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Interaction of Strategic Defenses with Crisis Stability

Part III. Summary and Conclusions

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INTERACTION OF STRATEGIC DEFENSES WITH CRISIS STABILITY

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by

Gregory H. Canavan

ABSTRACT

Retaliatory deterrence is now carried primarily by SLBMs. START would shift that towards aircraft. Moderate defenses would shift retaliation strongly towards aircraft. Combined boost- and midcourse defenses would increase stability. Mutual reductions of heavy ICBMs have little impact in the absence of defenses. It appears preferable to defend current missiles in place. Unilateral deployments of defense leave crisis indices unchanged while reducing the number of weapons delivered. One-sided reductions in conjunction with defenses produce intermediate indices. Interactive reduction of defense suppression could reduce penetration to marginal levels. Coupling between second strike and target set could be resolved by altering objectives or the target set.

I. INTRODUCTION

A companion paper, "Interaction of Strategic Defenses with Crisis Stability--Part I. Framework and Analysis," derives the equations that determine the crisis stability indices of various offense-defense configurations and uses them to discuss the impact of various SDI Phase I-related strategic defenses on the stability of START-constrained force mixes. The calculations lead to a simple picture of the impact of defenses. In the current deterrent configuration, fixed ICBMs largely act as sinks for reentry vehicles (RVs); submarine launched ballistic missiles (SLBMs) carry the bulk of the retaliation; aircraft and cruise missiles add a bit. START would only shift that picture quantitatively. Moderate defenses would make a larger shift. They would protect some ICBMs, though not enough to penetrate the other's defenses, strongly suppress SLBMs, and shift the bulk of retaliation to protected, penetrating aircraft or cruise missiles.

"Part II. Applications," applies that methodology to a set of related issues involving optimal mixes of boost and midcourse defenses and arms reductions. It indicates that mutual reductions of heavy ICBMs would, in the absence of defenses, have little impact on stability. With defenses they appear unnecessary; it appears preferable from both stability and cost considerations to defend existing missiles in place.

Unilateral deployments of defenses do not appear to be destabilizing. They change crisis indices little, and significantly reduce the number of weapons delivered. One-sided reductions of offensives in conjunction with the deployment of defenses increase stability indices.

Stability indices are sensitive to aircraft alert rates; even more to aircraft penetration. If defenses made RVs scarce that could reduce aircraft penetration. That would apparently destabilize deployments, although that result in part reflects sensitivity to the target sets used. The penetrativity of air-breathing vehicles is the most sensitive element of the model.

This part, III, summarizes the conclusions and implications of the first two. It does not attempt to describe all the analysis, hence it does not stand alone. It does try to at least indicate the main qualitative arguments. It is organized along the lines of the earlier parts, so that their quantitative roots can be located easily.

II. INTERACTION AND STABILITY MODELS

The analysis is based on exchange models[1] and stability indices[2] derived[3] and discussed[4] earlier. The exchange model used is a two-sided, sequential, deterministic description of U.S.-Soviet exchanges, which parameterizes each side's offensive and defensive force levels and effectiveness. The model treats each side as striking first or second and uses the ratio of the costs for doing so as an indicator of the pressure to show restraint in a crisis. The costs considered are those for the physical damage inflicted or denied; dollar costs are only a surrogate.

Boost-phase defenses are treated as non-preferential, i.e. random and subtractive in their removal of missiles and weapons. They are modelled on current space-based interceptors (SBIs). Midcourse interceptors are treated as long-range, preferential, and having roughly the characteristics of current ground-based interceptors (GBIs). Treating them as adaptive would increase performance slightly, but would not be consistent with near-term sensors and controls.[5]

SLBMs are assumed to be invulnerable before launch, but are attrited thereafter by available boost-phase defenses and midcourse defenses. Once airborne, aircraft are invulnerable to boost and midcourse defenses. Prelaunch survivability is calculated as a function of defense size and disposition. Penetrativity is generally treated parametrically; the loss of defense suppression for large defenses is studied explicitly.

Missile attacks can concentrate on missiles, aircraft, or value targets. So can defenses, but attacks and defenses that divide their resources about equally between them perform well and have little sensitivity for START conditions. Aircraft arrive well after missiles and aircraft are launched, so they primarily attack value. That is taken to be embodied largely in each side's projection forces, in accord with current U.S. and Soviet doctrine.[6]

In the model one side is assumed to strike first followed by the other's restrike. The strikes are calculated from aggregated models of boost and midcourse defenses[7] that have been compared with other exchange analyses.[8] The order is then reversed, and the damage to each calculated for both. Costs are a combination of those for imperfect strikes on the other's value and those for imperfect damage limiting. The costs to each side for each alternative are combined into a single crisis index that measures the relative costs of striking first or second.[9] The index does not determine whether or not either side would strike. That depends heavily on psychological and other uncontrollable factors. It does reduce complicated exchange calculations into a single index consistent with U.S. and Soviet analyses of correlations of forces. By this measure the current offensive-deterrence configuration is stable; the primary issue here is the extent to which these indices are shifted by varying boost or midcourse defenses.

III. DEFENSE SCALING

Part I discusses the sensitivity of stability indices to various levels of defenses. It predicts that for moderate boost-phase layers, ICBMs play little role even in first strikes, since too few are defended to penetrate boost-phase defenses. Heavy ICBMs play little role against large defenses; fast mobile singlets penetrate freely but provide too few weapons to alter stability calculations.

For fundamental reasons SLBMs are attrited harder than ICBMs even when clustered before launch; their impact is diminished by even small boost-phase defenses. The negation of SLBMs' retaliatory role by modest defenses is an obvious but little-remarked aspect of the analysis. For moderate defenses, the contribution from ICBMs and SLBMs is an order of magnitude less than that expected from aircraft and cruise missiles. The defenses' main role is to increase the survivability of value targets and of aircraft which deliver the bulk of the restrike.

Without defenses, bomber restrikes are critically dependent on alert rates; with defenses that sensitivity is weakened. Thus, defending aircraft is a key role for promoting stability, and one that boost and midcourse defenses should be able to execute as well as they could the protection of missile silos. Combined boost and midcourse defenses give increased stability because midcourse defenses can preferentially increase the number of surviving aircraft, whose retaliatory contribution is important. That increases the ratio of second to first strikes, and of first to second strike costs, making the stability indices of combined defenses much greater than those for boost only.

A rough summary of the calculations is that boost-phase defenses appear destabilizing; midcourse defenses appear neutral; and combined boost and midcourse defenses significantly increase stability indices. The fundamental difference between the three is that boost-phase defenses, which are non-preferential, suppress missiles without being able to protect retaliatory assets, while midcourse interceptors, which are preferential, enhance the contributions from aircraft. This contribution from midcourse defenses is the major modification of earlier calculations, which omitted them.[10]

Decoys could reduce composite stability indices, because saturating midcourse defenses with decoys would reduce combined stability results to those for boost phase. Attack and defense interactions indicate modest penalties for non-optimal defense allocations. Sensitivity to the target sets used is greater. Reducing second strikes without reducing the target set held at risk would apparently degrade stability even though fewer weapons would actually fall on either country.

IV. IMPACT OF INTERCEPTOR MIXES ON CRISIS STABILITY

These results are sensitive to the mix of space-based and midcourse interceptors. The number of reentry vehicles (RVs) penetrating to targets increases with the number of GBIs for any number of SBIs because the fraction of missiles protected preferentially scales approximately as the ratio of the number of

GBIs and SBIs. For START offensive force levels the number of penetrating missiles varies less with the number of SBIs, since more SBIs let more missiles survive to launch, but fewer of them penetrate the other's larger boost phase defenses.

The number of SLBM RVs delivered is over 3,000 at 0 SBIs, but falls to about 500 at 2,000 and 100 at 4,000. Below 2,000 the penetrating missile restrike is largely from SLBMs; above that it is largely ICBM RVs, although they are relatively few. The total number of ICBM and SLBM RVs delivered is a strongly, monotonically decreasing function of the number of SBIs and GBIs.

For more than about 2,000 SBIs the number of both first and second strike RVs is reduced to a few hundred, and missiles' contribution to deterrence is spent. The deterrent is then the number of weapons carried by surviving, penetrating aircraft. Beyond about 1,000 SBIs their restrikes are an increasing function of the number of GBIs, since additional GBIs protect more aircraft, whose penetration is not adversely impacted by the additional midcourse defenses.

Few non-alert aircraft survive without midcourse defenses; the few leaking RVs are adequate to destroy them. Survivability increases with GBIs, saturating at about 3,000 SBIs, where about 90% of the aircraft have been defended, independent of the baseline alert rate. As the penetrating RVs fall, the aircraft weapons increase; this complementarity causes the combined restrike to vary much less than either the missile or aircraft components. The connection between aircraft and defenses is strong and obvious: when defenses negate all the missiles, the aircraft are the only thing left.

Figure 1 shows the composite stability index. The bottom curve for 0 GBIs falls monotonically, indicating progressive degradation of crisis stability. The next curve is for 500 GBIs. It dips slightly for small numbers of SBIs, but then climbs to about 2.5 at 4,000 SBIs. The next curve for 1,000 GBIs is roughly constant at about 1.3 until 1,000 SBIs and then increases strongly, saturating at about 3.3. The top curve for 2,000 GBIs increases from the outset, rising sharply to ≈ 3 by about 1,000

SBIs and then slowly approaching a value of about 3.7. Each index is a monotonically increasing function of I, though those for few GBIs are not necessarily monotonically in SBIs.

The composite indices contain some interesting structure. For small numbers of SBIs all of the curves cluster at 1.2-1.4. Even a few thousand GBIs are not effective against START-level threats without boost-phase defenses. Conversely, the bottom curve shows that boost-phase defenses without midcourse layers degrade stability. The intermediate curves show that at moderate numbers of SBIs, increasing GBIs can be more effective than SBIs in increasing stability indices. Figure 1 is calculated without decoys. If decoys were used to dilute midcourse defenses, for each curve the actual number of interceptors deployed would have to be increased by a factor of about the number of decoys per RV to maintain performance.

According to Fig. 1, configurations with SBIs only should not be deployed; to avoid any dip in stability it might be best to deploy a thousand or more effective GBIs before deploying any SBIs. A secondary goal is to decrease the weapons delivered. The reductions could be a factor of three in first strike weapons and a factor of two in second strike while increasing stability.

V. CRISIS STABILITY DURING PARALLEL HEAVY MISSILE REDUCTIONS

Transitioning from a force of multiple RV heavy missiles to a force of largely single RV missiles is often advocated as a way of improving crisis stability within the current retaliatory deterrent. Shifting RVs to immobile singlets or heavy mobiles would not improve stability, so it is assumed that all RVs removed from heavy missiles are placed on mobile singlet missiles, which are assumed to be fast enough to elude most SBIs. Thus, they are non-targetable by offensive RVs and insensitive to boost-phase defenses. They are, however, still subject to attrition during midcourse. Terminal interceptors would not greatly alter the analysis, but would soften the results' sensitivity to decoys and penetration aids.[11]

In the absence of defenses the build down produces no change in first strikes and a 20% growth in second. The largest change is for aircraft second strikes. There is no change for the offense and boost-phase only defenses, since only alert aircraft survive with either. However, adding about 1,000 GBIs increases the restrike by about a factor of 3 at the beginning of the build down, although it falls to about a factor of 2 at the end, since the transition to singlets allows more missiles to penetrate and suppress more aircraft.

Figure 2 shows the composite stability indices for four cases. The bottom curve for small number of GBIs is the index for the transition from heavy silo-based missiles to fast mobile singlets without defenses. It increases from 1.2 to a little under 1.4, or about 15%, which is a rather modest increase, given the expense implied by the total conversion of the missile force. The curve above it is a rough bound on the impact of SLBM reductions, which was calculated assuming that SLBMs were reduced at the same rate as heavy ICBMs. The impact is small.

The third curve is for a 2,000 SBI boost-phase only defense. At 810 missiles it starts out 20% below the offensive curves, in accord with earlier observations that boost-phase only defenses are destabilizing. As heavy missiles are eliminated, however, the boost-phase layer does give a larger increase in stability indices than that from the offensive reductions. By 100 missiles it reaches about 1.6, which is about 10% above offenses alone. The top curve is for 2,000 SBIs plus 1,000 GBIs. At 810 missiles it is about a factor of 2 higher than the other curves due to the lower first strikes and higher aircraft second strikes.

From these curves it would appear that a build down to singlets could have some useful products, but in the absence of defenses, increased stability does not appear to be one. A boost-phase only defensive layer could exacerbate stability concerns in the early part of the transition, but phase-1 mixes of SBIs and GBIs could significantly stabilize it throughout.

Dollar costs are not the prime consideration here, but it might be noted that the SBIs required might cost about \$ 1 M/SBI x 2,000 SBIs ≈ \$ 2 B; the GBIs a like amount. Thus, for about \$ 10 B, including sensors and controls, defenses could stabilize a transition that would cost about \$ 100 M/missile x 1,000 missiles ≈ \$ 100 B. From a stability standpoint it would be preferable to keep the current number of missiles, for which the index is over 2.3 rather than build down to singlets, for which the index falls 10%. Moreover, providing defenses for current missiles rather than singlets would provide higher indices and save the \$ 90 B difference. Without defenses, mobility has modest impact; with them, the mobility of the ICBMs matters little.

VI. LAUNCH ON WARNING/LAUNCH UNDER ATTACK

Since there is apparently little gain from replacing heavy missiles with mobile singlets, a logical next step is to ask whether the heavy missiles' vulnerability could be reduced by changing to a policy of launch on warning or under attack (LOW). That can be evaluated without modification of the model used for the above calculations, which allows for arbitrary allocations of attacks and defenses between missiles, aircraft, and value.

The essence of launch on warning is to launch the missiles before the attack arrives. If that is known or thought to be the defense's policy, the attacker should logically not target his missiles. Thus, launch on warning can be studied simply by allocating no RVs of GBIs to missiles and dividing them instead between aircraft and value. Parenthetically, not targeting missiles would also be the logical policy if the attacker thought his missiles unable to kill the other's missile silos. That probably applies to the bulk of the U.S. missile force. Thus, the analysis also covers the impact of mutually invulnerable fixed missile silos.

In the absence of defenses, LOW increases the number of restriking heavy ICBM RVs by about 1,500, but ICBM RVs never play a dominant role. They are totally suppressed in the absence of defenses, where most of the restrike is by SLBMs. For large defenses, few penetrate midcourse defenses. There aren't enough to be pivotal in between, either, where the burden of retaliation is carried first by SLBMs and then by aircraft, with a crossover at about 1,500 SBIs. Near that crossover the contribution from the RVs saved by LOW is significant. There the SLBM RVs would be reduced to about 500 RVs and aircraft would only be up to about 1,000 weapons. Thus, the ≈ 500-1,000 RVs penetrating to target could make the difference between a restrike of ≈ 2,000 weapons under current policy.

Figure 3 shows the impact on stability indices. The lower curve is for current policy; the upper one for LOW. There is little difference for large defenses, largely because even launch on warning contributes few RVs there. At 1,000-2,000 SBIs the difference is interesting. The additional RVs essentially fill in the minimum in the current policy; the result is a monotonic increase in stability throughout. There is, however, no improvement in the absence of defenses, largely because SLBMs are adequate there, and dominant under either policy. Thus, launch on warning is apparently not useful for no or large defenses, but makes an apparently useful but modest contribution at intermediate levels.

Launch on warning appears to improve stability indices in that it reduces the pressure on decision makers in crisis. It would, however, have to be implemented through a very fast acting, highly-automated machinery that would leave little or no time for human decision making. That could decrease stability through the introduction of the possibility of accidental launch through machine error. Since one side adopting such a policy could result in the other adopting it too, the effect of such an error could be the launching of both arsenals against the other's aircraft and value. The strikes on both would even be a bit stronger since no RVs would be wasted on silos, resulting in mutual annihilation without the need for human assistance.

The two types of stability shifts are not commensurate. The gain is through the lessening of pressure on decision makers; the loss through the introduction of a mechanical decision maker that could bypass them. The latter is not accounted for in the current stability framework; it would be difficult to do so. It would appear, however, that the downside risk involved in LOW would outweight the small, transient gain it might afford.

VII. UNILATERAL DEPLOYMENTS OF STRATEGIC DEFENSES

Unilateral deployments are generally thought to be destabilizing, but they actually leave stability indices largely unchanged, primarily reducing the number of weapons delivered, which is a positive step. They can be studied with the model used for the earlier calculations by leaving one side's offensive forces at START levels while varying the other's defenses. A fixed ratio of 4 SBIs per GBI is used. Above 2,500 SBIs first strikes are roughly equal to the number of penetrating aircraft. The undefended side's second strikes remain much as before. By about 2,000 SBIs the defended side's first and second strikes are both restored to roughly their unattrited values.

The undefended side's first and second strike costs rise together until about 2,000 SBIs and then asymptote; the net shift is stabilizing. The undefended side's costs fall together until about 2,000 SBIs and asymptote. Figure 4 shows the resulting stability indices. The shifts appear large, but the scale is compressed. The undefended side's index climbs from 1.12 to about 1.18; the defended side's first falls from 1.04 to about 0.94, and then rises to about 1. The composite index reflects this dip, but returns to about 1.17 by 2,000 SBIs.

Thus, the overall impact of unilateral deployments on stability indices is modest. That is apparently at variance with concerns that even imperfect shields might be good enough to negate second strikes. Unilateral defenses do increase the undefended side's costs for first and second strikes, but they reduce the defended side's costs for striking first or second proportionally. Thus, the defended side sees no reduction in the relative costs of striking first and hence no incentive to take advantage of his "imperfect shield." The defended side could reduce the cost of striking first by using an imperfect shield against the other's second strike, but the overall cost of doing so would not be significantly less than that of defending against the other's first strike and then striking second for START-level forces. Strikes, costs, and indices are insensitive to the unilateral increases in defenses, so the configuration is quite stable. Unilateral deployments would thus appear to leave stability indices largely unchanged and primarily reduce the number of weapons delivered, which is positive.

VIII. REDUCTIONS OF OFFENSES WITH DEPLOYMENT OF DEFENSES

One-sided reductions of offensive forces in conjunction with the deployment of strategic defenses increase stability indices to an extent intermediate between increases for mutual and unilateral deployments. Below, the undefended side's forces remain at START limits; the defended side's offensive forces are assumed to be reduced by a factor of 4. Intermediate reductions roughly interpolate between these curves and those of unilateral defenses discussed above. For no defenses the defended side's restrike is about 1,200 weapons; by 2,000 SBIs is about 1,500; by 4,000 SBIs it asymptotes to about 1,700 weapons, about 75% of the 1/4 START or 2250 weapons deployed. It increases gradually due to the greater survival of aircraft and missiles. With one-sided defenses, retaliatory forces actually constitute a triad, whereas without them, the land-based missiles are essentially an RV sink.

The defended side's first and second strike costs fall much as for unilateral defenses, but stabilize at a higher level due to his reduced total offensive forces. The undefended side's first and second strike costs again increase roughly in parallel, but they start at much lower levels, so the ratio of first to second strike costs increases about 50% rather than the $\approx$ 10% for unilateral defenses. The result is that the defended side's crisis stability index is little changed from that for unilateral defenses, but the offensive reductions smooth out their dip at 1,000-2,000 SBIs, eliminating any transient degradation of stability. The result is 1.3-fold increase in composite stability to about 1.5, which is intermediate between the values for unilateral and mutual deployments, and comparable to, but quantitatively more precise than, earlier studies of the qualitative impact of unilateral reductions.[12]

The increase in stability is largely due to the reduction in the defended side's offensive forces, which reduces the other side's incentive to strike first in a crisis. The case discussed here of a factor of 4 reduction illustrates one point in what should be a continuous progression. They show that from START levels it is appropriate to eliminate about 9,000 x 3/4 = 6,750 offensive weapons to compensate for the deployment of about 4,000 SBIs plus 1,000 GBIs, or that the offset is about 1.5-2 offensive weapons per SBI. That counting rule can apparently be made about as precise, and rather more rational, than those for counting offensive forces.

IX. AIRCRAFT ALERT RATES

The previous sections' results for two-sided, one-sided, and unilateral deployments of strategic defenses all depend critically on the weapons delivered by aircraft at high levels of defenses. Those in turn are sensitive to alert and penetration rates. Ideally, the attacker could alert all aircraft to achieve an effective alert rate near unity in order to maximize his aircraft survivability, but doing so could alert the other side, allowing him to disperse his aircraft or increase their alert rate, and deprive the attacker of the benefit of striking first. Thus, some lesser alert rate, possibly not much greater than the normal alert level, would be used instead for deception.

Alert rate impacts the total second strikes directly. For 2,000 SBIs and 1,000 GBIs against START offenses, the second strikes vary from about 1,800 weapons to 2,400 weapons as prelaunch survivability increases from about 10% to 90%. That increase gives comparable increases in first strike costs and decreases in second strike costs that increase the stability index about a factor of 2 by 90% survival.

While increasing alert rates improves stability indices, it costs money. There are certain trends such as the faster warm-up and flyout times of advanced aircraft that could improve effective alert rates somewhat even without defenses, but there are other trends that could reduce them. SLBM RVs have shorter, faster trajectories than ICBMs, which reduce effective alert rates. Deployed closer to shore they would reduce warning times to tens of minutes. On depressed trajectories, which could be used since great accuracy is not required, they could reduce warning times to minutes. Even alert aircraft might not be able to escape then. Such trajectories would also underfly boost-phase defenses. If so, that could essentially eliminate all unprotected bases. Without defenses dispersal over many bases would only give a marginal improvement.

X. AIRCRAFT PENETRATION RATES

Penetration rates impact stability indices even more strongly. First strikes do not vary, but second strikes are linear in penetration for prescribed defenses. They increase from 400-600 weapons, mostly RVs, at 10% penetration to 2,400-3,300 at high. That increases both sides' first strike costs and reduces their second strike costs together. That leads to the stability indices shown in Fig. 5. The two sides' individual indices are within a few percent of each other except at very high penetration rates; the overall increase of each is about a factor of three.

The composite index rises more sharply, essentially as the square of the individual indices. Its total increase is about a factor of 10 over the range shown. It starts at a very low value for low penetration. The composite index is only about 0.5 at a penetration of 20%; it crosses unity at a penetration rate of about 1/3. It exceeds 2 by a penetration rate of ≈ 2/3, but it has a strong sensitivity. Penetration is quite sensitive to the assumed defenses. For 4,000 SBIs and 2,000 GBIs the composite reaches unity by a penetration of about 25%; conversely, for 1,000 SBIs and 500 GBIs the crossing shifts out to 50%.

To fully appreciate the impact of penetration rates on crisis stability, an analysis of the interaction between defenses and penetration rates is needed. Aircraft depend in part on defense suppression by ICBM and SLBM RVs for penetration. As defenses draw down the RVs, the fraction that can be spared for suppression decrease, and penetration falls. For a plausible variation of penetration with the number of RVs available,[13] penetration is about 60% in the absence of defenses, drops to 23% by 2,000 SBIs and 17% by 4,000, which would produce a composite index below unity.

That has an interesting impact on aircraft restrike weapons: over a wide range of defenses they are almost constant. The restrikes are the product of aircraft survival and penetration probabilities. As defenses increase, so does aircraft survival, but not so missiles: SLBMs fall; penetration falls faster; and the number of restrike aircraft is clamped at 500-800 weapons as fewer RVs are available to suppress defenses for them.

This interesting interaction should not, however, obscure the main point: RV depletion could clamp aircraft restrikes at a few hundred weapons rather than the few thousand predicted by calculations with high, fixed penetration rates. Strike costs all fall monotonically. Both sides' first strike costs fall by about a factor of 2 due to the much more effective damage limiting possible with interactive penetration. Second strike costs fall by 10-20%. The result is shown in Fig. 6, in which the individual indices fall about 30%, and the composite index about a factor of 2, which tends to support the common assumption that air defenses degrade stability.

The distinction lies along aircraft penetration technologies. Bombers such as B-52s have competent but modest on-board defense suppression. Thus, they are critically dependent on defense suppression by RVs; they are prototypical interactive penetration carriers. Bombers such as B-1s have advanced on-board defense suppression, which should allow them to detect and degrade defenses enough to penetrate in the near term. They are intermediate. B-2s, which should remain non-targetable to known fire control radars, are essentially independent of RV-aided defense suppression. They should have essentially prescribed, and potentially quite high, penetrativity.

Cruise missiles don't follow quite the same categorization. Current cruise missiles are inert but small. They should be able to penetrate suppressed defenses and possibly unsuppressed ones; but they, too, are partially interactive penetrators and would lose out to large defenses. Stealthy cruise missiles could penetrate about as well as B-2s. They should have prescribed, potentially high penetrativity. Thus, the fundamental distinction between the two modes of penetration would appear to be along the lines of stealth. Non-stealth aircraft would be degraded by defenses; stealthy ones would appear to be enhanced by defenses.

These penetration arguments distinguish between non-stealth aircraft and cruise missiles and stealthy ones, but not between stealthy aircraft and cruise missiles. It is conventional to package many cruise missiles per carrier and release them not that far from shore. In the present RV-rich environment that has modest operational penalties, but with strong defenses, when the stealthy aircraft are expected to penetrate on their own wits, the larger and more visible cruise missile carriers could be inviting targets to capable, unsuppressed forward-based air defenses with developed look-down, shoot-down technologies. That could push release points back to ranges where the cruise missile's advantages were less pronounced. The distinction between stealthy bombers and cruise missiles would thus appear to hinge less on penetration during ingress than on survivability once inside, and on flexibility in addressing important targets once there.

A summary of the impacts of prescribed and interactive penetration is that prescribed penetration gives adequate retaliation that increases with defenses, which is stabilizing, and interactive penetration gives marginal retaliation, which degrades stability rapidly with defenses. The distinction is largely in the sensitivity of the latter to the attrition by defenses of the RVs needed for penetration. The distinction is physical, fundamental and critical. Defenses would apparently have an untoward effect if applied with aircraft that relied on defense suppression for penetration.

XI. SENSITIVITY TO TARGET SETS

Part of the apparent degradation of stability is due to the reduced sizes of the strikes. As the sizes of strikes decrease for a given target set, stability indices decrease just due to the scaling of the value damage curves. If the target sets were reduced in proportion to the sizes of the strikes, the apparent degradation of stability would be eliminated. Thus, decreasing aggregate first and second strikes apparently degrades stability even if the number of weapons delivered goes to zero.

From the form of the exchange model it follows that for moderate defenses, first strikes are small; second strikes large; first strike costs large; and second strike costs small. Then, costs go to approximately the ratio of the second strike to the number of value targets to be held at risk. For the small second strikes encountered when defenses are large, missiles negligible, and aircraft restrikes marginal, stability indices decrease simply because the restrikes are small relative to the target sets demanded. This result doesn't depend on the details of the targeting strategy or cost metric used. Deleting the value-suppression function would only change results a few tens of a percent. Eliminating damage limiting and going only against value would only reduce the objective to assured destruction.

There seems to be two solutions: increase the restrikes or reduce the number of targets. The former would mean increasing offensive forces, which would amount to letting crisis stability overrule arms control stability. The latter would mean reducing the number of targets held at risk, i.e., progressively taking projection forces out of the target set as strategic resources fell. That reduction could mean reassigning projection forces to non-strategic assets or it could mean negotiating them away. The two approaches are logically equivalent from the perspective of strategic stability, but have quite different implications.

Strategic defenses have for some time been suspected of "making Europe safe for a conventional World War III." Decoupling strategic targeting from projection forces would be the implementation of that suspicion. At some point such a decoupling is automatic. If strategic defenses eliminated strategic offenses there would simply be nothing to which to couple. The implementation above would, however, be harsher and earlier than expected, since it would have to start with the initial defenses.

The other approach has more promise in the long term but more problems in the near, because it would couple conventional arms reductions talks to strategic arms reduction talks and make both an essential part of the strategic defense deployment policies of both countries. Bureaucratically it could be a nightmare, but there are two offsetting advantages. It would recognize the goal of reducing offensive forces as a significant motivation for deploying strategic defenses, and recognize the goal of minimizing expenditures on strategic defenses as a motivation for reducing projection forces, which might otherwise be maintained and serve as a bit of an attractive nuisance to strategic offenses.

XII. CONCLUSIONS

The stability index calculations discussed above lead to a simple picture of the transition from offensive to defensive forces. Under the current retaliatory deterrence fixed ICBMs largely act as an RV sink; SLBMs carry the brunt of the retaliatory forces; and bombers and cruise missiles add insult to injury. START would shift that picture slightly toward retaliation by aircraft.

Moderate defenses would strongly suppress SLBMs and protect some ICBMs, but not enough to penetrate boost-phase defenses significantly. The brunt of retaliation would thus shift to aircraft, if protected and penetrating. Boost-phase only defenses would be destabilizing; they would suppress SLBMs but not protect aircraft. Combined boost- and midcourse defenses could protect aircraft, so they would increase stability.

Two-sided reductions of heavy ICBMs have little impact on stability in the absence of defenses. With defenses they are unnecessary. It appears preferable from the perspectives of both stability and cost to defend current missiles in place. Launch on warning has a small positive impact on human decision making--at the risk of introducing accidental machine decision making with unbounded downside risk. Contrary to popular opinion, unilateral deployments of defense are not destabilizing. They essentially leave crisis indices unchanged, while significantly reducing the number of weapons delivered. One-sided reductions of offensive forces in conjunction with deployments of defenses produce stability increases intermediate between those for unilateral and mutual deployments.

Stability indices are sensitive to the treatment of aircraft alert and penetration rates. Prescribed penetration produces an favorable interaction with defenses, but interactive reductions of defense suppression could reduce penetration to levels at which stability indices were marginal. The distinction seems to lie along the lines of stealth. Stability at such levels reflects, in part, sensitivity to the target sets used. In part that is model dependent, but in part it reflects a real coupling between second strike diminution and the fixed projection force target set to be held at risk. That could be resolved either by altering targeting objectives or by negotiating the reduction of the actual target set.

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Fig.1. Stability vs midcourse defenses

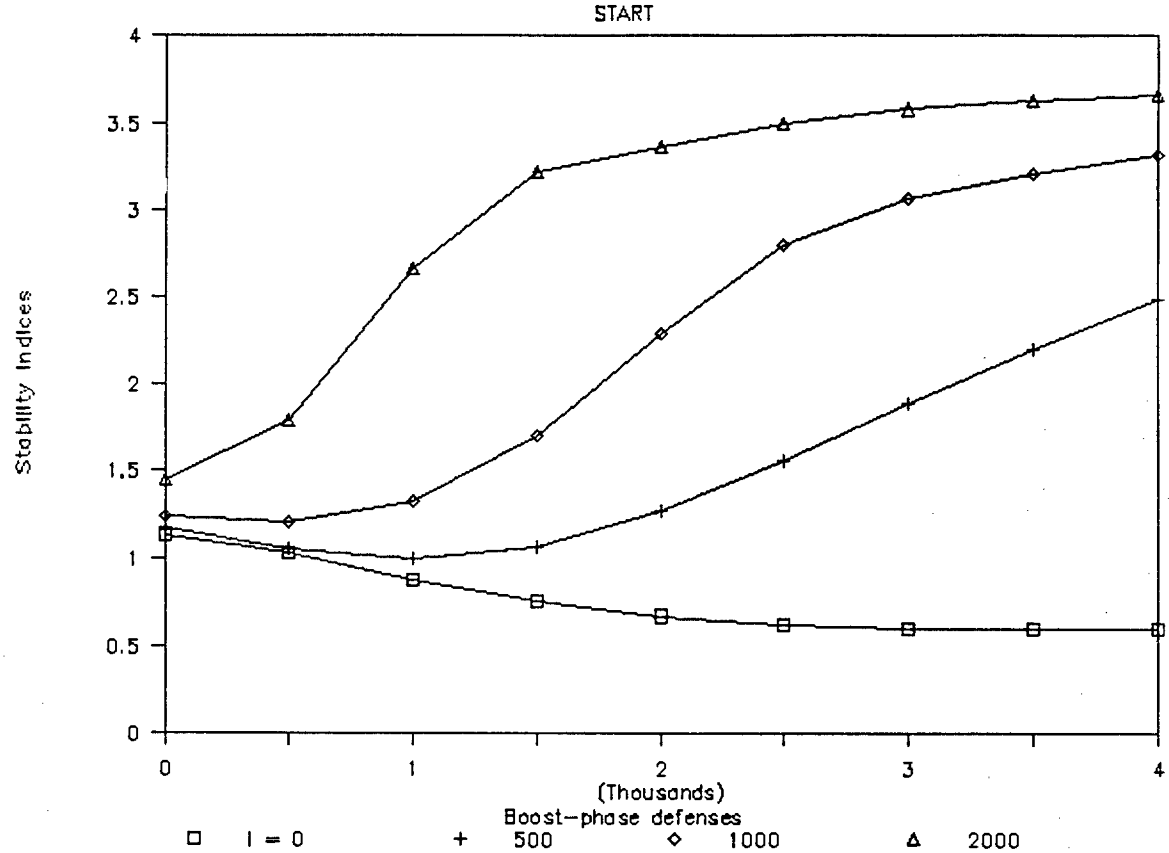

Fig.2. Stability indices for de-MIRV

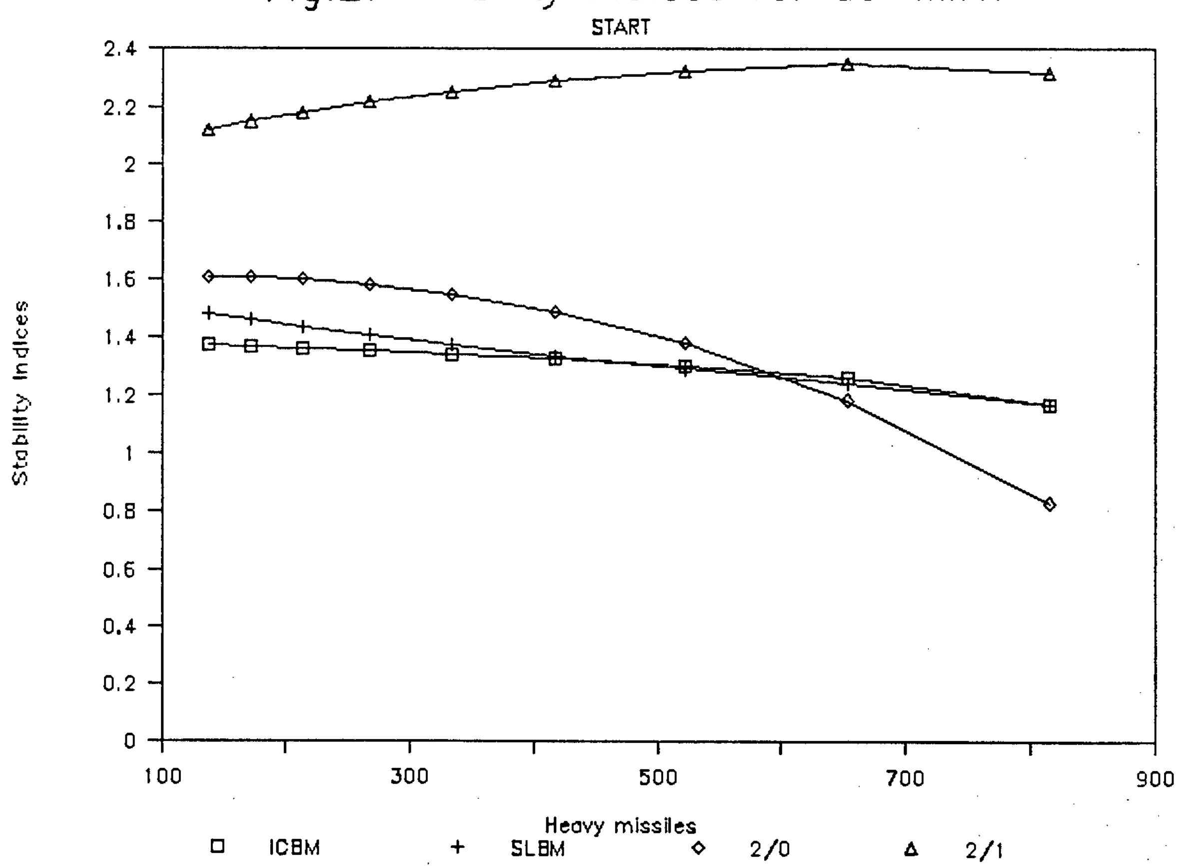

Fig.3. Stability for Launch on Warning

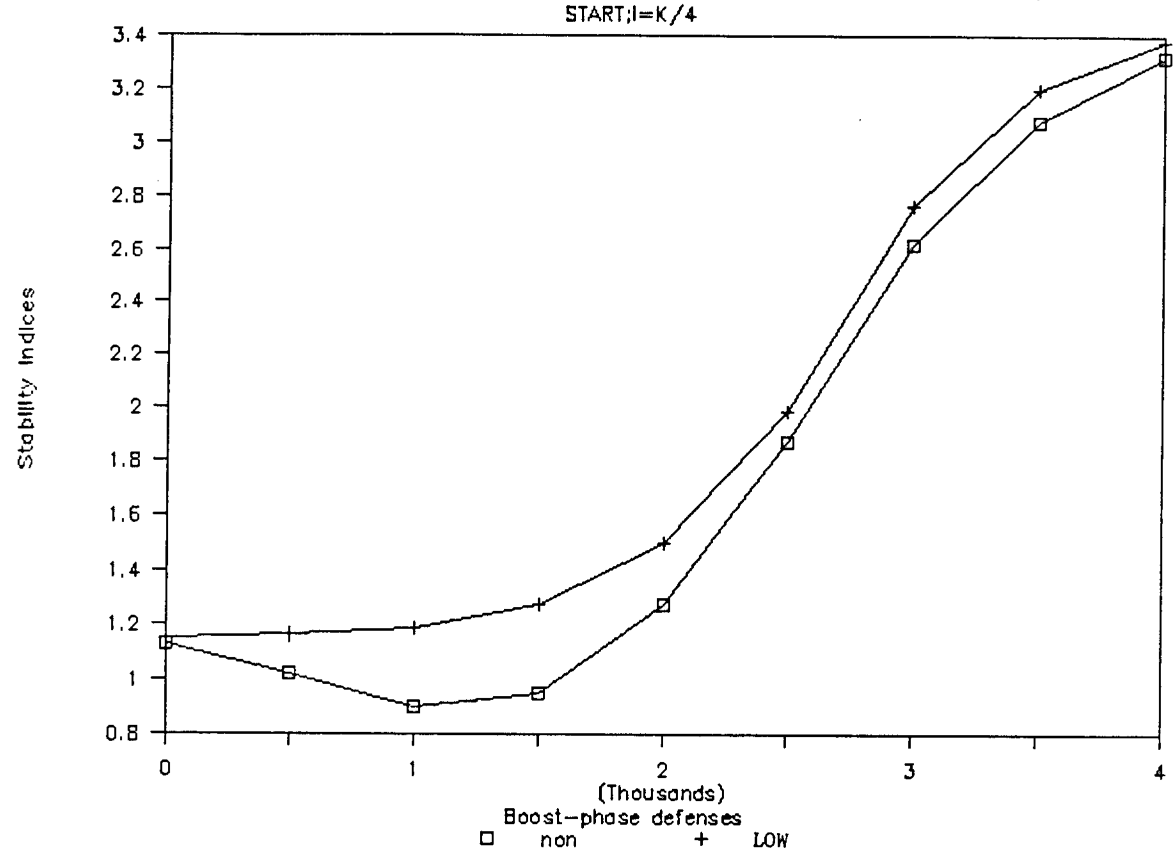

Fig.4. Indices–unilateral defense

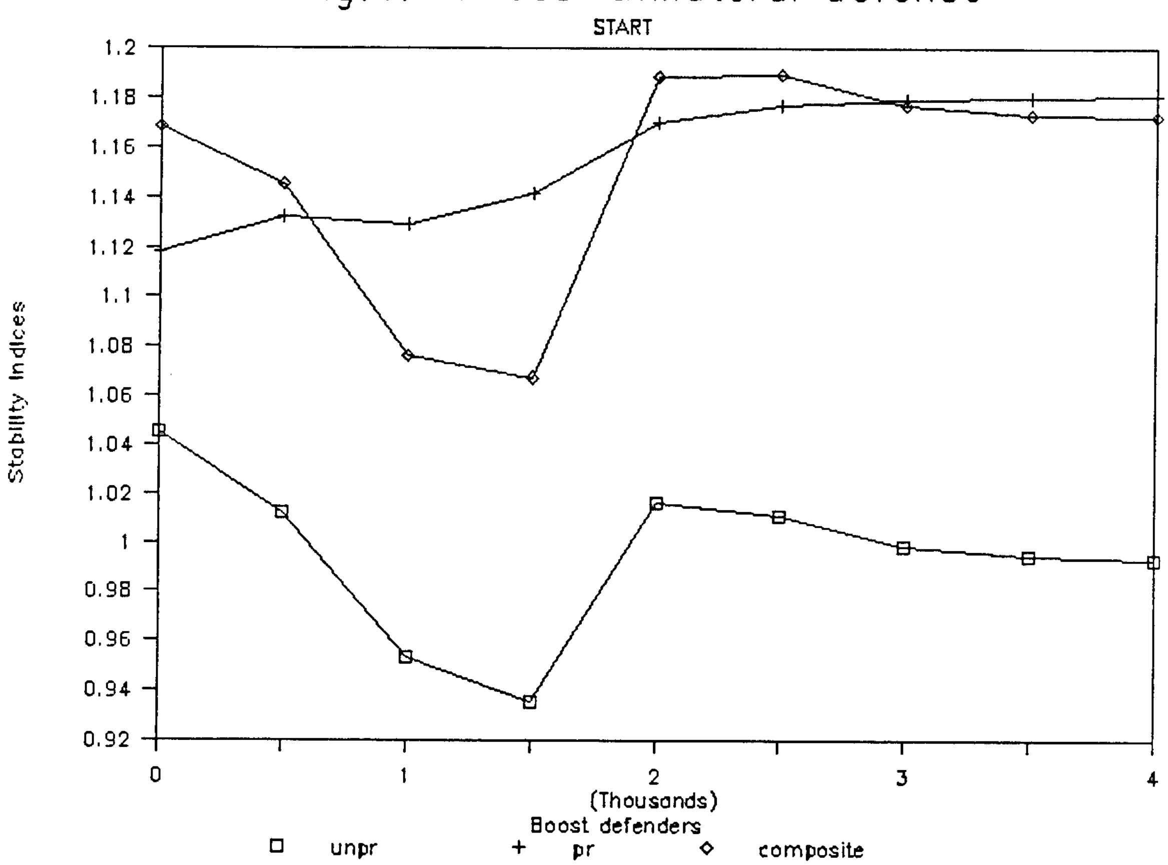

Fig.5. Indices for one sided defense

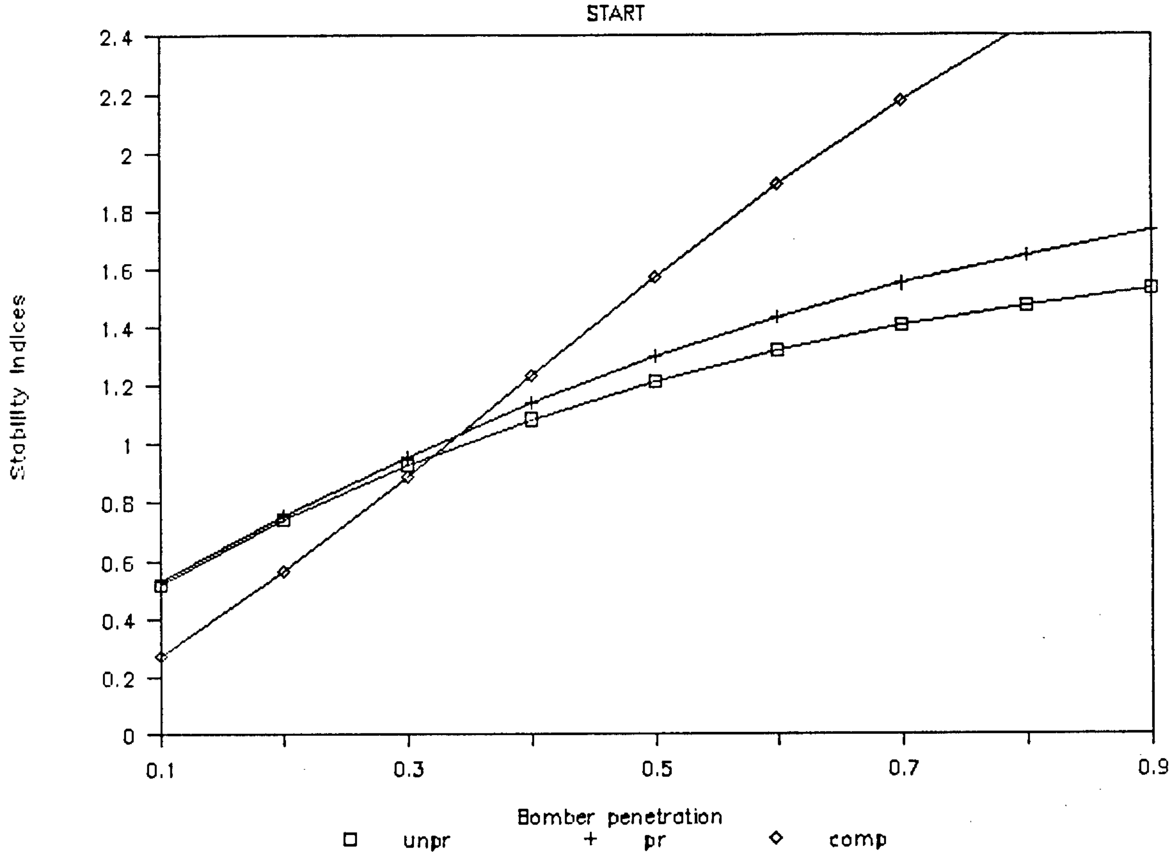

Fig.6. Stability indices vs defenses