Centre for International Relations Occasional Paper no. 41

MOBILE ICBMs IN THE CONTEXT OF START

By James S. Finan*

Centre for International Relations
Queen's University
Kingston, Ontario

August 1991

*Dr. James S. Finan is a Professor in the Department of Political and Economic Science, Royal Military College of Canada, and a Faculty Associate of the Centre for International Relations, Queen's University.

INTRODUCTION

A central element in the future strategic balance between the two superpowers is likely to be the structure of mobile intercontinental ballistic missiles (ICBMs) forces. Generally, there has been a good deal of concern associated with the deployment of these systems from the arms control community. The concern is that such systems will complicate the strategic relationship by decreasing both arms control and crisis stability--that is, they will encourage arms racing and in times of crisis, tendencies to launch-on-warning postures or even pre-emption. This can only be the case if such systems are in themselves more vulnerable target sets than systems now deployed or provide the superpowers with strategic technological offensive advantages hitherto unavailable in terms of the creation of significant numerical and/or technological asymmetries that can be converted into a credible pre-emptive strategy. At this point, the Soviet Union has deployed such systems while the United States has not. It appears, however, that the United States will probably seriously consider deploying some mobile ICBM force. The issues that then arise are ones of force comparability and related effectiveness in the context of the anticipated limits of any Strategic Arms Reduction Talks (START) agreement. This paper will attempt to consider some of these issues.

THE SYSTEMS AND THEIR EXPECTED CHARACTERISTICS

Both the United States and the Soviet Union have exhibited interest in mobile ICBMs with Soviet interest being more firm in that the USSR has already deployed significant numbers of mobile systems. Clearly, such systems offer advantages from the perspective of survivability at a time when the expected accuracies of ballistic missile re-entry vehicles on both sides are increasing significantly. In the case of the USSR, two systems are of concern. They are the SS-24 codenamed Scalpel and the SS-25 codenamed Sickle. The SS-24 is rail mobile or fixed- silo based and is capable of carrying 10 multiple independently retargetable re-entry vehicles (MIRVs) of 100 kilotons(kt) each.[1] The SS-25, on the other hand, carries one 750 kt warhead and is a road-mobile system deployed on a transporter erector launcher.[2] Accuracies for both systems are approximately 0.108 nautical miles (nm), which is quite high and near the limit of what can be achieved in purely ballistic terms. At present, the Soviet Union has deployed 60 SS-24s and 225 SS-25s.[3]

The United States for its part has indicated a positive interest in such systems. The Peacekeeper ICBM (previously the MX) can be deployed in a rail-mobile mode. The 50 launchers now deployed in a fixed-silo mode may well be redeployed in a rail-mobile format in the future. It is important to note that the maximum number of Peacekeepers to be deployed is likely to be fixed at the 50 now in place. The missile carries 10 MIRV each with a yield of 475 kt.[4] The small ICBM (SICBM), which has not yet reached initial operational capability (IOC) is expected to carry one MIRV of 475 kt.[5] A two-warhead version of the SICBM could be expected to carry warheads of a smaller yield. Yields in the order of 250 kilotons per warhead would be reasonable.[6] The SICBM is expected to be deployed in a road mobile mode on a hardened mobile launcher (HML). Expected accuracies for both systems are very high. Peacekeeper accuracy is expected to be .054 nautical miles (nm)[7] while the SICBM could be almost twice as accurate--that is, .030 nautical miles.[8] From a Soviet perspective, it is probable that planners would take a worst case position on such weapons and accept the highest expected values in terms of the accuracy of American systems.[9]

Given the information indicated above, it is clear that the survivability of ICBMs in fixed silos is being sharply challenged by the enhanced precision with which strategic systems are expected to strike targets over intercontinental ranges. Indeed, it is worth noting that the United States has in its Trident D5 the first submarine-launched ballistic missile (SLBM) which can pose an unequivocal threat to Soviet ICBMs in fixed hardened silos and their related launch control centres (LCCs). The implications for central strategic stability if this trend is not satisfactorily slowed could be quite negative. Mutual perceptions of increasing vulnerability could be encouraged. That being said, it is not clear what the force structures of the superpowers will look like in terms of deployed mobile ICBMs. An assessment of whether or not such systems will introduce a destabilizing element into the central strategic balance is contingent on the numbers of systems available to opposing forces as well as their capabilities. The next portion of the paper will attempt to give some sense of plausible force sizes within the context of proposed Strategic Arms Reduction Talks limitations.

MOBILE ICBMs IN THE CONTEXT OF START

While early American concerns about mobile ICBMs have moderated considerably, there is still a feeling that these systems need to be subject to some controls in the context of the on-going START negotiations. As of this writing, a START Treaty has just been signed, the details of which are not yet public. However, available information indicates that there will probably be a limit of 1100 mobile ICBM warheads.[10] If the United States deployed a maximum of 300 SICBMs and converted its silo-based

Peacekeepers to a rail-mobile mode, the largest number of warheads it could have on mobile systems would be 1100--that is, 10 x 50 or 500 Peacekeeper RVs and 2 x 300 or 600 SICBM RVs. The presence of the American inspired 1100 RV limit in START would suggest that the United States at a minimum wishes on the one hand, to keep its deployment options open in terms of mobile ICBMs and on the other, to prevent the unrestricted deployment of such systems by the USSR.

From a Soviet perspective, the final mobile force mix between the SS-24 and the SS-25 is not known. It is possible, however, to generate mobile ICBM force structures that are plausible. At present, the Soviets have deployed the SS-24 in both a fixed silo and mobile mode and have as well deployed 225 mobile SS-25s. It is not likely that the USSR would deploy new mobile systems and then decommission them in the near future. Therefore, it can be reasonably assumed that the number of SS-25s deployed will stay as it is, if not increase. If this is the case, then, the number of SS-24s required to generate an optimal force structure maximizing re-entry vehicles within the limits of START would be 87. At the same time, the number of SS-25s would need to increase from 225 to 230 to give a re-entry vehicle number of 1100. At the other extreme, the Soviets could choose to deploy no SS-24s in a mobile mode and have the entire force consist of 1100 SS-25s. The number of launchers for the Soviets could range from a low of 317 to a high of 1100.

The United States, if it deploys mobile systems at all, could similarly choose to deploy an SICBM with either one or two re-entry vehicles and a fixed number of Peacekeeper warheads (500). If the United States were to select a single RV SICBM, then its force structure in terms of allowable re-entry vehicles for mobile ICBMs would obviously be suboptimal. A single RV SICBM coupled with 500 Peacekeeper warheads would leave the United States 300 warheads short of the 1100 warhead START upper limit. The number of launchers would be 350, no matter what version of the SICBM was deployed. At a point in the paper during the discussion of preattack indicators, other reasons why such a force posture could be viewed as strategically unsound will be offered. Table 1 below sets out the range of re-entry vehicles and launchers available to be both sides depending on deployment options chosen.

Table 1

US and SU Mobile ICBM Deployments Within the START Mobile RV Limit

Country	Missile Type		Launchers	Warheads
USSR	SS-24	(hi)	87	870
		(lo)	0	0
	SS-25	(hi)	1100	1100
		(lo)	230	230
	Total RV	(hi)	1100	1100
		(lo)	317	1100
USA	Peacekeeper		50	500
	SICBMx2	RV (hi)	300	600
	SICBMx1	RV (lo)	300	300
	Total RV	(hi)	350	1100
		(lo)	350	800

MOBILE ICBMs AND STATIC INDICATORS[11]

Clearly, the relative effectiveness of mobile ICBM forces can be assessed in part in terms of numbers alone. A strongly asymmetric relationship in terms of strategic warheads (WHs) which is one static measure of relative force effectiveness is not likely to be acceptable in the long run. Given that warhead numbers are not too widely divergent, other static indicators designed to capture countervalue and counterforce effectiveness are likely to be of more importance in assessing the relative capabilities of each side. The degree to which the central strategic relationship is evaluated as stable, either overall or at any particular element, is almost certain to be contingent on these sorts of considerations. In judging the relative balance in terms of countervalue and counterforce capabilities for possible mobile missile forces, the Distinct Blasts Index (DBI) and the Pounds per Square Inch (PSI) Index respectively will be used.[12]

If comparative DBI values are considered first, some sense of the countervalue capability of Soviet and American mobile ICBM forces can be given. Recall that in Table 1 above the likely limits of force structures were offered, in part, in terms of what amount to a range of warhead mixes. Equally, it was indicated that other measures would suggest arguably more rational force structures. For Soviet systems, the equivalent megatonnage (EMT) for the SS-24 and the SS-25 is 0.22 and 0.83 respectively.[13] The combination of one of each of these warheads would produce an almost perfect distinct blast (DB) value--that is, 1.05 EMT. A perfect DB value is one EMT and therefore, the SS-24/SS-25 warhead combination is very close to the ideal. The more of this ideal warhead combination there is available, the better off the Soviet mobile ICBM force would be in terms of countervalue capability. The next Table gives the DB values for various Soviet mobile missile force structures.

Table 2

Soviet Mobile ICBM Force Structures
with Related DBI Values

SS-24 LNCHRS	SS-24 RVS	SS-25 LNCHRS/RVS	DBIs
0	0	1100	550*
10	100	1000	550*
20	200	900	550*
30	300	800	550*
40	400	700	550*
50	500	600	550*
55	550	550	550*
60	600	500	520
70	700	400	460
80	800	300	400
87	870	230	358

*Optimal DBI force.

It can be seen from Table 2 that from the perspective of optimizing DB values, the best force structure for the Soviet Union are to be found in a mix of 55 or fewer SS-24 coupled with 550 SS-25 or more. The reason this occurs has to do with residual DB values which are added to the total when the best DB combination--that is, one SS-24 plus one SS-25 warhead, is exhausted. For example, if 870 SS-24 warheads are deployed, it would take 230 SS-24 warheads plus 230 SS-25 warheads to produce 230 of the most efficient distinct blasts. There would be, however, a residue of 640 SS-24 warheads. If they were combined most efficiently to produce one DB, five of them with an EMT value of 1.01 would produce an additional 128 DBs (640/5=128). If this value is added to the initial 230 DBs, the overall value for a force of 87 SS-24 and 230 SS-25 is 358 DBs. Above 550 DBs, however, a new dynamic takes over. Residual warheads are then found in SS-25s rather than SS-24. Interestingly, in every case, the result no matter what the force mix is 550 DBs. For example, if 300 SS-24 warheads are available and are coupled with 300 SS-25 warheads, there is a residue of 500 SS-25 warheads. To maximize the DB value of these systems, the total number of residual SS-25 warheads is divided by two. This generates an additional 250 DBs. Note that the DB value in equivalent megatons for two SS-25 warheads is 1.66 and is considerably further from the ideal DB value of one EMT than is the SS-24/SS-25 warhead combination. Added to the original value, the overall force DB value becomes 300 plus 250 which equals 550 distinct blasts. Similarly, a force of 100 SS-24s leaves a residue of 900 SS-25 warheads which translates into a total force DBI value of 550. Consequently, after a force level of 550 DBs is achieved, there is no way of identifying the best force mix for the Soviets using only the countervalue criterion of distinct blasts.

In the case of American force structures, there are five optimal force structures which gives the highest value for DBI. Since the number of Peacekeepers is fixed at 50, the issue is one of the distribution between single and double warhead SICBMs. Table 3 offers a view of possible American force mixes and related distinct blast values.

Table 3

American Mobile ICBM Force
Structures with Related DBI Values

SICBMx2 RVs	SICBMx1 RV	PEACEKEEPER RVs	DBI
600	0	500	533*
580	10	500	533*
560	20	500	533*
540	30	500	533*
534	33	500	533*
520	40	500	530
500	50	500	525
480	60	500	520
460	70	500	515
440	80	500	510
420	90	500	505
400	100	500	500
200	200	500	450
0	300	500	400

*Optimal DBI Force Structures

In terms of the best DBI value for a force, it is clear from Table 3 above that a force mix of 50 Peacekeepers coupled with 267 to 300 double warhead SICBMs along with 33 to zero SICBMs with a single warhead are the most appropriate force structures. The value of a single Peacekeeper warhead plus a single warhead from an SICBM carrying two re-entry vehicles sums to 1.01 EMT which is extremely close to the ideal DB value of one. The same EMT and DB values are generated by combining a warhead from a single RV SICBM and a single warhead from an SICBM carrying two re-entry vehicles. The combinations in which all possible warheads from SICBM armed with two warheads are combined with either a Peacekeeper or single RV SICBM are the best of the possible American mixes. It is clear from the analysis that the highest possible countervalue capabilities for the Soviet and American mobile ICBM force structures are not the same. In the best possible situation, the United States would be weaker than the best Soviet case by 17 DBs(550-533). There would be little likelihood the United States would complicate its strategic command and control environment by mixing a small number of SICBMs with one warhead into a force composed mainly of Peacekeepers and the SICBM with two RVs. Planning optimally, the United States would select 600 SICBM warheads--that is, 300 SICBM with two RVs and an overall DB value of 533 which would give the Soviet Union a very marginal and strategically insignificant advantage. At the same time, the American force structure would have the maximum allowable number of warheads--that is, 1100 which would, of course, complicate Soviet targeting. If, of course, the United States were to deploy a suboptimal mobile force in terms of countervalue capability--that is, Peacekeeper coupled with only the single warhead SICBM, the overall American force DB total would be 400. The unrealized warhead capability would convert to 133 DBs removed from the American mobile ICBM force within allowable START limits.

Both superpowers could, then, deploy forces that would be, in two important measures, essentially symmetrical--that is, the numbers of warheads available and expected counter-value capability. In the case of DBs, in particular, this symmetry is likely to be of considerable importance in the context of helping to generate mutual perceptions that there can be in the context of any START deal a balanced and stable deterrent relationship at least in countervalue terms.

Counterforce or hard target kill capabilities are also likely to be of importance in assessing the stability of the strategic relationship. Certainly, the central strategic debate has exhibited a long-standing concern over this issue particularly in terms of the increasing Soviet ability to attack American ICBM assets in fixed silos and related launch control centres. It is for this reason that the United States has insisted on a limit of 154 launchers for the largest of the Soviet ICBMs, the SS-18. These facilities have been considerably hardened in the past few years so that their vulnerability to blast overpressure from nuclear attack has been substantially diminished. Nevertheless, relatively small increases in accuracy can theoretically overcome the expected capacity of hardened facilities to withstand attack.[14] Moreover, the hardening and superhardening of fixed facilities can be an extremely expensive proposition.[15] The combination of the relative ease with which efforts to enhance hardening can be defeated by increased accuracy coupled with the very significant costs associated with hardening or superhardening suggests that some new and different protective mode for land-based assets such as that some new and different protective mode for land-based assets such as mobility makes considerable sense in terms of enhancing stability. From this perspective, of course, mobile ICBMs make a significant contribution to mutual perceptions that superpower deterrence is based on a robust equilibrium by substantially reducing the probability of a credible first-strike as well as reducing the related tendency of both superpowers to move to relatively unstable launch-on-warning (LOW) or launch-under-attack (LUA) retaliatory postures. Even with substantial ICBM assets in a mobile mode, however, the issue of hard target kill capability will be of importance in evaluating the stability of central strategic relations since both sides will retain some fixed land-based time-sensitive and nontime-sensitive hard targets that will be vulnerable.[16] Therefore, it will be useful to get some sense of this relationship in terms of the relative counterforce capability of Soviet and American mobile forces. As was earlier indicated this will be done in terms of the PSI index.

This analysis has shown already that the Soviet force is likely to be a mix of both the SS-24 and the SS-25 and in terms of DBs, a set of best force mixes has been identified. In the case of the PSI index, the single shot kill probability is central to the development of the index values. For the Soviet and the American systems under consideration, SSKPs are given in terms of expected warhead effectiveness against a target hardened to withstand overpressures up to 2,000 pounds per square inch (psi). Single shot kill probabilities for the SS-24 and the SS-25 are 0.384 and 0.843 respectively against targets with this hardness.[17] Using these SSKP values the PSI index assessment for various Soviet mobile ICBM force mixes are given in Table 4.

Table 4

PSI Index Values for Various Soviet Force Structures

SS-24 RVs	SS-25 RVs	Force PSI
0	1100	927*+
100	1000	881*
200	900	835*
300	800	790*
400	700	744*
500	600	698*
550	550	674*
600	500	652
700	400	606
800	300	560
870	230	528

+Optimal PSI force structure
*Optimal DBI force structure

The counterforce trend in the force structures for the Soviet Union is quite clear from Table 4. As the number of SS-24 warheads increases, the overall value of the Soviet force PSI index declines. This is, of course, to be anticipated given the relatively weak expected performance of the SS-24 as a counterforce system compared to the SS-25. The SS-25s greater yield per warhead coupled with an accuracy equal to the SS-24 re-entry vehicle make it a considerably more potent weapon system. If the force mix which optimizes counterforce capability is considered, it is important to register that it is not suboptimal in the other measures of effectiveness--that is, in terms of warheads or distinct blasts. The decision for the Soviets would be whether or not they would choose to build a mobile ICBM force entirely around the SS-25 missile. It is probable that this would not be done since the combination of rail and road mobile systems would complicate American targeting options and in this case, complexity enhances expected levels of system survivability. That being said, the character of the Soviet mobile ICBM force might be used to indicate the strategic purpose of the force. Given that increases in the number of SS-25 above the 550 level would increase the counterforce capability of the Soviet mobile ICBM force, such a deployment pattern might lead to American concerns that the Soviets were anxious to emphasize the counterforce and offensive capability of their mobile forces while maintaining maximum countervalue potential.

In the case of American mobile ICBMs, the SSKP for potential systems is greater than it is for Soviet systems against the same level of hardness. For each Peacekeeper warhead, the value is .996. For the SICBM with one warhead, the expected single shot kill probability is 1.000 and for the SICBM with two warheads, it is 1.000.[18] In the case of the SICBM variants, it is interesting to note that the loss in counterforce effectiveness is quite small even though the yield of warheads in the two re-entry vehicle version of the SICBM is only half that of the single version. This condition exists because these systems are so accurate and confirms the comment made earlier in this paper that counterforce capability is enhanced much more by increases in accuracy than by increases in yield.

The counterforce capability for possible American mobile ICBM force combinations reflects a different form than does its Soviet counterpart. As the number of single re-entry vehicle small ICBMs increases the overall PSI index for American mobile forces declines. That is to say, the force structure maximizing SICBMs with two warheads which generated the best DB value is the same as the force structure with the best PSI index value. At the same time, it maximizes warheads. Table 5 below indicates this relationship.

Table 5

PSI Index Values for Various American Force Structures

SICBMx1 RV	SICBMx2 RV	Peacekeeper	PSI Index
0	600	500	1098*
50	500	500	1048
100	400	500	998
150	300	500	948
200	200	500	898
250	100	500	848
300	0	500	798

*Optimal PSI and essentially optimal DBI force structure.

It might be possible to infer from force structures the strategic intention for Soviet and American mobile missiles--that is, if a maximal counterforce emphasis were being sought along with maximal countervalue capability. Given the fact that only one force structure essentially satisfies the optimal conditions for both countervalue and counterforce, in the case of both the Soviet Union and the United States, the deployment of such forces could cause heightened mutual concern. The United States, however, has good technical and economic reasons such as better command and control and reduced costs for deploying the mobile ICBM force which just happens to maximize counter-force as well as counter-value potential. Such a condition could possibly offer the United States strategic planning flexibility. If the Soviet Union were unable to judge with high confidence the clear intentions of the United States in relation to this part of its central strategic force structure, Soviet planners might be presented with the requirement to adopt a more complex strategy to deal with both possibilities. In this context, it is again the case that planning complexity likely translates into increased survivability and heightened stability. On the other hand, since the United States could evaluate that a mix of 550 SS-24 and SS-25 warheads respectively would maximize Soviet countervalue capability without maximizing counterforce capability, it might be in a position to question the general strategic and specific retaliatory utility of a force of SS-25 missiles above the level of 550. In this context, Soviet and American cases are not strategically symmetrical, of course, because the Soviet Union has already embarked on the deployment of mobile ICBMs with different arming characteristics while the United States has not.

MOBILITY AND SURVIVABILITY

Mobile ICBM forces are relatively immune to the kinds of counterforce threats with which forces in fixed silos must contend. If the ICBM assets of either superpower were mainly or completely in a mobile mode, prompt hard target kill capability is not likely to be a pivotal issue in force posture planning. In the case of mobile ICBMs, the issue of the survivability is decided not by the ability to withstand high destructive overpressures but mainly by the inability of an opponent to find and to attack effectively such a force.[19] Consequently, the question of either side's proficiency in counterforce capability may be one of declining concern to the Soviet Union and the United States as more ICBM forces become mobile.[20] In this context, the Report of the President's Commission on Strategic Forces (Scowcroft Commission) comments that accuracy is ultimately likely to overcome any efforts at silo hardening and comments further on the utility of mobility:

> Mobile deployments of US missiles would require the Soviets to try to barrage large areas using a number of warheads for each of our warheads at risk, to develop very sophisticated intelligence systems, or both. In this context, deployment of a small single-warhead ICBM in

hardened mobile launchers is of particular interest because it could permit deployment in peacetime in limited areas such as military reservations.[21]

From an American perspective, the deployment of SICBMs with one or two warheads would meet the objectives indicated above particularly in the context of a START agreement which limited both Soviet mobile ICBMs and "heavy" SS-18s which also pose a serious threat to American ICBM assets. It would seem sensible for the United States to deploy an SICBM with two warheads rather than one given the advantages that would accrue in terms of amplifying the countervalue and retaliatory character of the mobile force. Such an advantage could be achieved without offending any of the principles associated with the SICBM approach indicated in the Scowcroft Commission report.

The strategic benefits which would derive from mobility in relation to American strategic forces would presumably apply with equal force to their Soviet counterparts. The array of plausible force structures which maximize DBs offers the Soviet Union an assortment of strategic planning opportunities. It would be sensible, therefore, to conclude that the overall stability of the strategic relationship would be enhanced by the Soviet deployment of mobile ICBMs within the confines of a START regime. Moreover, the increased counterforce potential in a force with more than 550 SS-25s is not something which could be seen sensibly as a challenge by the United States. If the United States were to raise concerns over an apparent Soviet effort to enhance the counterforce capability of its mobile force by deploying large numbers of SS-25s (greater than 550), this would hardly be a credible grievance given the relative superiority the optimal American mobile ICBM force structure would have in this dimension of strategic capability. In fact, it is more likely that if negotiating complexities hamper the conclusion of a START treaty, they will relate to, among other things, significant Soviet apprehension about this considerable American counterforce advantage. Nevetheless, diminished concern about the vulnerability of fixed ICBMs that is likely to develop as mobile ICBMs are deployed in the context of an appropriate strategic arms control agreement may mean that the long-standing and vexatious counterforce problem could be eliminated from superpower strategic consideration.

MOBILE ICBMs, VERIFICATION AND ARMS CONTROL

Arms control concerns about mobile missiles relate largely to the issue of verification. More precisely, there is the concern that one or both sides could exceed agreed limits without being detected and that this numerical edge could translate into a significant military advantage particularly during a crisis. Indeed, it is argued that if this advantage were great enough, the party that felt itself to be in a stronger position might be tempted to pre-empt an opponent and to convert technological superiority into direct military payoff. Since both sides are aware of this prospect, it is argued further that there would be a mutual incentive to seek simultaneously a strategic edge and to reduce thereby strategic vulnerability. This entire line of argumentation is driven largely by the notion that since mobile systems can move, it is difficult to detect them and therefore, it would be easy to cheat on any agreement. In general, those concerned about mobile ICBMs fear that such systems will contribute to both arms control and crisis instability.

In fact, it may not be more difficult to monitor adequately the numbers of mobile missiles than land-based missiles housed in fixed numbers of mobile missiles than land-based missiles housed in fixed hardened silos or the numbers of submarine launched ballistic missiles. In general, mobile ICBMs need to be verified effectively 1) so that the likelihood of significant cheating is quite low and 2) so that an inspector will not have a feasible chance of using the inspection process to enhance significantly the prospects for directing a viable pre-emption against the inspectee's forces. A comprehensive verification approach for mobile ICBMs could involve existing national technical means; a constrained touring area with a controlled entry/exit point and a challenge inspection regime including intrusive inspection based on the "open-skies" model. The size of any touring area would likely be a function of the number of mobile systems deployed coupled with an assessment of an opponent's capacity to barrage effectively such an area in an attempted surprise attack. Existing national technical means of verification could likely be used to maintain the integrity of touring areas as well as helping with monitoring a controlled access point. A potentially effective statistical method of verification for mobile missile forces in the context of challenge overflights has also been suggested. This last verification element is worth looking at in some greater detail. The approach suggests the use of tags as one way of satisfying the two requirements set out above in the context of instrusive inspection. A general description of tags will help to introduce the approach:

> "Tags are entities which somehow label an individual or class of weapon systems, physically or otherwise, to increase a verifier's confidence in his observations."[22]

Such a method, coupled with existing national technical means of verification could operate so that an overall verification regime could be developed to monitor effectively mutual inclinations to breakout. Thus, their ability to reduce significantly system vulnerability could probably be achieved simultaneously with a credible verification regime which should ensure that neither arms control nor crisis stability would be increased if such systems were deployed.

To give more detail to the overflight verification argument it may be useful to illustrate what is possible by applying the "tagging" scheme referred to earlier. Using overflights[23] of mobile ICBM fields with presumably some form challenge inspection regime, it would be possible not to discover the exact number of mobile systems, but rather to gain a sense of what the probable maximum level of deployed missiles would be. If, for example, both the USA and the USSR deployed the optimal countervalue force structures indicated above--that is, 350 launchers and tags for the United States and 550 launchers and tags for the Soviet Union a valid evaluation of the mean, high and low expected numbers could be gained. The low value would not, of course, be of much interest unless it indicated that the distance between expected high and low limits was becoming unacceptably wide. Using the illustrative numbers for tagged and untagged observations during independent inspections[24] given in the tables below, the values indicated for American and Soviet forces can be acquired.

Table 6

US Inspection of SU Mobile ICBMs

Total Inspections	Total Systems Seen	Systems With Tags
130	90	88(80)
121	69	69(60)
93	93	91(90)

In the situation above, American inspectors in the first challenge carried out 130 inspections and saw a total of 90 mobile ICBMs. Of that total, 88 were colocated with active tags. The subsequent challenges can be similarly explained. For an American inspection of the Soviets, using the illustrative numbers for inspections and detections in Table 6, results would be an average number of mobile launchers of 559 with a 90 percent probability that the actual launcher number would be between 550 and 568. If, however, the difference between the number of systems detected and the number of systems detected with tags became too great, the distance between the upper and lower limits would increase. For example, if the launchers detected with tags became the numbers in parentheses in Table 6, the expected value for mobile launchers would become 608 with related low and high limits of 564 and 651 respectively. A high value of 651 if it were true would likely pose an immediate and serious sense of uncertainty in terms of perceptions of the increasing vulnerability of significant elements in the American target set. Depending on the type of systems with which cheating was being done, a substantial warhead advantage could be available to the USSR.

The next table indicates illustrative inspection values for the Soviet verification of an American field.

Table 7

SU Inspection of US Mobile ICBMs

Total Inspections	Total Systems Seen	Systems With Tags
100	50	49(30)
95	45	45(20)
108	86	85(50)

For a Soviet inspection of the United States, the expected number of launchers would be 354 with a 90 percent probability that the actual number of launchers would be between 350 and 358. Illustrating a worse case again using the numbers in parentheses, the expected quantity of launchers would become 640 with a high and low limit of 774 and 507 respectively. Such a difference might well be problematic for the USSR. If it were to view the high value as valid and suspected the United States of cheating on the deployment of SICBMs with two RVs or the Peacekeeper, the Americans could have a warhead excess which would be substantially over the 1,100 warhead START limit. Such potential discrepancies as those indicated above might well need to be checked closely by both the United States and the Soviet Union respectively if they were to regain a sense of confidence in the any strategic arms control arrangement. It would be prudent, therfore, to complement the process of verification through technical means via overflights in response to a tag signal by a follow-up visual sighting. This would help to ensure that cheating was not occurring for example, by co-locating more than one launcher with one tag. It would not be the case necessarily that such an apparent act of cheating would comprise a certain violation of treaty agreements. It could indicate, for example, that tags were unreliable or turned off.[25] In either case, a subsequent and more precise challenge could be initiated which could include an on-sight evaluation of suspicious situations. The point of all this, of course, is that such an extended verification procedure could reduce substantially fears about strategic breakout through cheating on prescribed limits. At the same time, the system could be devised so that a verification system could not be used to advantage in terms of providing useful information around which to organize an effective attack on mobile systems. Given that mobile launchers can relocate at reasonable speeds, they could easily and very quickly move from positions in which their presence had been detected for verification purposes and thus reassert the targeting difficulties normally associated with mobility. The illustrations above have dealt with road-mobile systems. The approach could, of course, with some alterations be adapted for the inspection of rail-mobile ICBMs.

CLOSING REMARKS

From the perspective of classical deterrence theory, increases in the vulnerability of deterrent forces of the magnitude probable if mobile ICBMs are not deployed would undercut seriously the way in which a stable deterrent relationship is expected to operate. What must be avoided if at all possible in the context of stable deterrence is a situation where military planners on either side must accept the stark options of either loosing a very significant element of their deterrent inventory or using such assets before they are destroyed. Neither side in the central relationship can expect stability if for whatever reasons strong tendencies to pre-emption or LOW/LUA strategies are stimulated. Mobile ICBMs deployed by both superpowers within the context of START and a related credible verification regime could help significantly in forestalling such developments. In effect, what mobile ICBMs offer land-based forces is the sort of protective and stabilizing characteristics normally associated with the SLBM/SSBN[26] combination in the context of superpower strategic relations. Anticipated high levels of invulnerability would seriously hamper tendencies to pre-emption. Concern over the deployment of mobile ICBMs from an arms control perspective particularly in relation to

ICBMs from an arms control perspective particularly in relation to effective verification should not become markedly greater than is now the case. It is reasonable, therefore, to argue that the verification of mobile systems is likely to be manageable in technical terms.

The observation that the issue of the deployment of mobile ICBMs is a complex one is not overstated. It simultaneously impinges on concerns about enhanced strategic stability and diminished confidence in verification. On balance, however, the positive implications for stability are likely to overshadow possible increases in verification complexity for which there are workable solutions.

Notes

The author would like to acknowledge gratefully the advice and useful criticism received from Dr. William J. Hurley, Department of Political and Economic Science, Royal Military College of Canada in the course of preparing this paper. Errors and omissions are, of course, entirely the author's responsibility.

[1]In The Military Balance 1990-1992, London, The International Institute for Strategic Studies, 1990, p. 221 the yield of the SS-24 is given as 100 kt per warhead.

[2]Ibid., p. 221.

[3]Ibid., p. 221.

[4]The yield per warhead for the Peacekeeper is given as being 300 to 400 kilotons (kt). Ibid., p. 216. Elsewhere the yield is indicated as being 300 kt on deployment with a capacity to be upgraded to 475 kt. See Thomas B. Cochrane, William M. Arkin, and Milton Hoening, U.S. Nuclear Forces and Capabilities, vol I, Natural Resources Defense Council Inc., 1984, p. 126. From a Soviet perspective, it is almost certain that they would "worst case" their assessment of the Peacekeeper and put the yield per warhead at 475 kt which is the value to be used in this analysis.

[5]The single warhead SICBM is likely to carry one W87 warhead similar to the ones on the Peacekeeper. See Ibid., pp. 125 and 132 to 133.

[6]Warheads that now exist such as the W76 with a yield of 100 kt might be candidates in that they could be accommodated within the throw-weight limits of the SICBM, but such a low yield would not likely be very suitable from the perspective of American force planners. Other warheads such as the W78 offer acceptable yields but are too heavy for two to be carried on the SICBM. The W80 designed for both the air-launched and sea-launched cruise missiles has a yield and weight that is acceptable (yield = 200-250 kt; weight = 270 pounds). Presumably, such a warhead could be modified to meet the needs of a SICBM carrying two re-entry vehicles. See Ibid., pp. 74, 75, and 79.

[7]The Military Balance 1990-1991, op. cit., p. 216 gives a circular error probably (CEP) for Peacekeeper of 100 metres which is .054 nm.

[8]Data on SICBM accuracy is from Thomas B. Cochrane, et. al., op. cit., p. 133.

[9]This paper is based on the assumption that the United States will in fact deploy a force of mobile ICBMs. It could, of course, continue with its present ICBM force Minuteman II, Minuteman III, and Peacekeepers in fixed silos. If this is done, however, the vulnerability of these assets could become perilously high as Soviet accuracies increase. Such a deployment posture would not be prudent in the context of maintaining and enhancing the stability of the central deterrent relationship.

[10]The limit of 1100 warheads for deployed mobile systems as a START constraint is given in Soviet Military Power 1990, The United States Department of Defense, Washington, D.C., 1990, p. 14.

[11]For information on static (preattack) indicators see Jeffery T. Richelson, "Evaluating the Strategic Balance," American Journal of Political Science 24 (4), November 1980, pp. 779-803 and Jeffery T. Richelson, "Static Indicators and the Ranking of Strategic Forces," The Journal of Conflict Resolution 26(2), June 1982, pp. 265-282.

[12]The DBI is defined as "...the maximum number of distinct one-equivalent megaton or greater blasts that can be generated from a strategic arsenal. Each one-equivalent megaton or greater blast could be generated from either a single weapon or a combination of several weapons. The selection of one equivalent megaton as the unit of division is justified by the observation that all cities can be either severely damaged or totally destroyed by a one-equivalent blast at their centre." Richelson (1980), op. cit., p. 784. The PSI index sums the kill probability of all warheads against a nominal hard-point target value. See Richelson, op, cit., (1982), pp. 274-275. The equations used for the calculation of SSKP are given in Lynn E. Davis and Warner Schilling, "All You Ever Wanted to Know About MIRV and ICBM Calculations But Were Not Cleared to Ask," The Journal of Conflict Resolution XVII(2), June 1973.

[13]EMT calculated by the author.

[14]Increasing accuracy is always better than increasing yield. If the accuracy of system is doubled, the destructive capacity of the warhead increases by a factor of about four without any increase in warhead yield. For a detailed exploration of this phenomenon see James S. Finan, "Arms Control and the Central Strategic Balance: Some Technological Issues," International Journal XXXVI(3), Summer 1981, pp. 435-436.

[15]Dunnigan argues that increasing silo hardness from 300 to 1,000 psi raises the cost per silo of $ 1.2 million and that hardening to 3,000 psi increases that cost to over $ 5 million per silo in 1982 American dollars. See James F. Dunnigan, How to Make War: A Comprehensive Guide to Modern Warfare, William Morrow and Company, New York, 1982, p. 296.

[16]Time sensitive hard targets are ICBMs in fixed silos and related LCCs. Non-time sensitive hard targets comprise hardened urban/industrial infrastructure targets and strategic battle management and control facilities.

[17]SSKP values calculated by author.

[18]The expected effectiveness of the SICBM in either variant is so great its SSKP is essentially 1. This is a remarkable technological advantage for the United States and highlights the Soviet requirement to deploy its ICBM assets in a mobile mode before the United States brings its newest systems into its strategic inventory.

[19]For some useful detailed comments on this issue see Jeffery T. Richelson, "Multiple Aim Point Basing: Vulnerability and Verification Problems," Journal of Conflict Resolution 23(4), December 1979, pp. 626-627.

[20]There is concern about the most modern large single warhead of the SS-18--that is the SS-18 mod 6. In the context of START the SS-18 will be limited to 154 launchers. Each additional SS-18 mod 6 that is deployed would count against this limit of 154 launchers. In effect, every SS-18 mod 6 deployed would deprive the USSR of 9 SS-18 mod 5 RVs. Possibly, the Soviets might consider the SS-18 mod 6 as a system which could be used to barrage mobile systems in concentrations prior to their being flushed in crisis. There is very little data on the SS-18 mod 6 in the open literature. In Soviet Military Power 1990, op. cit., p. 52, the observation is made that:

> "Silo conversion is underway to replace older versions of the SS-18--the bulwark of the SRF (strategic rocket force) hard-target kill capability--with more capable versions. These include the SS-18 mod 5 [with substantially more accuracy and warhead yield and equipped with multiple independently targetable reentry vehicles (MIRVs)], and the single warhead mod 6."

No indication of yield is given for the mod 6, but it will certainly be large. Previous single RV versions of the SS-18 were the mod 1 at 25 megatons (mt) and the mod 3 at 20 mt. See Bernard Blake, ed., Jane's Weapon Systems 1988-89, Jane's Information Group, Coulsdon, Surrey, 1988, p. 8. Such a system might be of utility in attacking drag sensitive targets such as mobile ICBMs in rail and road mobile modes respectively. In the case of rail mobile systems caught in the open, severe damage could be expected from a 20 mt blast at about 31/2 miles while for a 25 mt blast, similar damage would be expected at about 4 miles. For road mobile in the open systems severe damage could be expected at about 6 miles and from either a 20 or 25 mt warhead. Values calculated from Samuel Glasstone and Philip J. Dolan, eds., The Effects of Nuclear Weapons, 3rd edition, prepared and published for the United States Department of Defense and the United States Department of Energy, 1977, Figure 5.146 Damage-distance relationships for drag-sensitive targets, p. 223.

[21]Report of the President's Commission on Strategic Forces, Washington, April 1983, p. 15.

[22]A useful article on verification with direct reference to mobile ICBMs and statistical methods of effective verification can be found in Steven B. Davis, "Verification and Compliance for Arms Control," Comparative Strategy 9(4), 1990, pp. 403-413.

[23]It is interesting to note that the approach is based on the "open skies" mode of verification which has recently been of interest to the Canadian government in early 1991.

[24]David is not entirely clear as to what comprises an inspection other than to indicate that they must be independent for statistical reasons. In the context of this paper, an inspection is defined as a single effort by an overflight inspector to verify the existence of a single mobile ICBM either by acquiring a tag signature or through visual acquisition.

[25]Davis makes allowance for tags being turned off which would, of course, be a useful confidence building feature so that if a crisis occurred neither party could use verification technology to enhance attack effectiveness.

[26]An easier way, of course, to gain the benefits of SSBN invulnerability is to deploy these systems directly rather than relying on mobile ICBMs. If for technical reasons, ICBM technology is better than SLBM technology which may well be the case with the USSR, then mobile ICBMs become a sensible option.