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Stability of Large Offensive Force Reductions

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Stability of Large Offensive Force Reductions

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STABILITY OF LARGE OFFENSIVE FORCE REDUCTIONS

by

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ABSTRACT

Decreasing offensive forces with fixed defenses has much the same effect as increasing defenses with fixed offenses. Both increase stability. First and second strikes are increased but are largely shifted to non-alert aircraft. In the absence of defenses, offensive reductions could reduce stability.

I. INTRODUCTION

A companion report on "Crisis Stability Indices for Adaptive Two-Layer Defenses" discusses crisis stability indices for two-sided exchanges between symmetrical offensive and defensive forces.[1,2] In it the offensive forces are held at START levels, and defensive forces are varied. This report studies the effect of significantly reducing offensive forces while defenses are held fixed.

II. FORCES

Offensive forces begin at START levels of $M = 270$ land-based intercontinental ballistic missiles (ICBMs) with $m = 10$ re-entry vehicles (RVs) apiece; $N = 400$ submarine launched ballistic missiles (SLBMs) with an average of $n = 6$ RVs apiece on 20 submarines; and $B = 4,500$ airborne weapons on aircraft dispersed over 100 airbases. These offensive forces are then reduced proportionally (i.e., with $M \alpha N \alpha B$), to levels an order of magnitude below current values.

During the reduction, each side has fixed and equal defenses of $K = 2,000$ space-based, boost-phase interceptors and $I = 1,000$ preferential downstream interceptors. Sensitivity to variations in crisis stability during the reductions is discussed, using the analysis derived in "Crisis Stability."

III. RESULTS

This section discusses a set of figures, that is a subset of those in "Crisis Stability," that describe how stability changes as offensive forces are reduced. Since M, N, and B are proportional, only one need be shown; M is used as the abscissa below.

A. Baseline Indices

Figure 1 from "Crisis Stability" shows the variation of stability indices with defensive forces for START-level offenses. Deploying various levels of preferential downstream defenses by themselves would decrease stability by 10-15%, but boost-phase defenses alone would not decrease stability until they passed $K \approx 2,000$ space-based interceptors. Combinations could minimize the impact of defensive deployments.

Boost-phase defenses would not by themselves increase crisis stability. But first deploying boost-phase defenses and then switching to combinations--e.g., (I,K) = (2,000, 1,000), (1,000, 2,000), or (500, 2,500)--would place the defenses on trajectories on which it would be possible to increase stability through the addition of defenses in the mixes indicated.

Here, interest attaches to how those indices vary as M, N, and B are reduced strongly. To study that, it is adequate to study how indices vary for (I,K) = (0,0) and (1,000, 2,000). The former represents no defenses; the latter a typical defensive mix. The variations for other combinations of defenses are similar, as indicated below.

B. Missile Strike

Figure 2 shows the size of the missile first strike for (I,K) = (0,0), which is the top curve, and (1,000, 2,000), which is the bottom. The difference is mainly due to the moderately strong boost-phase defenses in the latter, which strongly attrits first-strike missiles in boost. At START levels the difference is about a factor of five; at offensive levels 10% as large, the ratio is much larger. With defenses the missile first strike is essentially eliminated by M = 100.

Figure 3 shows the resulting missile strikes on value. Here, the difference is even larger. With defenses the preferential interceptors attrit the already thinned missiles even more for small M.

C. First Strike

Figure 4 shows the total missile and aircraft first strike on value. The number on the top curve, with defenses, is larger than that for the lower curve, which is without. With defenses, fewer missiles penetrate. But for most offensive levels, most non-alert aircraft survive, which leads to a larger total first strike, most of which is carried by aircraft.

Figure 5 shows the fraction of the defender's ICBMs that survive the first strike and penetrate the attacker's boost-phase defenses. Without defenses that fraction is essentially zero. With defenses it is significant above $M \approx 60$, reaching a maximum of ≈ 0.3 at $M \approx 210$. However, below $M \approx 60$, defense of missiles is ineffective, and the missile restrike is small.

Figure 6 shows the number of ICBM and SLBM missile weapons in the restrike. The upper curve for no defenses is linear in M. The lower curve with defenses lies about 1,000 weapons lower, falling essentially to zero below M = 100. No restrike missile weapons penetrate the downstream defenses of value.

Figure 7 shows the number of second strike aircraft weapons. The lower curve for no defenses is linear. It is composed only of the alert aircraft; no non-alert aircraft survive the missile restrike. Below $M \approx 200$, the upper curve with defenses is essentially the full number of alert and non-alert aircraft, which is much larger than that for no defenses.

Figure 8 shows the total restrike on value. The lower curve for no defenses is the sum of missiles and alert aircraft. The upper curve for defenses includes almost all aircraft. The latter is much larger for both the initial START offenses and proportional reductions from them. Thus, with defenses the restrike on value is typically 1.5-2 times that without defenses.

D. Costs

The bottom curve of Fig. 9 is that for striking first without defenses. The clustered curves above it are those for striking second without defenses and for striking first or second with them. The latter three are essentially equal below $M = 250$. Defenses equalize the cost of striking first and second.

E. Stability Indices

Figure 10 shows the stability indices with defenses, on top, and without them, on bottom. With defenses, below $M = 200$ the index goes to unity. Without defenses the index remains at about 0.8 throughout. Figure 11 shows the complement of the stability index, which is roughly the probability of a strike, given a crisis. Figure 12 shows the product of this strike index and the resulting number of weapons delivered on value from Fig. 3. With defenses the expected loss drops to zero by $M \approx 240$; without defenses it remains over 100 weapons until $M \approx 80$.

IV. DEFENSIVE VARIATIONS

It was stated above that similar results hold for various defenses. Inspection of Fig. 1 shows that a transition from no defenses to defensive combinations of (I,K) = (2,000, 1,000), (1,000, 2,000), or (500, 2,500) could be done without loss of stability. The calculations above used the combination (I,K) = (1,000, 2,000), which is typical of current studies and is one of those combinations.

Figure 13 shows the stability indices as functions of M for all three combinations of defenses, each labelled by the value of I. The top two curves are for (I,K) = (2,000, 1,000) and (1,000, 2,000); the middle curve is for (500, 2,500), i.e., a weak preferential layer; and the bottom curve is for no defenses. There is some difference between the three defenses above M = 200, little below it. Figure 14 shows the expected loss for each. Again, there is little difference between the three defenses, each of whose losses lie far below those without defenses.

V. ALTERNATIVE DEFENSES

The attacks above kept about a third of their weapons on missiles, aircraft, and value, in accord with the rough optimization derived in "Crisis Stability."[3] As the number of weapons in the strikes falls, there is a tendency to shift targeting more toward value to keep up the total value held at risk. This is studied by assuming that the fractions x and y of missiles targeted on missiles and aircraft, respectively, decrease in proportion to M and N, and that the remaining $(1-x-y)(mM + nN)$ missile weapons are targeted on value.

There are differences in detail from the calculations above, but the overall effects are indicated in the crisis stability index of Fig. 15. It shows that the index with defenses still climbs to unity by about M = 200, but that the index without defenses falls to about 0.7. Figure 16 shows that the expected loss, given a crisis, is still small with defenses but remains large to smaller M without defenses. In the range of M = 50-100 the losses are about twice as large as those of Fig. 14, so this shift of targeting makes offensive force reductions more difficult without defenses.

Part of the problem is that as the number of weapons is decreased, there are progressively fewer weapons per target. Thus, as an adjunct to offensive reductions it might be useful to reduce, through arms control or other means, the number of targets for which strategic weapons were held accountable. That approach can be studied by reducing the number of targets in proportion to the number of offensive forces. Figure 17 shows the resulting indices. With defenses the index goes rapidly to unity; without defenses it remains at about 0.8 until M drops to about 50.

Figure 18's expected losses have a different shape than those above, but the curve with defenses again goes to zero and that for no defenses remains large to small values. The index without defenses is intermediate between that of Figs. 14 and 16. Without defenses, reducing the number of targets reduces the penalty for offensive reductions. But the reduction is much smaller than that produced by defenses.

VI. SUMMARY AND CONCLUSIONS

The effect of decreasing offensive forces with fixed defenses is much like that of increasing defenses with fixed offenses as studied in "Crisis Stability." Both increase stability. Even moderate boost-phase defenses strongly attrit first-strike missiles. Preferential attrition by downstream interceptors reduces missile strikes on value even more. But the missile and aircraft first strike on value is larger with defenses than without, because of the increased survivability of non-alert aircraft.

Without defenses the fraction of the defender's ICBMs that survive the first strike is essentially zero. With defenses the number that survive and penetrate boost-phase defenses is significant, but the number that penetrate the preferential defenses downstream rapidly falls to zero. Without defenses the second-strike aircraft are limited to alert aircraft. With defenses the number is essentially the full number of aircraft, which is much larger. Without defenses the total restrike is the sum of missiles and alert aircraft; with defenses it is all of the aircraft.

The cost for striking first without defenses differs, but other strike costs are clustered. With defenses the stability index rapidly goes to unity; without them the stability index remains lower throughout. With defenses, the expected number of missile weapons on value drops rapidly to zero; without defenses it remains high to low levels of offensive forces. This pattern holds for various combinations of defenses and attacks. Without defenses, offensive reductions could lead to large reductions in stability; with defenses, large reductions would increase stability.

REFERENCES

1. G. Canavan, "Crisis Stability Indices for Adaptive Two-Layer Defenses," F. Kane, Ed., Proceedings Crisis and Arms Control Stability Meeting (Operations Research Society of America/TIMS: Anaheim, California, 5 November 1991) [Los Alamos National Laboratory report LA-11974-MS, March 1991].

2. G. Canavan, "Errata to Crisis Stability Indices for Adaptive Two-Layer Defenses," Los Alamos National Laboratory document LA-UR-draft, January 1992.

3. G. Canavan, "Crisis Stability Indices for Adaptive Two-Layer Defenses," op. cit., pp. 13-16 and Figs. 15-19.

Fig. 1 Crisis stability index

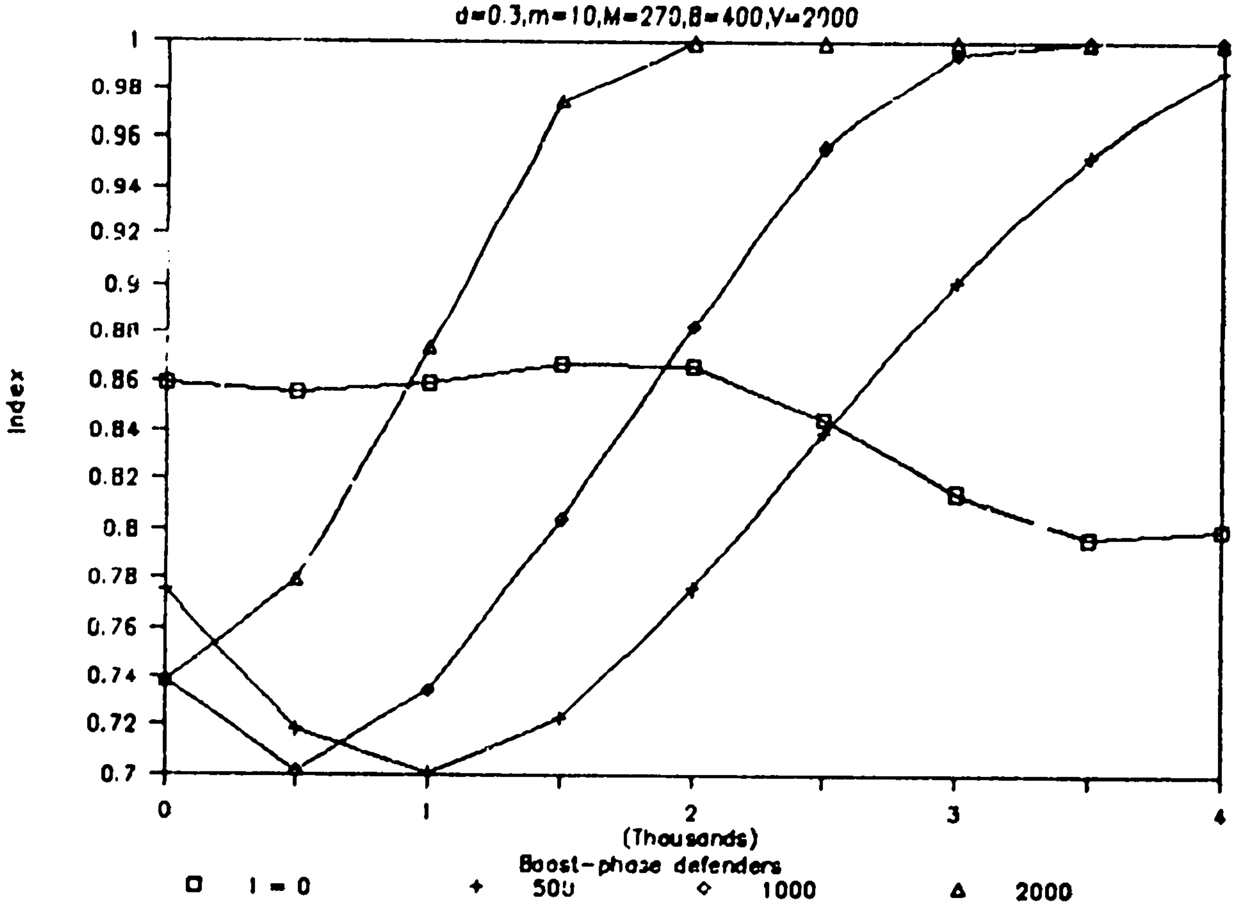


Fig. 2 Missile first strike

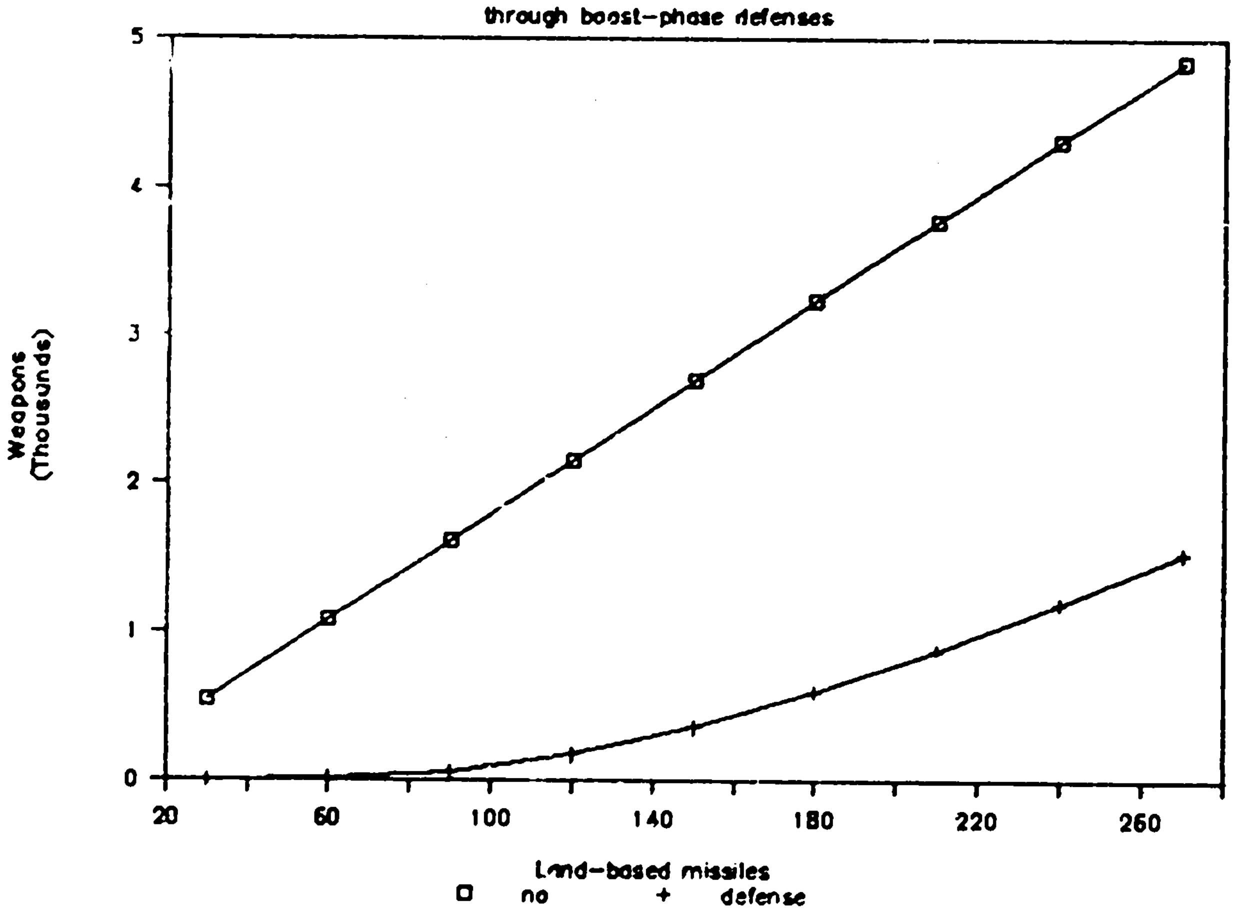


Fig. 3 Missile first strike on value

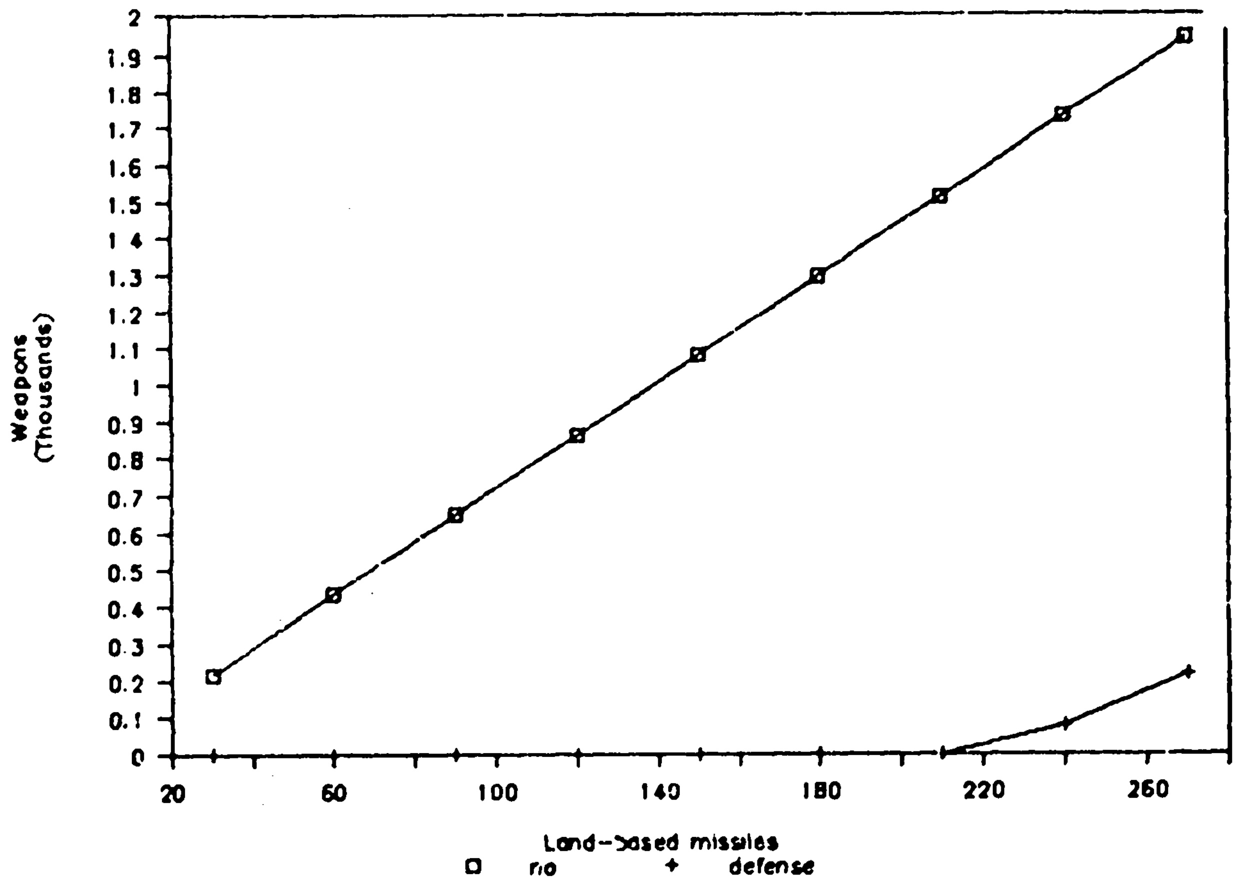


Fig. 4 First strike on value

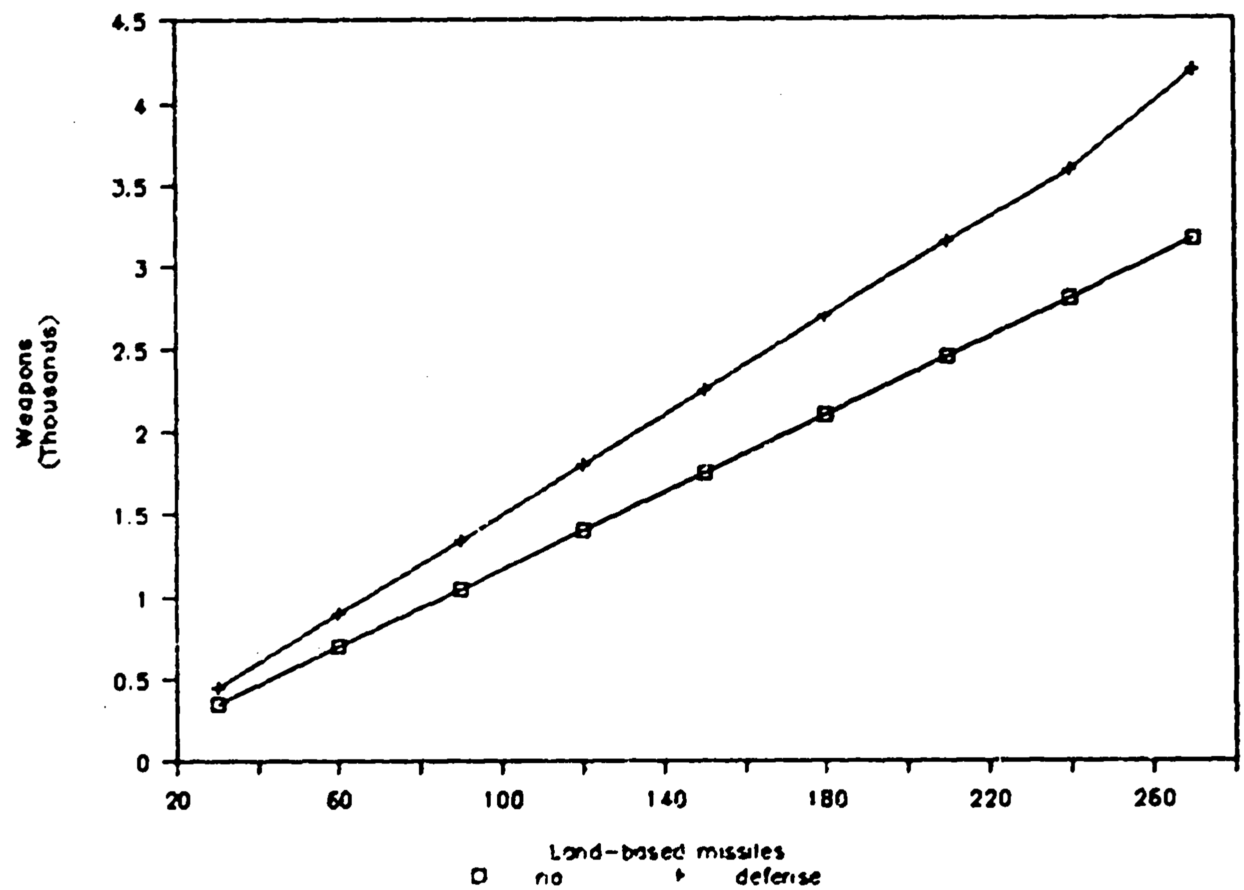


Fig. 5 Surviving, penetrating missiles

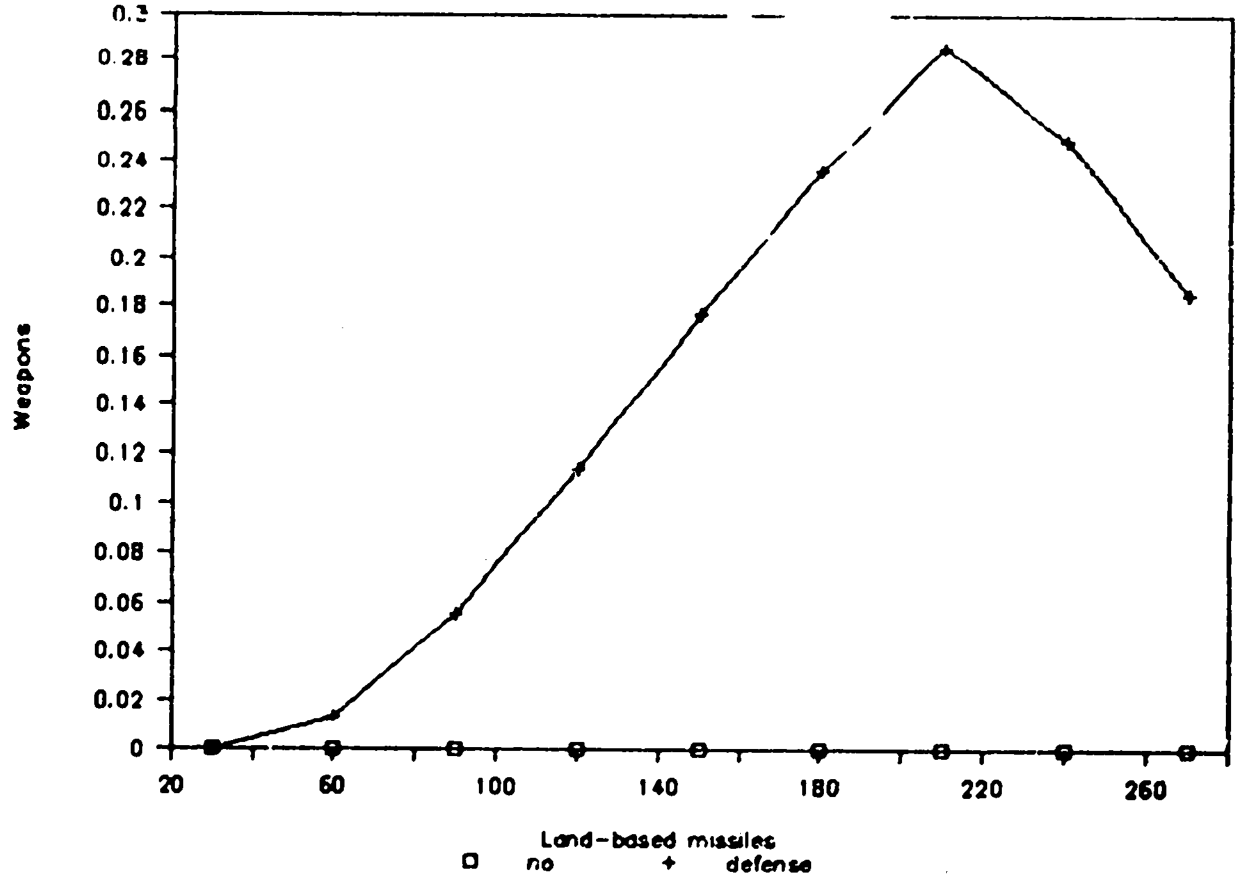
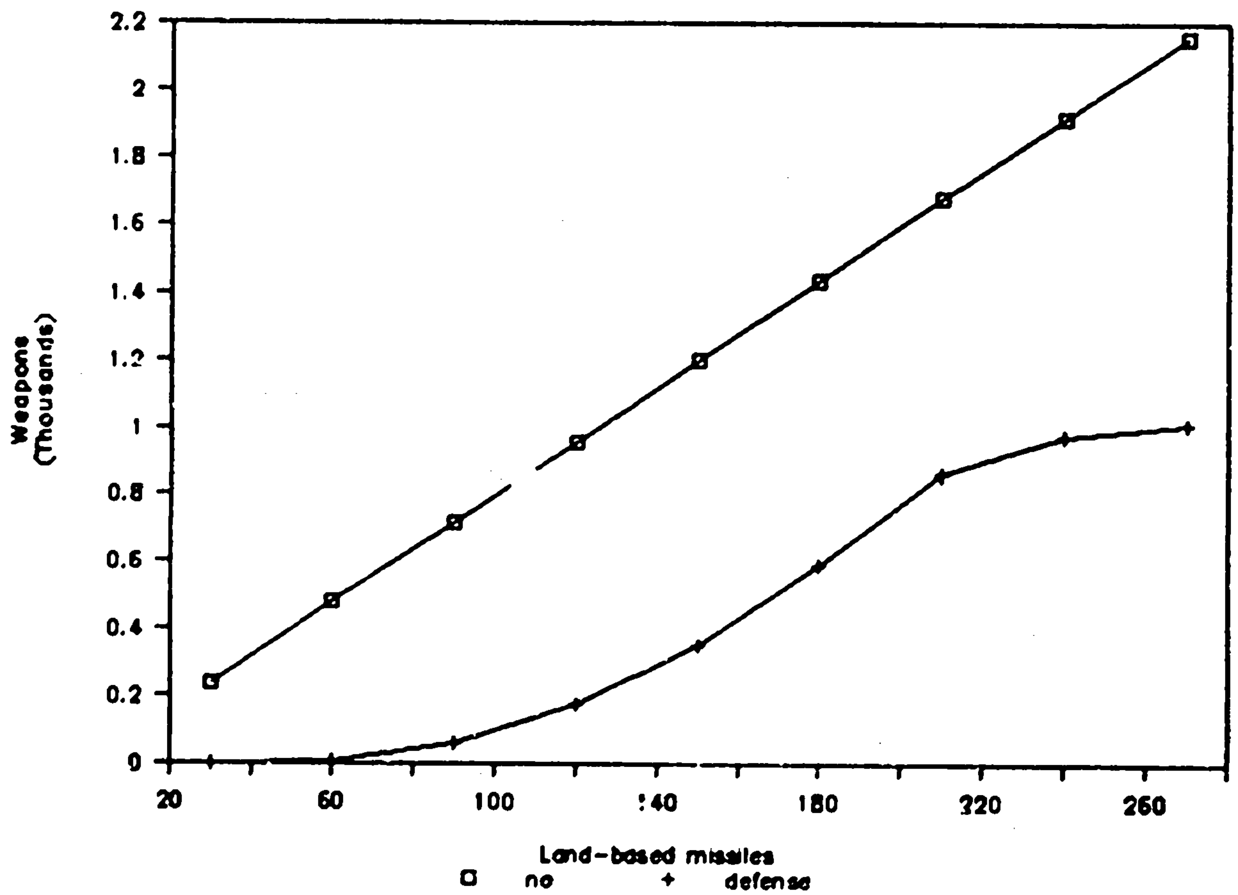


Fig. 6 Restrike missile weapons



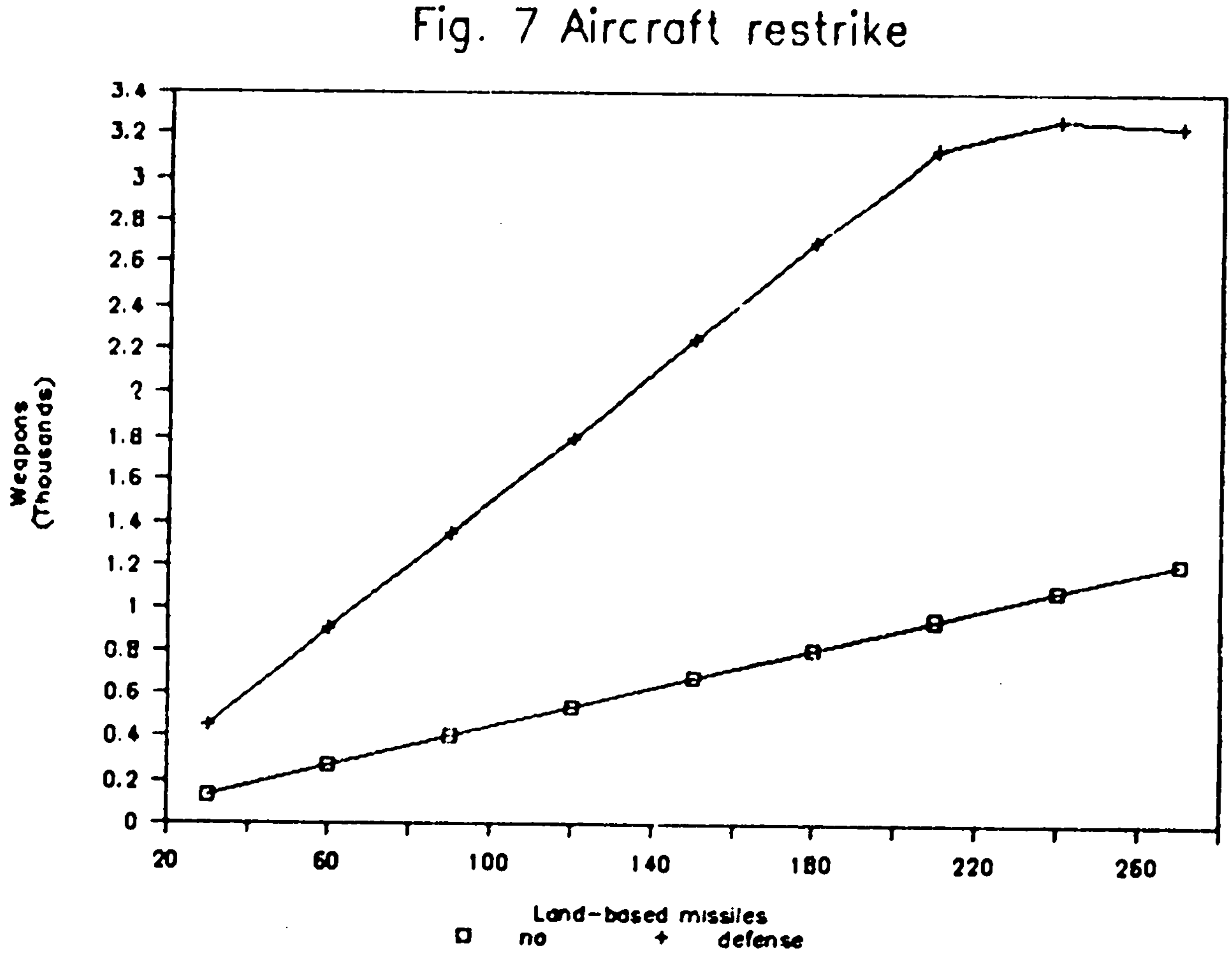


Fig. 7 Aircraft restrike
Weapons (Thousands)
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
60
100
140
180
220
260
Land-based missiles
no
defense

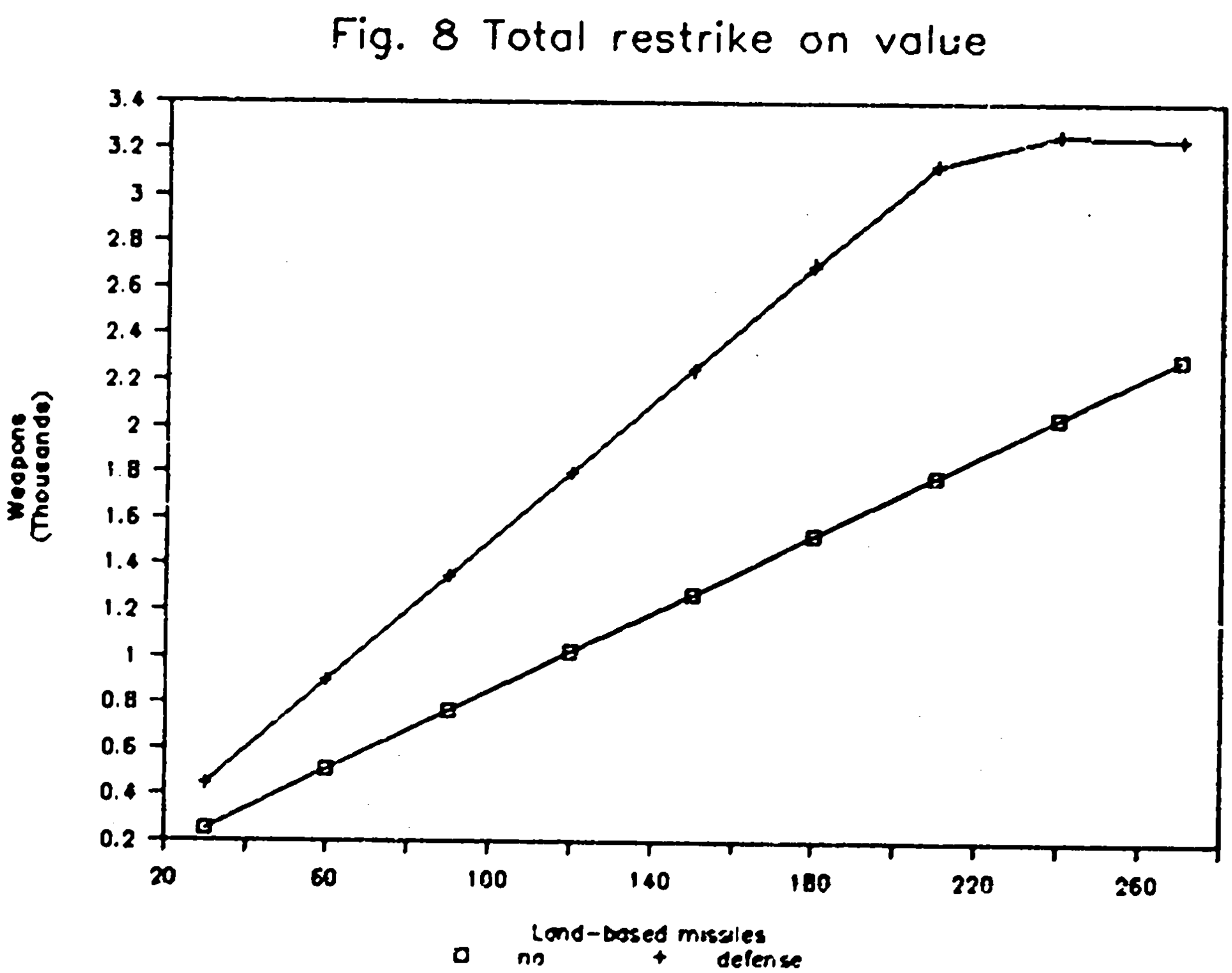


Fig. 8 Total restrike on value
Weapons (Thousands)
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
20
60
100
140
180
220
260
Land-based missiles
no
defense

Fig. 9 First & second strike costs

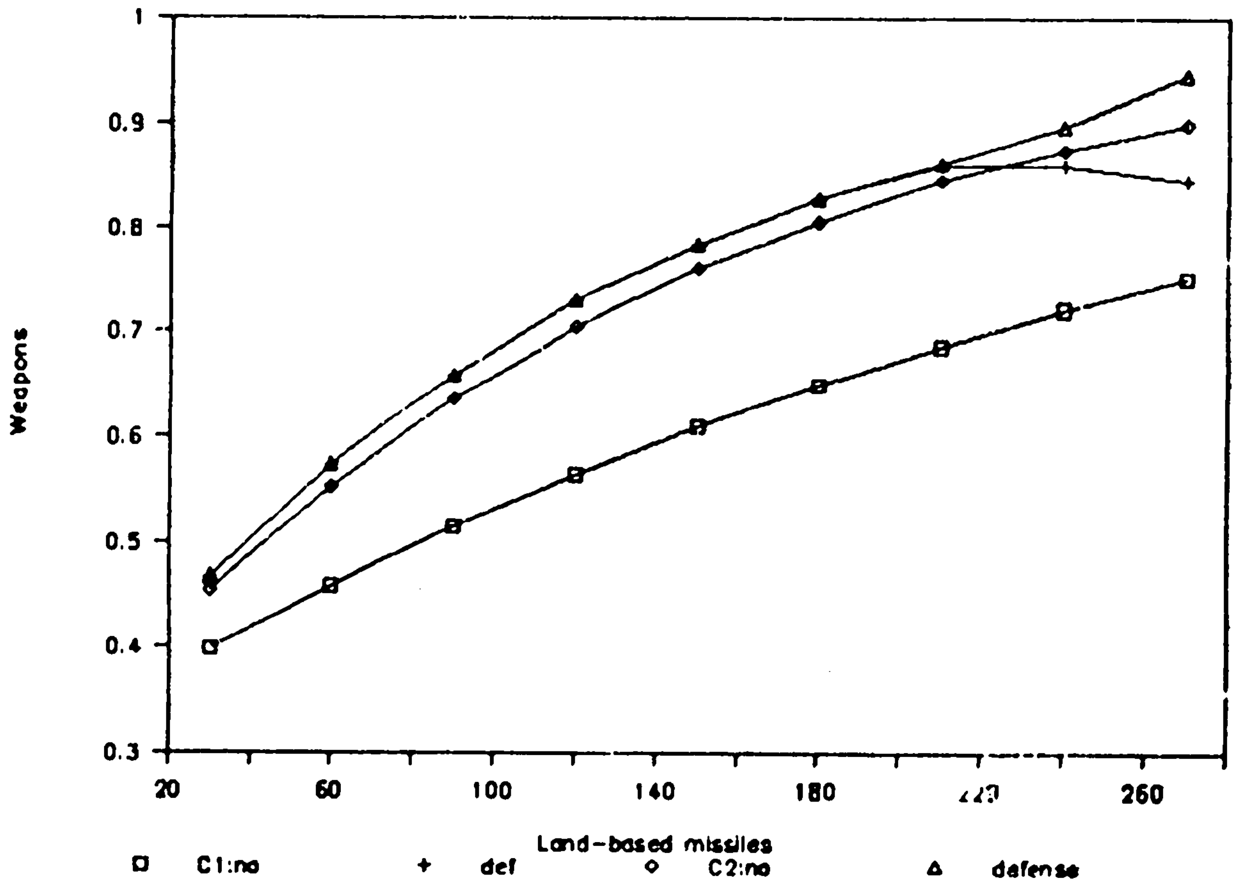


Fig. 10 Crisis stability index

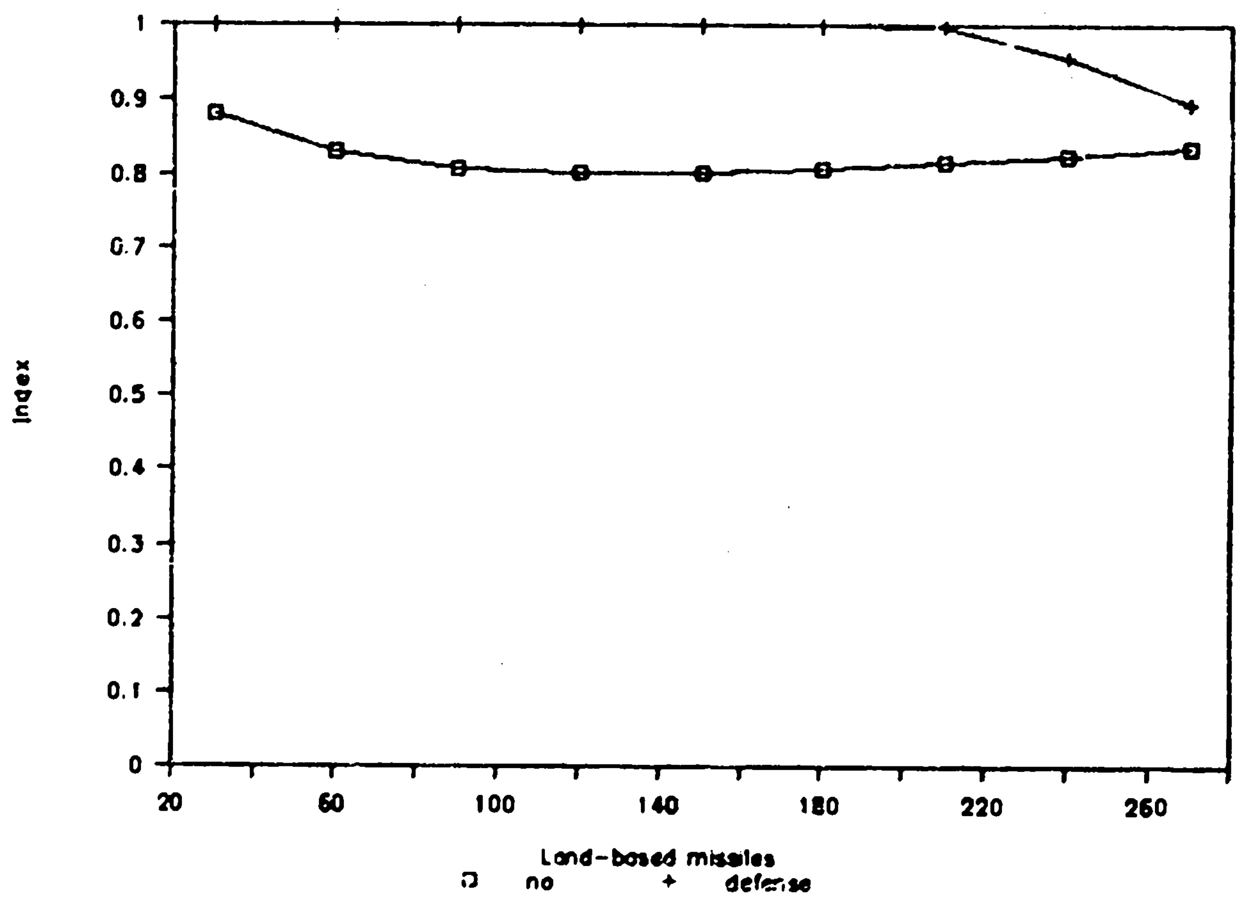


Fig. 11 Strike index

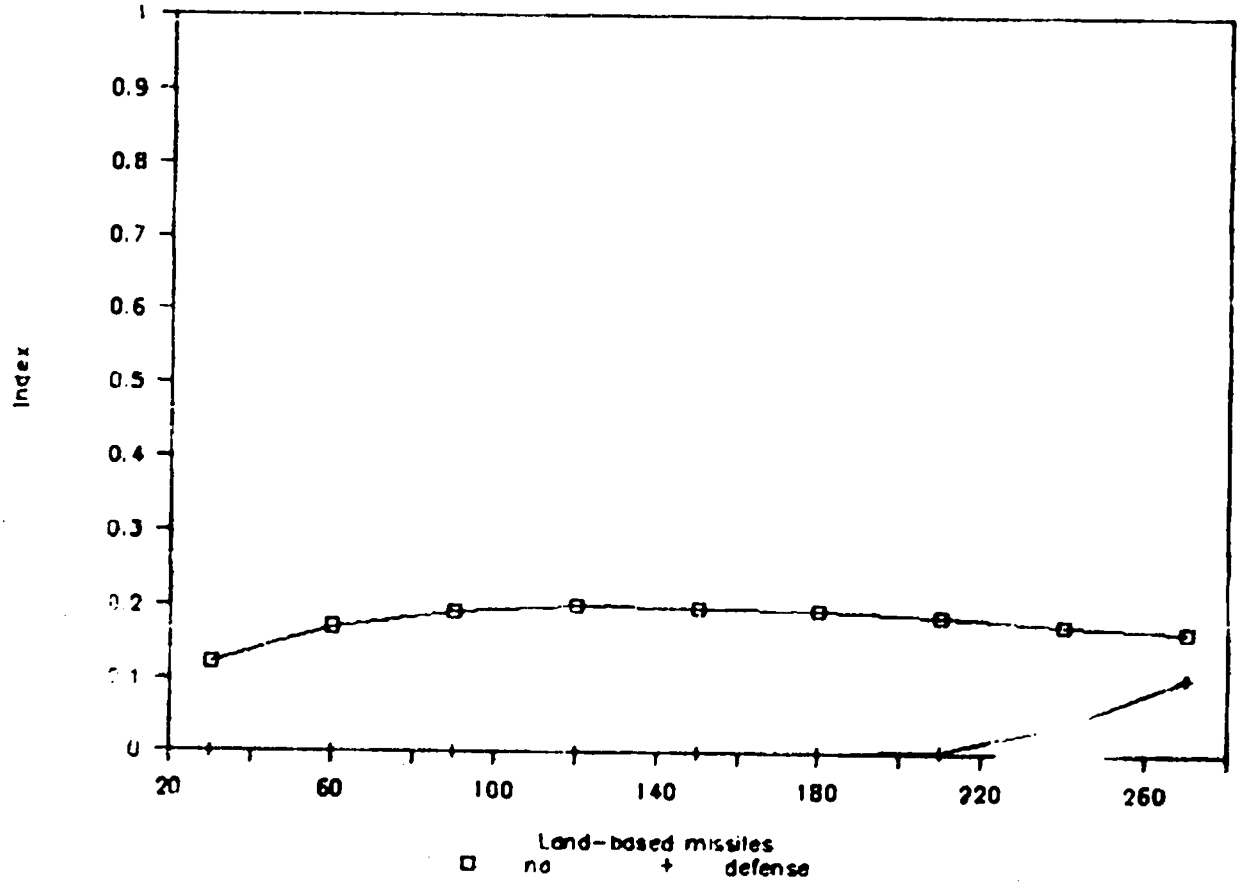


Fig. 12 Expected loss

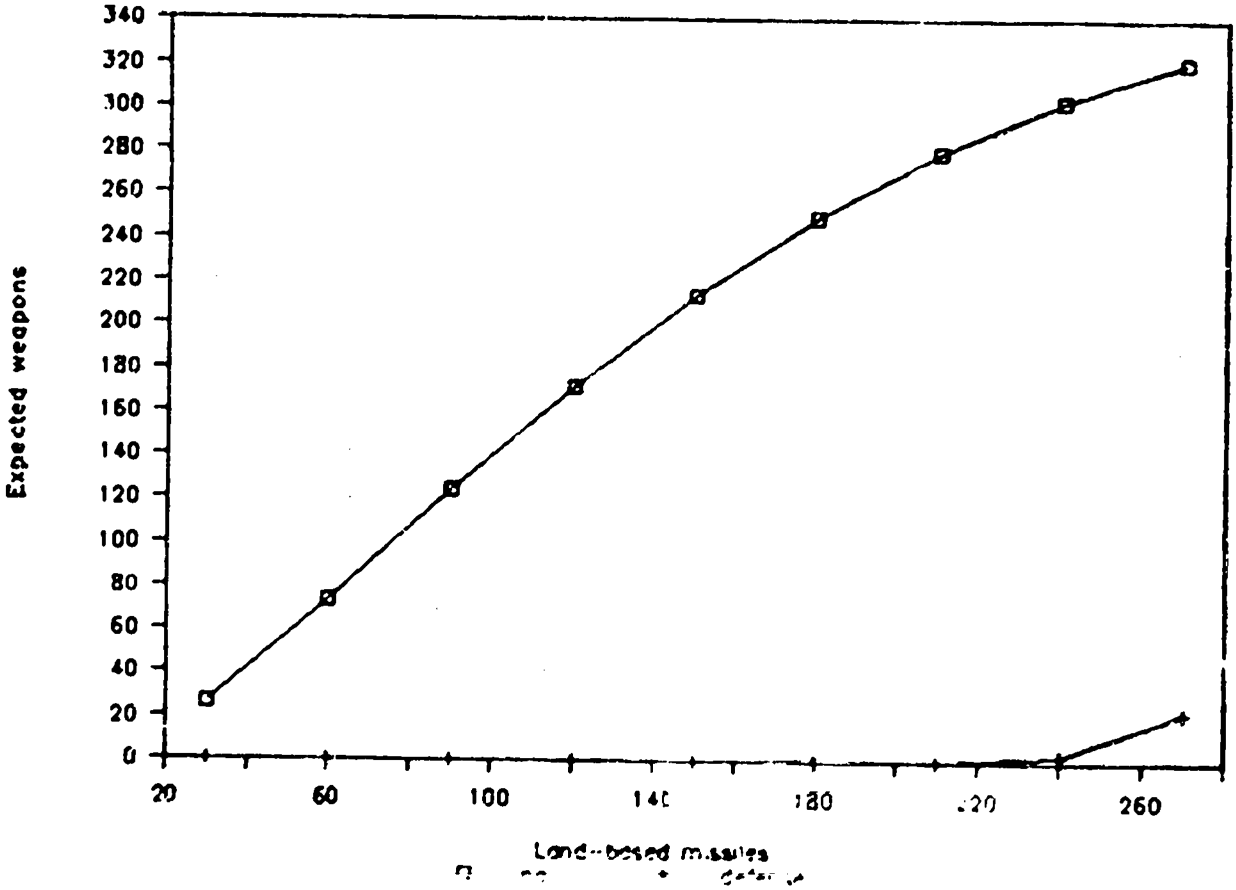
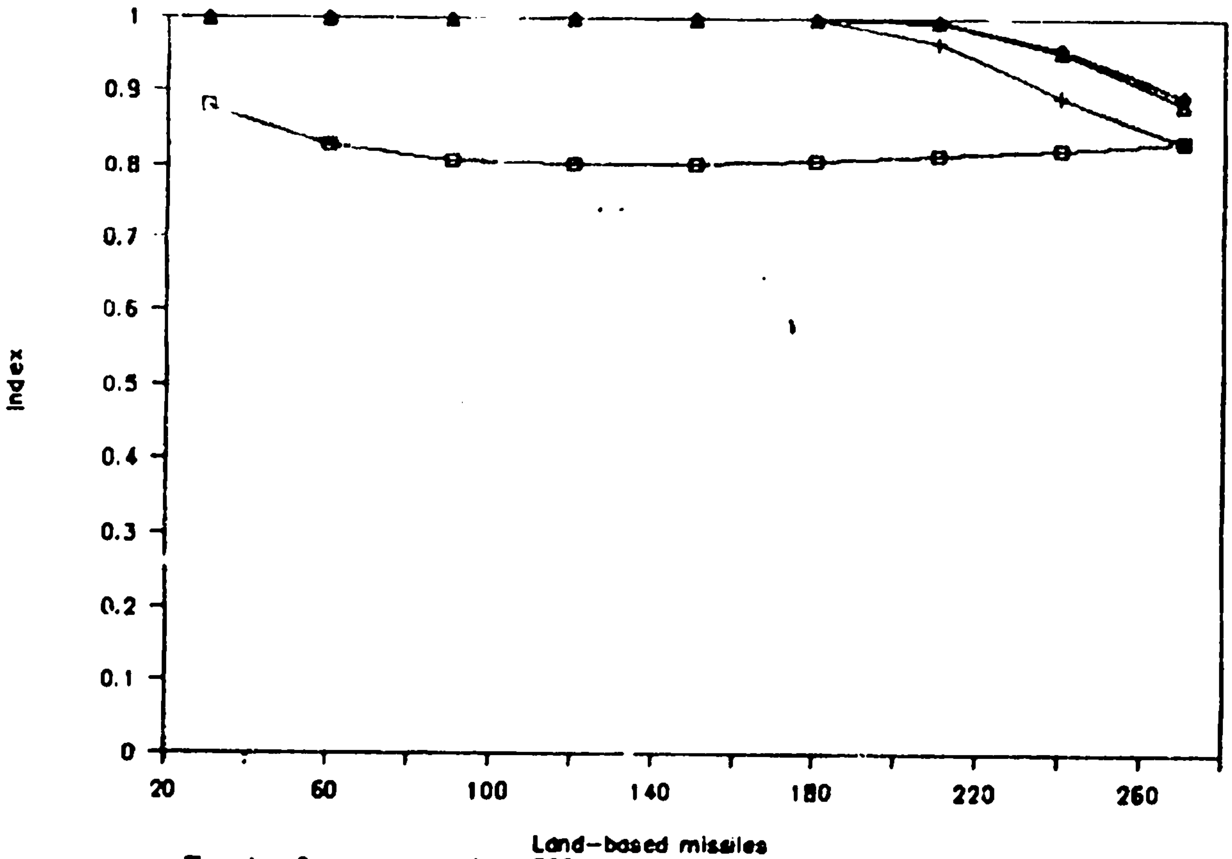
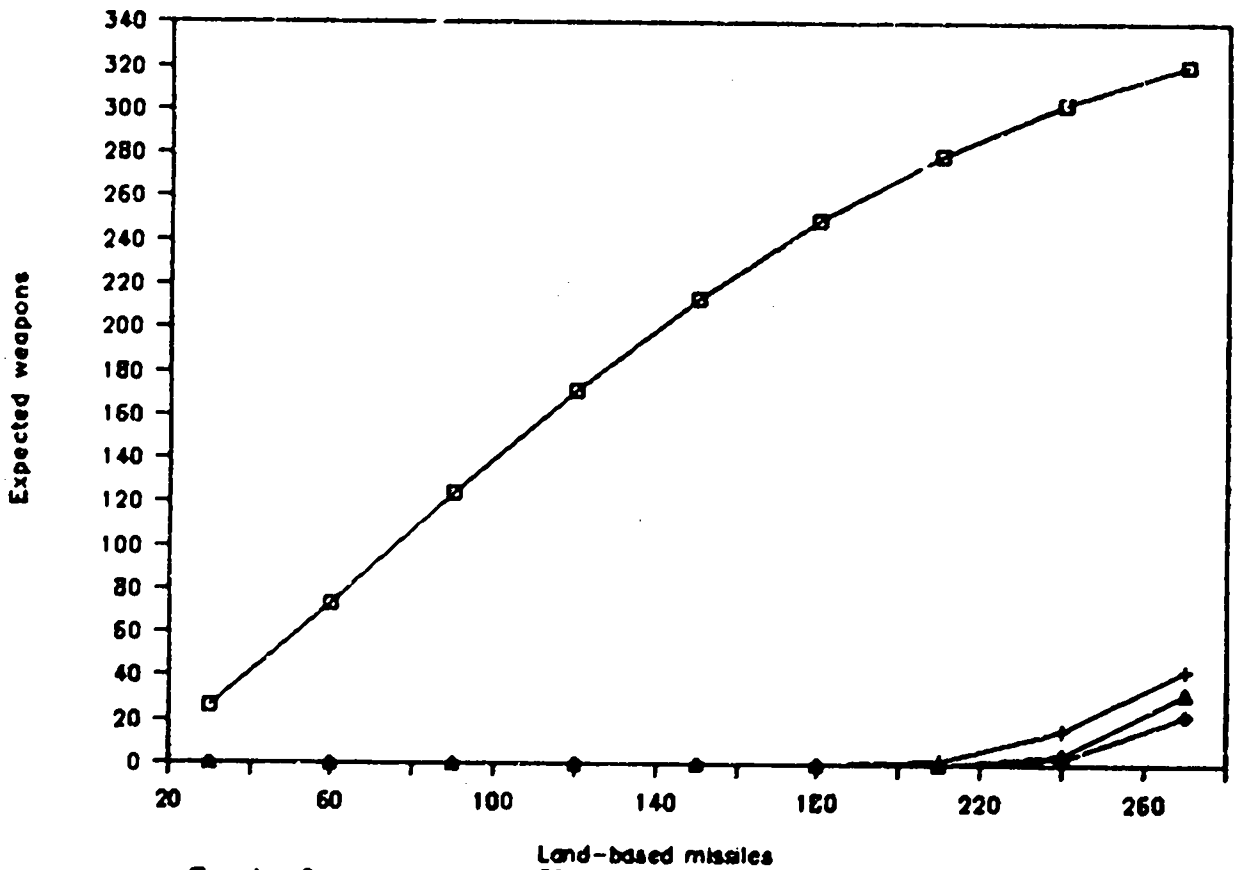


Fig. 13 Crisis stability index



□ I = 0 + 500 ◇ 1000 △ 2000

Fig. 14 Expected loss



□ I = 0 + 500 ◇ 1000 △ 2000

Fig. 15 Crisis stability index

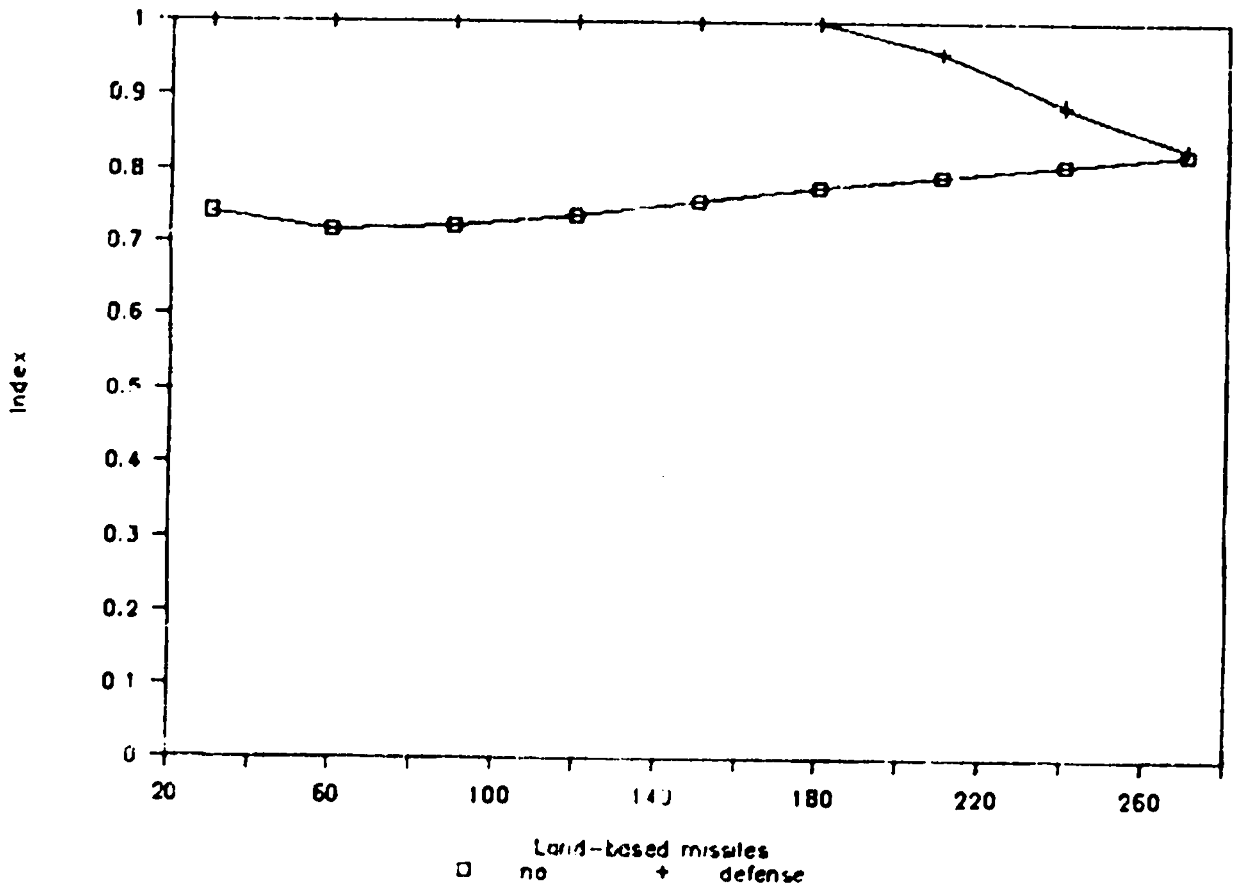


Fig. 16 Expected loss

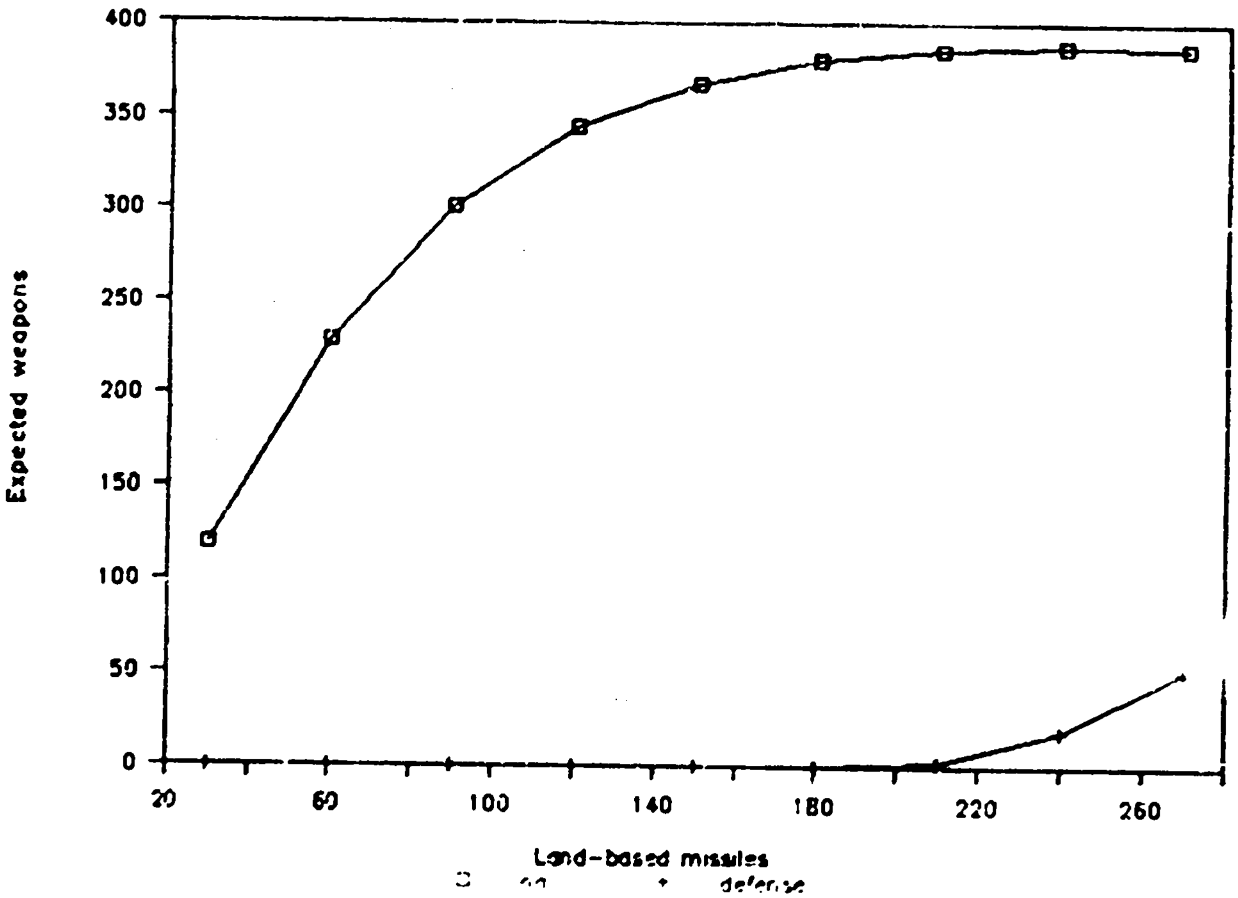


Fig. 17 Crisis stability index

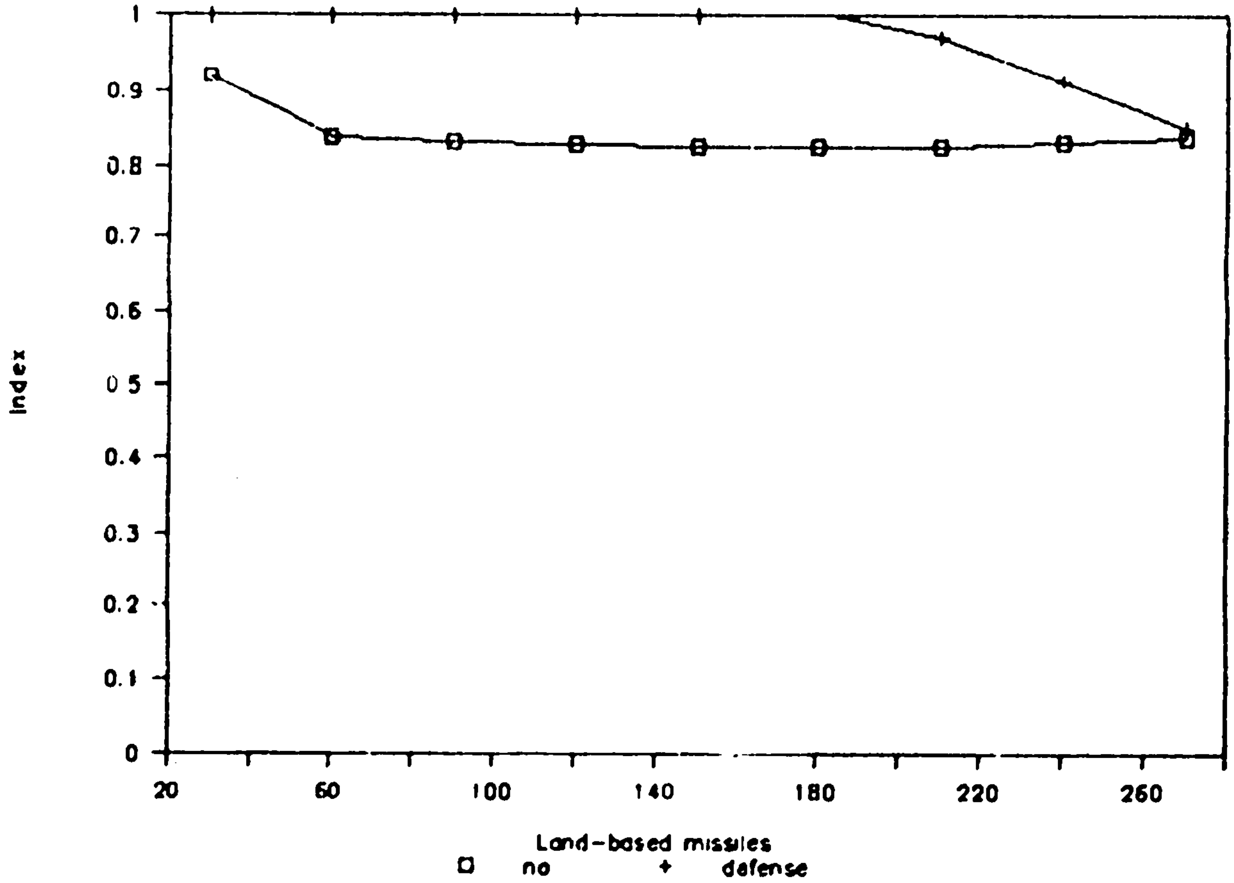


Fig. 18 Expected loss