Evolving Strategic Arms and the Technologist

New strategic options raise questions outside the framework of existing theory.

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Scope of the Problem

It has been roughly 20 years since essential features of the strategic theory for intercontinental ballistic missiles bearing nuclear warheads were enunciated. The large body of thought and writing on the role of such missiles in the strategic posture of the United States rests upon that platform of thought, which now might well be called classical strategic theory. Theory, furthermore, is the proper term since these concepts are based neither on experience nor on historical precedent.

The apparent success of this theoretical framework, which was nearly fully developed within the decade following the advent of the nuclear age, has been striking. It has defined a broad arena for investigation and has provided the underlying rationale for developing major U.S. military systems, both land- and sea-based. While classical strategic theory has demonstrated its utility by resolving in a consistent and seemingly sensible manner questions of policy about the strategic posture of the United States, the question now is, Will it continue to prove adequate? Will it provide a sufficiently broad basis on which to resolve the strategic policy decisions anticipated in the near future?

It is conjectured here that strategic theory as now formulated will prove obsolete and inadequate in the near future. These deficiencies will derive from its failure to encompass parameters of obvious and growing significance, such as treaty limitations, MIRV's (*1*) with greatly enhanced accuracy, real-time attack assessment systems, and missile quick-launch capabilities. The question raised is not one of validity within the existing theory's domain of applicability. Rather, it is a call to extend existing theory to encompass a broader range of extremely significant factors.

As a point of departure, it is important (i) to reexamine the essential features of existing strategic thought to recognize the constraints limiting its range of applicability; (ii) to note explicitly those foreseeable changes that may require the extension of existing theory if it is to continue as a basis for decisions; (iii) to demonstrate convincingly that a more encompassing theory will indeed be required; and (iv) to suggest an approach to a more broadly applicable strategic theory that includes the foreseen changes.

Existing Theory

The details of classical strategic theory and the historical sequence of the changes in the military capabilities of the United States and the Soviet Union that have led to the current postures have been adequately described and discussed on many occasions. It is essential, however, to examine classical strategic theory from the viewpoint of assessing its fundamental implicit assumptions and constraints, for these are what limit its relevance to the new situations.

From this special viewpoint, one of the key underlying features of classical theory as it applies to strategic missile forces is that the detailed tactics of operation—targeting and timing in particular—are, at least in the United States, largely predetermined. These decisions result from a planning process and are set forth in a document known as the "Single Integrated Operations Plan." Selection of zero or initiation time and specification of geographic exclusion areas are, of course, left open to choice. Changes in this plan are made routinely after appropriate study and analysis. However, it is not envisioned that U.S. actions will be adjusted as the strategic engagement unfolds. Thus, option or suboption choices are not keyed in any substantial way to the perceived details of enemy hostile actions. Even the repeated calls by a President for greater flexibility are most often interpreted as a desire to have greater diversity in "precut" options, not flexibility that would include detailed in-battle selections among options.

A second key feature of classical strategic theory is that it encompasses only exceedingly simplistic, first-order calculations of the interactions between our strategic units and those of a putative enemy. In considering the possibility, for example, of a Soviet countermissile strike, while miss-distance, yield, and silo strength are combined to calculate the probability of silo and missile destruction, in most cases no other type of interaction is included. Evaluation of the capability of the United States to mount a retaliatory countermissile strike is viewed as requiring inclusion of these same parameters plus a factor to correct for some fraction of the Soviet missile silos having already been used. Essentially the theory assumes that the attacked side is static while the attack occurs.

Only in discussions of ballistic missile defense have notions of dynamic interaction been introduced in a fundamental way into strategic evaluations. Yet even in this case, preplanned tactics are, in most cases, the only type of operation seriously considered. And these moves toward dynamic interaction have not as yet been carried over in any significant way into U.S. thinking about the interaction of strategic offensive missile forces.

A third key feature of classical theory is the simple measure of utility generally considered. For the countervalue case, total fatalities and manufacturing floor space destroyed are the customary measures. In the case of a countermissile strike, the number of missiles left or the associated ratio of missiles expended to missiles destroyed, an exchange ratio, has been the only generally used measure of effectiveness. The strength of a given country's strategic missile system is still discussed in terms of elementary (bean counting) parameters such as number of reentry bodies, silos, and missiles, or total throw weight or deliverable yield.

For the 1960's, these descriptors and calculational procedures seemed adequate largely because the questions posed were comparably simple. Countervalue (rather than counterforce) attacks and the threatened massive loss of life and destruction resulting therefrom were the primary de-

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terrents these systems were publicly called upon to pose. Early concerns with counterforce strikes against strategic systems were effectively limited by switching from soft systems to hardened silo launchers, seaborne concealment, and aerial alert.

However, numerous questions once easy to avoid or lacking technical credibility are now coming to the fore. As will be shown later, the theoretical aspects of both interaction and utility functions can no longer be kept so simple. At this point it is worth noting more explicitly some of the underlying changes.

New Factors and Parameters

It does not require looking far into the future or invoking exotic possibilities to perceive developments that will have great impact on strategic force decisions. Many changes of importance are, in fact, already well under way; their impact will be felt soon. Four areas of change are singled out for discussion here: treaties and agreements, MIRV's with enhanced accuracy, surveillance, and quick launch. Ongoing developments in these areas alone will carry strategic policy decisions well outside the framework of classical theory.

Treaties and agreements. The SALT exchanges exemplify the multiplicity of arms control negotiations now taking place with increasing frequency and giving rise to two interrelated phenomena. The first and most obvious phenomenon has been agreements to limit some aspects of the so-called numbers race. The most recent agreements, those resulting from the Vladivostok meeting in November 1974, have set limits on total numbers of strategic delivery systems, and within this framework, on the numbers of "MIRVed" systems. Other numbers limitations relating to various weapon classes have also received consideration.

One result of numerical constraints will be to shift attention to more detailed questions about the structure of the strategic nuclear forces. There will be heightened concern with the qualities of these forces and new efforts to quantify these qualities. Furthermore, more attention will be devoted to the contributions that ancillary systems can make to the utility of limited strategic missile assets.

A second phenomenon deriving from continued arms control discussions is a likely increase in the detailed examination given by all parties to relevant military capabilities. Certainly the discussions to date with the Soviet Union have caused the United States to focus more attention on precise and detailed estimates of Soviet strength. These discussions have made us reexamine our own posture: not only as a prelude to accepting limitations, but also because reflection through the prism of Soviet concerns has suggested additional (though not necessarily valid) concerns. These detailed studies also tend to draw more attention to what previously were considered only secondary features of the military postures of both sides, for example, characteristics such as propellant volume, guidance precision, and command facilities.

It is also important to note that no matter how extensive and detailed limitation agreements may become, and despite intensive study, it is unlikely that either party will be able to feel confident about the other's operating plans and intentions. Should there be greater movement toward similarity in hardware on both sides, then even greater emphasis will be accorded to innovative operational planning. Thus, ongoing developments in the area of treaties and agreements are likely to raise new and significant questions about military posture evaluations, ancillary systems, and employment tactics.

MIRV's with enhanced accuracy. A second major area of change that strategic theory must encompass is the increasing technical sophistication and capabilities of the payloads for strategic missiles. For both the United States and the Soviet Union, MIRV's are a reality. Beyond MIRV, maneuvering reentry vehicles, extremely hardened reentry bodies, or terminally guided reentry systems (or combinations) are potential force additions. Proceeding apace with these developments is steadily improving accuracy. Where once a circular probable-delivery error of a mile was considered an outstanding achievement for an ICBM system, current goals are measured in small fractions of a mile.

"MIRVing" with markedly enhanced delivery accuracy is a change of great importance. Greater accuracy reduces the yield and thereby the weight of a warhead required to achieve a high probability of silo kill with each reentry body. The lighter the warheads, the greater the number of reentry bodies that can be delivered by a given missile. These technologies can lead to a capability whereby one missile can be used to threaten or destroy several of the opponent's missile silos.

This possibility, that ICBM's may be used against each other rather than only against extensive soft targets such as cities, clearly must be encompassed by an adequate strategic theory. It is easy to see that the acquisition of such capabilities will give rise to operational employment questions. Furthermore, it may lead to new forms of mutual force instabilities (between the United States and the Soviet Union) and result in additional force posture changes.

Surveillance. A third major area of change is the growing capability of the United States and the Soviet Union alike to observe what is happening in a strategic exchange. Indeed, the growing belief in the capabilities of "national means of verification" has played a major role in promoting U.S. acceptance of arms limitation agreements. What can be achieved by these means is growing rapidly. There is every reason to believe that these capabilities will have an impact on warfare capabilities. Yet public discussions of these impacts have been singularly limited.

Studies of ballistic missile defense systems have indicated that it is technically feasible to determine which silo is threatened by a given reentry body at least several seconds before the body arrives at the silo. Information as to the general area of warhead impact can be provided much earlier. As the general capability of radars and computers increases, what is technically feasible in this area will grow.

National means of verification can also be upgraded to provide more nearly real-time information about launches. In fact, the United States has announced that it can now sense immediately a Soviet rocket launch. An ability to identify from which silo a missile has been launched soon after firing might become a reality for both the United States and the Soviet Union in the near future.

In the past, capabilities for silo surveillance have been discounted by some because of a dependence on satellites, which were limited in their capabilities and vulnerable to enemy action. But the general capabilities of satellites that might be applicable to silo surveillance are being developed and expanded for a variety of reasons. Furthermore, while satellite vulnerability appears to be a key issue, their maneuverability and self-protective surveillance may eventually be improved and combined to ameliorate even this problem. Thus, surveillance has been, or is about to be, improved to a level where, in terms of knowing what the opposition is doing, tactical interaction in the strategic arena will become a possibility deserving consideration. As this becomes so, capabilities of those systems that permit attack prediction, enemy posture evaluation, and damage assessment require quantification and inclusion in the strategic calculus.

Quick launch. Almost from their inception, the ICBM systems of the United States have been designed to have what is called "readiness." Typically, both Minuteman and Polaris are reported to be capable of launching from their normal posture in minutes. The genesis of this require-

ment is not clear, although it does considerably simplify attack integration. Furthermore, in an era when all launch configurations were soft, it could have had some survival value against slow and observable attacks such as those by bombers.

Ballistic missile defense discussions, however, were based on an ability to launch defending missiles in times far less than 1 minute. In some cases the times quoted were specified to be much less than that required for the attacking reentry body to descend through the atmosphere.

This growing capability to design large payload missiles that can quickly depart from the launch area again suggests a future in which the tactical interaction of strategic systems will become a reality. Coupled with the enhanced surveillance capabilities noted above, the result can be to give the United States and the Soviet Union an ability both to know what the other is doing and to react while that hostile action is taking place. These capabilities must also be addressed by a comprehensive strategic theory.

An Extreme Example

In the preceding section an imminent set of changes in strategic systems has been outlined, and due allowance for these changes should be made in the framework of strategic theory. Implicitly suggested is the possible tactical interaction of strategic systems, that is, a countermissile role. An easy way to demonstrate that these changes raise new questions in strategic policy is to consider a situation that could arise should some of the suggested developments be brought to fruition. This illustration is meant to be heuristic only. It assumes an extreme and simplified situation which is much less complex than that likely to occur.

For simplicity, imagine that both sides have negotiated a quota system in which one side has 1000 missiles and 2 MIRVed warheads per missile, while the other has 500 missiles and 4 MIRVed warheads per missile. Thus both sides have 2000 reentry bodies. Assume further that all of these missiles are land-based and fixed, and that both sides' reentry bodies have a 0.8 probability of destroying an opponent's silo and its missile.

As a motive for calculation using classical strategic theory, assume that the side having 1000 missiles is considering the use of one-quarter of its forces in a countermissile, disarming strike. Its objective is to alter the existing 2000 : 2000 reentry body ratio in its favor. A question that might be raised is, "What improvement in the ratio of reentry bodies can the attacker gain?"

	Missiles		Reentry Bodies	
	A	B	A	B
Preexchange totals	1000	500	2000	2000
Used by A in strike	250		500	
Launched by B to avoid destruction*		450		1800
Destroyed by B's reactive launch†	696		1392	
Poststrike totals	54	50	108	200

*B launches missiles from all threatened silos.
†B attacks without knowledge of which of A's silos no longer contain missiles.

Fig. 1. Summary of exchange. The side striking first (A) loses the advantageous ratio. A single-shot kill probability of 0.8 is assumed for both sides.

Using 250 of its 1000 doubly MIRVed missiles permits the attacker to strike at each of the opposition's 500 silos. With a single-shot kill probability of 0.8, this attack can be expected to destroy 80 percent or 400 of the attacked systems, leaving the opposition with only 100 usable missile systems. The reentry body ratio of 2000 : 2000 would become 1500 : 400 in favor of the attacker. The usable missile ratio would also be improved from 1000 : 500 to 750 : 100.

Now add an innovation to this scenario. Assume that the side being attacked has the capability to discern which of its missiles is threatened and also has the capability to launch these missiles quickly enough to avoid their destruction. It is not reasonable to assume, even if its silos are widely dispersed, that the attacked side will be able to determine with absolute certainty in advance of the event just which of its missiles will actually be destroyed. To some extent this will depend on precisely where the incoming warheads impact, the nature and reliability of their fusing systems, and the like—factors knowable only after the destruction has occurred. Thus, although the end result of the 500 reentry body attack will be the survival of 100 out of the 500 attacked silos, the attacked side will not be able in advance to know with complete certainty which will survive. However, the attacked side may well be able to perceive that because of incorrect targeting, guidance errors, or other malfunctions only 450 of its silos or missiles (or both) are in jeopardy.

Assume that the attacked side fires these 450 threatened missiles in time to avoid their destruction. Firing 450 missiles (of which 400 would otherwise be destroyed) with their 1800 reentry bodies at 1000 aim points will result, using the 0.8 kill probability, in the expected destruction of 928 silos—800 being attacked with 2 warheads each and the remaining 200 with only 1. Of course, some of the silos being hit will be empty, their missiles having been used by the attacker in his first strike. (A capability of the type required to preclude this "wastage" could also have been assumed. Since such a capability, and particularly one not vulnerable to attack, may not be practically attainable for some time, it was not assumed to be available in this scenario.) Allowing for this factor results in the original attacker being left with 54 usable missiles and their 108 reentry bodies. The responding side is, of course, left with the 50 missiles or 200 reentry bodies which, it was able to determine, were not threatened by the attack. Thus, here the result for the original attacker is an adverse change from 2000 : 2000 in reentry bodies to 108 : 200, and in usable missiles from 1000 : 500 to 54 : 50. The attacker, far from gaining by going first, actually loses in relative position. These numerical results are summarized in Fig. 1.

This scenario, even though extremely simple, illustrates a number of points: (i) the importance of a posture description that includes more than numbers of missiles, degree of MIRVing, and kill capabilities; (ii) an operating decision that may usefully be made during the exchange to take advantage of knowledge that only then becomes available; and (iii) the possible importance of including nonmissile systems, such as those for surveillance and control, in any attack utility function. These issues are discussed more generally in the following section.

Prescription for an Expanded Theory

The above discussion pinpoints some of the shortcomings of the classical strategic calculus. A closer examination of these defects enables one to formulate more precisely the necessary form and content of an expanded theory. These requirements can be conveniently grouped for discussion into three areas: posture description, in-

teraction dynamics, and utility functions.

Posture description. It is clear that current general strategic posture descriptions are incomplete and inadequate. Today those parameters which are generally included—number of missiles or reentry bodies, payload or explosive power, accuracy, and silo or missile hardness—focus solely on the munitions system. Even here one must add qualities such as targeting flexibility, time required for launching, and maneuverability. Furthermore, and possibly of even greater importance, is the addition of those attributes of ancillary systems that may greatly affect the utility of these munitions delivery systems. As has been illustrated, systems that enable us to detect threats to our military units, to know the location and status of enemy offensive systems, and to control and apply our own forces in a timely manner are very important components of strategic posture.

One reason that these features have not been incorporated into the strategic calculus is that it is not easy to do. For example, whatever sense it may make to count missiles, it clearly makes less sense to "count" surveillance systems. The proper concern is not with quantity, but with functional capability. Yet if such functional capabilities are to be introduced into the strategic calculus, they must be at least partially quantified. Strategic posture descriptions will prove inadequate until and unless such important attributes are included.

Interaction dynamics. The second area requiring attention is the overly simplistic action-retaliation character of classical strategic theory. Insofar as knowledge can be gained about enemy actions, it should be possible to use this knowledge to advantage. Tailoring our tactics to the enemy's actions should yield advantages over responding according to a preformulated plan. It would, at the very least, be advantageous to have many preformulated plans (that is, options and suboptions) with an execution choice based in some detail on perceived enemy actions.

If near-future technology will yield the ability to "see" what assets the enemy is using, know what targets he is attacking, and assess the damage done by our own munitions, then clearly a posture should be sought that permits us to use this information (*2*). Both the United States and the Soviet Union appear to be developing relevant surveillance, damage assessment, and command and control technology. Hence, it seems impossible not to conclude that interaction dynamics will play an increasingly important role in strategic planning. Any expanded strategic theory should specifically include such dynamic interactions. Moreover, this very area may hold the greatest promise of impact, for history is rife with cases where tactics were more important in determining outcomes than the weapons involved.

Utility functions. A third area requiring major reevaluation is target selection, or more broadly, attack utility functions. The value of ancillary systems, such as those that permit timely threat assessment and provide data on enemy weapons systems use, has been discussed above. The destruction of these systems would be of military value. Indeed their freedom from attack is one of the key simplifying, but possibly unrealistic, aspects of the illustration provided.

Furthermore, there is growing U.S. interest in assessing the totality of potential roles that strategic forces might play. A more inclusive view of the systems contributing to strategic strength, a greater concern with the time-relatedness of events, and a proliferation of strategic force objectives tend to expand the number of factors that should be included in a reformulated attack utility function or set of targets and their priorities.

Conclusions

The foreseeable consequence of current developments will be to raise new questions about the strategic posture of the United States. Changes in treaties and agreements, MIRVing with enhanced accuracy, surveillance systems, and quick-launch capabilities are some of the most important of these developments.

The questions thus raised cannot be adequately addressed within the framework of classical strategic theory. Its calculus requires expansion to allow specifically for a more comprehensive description of strategic posture, to include the dynamics of interaction between opposing systems, and to permit the specification and evaluation of a more complex and inclusive attack utility function.

This is a substantial challenge. Perfection will not be achieved at a single step, but progress must be sought. For without such progress, the United States will be faced with resource allocation, arms control negotiations, and doctrinal and operational decisions that existing classical strategic theory simply does not address. Furthermore, it is important to recognize that developments such as those suggested in this article will further strain our ability to assess an opponent's capabilities.

By supplying the insights necessary to deal effectively with these issues, technologists can have a major impact on the evolution of strategic armaments. In fact, their contributions are essential if security and tranquility are to be effectively pursued.

References and Notes

1. Acronyms: MIRV, multiple, independently targeted reentry vehicle; ICBM, intercontinental ballistic missile; SALT, strategic arms limitations talks.
2. It should be noted that what is being addressed here is only an active battle portion of interaction dynamics which in the broadest sense must include negotiations, intelligence, counterintelligence, deception, countermeasures, the information war in the general sense as used by T. P. Rona, *Proceedings of the AOC Conference on Electronic Warfare*, 23–25 September 1975, San Diego, Calif.

3. This article was prepared as an account of work sponsored by the U.S. government. Neither the United States nor the U.S. Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.