

**COST AND EFFECTIVENESS: PRELIMINARY INSIGHTS
ON SOVIET VIEWS**

by

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EXECUTIVE SUMMARY

The Problem

Since the announcement of the SDI program, several criteria have been proposed for assessing the desirability of deploying SDS. Of these, the criterion of cost-effectiveness at the margin has received considerable prominence. Eventually, the criterion achieved legal status when Congress mandated that the President must certify the SDS:

...is cost effective at the margin to the extent that the system is able to maintain its effectiveness against the offensive at less cost than it would take to develop offensive countermeasures to overcome it.

Originally, the Nitze criterion was put forward as a way of judging SDS solely from the U.S. perspective. Recently, however, there has been considerable interest in using the results from such analyses as a way of estimating the likelihood of potential Soviet responses. In responding to Congressional requirements and in building tools for our own countermeasures analysis, great care must be taken to ensure that U.S. values and views are not ascribed to the Soviets. This means examining: (1) how the Soviets define cost and effectiveness and (2) how they employ these concepts as a decision-making criteria.

Major Insights and Hypotheses

Our analysis of past Soviet weapons acquisition decisions provides some preliminary, general observations about the relationship of cost and effectiveness. These are:

- Because the Soviets do not use comparative U.S.-Soviet costs either to define mission requirements or to evaluate alternative approaches to meeting mission requirements, the results of U.S. cost-effectiveness at the margin analysis are irrelevant to predicting Soviet responses.
- Soviet military mission requirements are established without regard for cost or effectiveness considerations. Occasionally, however, cost considerations play a role in setting the priorities among those mission statements. But regardless of how mission priorities are established, once set, they have implicit budgetary implications. That is, high priority requirements receive resource allocations whereas low priority ones may not.
- Soviet military decision-makers seem to emphasize cost over effectiveness by optimizing for war-time situations (where equipment life spans are expected to be short) rather than peace-time. This means, for example, less demanding reliability standards than would be necessary to achieve longer operational lifetimes and the substitution of commonly available materials for more exotic ones. All this translates into lower procurement costs but higher opportunity costs (e.g., decreased daily availability of equipment).
- Soviet military planners use more than one measure of effectiveness in evaluating their options. This, in turn, can complicate the assessment process because an option may not score well against all the measures. This suggests that U.S. analysts must avoid using a single measure of effectiveness when assessing Soviet options, even if it is a complex one like correlation of forces which takes into account multiple factors.

More specific insights include:

- The Soviets define cost as resources (raw materials), necessary components and sub-assemblies, and labor (expressed in man hours by labor category). Because the Soviet economy is one of scarcity and central allocation, Soviet managers do not think in terms of money since no amount of money can be translated into goods and services without an allocation of resources from the central planners.
- Gross resource allocations are made among military services based on the priority of missions assigned. Because of the sheer magnitude of the planning data, it is nearly impossible for the State Planning Commission to conduct "zero-based" budget reviews. As a consequence, it is difficult to disrupt the momentum of on-going programs.
- Cost analysis has both a macro and micro level focus. At the macro level, the concerns focus on minimizing cost or maximizing effectiveness to get the most out of a predetermined and fixed resources budget. At the micro level, weapons designers rely on "rules of thumb" based on historical analogies and key technical parameters to estimate development and procurement costs.
- Like cost, military effectiveness is evaluated in both macro and micro terms. Micro analysis investigates the ability of the proposed system to carry out the overall mission. For example, micro analysis might investigate the probability of penetrating the defense whereas macro analysis would look at the broader question of the ability of the system to avert loss, its coefficient of strike prevention, relative damage, and overall impact on the correlation of forces.
- Cost consciousness seems to be a major consideration in technological decisions regarding whether to move beyond minimum baseline mission requirements and technological capabilities. When the only way of achieving minimum mission requirements is to use "high tech" and the mission being satisfied has sufficiently high priority, the Soviets seem willing to accept the extra cost. Where both conditions are not present, they are generally unwilling to pay the price.
- When short-term budgetary problems arise, Soviet military leaders apparently prefer to take short-falls out of operational expenditures since this is an area that can be turned off (and back on again) rapidly. Procurement, by contrast, with its tight planning and long lead times is hard to stop quickly given bureaucratic momentum and, once stopped, hard to restart because of the inertia inherent in a centrally planned economy.

The Soviets do not make cost-effectiveness at the margin assessments. Consequently, the Soviets will not be dissuaded from responding to SDS deployment by cost-effectiveness at the margin considerations, even if ratio runs considerably against them. Similarly, cost-effectiveness at the margin is not a good metric for predicting how the Soviets might respond to SDS. Nevertheless, cost and effectiveness considerations do play a large part in shaping the outcomes of the Soviet weapons development/procurement process and so merit considerable attention by U.S. analysts. However, the U.S. must look at these factors through Soviet eyes.

I. The Problem

Since the announcement of the SDI program, several criteria have been proposed for assessing the desirability of deploying SDS. Of these, the criterion of cost-effectiveness at the margin has received considerable prominence. Eventually, the criterion achieved legal status when Congress mandated the President must certify the SDS:

...is cost effective at the margin to the extent that the system is able to maintain its effectiveness against the offense at less cost than it would take to develop offensive countermeasures and proliferate the ballistic missiles necessary to overcome it¹

Originally, the Nitze criterion was put forward as a way of judging SDS solely from the U.S. perspective. Recently, however, there has been considerable interest in using the results from such analyses as a way of estimating likelihood of potential Soviet responses. For example, the SDIO Technical Red Teams have become increasingly interested in costing Soviet countermeasures options as an input to their deliberations. The desire to have better (i.e., more empirical) ways of gauging the non-technical aspects of Soviet decision-making may also be reinforced by Soviet propaganda that they will deliberately choose counters that are less costly. This, in turn, implies that cost will be a major factor in how the Soviets will deal with SDS.

In responding to Congressional requirements and in building tools for our own countermeasures analysis, great care is needed to ensure that U.S. values and views are not ascribed to the Soviets. This means examining: (1) how the Soviets define cost and effectiveness, and (2) how they employ these concepts as a decision-making criteria.

The following discussion addresses these questions in a preliminary fashion. In reading this paper, it is important to keep in mind that this is not a research paper with all that term implies. Rather, this paper is a first-cut attempt to examine how the Soviets view cost and effectiveness. In keeping with that perspective, the results are better described as insights and hypotheses rather than findings and conclusions. Nevertheless, this limited discussion is still useful in stimulating interest, sparking controversy, and prompting more detailed investigations of these topics. All of which should lead to much better assessments of Soviet intentions.

¹The Committee of Conference, Conference Report, Department of Defense Authorization Act, 1986, July 29, 1985, p.33.

A. Cost

The Soviets view cost as composed of resources (raw materials), necessary components and sub-assemblies, and labor (expressed as man-hours by labor category like engineer or laboratory technician).² Because the Soviet economy is essentially one of scarcity where commodities and labor are centrally planned and allocated, it is unlikely that Soviet managers think in terms of money since no amount of available rubles can be translated into goods and services without an allocation from the central planners. In a sense, the Soviet economy is much like that of the World War II America where a person could only buy consumer goods if he had a ration coupon and money. Without the former, the latter was of little use except for an occasional illegal transaction. It is also important to note that, consistent with the Marxist nature of the Soviet economy, labor is regarded as the most important determinant in projecting cost.³

Cost evaluation, in the broadest sense, has both macro and micro perspectives. At the macro level, gross resource allocation is made among military services based on the priority of the missions or tasks assigned. This broad resource allocation is generally predictable to the service chiefs well before the overall defense budget is finalized. Consequently, a service chief's problem is how to minimize costs or maximize effectiveness to get the most out of his fixed pool of resources. The advantage of this approach to a service chief is that he is assured of essentially steady state funding from year to year with little need to conduct annual "zero-based" reevaluations of his program. Indeed, the sheer magnitude of the economic planning data used in the Soviet economy as a whole makes it nearly impossible even for the State Planning Commission (Gosplan) to conduct such "zero-based" reevaluations of military programs.⁴ There is a down side to this steady state approach as well. It is very difficult, but not unprecedented, for a service to receive a major increase in funding from one year to the next, especially if that increase is disproportional to other services.

²I.S. Tsygankov, "Cost of Armament", Soviet Military Encyclopedia, Volume 7, p. 543.

³Peter Almquist and Eric Heginbotham, "Soviet Perspectives on Weapons Costs", IDA Draft Memorandum Report, February 19, 1988, pp. 1-3.

⁴The Soviet Weapons Industry: An Overview, Directorate of Intelligence, Central Intelligence Agency, DI 86-10016, September, 1986, p. 13.

At the micro level, a proposed weapons system, or group of systems, undergoes Tactical-Technical Economic Analysis between each stage preceding a development/procurement decision. (See Figure 1) There are several ways to forecast potential costs, but the clearest (and apparently the most commonly used by the Soviets) is based on analogies and key parameters. In the case of aircraft, for example, the estimator calculates cost based on the weight of the empty aircraft and its speed.⁵ The projected cost of an aircraft engine is determined in the same way, except the characteristics incorporated in the estimate are thrust, pressure, and temperature. Similar "rules of thumb", involving launch costs and payload weight, appear to be used in the development of missiles.⁶

B. Effectiveness

Micro level military effectiveness criteria are established by the Technical Directorates of each service and embedded in the Tactical-Technical Requirements package for the specific weapon system being procured. These effectiveness criteria tend to be single, rather narrowly focused ones. In judging defensive forces for instance, effectiveness measures include:

- o probability of penetrating the defense;
- o probability of destroying K of N targets;
- o probability of target detection.

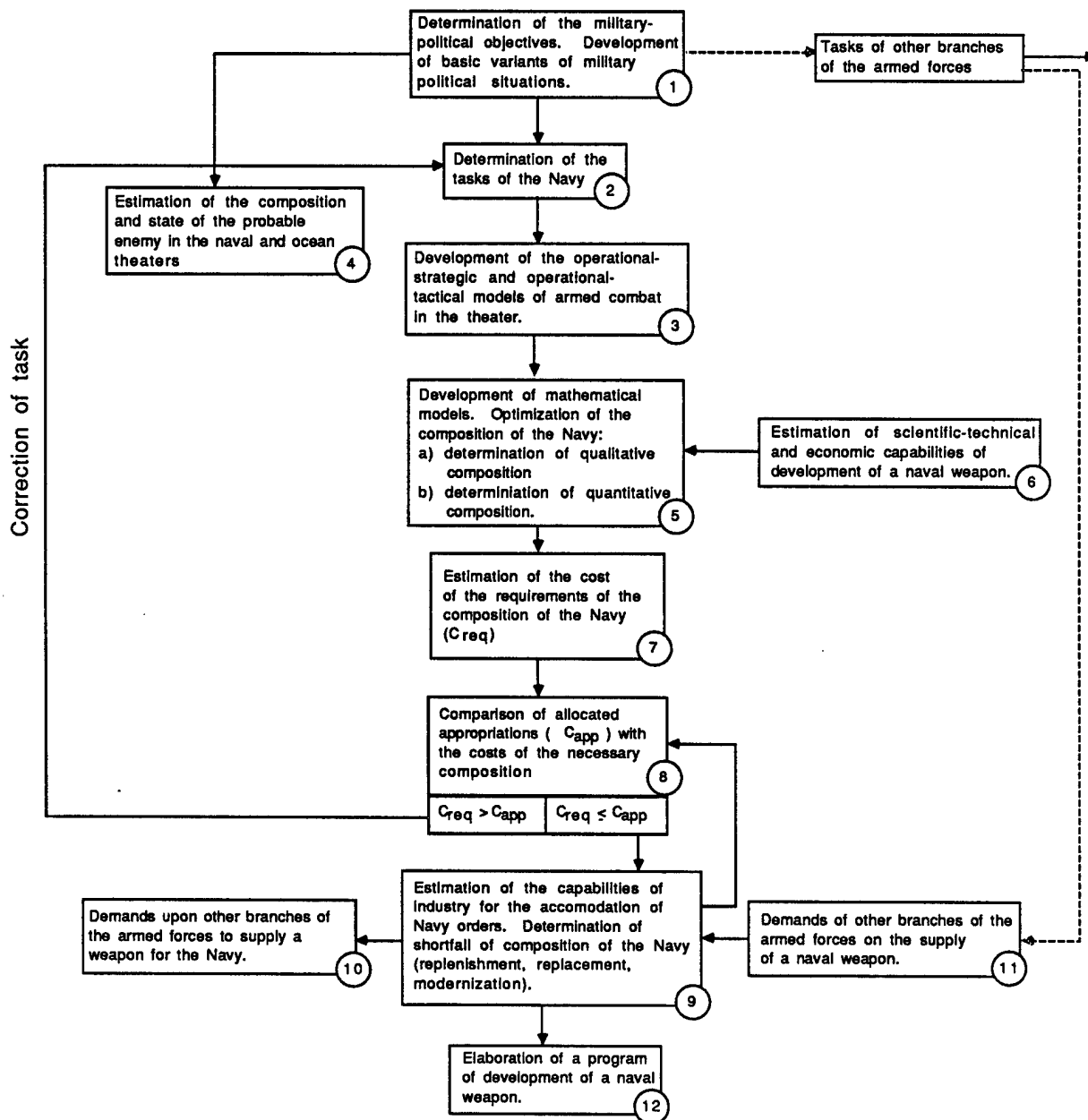
Although the effectiveness criteria specified in the Tactical-Technical Requirements package are important, the Soviets also consider more macro issues like the military effectiveness of a system in broader contexts. (That is, they are judged by measures of effectiveness made up of multiple factors.) For example, the overall goal of defensive systems is to prevent damage of the Soviet Union in the event of war. Therefore, the broadest and most important effectiveness criterion for the acquisition of defensive systems is loss aversion.

Averted loss is normally defined by the Soviets in terms of the ratio of probable losses with defense (or a defensive system) to the probability of losses without defense. A defense that does not avert loss is not effective regardless of how many penetrators are shot down or how much the leakage rate is reduced. Conversely, a defense which does avert loss is assessed

⁵Almquist and Heginbotham, op. cit., p. 9.

⁶Almquist and Heginbotham, op. cit., pp. 9-10.

Development of a Naval Weapon



Source: B. Makeyev, "Nekotoryye vzglyady na teoriyu vooruzheniya VMF,"
Morskoy sbornik, number 4, 1982, p. 28.

effective regardless of the number of penetrators that leak through. Put another way, defense which leads the enemy to divert excessive offensive weapons to some targets allowing others to survive averts loss and is judged effective. Similarly, if the attacker fails to strike some heavily defended targets because of the offensive resource requirements, then again loss is averted by the defense.⁷

The Soviets appear to apply other effectiveness criteria to strategic defensive and offensive systems as well, including:

- o Coefficient of strike prevention--the fraction of enemy nuclear potential destroyed due to a Soviet first strike;
- o Relative damage--the difference/ratio between damage inflicted and damage sustained;
- o Impact on overall correlation of forces--ratio of post-nuclear exchange residual forces.⁸

In doing effectiveness analysis, Soviet military planners face a number of problems. For one, there are serious unknowns about system effectiveness, especially for strategic offensive forces which will go against a first generation U.S. SDS of uncertain capabilities. But even leaving aside the problem of system effectiveness, Soviet military planners face the issue of what to do when the effectiveness analysis is inconsistent from one measure to another. For example, withholding all Soviet strategic offensive forces through a U.S. first strike would shift the correlation of forces heavily to the Soviet advantage, but would have very negative consequences for averting loss. Conversely, going first might avert Soviet loss but leave them with a very undesirable correlation of forces if the U.S. SDS was reasonably effective. Because multiple Soviet measures of effectiveness can yield far different results, it is important for U.S. analysts to avoid using a single measure of effectiveness when assessing Soviet options (even if it is a complex one like correlation of forces which takes into account several factors).

⁷For a fuller discussion of this point, see Michael W. Summers, Soviet Views on U.S. Criteria for SDI, March 11, 1988, Science Applications International SAIC-88-6022&FSRC, pp. 7-8.

⁸Daniel Goure, Linda Hor, Geoffrey Bent, Matthew Spalding, "SDI: Impacts on the Soviet Assessments of the Correlation of Forces" (U), SRS Technologies, April 14, 1988, Vugraphs 6 and 7.

C. Trading And Effectiveness

Given the preliminary nature of this paper, it is impossible to say anything definitive about how the Soviets trade cost against effectiveness in the weapons procurement process. However, examining what the Soviets chose to field in the past does offer some insights.

Cost consciousness seems to be a major factor in technological decisions that mean moving beyond minimum baseline mission requirements and technological capabilities. This tendency is exemplified by Soviet aircraft construction which has long minimized "unnecessary" fight instrumentation and which has sought to substitute relatively common, cheaper materials like steel for more exotic, expensive materials like titanium. (The MiG-25 FOXBAT is a particularly good example of such substitution.) On the other hand where exotic materials are the only way of achieving minimum mission standards and the mission has a sufficiently high priority, the Soviets appear willing to bear the higher cost as in the case of the Alpha class submarines with titanium hulls.

Cost consciousness may also partly explain the common Soviet practice of designing single mission weapons systems, despite conventional Western thinking that multiple mission systems are a more effective use of resources. Conversely, the Soviets seem willing to pay a disproportionately high cost (by U.S. standards) for systems of limited technological capability (e.g., the Galosh ABM) in order to get as near to minimum mission goals as possible. At other times, fielding systems with limited capabilities may partly reflect a Soviet preference for holding down initial procurement costs by introducing a system of limited initial capability and then up-grading it through a series of model changes over time. For example, one Western source estimates that the step-by-step modernization of the MiG-23/27 family through new propulsion systems, avionics, on-board weapons, titanium components, and laser systems only made Soviet expenses grow by 7% per year.⁹ Thus, Soviet decision-makers avoided the stark choice of either making an initial buy of aircraft that were very costly, but quite sophisticated, or not buying anything at all. Finally, buying systems with limited initial capability may indicate a Soviet belief that if production is not started immediately there will be an inordinate (and costly) delay in turning later technology developments into operational systems that do meet the mission requirements. Or at least in doing so in a timely and resource efficient way.

⁹"The Soviet Aviation Industry", Osterreichische Militarische Zietgchrift, #2, 1984, as translated in LN1136-84, p. 24.

The Soviets also appear to anticipate relatively short life spans for equipment in combat and so design equipment with shorter service lives in mind. This approach has a positive impact on procurement costs; i.e., it leads to less demanding reliability standards than would be necessary to achieve longer operational life-times and (as in the case of aircraft) the substitution of commonly available materials for more exotic ones. Conversely, it has a negative impact in the operational arena where field commanders are faced with a choice of reducing day-to-day equipment use to conserve it or accepting the higher maintenance costs that spring from relatively short service life-spans and rather short times between overhauls. This dilemma is particularly well illustrated by aircraft engines which have notoriously short service lives by Western standards. (For example, the Soviet R-11-300 jet engine in the MiG-21 FISHBED must be overhauled after only 300 hours of operation as opposed to 1,500 hours for the comparable J-79 of the U.S. F-4 Phantom.¹⁰) Short equipment life spans also force military service chiefs to procure more units to ensure peacetime availability to meet minimum operational requirements.

The above discussion suggests the Soviets may be emphasizing cost over effectiveness in making design choices because of the military's belief that systems will enjoy rather short life spans during war time. Another interpretation is that the Soviet military planners have opted to maximize war-time cost-effectiveness (characterized by high attrition rates) over peace time cost-effectiveness with its emphasis on longer equipment life, greater reliability, and reduced meantimes between failure. In choosing to optimize cost and effectiveness tradeoffs for war time, Soviet military planners have consciously accepted the associated peace time opportunity costs (e.g., much lower day-to-day equipment availability.)

When a short-term budgetary squeeze arises, Soviet decision-makers look to the operational arena for cut-backs. Late in the Brezhnev era, for example, the leadership first called for greater thrift and conservation of operational resources rather than for reducing procurement.¹¹ More recently, the Director of U.S. Naval Intelligence cited budgetary problems to explain decreased Soviet naval deployments over the last three years.¹²

¹⁰The Soviet Weapons Industry, op. cit., p.25.

¹¹Rebecca Strode, "The Soviet Armed Forces: Adaptation to Resource Scarcity", The Washington Quarterly, Spring, 1986, pp. 16-17.

¹²Adm. William Studeman, as referenced in "Economics force cut-back in naval power", Jane's Defense Weekly, 26 March 1988, p. 600.

Although it appears that Soviet military leaders prefer to take budget short-falls out of operational expenditures, this is not to say that procurement never suffers. Indeed, smaller production runs of Soviet aircraft in recent years have resulted partly from rapidly escalating per unit costs for more technologically sophisticated planes.

The appeal of reducing operational expenditures as a preferred solution to budgetary problems may lie in two directions. First, it may spring from the deeply in-grained Soviet notions that one does not waste scarce resources of the state, especially in peace time. But perhaps equally important, the operational arena is a place where military leaders probably have the greatest unilateral control over resources and it is a sector of the budget which can be turned off (and later back on) easily and quickly as more resources become available. Procurement, by contrast, with its tight planning and long lead times is hard to stop quickly given bureaucratic momentum and, once stopped, hard to restart because of institutional inertia.

D. Final Observations

Several members of the SDIO Strategic Red Team have argued that domestic cost considerations generally play little or no role in defining mission requirements or in setting priorities among them. There are, however, occasionally major exceptions to this rule. For one, Khrushchev believed in the late 1950s that the role of ballistic missiles made many Ground Force missions unnecessary or at least greatly reduced their traditional importance. In light of what he saw as greatly changed relative mission priorities, Khrushchev argued that a much more effective use of resources was to build a strategic ICBM force while simultaneously cutting back spending on conventional forces. Khrushchev was not asserting that mission requirements were being effected by cost and effectiveness considerations, but rather that the priorities among them were.

Regardless of how mission priorities are established, once set they have implicit budgetary implications. For example, Khrushchev in the mid-1950s decided to cut back naval surface fleet construction drastically when its mission was primarily coastal protection and interdiction of Western sea lines of communications. But six years later, the Soviets were spending heavily for a surface fleet of anti-submarine warfare vessels to counter the emerging Polaris SLBM threat. This big turn-around in Soviet willingness to invest in surface vessels was apparently due to the change in mission priorities; i.e., a change from coastal protection and anti-sea lines of communication (a low priority) to strategic ASW (a high priority). More recently, some Western analysts have argued that internal Soviet military debates over the importance of nuclear

versus conventional missions are having similar budgetary implications under Gorbachev.¹³

Military effectiveness considerations also seem to play no role in determining mission requirements. This is not surprising since the function of mission requirements is to say what needs to be done given the threats faced and the kind of force structure and capabilities desired by the Soviet military. Indeed, it appears that Soviet military leaders are willing to define unreasonable (in terms of existing technological capabilities) requirements with an eye toward allowing technology to catch up to what is wanted, even if this should take quite a long time. Until such technological breakthroughs are achieved, the Soviets appear willing to buy modest initial capabilities which can be incrementally upgraded.

Mission requirements are operationalized through the development and procurement of specific weapons systems. During this development/procurement process, each project is evaluated numerous times for cost: how many resources are necessary to do the job, are those resources available, how does the cost of this system compare to the cost of alternative systems for doing the same job? The proposed system is also examined on effectiveness grounds: what are its capabilities, how do they compare to the goals set in the statements of mission requirements, how does system performance compare to the threat posed by foreign weapons? In looking at cost and effectiveness factors, the aim is to evaluate the desirability of alternatives to meet a mission requirement rather than of judging the value of the mission itself.

It is also important to note that the Soviets do not compare the cost of what they wish to do with what the Americans are doing. This may explain why some of their choices differ so markedly from U.S. expectations. For example, the comparatively expensive Soviet response to the relatively modest U.S. investment in an air-breathing nuclear threat is almost certainly not cost-effective. However, this has not deterred the Soviets from responding to what they see as a critical, high-priority mission area.

The foregoing has a major implication for U.S. analysts trying to assess which countermeasures the Soviets will adopt to SDS. Because the Soviets do not use comparative U.S.-Soviet costs

¹³James M. McConnell, "SDI, The Soviet Investment Debate and Soviet Military Policy", Strategic Review, Winter 1988, Vol. XVI, No. 1, pp. 47-60.

either to define mission requirements or to evaluate alternative weapons options for meeting those requirements, the results of U.S. cost-effectiveness at the margin analysis are irrelevant in predicting likely Soviet responses. Instead what constitutes "reasonable" Soviet options must be identified from the perspectives of what mission does a countermeasure satisfy, what is the priority of that mission requirement, what is the cost of implementing one countermeasure (and its effectiveness in doing the job) versus an alternative available to the Soviets in roughly the same timeframe, and finally what would the Soviet military need to give up to afford the countermeasure and still remain within their relatively fixed budget? Admittedly it may be nearly impossible to answer the last question and so we may have to be content with merely understanding whether the resource implications are large or small and then estimating whether a resource drain of that magnitude would pose a serious impediment to implementing the countermeasure. But regardless of our ability to address all these questions adequately, we must try to ensure that the assessments are done through Soviet eyes.