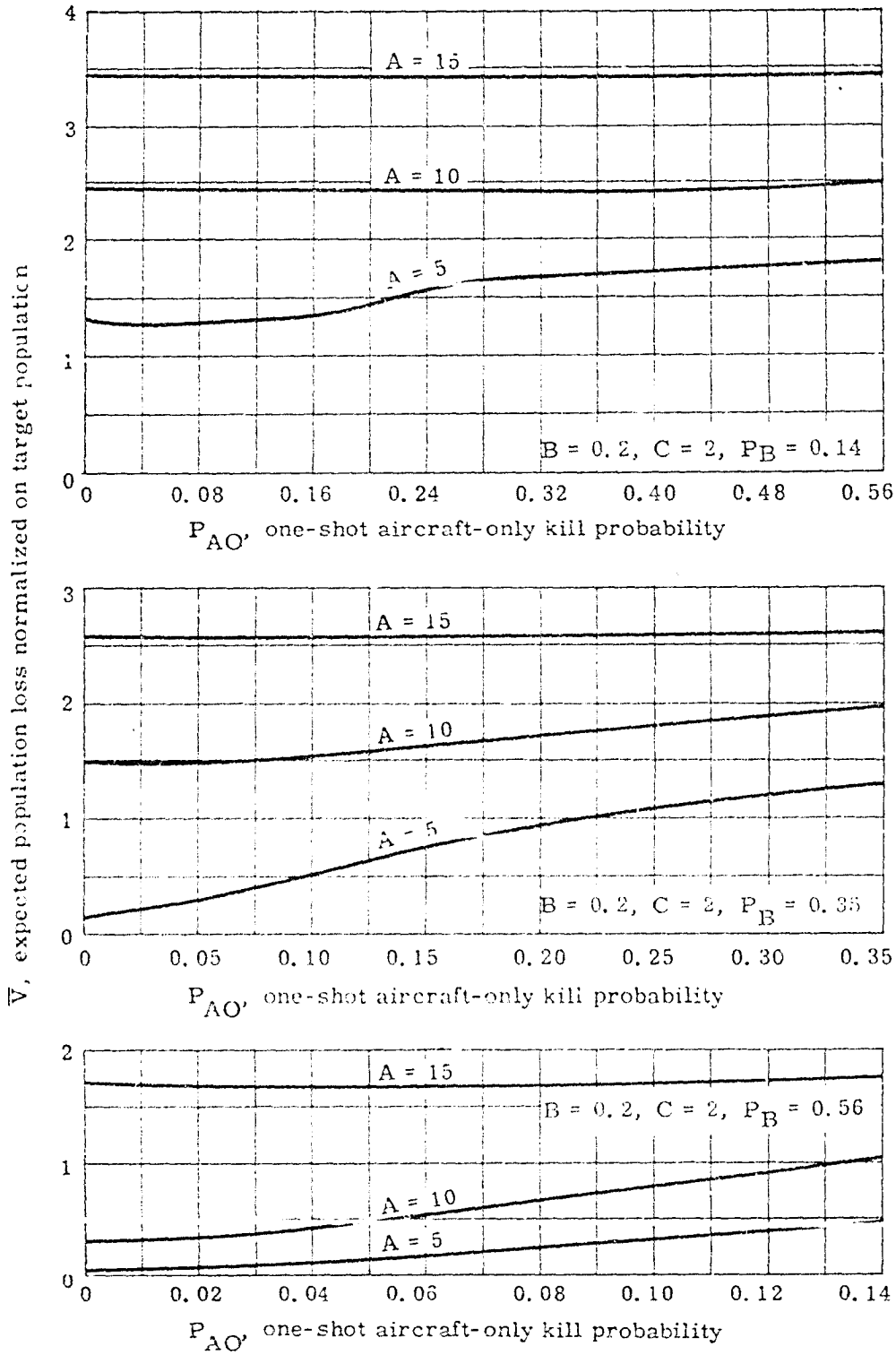

Fig. 8 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.2 and C = 2

[redacted]

A = number of attacking aircraft
B = ratio of off-target population loss per surface burst to target population
C = number of off-target surface bursts required to destroy target population
P_B = one-shot bomb-plus-aircraft kill probability

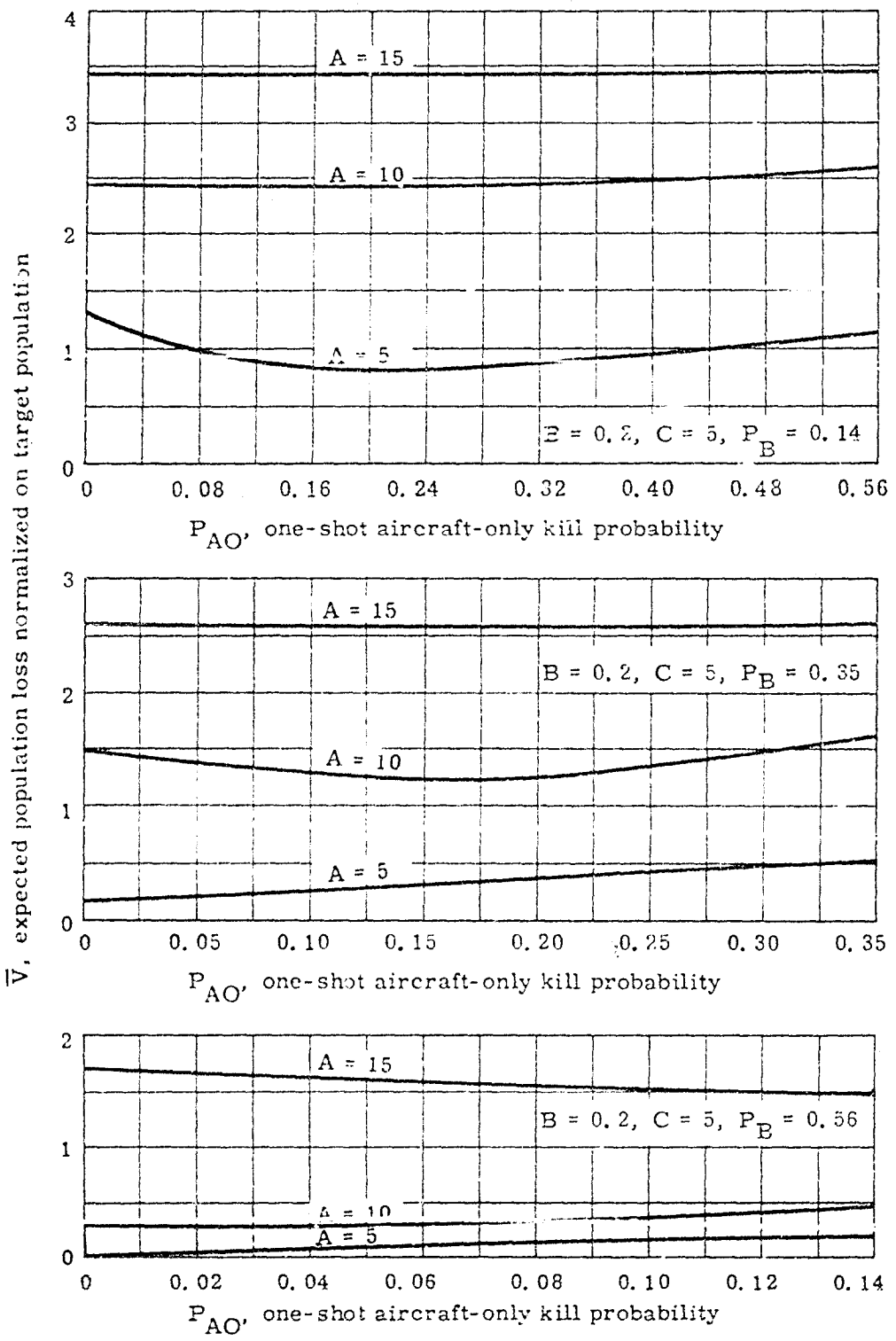

Fig. 9 -- Plots of $\overline{V}$ versus P_{AO} for B = 0.2 and C = 5

[redacted]

A = number of attacking aircraft

P_B = one-shot bomb-plus-aircraft kill probability

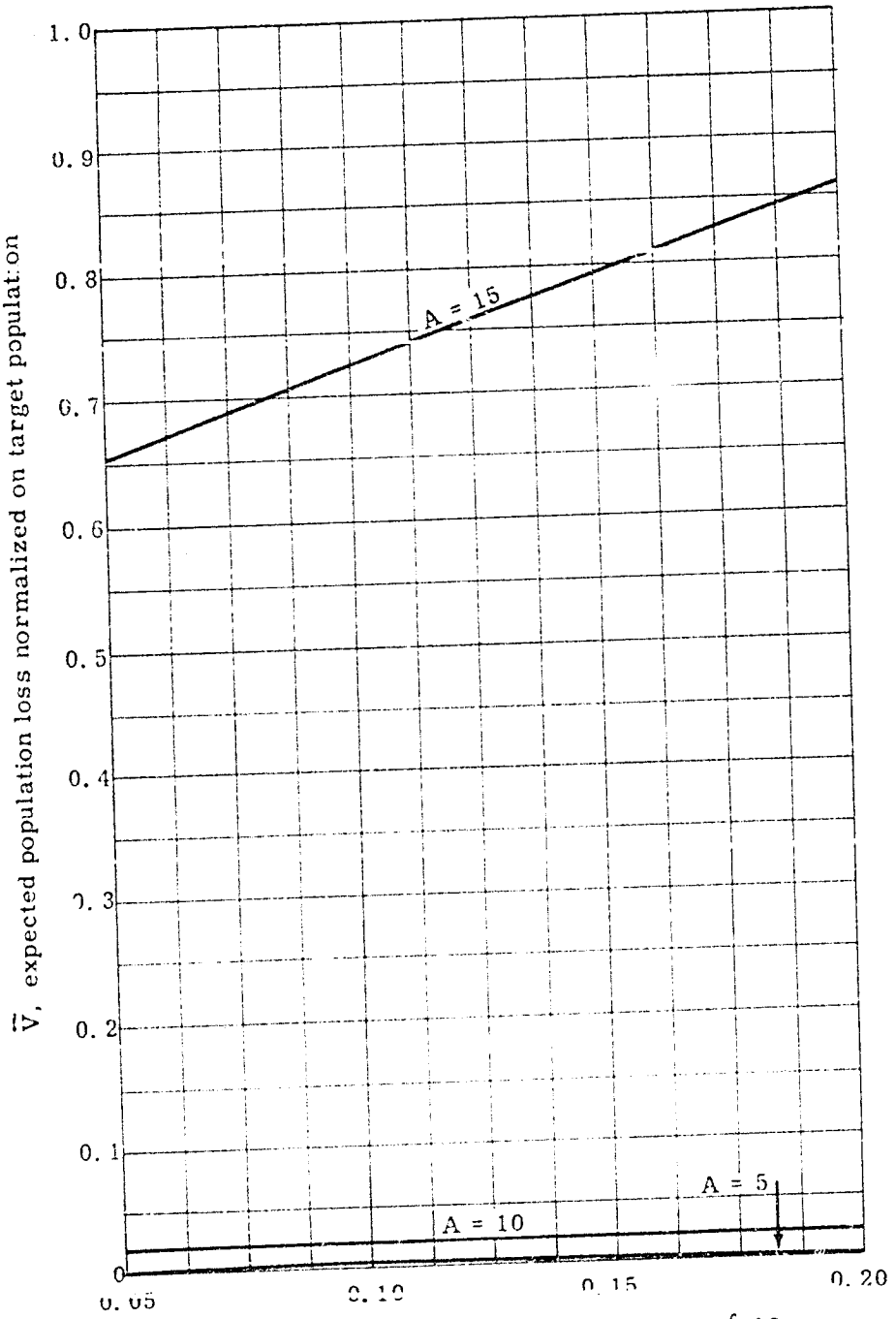

Fig. 10 -- Plots of $\bar{V}$ versus B at $P_B = 0.7$

[redacted]

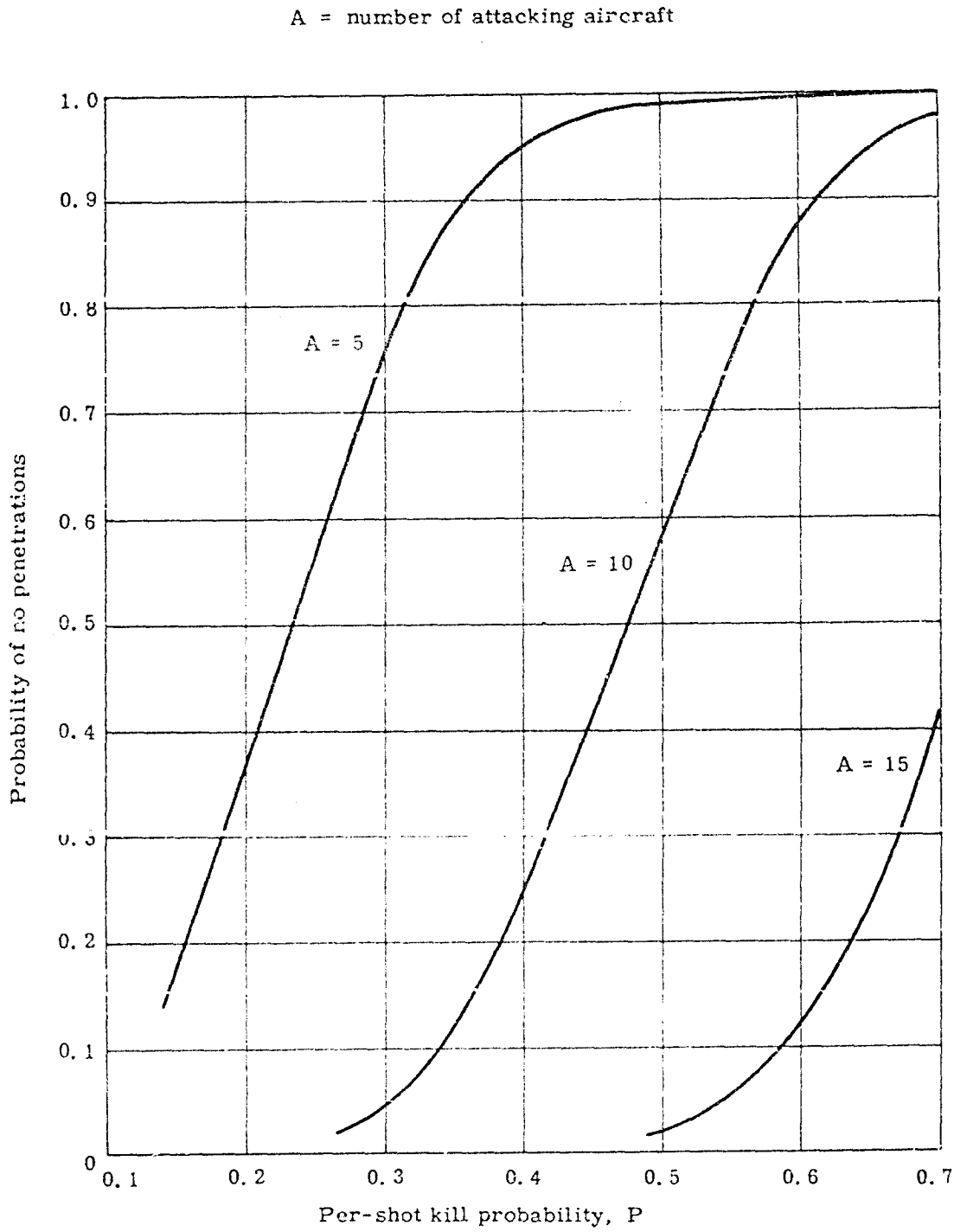

Fig. 11 -- Probability of no penetrations versus per-shot kill probability

[redacted]