CONCLUSION:

A BRIEF SUMMARY AND QUESTIONS OF ARMS CONTROL

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The Relation of Scientific Research to Weapons Development: The Tables

As the case studies which make up the greater portion of this study deal with particular systems, the purpose of the opening chapter of this study was to explain what military R&D is and how it works. The contribution of basic and applied scientific research to producing every piece of military hardware that exists is essential. Whether it is an ICBM or an aircraft, or any other weapon or piece of support equipment every system and subsystem that one can enumerate is the product of a concerted research effort: the metal alloys, the fuels, the radar, the micro-electronics, the guidance equipment, the sensors, the satellites, the counter-measures, the ordnance, the (knowledge of) aerodynamic, geodetic, climatic effects, and so on. The knowledge and the products do not, however, appear in a random environment or in a policy and management vacuum. Military R&D is guided and directed: questions are put, particular materials, effects, performance capabilities are sought, and research funding is allocated accordingly. The tables that accompanied the opening chapter were designed to explain this process as best as possible. For this purpose they were organized into five groups, as follows:

Group I: What is one looking for in military R&D, the capabilities and applications — and some indications of the process.

Group II: Where does one look: the funding of research in the basic sciences. (The "D.T. & E." — development, test and evaluation — of R&D are for the moment set aside.) It is important to stress that this search takes place in virtually every discipline and subdiscipline in nearly every area of theoretical, basic, and applied science.

Group III: How does one organize the search: the "In-House" laboratories of the US military services were used by way of example, although less than one-third of US military R&D expenditure is allocated to these institutions and nearly two-thirds are expended by contracting to private industry. The choice was made in order to permit the greatest clarity of explanation and to be able to present a coherent organized illustration. Details were provided on the organization of this laboratory structure in the United States, and of the functioning of US advisory panels, because in the case of the US evidence is readily available and can be provided, program direction and results can be quoted. The organizational structure is equally important as regards military R&D in the USSR, however evidence regarding it is extremely sparse in comparison with that for the US. What one knows about military R&D in the US, USSR, France, England, FRG, India, Israel, Sweden, Netherlands, South Africa, Australia, etc. indicate a very similar process in all cases, although the national organization and funding structures may differ.

Group IV: How does the process work: examples of nine weapon-development histories of US weapon systems are given, as well as some examples of parallels in US and USSR weapon development.

Group V: What is the result: the weapons. Since the four case studies in the book and the greater part of all the tables in Groups I, II, II, and IV are derived from materials dealing with the United States, the examples of final weapons systems are provided from those of the USSR. The essentials of the R&D process is basically the same; the laws of nature and the methods of science make that a certainty. However, as in Group III, one aspect of the Soviet military R&D process was selected out for examination disproportionate to its probable place in the entire elaboration of USSR military R&D. This is the aspect of technology acquisition from abroad. This was done partly because it plays a more important role in the overall functioning of USSR military R&D than it does for the US, and at the same time to again provide the best demonstration of the phenomenon.

The information provided in the opening chapter demonstrates unequivocally that weapon development, and the basic and applied R&D on which it is based, is not an autonomous process. It is a cultivated, organized, goal-oriented, purposeful process, In the area of weapons development and procurement decisions in particular there seems to be extremely little "technological imperative" without the ground for it having been prepared rather methodically. Military R&D, the activity and the knowledge and technological products that it produces — like most products of modern society — are a result of prior government decisions and expenditures whose purpose it was to produce that knowledge and those technological products. Military R&D is therefore not likely to be the cause of the arms competition between the US and the USSR, or of any other "arms race". Neither can its product, the weapon systems, divorced from the decisions to develop and procure them, properly be understood as a cause. They were produced by an enormous enterprise consciously established by political decision to produce them. That enterprise is military R&D. The tables demonstrate its scope and functioning. The resulting weapons are neither an accident nor a mistake — in the sense that no one asked for them. The weapon capabilities produced by the R&D process may drastically exacerbate the political climate, and they may do so in a step function if the weapon developed is dangerous enough. But the decision to procure the systems in always a political one, and the R&D that produced the weapon was mandated in the first place.

Everyone is familiar with the remarks in Dwight Eisenhower's farewell presidential address in which, after noting that research played an increasingly crucial role in our society and that the ways in which it was conducted had changed radically in recent years, he said:

> "Yet in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite."

This expression by the President was, however, one of a pair on the subject, and it was actually the second. "Part I" was in a radio and television address to the American public on November 7, 1957, which began with the words "My subject tonight is 'Science in National Security'." In this case President Eisenhower explained:

> As of now, the United States is strong. Our Nation has today, and has had for some years, enough power in its strategic retaliatory forces to bring near annihilation to the war-making capabilities of any other country.
>
> This position of present strength did not come about by accident. The Korean war had the effect of greatly expanding our peacetime defense forces. As we began the partial demobilization of these forces we undertook also an accelerated program of modernization.
>
> As a first step, scientific surveys were instituted soon after the Korean armistice. The result was a decision to give a "New Look" to the Defense Establishment, depending for increased efficiency more upon modern science and less upon mere numbers of men.

In short, it was the decisions of the Eisenhower administration which extablished the "scientific-technological elite" that he was to warn of only three years later.

The presentation provided in this study is in marked contrast to others that can be found frequently. Sir Solly Zuckerman, for example, Chief Scientific Advisor to the Minister of Defense in Great Britain from 1960 to 1966, has written as follows:

> It is my view, derived from many years of experience, that the basic reason for the irrationality of the whole process is the fact that ideas for a new weapon system derive in the first place, not from the military, but from different groups of scientists and technologists who are concerned to replace or improve old weapons systems — for example, by miniaturising components — or by reducing weight/yield ratios of nuclear warheads so that they can be carried further by a ballistic missile (that is to say, by packing greater explosive power into a smaller volume and weight). At base, the momentum of the arms race is undoubtedly fuelled by the technicians in governmental laboratories and in the industries which produce the armaments.
> ...
> In the nuclear world of today, military chiefs, who by convention are a country's official advisers on national security, as a rule merely serve as the channel through which the men in the laboratories transmit their views. For it is the man in the laboratory, not the soldier or sailor or airman, who at the start proposes that for this or that reason it would be useful to improve an old or devise a new nuclear warhead; and if a new warhead, then a new missile; and, given a new missile, a new system within which it has to fit. It is he, the technician, not the commander in the field, who starts the process of formulating the so-called military need. It is he who has succeeded over the years in equating, and so confusing, nuclear destructive power with military strength, as though the former were the single and a sufficient condition of military success. (1)

This is fatuous: the scientists are placed in the laboratory and payed for by the political and military leadership of the state — not by themselves. They are doing the job that they are hired to do, by military and political decisionmakers. It is also ironic that some of the major spokesmen for the argument of technological imperative spent large portions of their career as senior managers of national military R&D programs.

Other statements are virtually a parody. A recent example was a brief paper by a senior French administrator entitled "Irresistable, Irrational, Indomitable, Military Technology."

> Military technology is the wicked fairy mainly because it goes its own way... in laboratories and industries that are not known, very often not even by the governments involved....
>
> Governments, of course, could stop this if they decided to give no more money to military research. But because of their fear of other countries they cannot do so....
>
> Military technology is irresistible. When a device is invented, who would be strong enough or feel safe enough to say: "We will not produce this devise?" It is asking too much....

> Politicians have no power to stop a project that has cost so many years, so much money and so much work. When it is ready, it comes out — and the world is shaken. Each side accuses the other of imperialism, bad intentions, and so on....
>
> It appears that technology goes entirely its own way, even in the most planned economies. When something can be done, it is impossible to resist trying it. And when it has been tried, it seems impossible not to implement it. It all ends with a race between technologists, and not between politicians. It is natural, automatic...
>
> How is it possible to stop a technology that secretly goes its own way? No one knows about it except those involved: "top secret" is written everywhere. Then when a new weapon appears, all governments, including that of the country where the weapon was made, are completely flabbergasted. (2)

The evidence provided in the opening chapter should make clear that this description is a fairy tale.

This study was not able to address the integration of military R&D with the other major components of weapons acquisition: in the United States for example, the interests of the military services, executive decisions, congressional guidance and mandate, the positions of different agencies in the US Dept. of Defense such as the Office of the Secretary of Defense (OSD) or of DDR&E, ARPA, etc. Similarly it did not attempt to evaluate the relative contributions of "push" effects from developers, vs. "pull" effects from users, the roll of doctrine, or the "follow on imperative" produced by long-established systems (aircraft, tanks, ships, etc.) and missions. Within the area of R&D itself it did however emphasize the effect of simultaneous contributions built up bit by bit in widely differing areas of scientific research on the ultimate ability to compose these into a single sophisticated weapon system. This conception is not very different from that described by Kosta Tsipis, and which he called the "building block" principle of weapon development.

> The details of a research and development project that ultimately results in the deployment of a new military system are little known to the general public or even to many of those directly concerned with national security policy. Secrecy, bureaucratic complexities, and highly specialized technology hinder public awareness of the cost and danger of deploying such weapons systems. With the possible exception of the ABM system, there has been little public interest in the detailed technical characteristics of strategic weapons, and how they came to be established.
>
> This article on strategic reconnaissance... reveals still another reason, a central one I believe, why it is so often difficult to identify and follow a new weapon system from the early R&D stages of its development. It is what I would like to call the "building-block" principle of weapons systems development.

> Quite often a major military system grows out of the maturing of several seemingly unrelated technologies — the building blocks — which when pulled together, form a new and often unexpected system or make technically possible a system envisioned years before. The surveillance satellite program ... displays the same building block origin as the Polaris submarine, which was made possible by the confluence of two unrelated technologies: the portable nuclear reactor and the inertial guidance system.
>
> Two other examples are the modern cruise missile, now being deployed by the United States, and the remotely piloted vehicle, now emerging as a practical military system. The former is a "cross-product" of microminiaturization of electronic components and the development of a small, efficient turbofan jet. The latter springs from the development of new sensors and the miniaturization of control electronics, which have made available inexpensive, lightweight, jamproof datalinks for remote control and image transmission.
>
> The list could go on. The conclusion, however, is clear: Weapon systems, even major ones, are rarely deployed as the end-result of a categorical decision to create them made at some level of the political, or even military, leadership of the country. Rather, weapon systems more or less emerge from an on-going R&D process that often develops entire new technologies rather than specific pieces of hardware, and that is guided in an overall way by technological leaders who are very much aware of and strongly share in, the general perceptions of the international situation.
>
> Where the defense imperatives, or the prevalent strategic doctrine, and therefore the central decision-making role of the political and military leadership enter is in choosing which of the many systems — made possible by the evolving technology and served up to the military by the industry — will be funded, at what level, and when along their development cycle.
>
> These choices affect the eventual deployment of a system, since not all systems that emerge from the R&D process are deployed. It is at this early point in the evolution of a weapon system that arms control considerations must be injected into the selection process.
>
> If arms control measures are to take timely effect, there is a clear need for constant monitoring of a broad spectrum of weapons-related technologies. (3)

There is one very significant difference however, in this summation from the information provided in this study, and that is Tsipis conclusion that

> Weapon systems, even major ones, are rarely deployed as the end result of a categorical decision to create them made at some level of the political, or even military leadership of the country.

The evidence of the "Summer Studies" and of the von Neumann committee referred to in the opening chapter contradicts Tsipis statement, and indicates that many major systems did result from a "command decision" from above. This was also the case for the development of the US nuclear and thermonuclear weapons, as well as those of the USSR, Britain and China.

Another description of the effects of military R&D on major weapons competition between the US and the USSR which sounds superficially similar to both that of Tsipis and the one presented in this study is the notion of "technology creep" presented by Deborah Shapely in a series of articles in the journal Science in 1978 (4). However Shapely's description entirely omits consideration of exactly the military R&D infrastructure which this study takes pains to document: its establishment, organization and operation and only thereby its production of the technology which is "creeping". Shapely's presentation again fails to take into account the context in which the process takes place, and thereby misses the main point: the "creep" is not an accident or an artifact, it is precisely the function of the system to produce it, and it was established and designed to do exactly that.

Lessons From the Case Studies

The largest portion of this book is made up of four case studies of weapon system development. The four are:

1. The Origins of MIRV (Multiple Independent Reentry Vehicles — for ICBMs and SLBMs)
2. The History of the Development of United States ASAT (Anti-Satellite) Weapon Systems
3. Weather Modification: The Evolution of an R&D Program into a Weapon System.
4. Research and Development in (C)BW: a study intended to examine in particular the questions of "Basic" versus "Applied" research, "Civil" versus "Military", and "offensive" versus "Defensive" research.

The central focus of each of the studies is somewhat different, but most have — in addition to the involvement of military R&D questions — two important considerations in common:

— Arms control has had an impact on weapon-development processes in three of the cases (weather modification, BW, ASAT)
— Two are categorized as weapons of mass destruction or the equivalent, (BW and weather modification), and the third at least in its earlier years involved nuclear weapons either in the ASAT or its presumptive target. MIRVs, of course, concern nuclear-weapon delivery systems.

All of these case studies are very much, if not primarily, concerned with the development process of the weapon systems, and the decisions that were taken regarding them. The case studies except in the study on BW, are not focused on the research per se: that is dealt with in the opening chapter.

Aside from the first study on MIRV, however, none of these systems represent the weapons now basic to all military forces — tanks, planes, ships, missiles — all of which involve successive generational replacement. The lessons that will be learned from these case studies can therefore be expected to be unrepresentative of those that might obtain regarding the more "conventional" categories of weapons. The relations of R&D to the development process will, however, probably not differ significantly.

The first study, The Origins of MIRV, seeks to isolate the reasons for which MIRVs were developed and to assess the degree to which "technological imperative" did or did not play a role. MIRV development appears to have clearly been typical, "regular", as regards all of its major determinants except one. There were numerous reviews and internal debates on its characteristics, and changes in its development program in the years 1962-1966. The motive for the weapon also seems rather clearly to have been the larger military-political considerations. The major studies on MIRV genesis in the United States by Greenwood, Tammen and Sapolsky all demonstrate explicit policy interest in the development of the system. The single brief study by York that attributed the origin of MIRV to technological imperative appears to be extremely selective and oversimplified in its treatment: only one element is discussed, and the history of decision making regarding the weapon is omitted entirely. The one significant difference in the MIRV development program from more routine "bread and butter" systems, a characteristic it however shares with some of the other case studies covered here, is that all decisions, including procurement, were made in secret.

The second study, a history of the development of US antisatellite systems, concerns far more complex technological systems than are dealt with in the other studies. ASAT — and the related early programs which surrounded it — made far greater demands on coordinated research and significantly more in terms of expenditure. The study also deals with the political determinants of the development of the system, and of direct US/USSR interactions and negotiations that affected the development process. The USSR's ASAT development program is also described.

The original ideas for a (US) ASAT were born in the bravura period of 1958-60-62. It was a period of both political and technological excitement, full of threat perceptions. The systems proposed were technologically demanding and they were expensive. Not all of the senior Air Force military decision makers — the service in which development took place — agreed on the desirability of the program, particularly its manned space element. The program was essentially rejected by all senior civilian Dept. of Defense officials. The decision to procure essentially a substitute direct ascent missile-launched system of extremely limited capability was made in secret. All tests of the system in subsequent years were also kept secret: he United States did not want to jeopardize its own use of military satellites.

The impact of negotiations in 1962 and in 1968 on ASAT development programs both in the US and in the USSR is ambiguous, or perhaps can be assumed to have been inconsequential. The USSR assumedly did not deploy any space orbiting nuclear delivery systems and the US had no interest in developing these. However, the cancellation of the major US ASAT programs did not impede USSR orbital ASAT R&D, or USSR manned programs. Continuous low level R&D in the US, much of it under the ABM R&D program, developed an active homeing conventional destructive device and eventually produced the capability for a new ASAT program in 1976-1982. Major political decisions on the new program, now in the context of an ongoing USSR ASAT R&D program, were made by the end of the Ford administration in 1976 and in 1977-78 under President Carter. Harold Brown, Secretary of Defense in the Carter administration, had been instrumental in 1962 as Secretary of the Air Force in cancelling the more extravagant US orbital ASAT R&D-programs. It is interesting also to note that in the relatively rare case of the cancellation of the Dyna-Soar program, its technological capabilities if not its mission conception were more or less reborn in the US space shuttle program. ASAT negotiations during 1977-1979 produced no results and the Reagan administration introduced an extravagant bravura period again, not unlike 1958-1960 in some ways, and one program on which this atmosphere had a direct effect was the new US ASAT. Even if one assumes that earlier negotiations in the 1960's had had some restraining effects by reducing threat images and inhibiting interest in ASAT system development in the United States, it would appear that it did not restrain Soviet ASAT development, and after 15-20 years the restraining effects on US programs were wiped out by a combination of new technology and a new political situation.

The third study is concerned with weather modification. Both the discovery of the phenomenon and its use as a weapon in war came only recently. Its use came as a total surprise to the scientific, military and international political community. The disclosure of its use also led almost immediately to negotiations for its control as a weapon of war. The focus of the paper is on the question of control — or lack of control — in the development of weather modification from its discovery during WWII to its use some twenty years later in a theatre of war, in Indochina.

Weather modification came to be used under the pressure of (or with the opportunity of) the US war in Vietnam. It was only one of a substantial group of exotic, substantially improvised and covert operations — herbicides, chemical warfare, weather modification — sponsored primarily by organizations other than the uniformed services, by agencies such as the ARPA, the Advanced Research Projects Agency in the Dept. of Defense, and the CIA. The weather modification program succeeded in remaining super-secret long after use began. The others were compromised upon initiation of the program since the operations were easily noted by the enemy target. The programs were all rushed into use and received only marginal and grossly innadquate prior review. All of the programs were either operational failures or military/ political diplomatic disasters or both, and eventually had to be forcibly curtailed by presidential order. Weather modification and chemical warfare use both led directly to international negotiations on their restriction

The fourth study, on R&D primarily in the area of biological weapons, is an attempt to probe the relation of R&D to arms control and disarmament agreements, and the problems of verification in conjunction with such agreements or of confidence assessments in the absence of verification. It is also a more or less unique attempt to deal with the problem of distinguishing between three pairs of opposed terms used to describe research: basic versus applied, civil versus military, offensive versus defensive. It is also possible to examine a historical example of conversion of military R&D facilities in this study, the Fort Detrick and Pine Bluff BW R&D and production facilities in the United Staates that were closed down and converted in the early and mid-1970's.

Military R&D And Arms Control

It has not been the primary purpose of this study to go into arms control questions in detail, but we can briefly survey some of the studies that have focused on the relation of military R&D and arms control.

Very early after WWII the nuclear physicist Niels Bohr, in an extravagantly idealistic plea, argued that "... the free access to information necessary for common security...", the removal of secrecy regarding the secrets of nuclear energy and the transfer of such information to all states would remove the suspicions that bred international military competition (5).

As we will see, the removal of secrecy and greater openess of information has been suggested also in more general frameworks as a constraining influence on national military R&D programs. At another extreme, in a far more realistic attempt to deal with the existing international reality, Lewis Mumford essentially suggested an R&D moratorium in papers published in 1954 and 1955 (6). Although these proposals were an attempt to deal with the most basic political and societal aspects of the problem, they were ridiculed by the scientific community and were considered an atavism. Nevertheless, Sir Solly Zuckermann, formerly Chief Scientific Adviser to the British Ministry of Defense and then to the British Government, suggested the same thing some thirty years later. He argued that a moratorium on military research and development was the first essential step to arms control. (7) In a public address in Stockholm in the spring of 1983 he again suggested that "a halt in funding for laboratories performing military R&D would be the best method to stop the arms race, particularly the laboratories in East and West that design new nuclear weapons."

Any suggestion for the curtailment of military R&D has always been fiercely opposed by the senior military officials responsible for the management of military R&D. Their arguments are always composed of a combination of claims of pragmatic national security, combined with a claim to an ultimate philosophical position which is supposed to remove the question from any possibility of disagreement or debate. Military journals which deal with R&D frequently carry exhortative articles on one or the other of the two themes, or at times the combination of both. (8) The first theme reiterates the need to keep ahead of the enemy in a technological race and makes clear that tomorrow's weapons derive from and depend on today's research. The second propounds the philosophical view that "science can't be stopped," "progress can't be stopped." The conjunction of "progress cannot stop," and "we do not want it to stop" is frequent and hardly accidental. The continuity, for political reasons, of the process of research-development-device procurement itself then becomes the claimed proof of the thesis that "science can't be stopped," as if this were a somehow ordained or predetermined process, as certain as the motions of the planets and impossible to alter even if one wanted to — rather than what it actually is, a well-organized and highly successful goal-directed effort funded and administered by the very authors of the journal articles. The senior US military leadership has not only maintained this position for rhetorical purposes but has significantly made major policy choices on national security questions on very similar grounds. On the question of a Comprehensive

(Nuclear) Test Ban Treaty in 1963, the US Joint Chief's explicitly prefered to continue both US and USSR nuclear testing, despite the ability of a comprehensive treaty to freeze what they recognized as a US advantage at the time. They believed that with continued testing the US would always maintain a selective "lead" over the USSR on the basis of its examples of past R&D successes. They have maintained this position in general despite the numerous successive historical examples during the post WWII period which demonstrate that provided the additional years to continue R&D the USSR has in every case eroded any US technological advantage which existed and erased the "lead".

More significant perhaps is the fact that there was virtually no opposition to this argument on the part of arms control specialists until very recently. The case of ABM has been a prime example.

> Until recently, official scientific advisers and some of the scientific community interested in such matters have advocated research and development to improve certain weapons technologies, even when they have strongly opposed the deployment of the corresponding specific weapons, whether because they were ineffective or because they would accelerate the arms race. Over a period of nearly fifteen years, independent scientific advice discouraged deployment of successive ABM systems. But each time the independent scientists recommended against deployment, they also advocated more research aimed at the next level of improvement, primarily on the grounds that we could not afford to be taken by surprise over what was technically possible. Thus Nike Zeus was abandoned in favor of the development of Sentinel and, subsequently, of Safeguard. Next, the limited deployment of Safeguard was accompanied by advocacy of a strong research and development program for Hardsite, which turned out to be a system designed to meet the arguments of those who had publicly opposed the deployment of Safeguard. Only the ABM treaty brought about the abandonment of this program.
>
> Since SALT, however, one hears less talk of the pursuit of R and D as an alternative to deployment. The possibility of limiting technological progress in weapons prior to a deployment decision is beginning to be seriously discussed by those interested in arms control. (10)

Jerome Wiesner's testimony to Congress during the ABM debate can be considered the classic demonstration of this position. The argument may have been made out of conviction or for political reasons, deemed necessary to make opposition to ABM deployment politically credible.

Even more, increases in R&D have been demanded by the Joint Chief's of Staff in return for their support of particular arms control treaties. The following four "Safeguards" were understood as conditions for support of the Partial Test Ban Treaty in 1963. These were

> A. The conduct of comprehensive, aggressive, and continuing underground nuclear test programs designed to add to our knowledge and improve our weapons in all areas of significance to our military posture for the future.

B. The maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology which will attract, retain, and insure the continued application of our human scientific resources to these programs on which continued progress in nuclear technology depends.

C. The maintenance of the facilities and resources necessary to institute promptly nuclear tests in the atmosphere should they be deemed essential to our national security or should the treaty or any of its terms be abrogated by the Soviet Union.

D. The improvement of our capability, within feasible and practical limits, to monitor the terms of the treaty, to detect violations, and to maintain our knowledge of Sino-Soviet Nuclear activity, capabilities and achievements. (11)

Eight or more "Safeguards" were again demanded by the Joint Chiefs and Sec. of Defense Laird in 1972 in compensation for approval of the SALT I agreement. On May 26, 1972, the treaty on the limitation of anti-ballistic missile systems (ABM treaty), the Interim Agreement on the limitation of offensive weapons and an additional protocol on the number of ballistic missile submarines and launchers on submarines were signed in Moscow. Within a week U.S.Secretary of Defense Melvin Laird and John S.Foster, Jr., Director of Defense, Research and Engineering, had presented a series of "SALT related adjustments to strategic programs" in placing their budget request for fiscal year 1973 before a U.S.Congressional committee. (12) These adjustments were, in various presentations, six or eight new or accelerated strategic weapons programs. Foster's position was that the United States must prepare to deploy weapon systems permitted by SALT and to procure strategic systems to give the United States a "timely and credible hedge" against abrogation or expiration of the SALT arms agreements:

Both Secretary Laird and Admiral Thomas H.Moorer have made clear that the full success of SALT depends on sustained U.S. strength and that programs necessary to sustain that strength must go forward if the viability of the agreements is to be assured. There are several reasons for that position:

First, the initial agreements have slowed but not stopped the increase in Soviet strategic strength. They embody as effective limitations as we could get the Soviets to accept at this time. Although they impose no limits on some threats such as ASW (antisubmarine warfare), air defense and qualitative improvement in ICBM and SLBM (submarine-launched ballistic missile) forces, the agreements do provide for the U.S. programs necessary to counter Soviet developments in these areas. Our security depends on continuing the programs necessary to counter the threats not limited by the agreement.

Secretary Laird and Admiral Moorer, head of the Joint Chiefs of Staff, went so far as to say that they could not support the SALT agreements unless these programs were approved. Foster listed eight programs:

1. The Trident submarine and the ULMS (undersea long-range-missile system) submarine (to replace the U.S.Polaris-Poseidon fleet).
2. Satellite bomber basing (to disperse the U.S.strategic bomber force to additional bases as a protective measure).
3. The B-1 bomber (a supersonic replacement for the B-52 and FB-111 strategic bombers).
4. Site Defense or "Hardpoint Defense" and ABM system: "The objective of the program is to develop and preserve the option to responsively deploy a strategically significant terminal defense of U.S.ICBMs".
5. NCA (national command authority) Defense (an ABM system for Washington, D.C.).
6. Command, Control and Communications (and Advanced Airborne Command Post, and other aspects).
7. Submarine-Launched Cruise Missiles (a return to the Regulus-type missile program deployed from 1955 to 1964-1965, which the U.S.Navy had replaced with the Polaris system).
8. Augmented Verification Capabilities (to further improve the National Means of Verification through such methods as satellite reconnaissance).

Secretary Laird listed five of these eight (2, 4, 6, 7, 8,/ but added a rather important ninth program: "develop improved reentry vehicles for ICBMs and SLBMs" (Laird, 12, p. 16). In the subsequent Senate records this was identified as coming under the ABRES program (Advanced Ballistic Missile Reentry Systems (13), an ICBM warhead development program going back over 10 years. Still other programs appeared as "hedges against future threats or requirements":

- mobile ICBMs,
- early warning radars for the SLBM "threat,"
- and the Sanguine VLF (Very Low Frequency) communication system for the U.S.Polaris-Poseidon fleet.

The budget had also already contained substantial amounts for site defense ABM development and for other advanced ABM technology.

> Neither did the Pentagon regard recent arms control agreements as a justification for cutbacks in military R&D. Because the Vladivostok agreement limited total numbers of weapons and weapon carriers, the accord "re-enforces our need for technological progress. Evolution in performance of strategic systems will now be the decisive motivator on both sides as we seek further agreements."
>
> Both arguments deserve careful scrutiny since they put the Pentagon in essentially a "never lose" position. Detente and arms control are given as reasons for increasing R&D efforts. What if detente were

replaced by a more hostile political environmental and arms control gave way to an arms race? In such a case wouldn't the Pentagon also cite those developments to justify greater R&D spending? Whatever happens to those external variables, the result seems to be a request for additional funds. Apparently those variables are decidedly secondary and subordinate to the central test, which is the strategic value of weapons systems. As the Director of Defense Research and Engineering told the Senate Armed Services Committee in 1971: "if there were no Soviet threat, if there were no threat around the world, I would be the first to come in and ask this committee to reduce the research and development budget of the Department to zero."

The claim that detente requires a "renewed emphasis" on technological competition is not elaborated in the Department's published justification statement. When Senator McIntyre asked why competition could not be eased, Dr. Currie replied: "I think that long-range competition is uncontrollable from our point of view. That is the world environment... We are in a position of having to respond. We just don't have a choice in the matter."

The proposition that arms control requires greater R&D efforts received more attention. The request for funds for ballistic missile defense was justified in part as a hedge against sudden abrogation of the ABM Treaty. But other Pentagon officials plan their budgets on the assumption that there will not be abrogation. Mr. Leonard Sullivan, Jr. Assistant Secretary of Defense for Program Analysis and Evaluation, told the House Committee on the Budget that his five-year budget projection was based on the assumption that there would be no abrogation of SALT agreements.

Dr. Currie maintained that in an era of mutual restraints and arms limitation "we should continue to pursue promising technological options in our strategic programs both in order to preserve our capabilities and to encourage the Soviets to negotiate future arms limitations by convincing them of the futility of attempting to surpass us." (14)

Clearly, the same thing happened in the USSR — or perhaps a bit more. In the middle 1970's, during the period of ostensible maximum East-West and US - USSR political relaxation, following the West German "Ostpolitik", the 1975 Helsinki Accords, and the SALT agreements, the USSR made advanced development or deployment decision on

(1) the SS-20 missile
(2) higher CEP warheads for the SS-18 and SS-19 MIRVed ICBM's
(3) the SS-21, 22 and 23 shorter range ballistic missiles
(4) new SLBM missiles
(5) large aircraft carriers
(6) the Typhoon and Oscar class nuclear submarines
(7) strategic cruise missiles
(8) immediately following the deployment of a new generation of longer range tactical strike aircraft in 1974-75, the development of follow-ons to these

It was obsolete in 1957, and it gets more so with every passing year. It is even misleading. It does not begin to take into account the elements which it must in order to understand the interaction between scientific research and the weapons-acquisition process, and it is the misdirection of scientific knowledge which these elements bring about which is the paramount problem of science in our time. (19)

These elements have come from outside the scientific process, have superimposed themselves on it, and have used the scientific process for purposes of national politics. The elements which have adapted the outputs of the scientific method are systems for managing science, applying it, organizing it, funding it, and directing it to serve particular goals.

To aggravate matters, a faith in the classic dogma facilitates the utilization of the scientific process by the imposed elements at the same time as it makes the scientific community extremely reluctant, in the face of its idealized credo, to realize what is actually taking place.

One can suggest a very crude three stage model describing the social utilization of science and the interactions of science with society: (a) in the earliest phase of its evolution, science subordinates itself to politics, claiming to be value-free and neutral; (b) with time, the results of scientific research influence the society but do not yet cause any disruption in its framework — the influence may be significant, but the established institutions have not yet given way to the selection of one applied social utility to be benefited at the expense of all others; (c) eventually the consequences of science and technology may be so great so as to change the very institutions of society, perhaps even developing mechanisms whereby scientific and technological development become the purpose of other social and political activities.

The trouble with the classical scientific dogma is that it fits only a world which is still in the earliest of the above three stages, whereas many societies today have long passed into being some amalgam of the latter two. There exists no theoretical or conceptual framework which deals with the new context. It is here that the insights in 1937 by Hans Kohn and in 1905 by Henry Adams are in important aspects more to the point than the responses of most of contemporary society. As was indicated, Lewis Mumford's suggestions in the mid-1950's based on these insights are rejected.

The break in the traditional way of thinking began around 1970. It had by then become obvious that arms control negotiations concerning a single major strategic system — if at all successful — could take three to six years, or longer. Within the same time the military R&D process on one or both sides could produce several new strategic systems which bypassed the controls put on the negotiated one. (18). Wolfgang Panofsky wrote:

> Our knowledge of science will indeed increase continuously: the facts of nature are there to be explored, and they will not, and should not, remain hidden. But the process of going from science to military technology involves a protracted series of planned steps, including development, test, production, and deployment. This chain extends over many years, or even decades, and it is up to man to decide through his political processes to undertake such steps or not to...
>
> I see no valid excuse why we should acquiesce in the development of weapons of ever-increasing lethality. If we subscribe to the belief that technology has a life of its own and that its progress in any direction, however antisocial, cannot be impeded, then it is indeed true that man has lost control over his own destiny. (19)

A major contributor to the conception of imposing restraints on the military R&D program was the 1971 volume Impact of New Technologies on the Arms Race authored by major scientific figures with senior experience in military R&D and in government. (20) Two more general papers by Franklin Long were also important. (21)

Herbert York's 1971 paper listed seven proposals to limit military R&D both in general as well as in specific areas. The proposals were for

1) A Comprehensive Nuclear Test Ban
2) A Missile Launch Rate Limitation
3) Specific Prohibitions of Certain Missile Improvements
4) Restrictions on ASW R&D
5) Restrictions on ASW Test and Evaluation
6) Gradual Demobilization of Manpower and Facilities Devoted to Military R&D (22)

Harvey Brooks repeated these same seven suggestions in 1975 with the addition of three more, i.e.

1) Restrictions to Permit International Observation on the Location of (missile) Target Areas
2) Unilateral Action of Scientists as a World-Wide Community to Withhold Their Services from Military Research and Development
3) Reorganizing Research and Development to Minimize the "Technological Imperative." (23)

Several of these suggestions have received more detailed treatment by other authors. Sidney Drell emphasized ICBM test limits, and there was some hope that these might have been incorporated into SALT III. (24) A very large group of limitations were included in the SALT I - ABM and in the SALT I - Interim Agreement. These have been summarized by Makins and are included in a group of tables following this section . (25) Makins points out that

> Many of these limitations were introduced into the negotiations primarily to close theoretical, but in practice unattractive, means to circumvent the intent of the major limitations. Acceptance of them represented little more than a willingness to accept the logical consequences of the major limitations. (26)

It is uniformly understood that the same criteria on a larger scale were all that made possible the arms control treaties agreed to by the US and USSR such as the Antarctic, Outer Space, and "Sea-Bed" treaties. Agreement on these was possible only because neither the US or USSR had any major weapon development programs which they considered feasible for deployment in these areas. In the case of sea bottom mounted strategic delivery systems for example, the 1964 US Sea-Bed "Summer Study" whose role it was to determine "the US requirements for future sea-based strategic deterrents beyond the Polaris/Poseidon..." decided that strategic delivery systems mounted on the ocean floor were impractical and undesirable. Given prior US military R&D decisions ruling out such areas of interest, it was possible to reach agreement on a sea-bed treaty with the USSR in 1967.

At the same time more than one arms control specialist has emphasized the desirability of even these measures in order to "close off" areas from expanded future efforts of military R&D programs.

> It is an old question whether it is possible and feasible to put restrictions on research and development activities in order to prohibit possible expansion of the arms race into new areas...
>
> The central difficulty is of course that a piece of research can serve the purposes both of peace and of war.In the latter case it can be good for both offense and defense. One example is microbiological research promoting at the same time both public health and the development of biological warfare or protection against such warfare.
>
> Another problem is that control measures established to verify international agreements must be easily described in treaty terms and they must be easily formalized to become suitable as a basis for political decision-making and action.
>
> There is, therefore, no general way of controlling military R&D, as this control would sometimes have to deal with the intentions and thoughts of individual scientists. In specific areas, however, practical measures might be envisaged.

One example is R&D activities involving operations of such a magnitude that distinct features of obvious significance for weapons development can be easily identified and observed in a formalized manner. The obvious example, of course, is the nuclear test ban, prohibiting activities where one single experiment has dimensions of geophysical size. On the same grounds, a MIRV test ban has also been suggested.

The question, then, is whether there are attractive indirect ways to restrict military R&D in order to stop potential new arms races in new areas of potential confrontations. Here, certain recent arms-limitation agreements are of great importance. The Antarctic treaty, the outer-space treaty, the non-proliferation treaty, the sea-bed treaty about to emerge, etc. will be of great significance. It is also worth mentioning the further restrictions on biological and chemical weapons now under serious negotiation. These have been criticized because they do not result in real disarmament. This may be true:

but the fact that they exclude militarily untouched areas from being flooded by spectacular new weapons is important enough to justify them and to invoke further measures of this kind. In particular, it would be desirable to conclude such arms limitation agreements now, before these areas have been massively invaded by either military or peaceful activities, in order to establish first the security framework within which peaceful activities can then develop

This would exclude such new sectors from the arms race, make intended military R&D meaningless and justify peaceful developments only.

Another indirect type of restriction would be the internationalization of research efforts in the new areas. This does not necessarily mean the setting up of new international bodies to take over activities now national but rather to fulfill the function of opening up research results for common observation.

To make this effective, the international cooperation must be extensive enough to make it definitely attractive for institutions to participate actively. The efforts now undertaken by the United Nations to establish an international cooperation scheme are of great significance for this. Examples of possible future significance are weather and climate manipulations.

A last comment touches on the area between R&D and production. In certain cases the size of research operations overlaps that of small production and deployment. This is true, e.g. for bacteriological laboratories, from which a biological attack might be launched directly out of the peacetime research operation. Control, aiming at early detection of possible attacks of this kind, could be limited to an overall assessment of the nature and size of what is going on in the various laboratories. Other examples of this kind may be found to arise in the future. (27).

However, it would appear that these kinds of relatively blank areas on the military R&D map can be filled by continuous low level R&D programs that do not directly contravene the treaty provisions. This has clearly happened in the case of the ABM treaty, where it would appear that the

USSR has evaded the margins of the treaty as regards radars, and the US has done the same as regards testing of new interceptors. (28) The same may very likely have happened with the 1972 BW treaty, whose restrictions explicitly included development. (See chapter)
In this case genetic engineering capabilities developed subsequent to the treaty may very well erode its provisions, if they have not done so already. In a more difficult interaction, the problems in evaluating the USSR's CW posture and procurement policy, and the difficulty of evaluating intelligence on this score, may eventually also serve to undermine the BW convention. The pressure of continuous development was also emphasized by the 1971 Impact of New Technologies volume, which essentially posed the same question for the basis of its study as did the Makins' report exactly ten years later.

> We are faced today with several new weapon systems, ABM and MIRV, which are at the stage of being deployed. The question to which we addressed ourselves is: Could the development of these systems have been avoided and can future weapon systems be avoided by some sort of national or international policy on R&D?
>
> We see today that technology which was considered remote or even unachievable only ten years ago has in fact been realized. Startling breakthroughs in computer technology and missile guidance are now taken for granted. Indeed, in retrospect, these advancements were made far more easily than could have been imagined.
>
> It seems that there is a general principle operating here: whatever appears to be even remotely possible turns out to be easy. This observation has frightening consequences, for scientists and engineers seem to have accepted the challenge of constructing whatever is possible. It is difficult to be optimistic about the prospects of changing this policy in the future. (29)

Makins devised a series of tables to attempt to define the point — or "time-window" — at which bilateral arms control negotiations regarding specific strategic systems would be most feasible, as well as the point beyond which they are too late. The tables for MIRV, ABM, Cruise Missile, and High Energy Laser are included below. Makins describes the somewhat amorphous conclusions of the study as follows:

A number of representative cases or episodes of special relevance were briefly surveyed on the basis of readily available sources and the direct experience of selected individuals. The cases chosen were MIRV, ABM, cruise missiles, European theater arms limitation and CW. These cases were used to establish preliminary hypotheses about the arms limitation/defense procurement planning relationship which could form a basis for evaluating future possibilities. Three aspects of the process by which the United States and the Soviet Union develop new technologies for military application were identified as being critical to the arms limitation/defense procurement planning relationship.

Application Diversity: some technologies are so multifaceted and broad in appeal that the strategic and bureaucratic momentum behind their application is hard to slow. Thus even though attractive arms limitation bargains covering certain applications of a given technology might be formulated, they could fail to be adopted because of a fear either of circumvention (because the bargains did not extend to cover the full range of potential applications of that technology) or of spillover (onto other applications of the technology on which limitattions were strategically undesirable).

Technological Momentum: applications which require relatively little further advance in technology development and towards which development is progressing smoothly and rapidly are relatively difficult to slow or stop by arms limitation negotiation and agreement. By contrast, those applications for which the additional development required before successful deployment is relatively great and the momentum of the development is relatively low, whether due to technical difficulty in the development or to budgetary restraints, are more likely to be suitable candidates for successful — and mutually advantageous — arms limitations.

Technological Asymmetry: advantage can be derived in arms limitation negotiations by the side that has a real or perceived technological lead in a vital area. However that advantage can normally not be applied to situations in which an agreement would in effect freeze the other side out of a technology application which its rival was close to being able to deploy and could, if necessary, deploy covertly to achieve a strategic advantage through breakout. A corollary of this is that there may be "time windows" in the development cycle of systems involving the application of new technologies during which arms limitation agreements based on prohibitions on development, as opposed to quantitative limits on prohibitions on development, as opposed to quantitative limits on deployment, may be possible, in the sense that neither side is yet the master of one or more of the relevant technologies.

The study of the five cases yielded some important perspectives for the subsequent analysis of future arms limitation opportunities:

1. The interactions between national strategy, international relationships and arms limitation are of critical significance. Where national objectives are indeterminate, inconsistent or subject to frequent or rapid change, the use of arms limitation — or any other means of policy — is likely at times to prove unsuccessful and even self-defeating. The lesson of the experience of the 1970s is that analysis of future arms limitation possibilities must be based on precise and explicit assumptions concerning both U.S. and Soviet strategic concepts,

objectives and policies. The question for analysis is whether either side, or both, in the light of their assumed, different strategic objectives and policies would be likely to see advantage in the proposal. It is a matter of policy decision as to whether to accept the assumptions on which the analysis rests. The ABM Treaty case was especially instructive on this point and is a good point of reference in connection with the prospects for both BMD limitation and arms limitations in other areas.

2. The disparity between the inherently dynamic nature of the East-West military and technological competition and the relatively static nature of arms limitation agreements is an important one. While such agreements can be changed, this can by and large only be done with some difficulty. But if such agreements are not of some significant duration, they are likely to have little certain practical impact on the course of the strategic competition.

3. There are time periods — or "windows" — within which attempts to negotiate arms limitations in the form of the prohibition or effective prohibition of new technology applications which may be assessed as being in the U.S. national security interest have the treatest chance of being successful. These time windows are defined by the three factors cited earlier, namely, technological asymmetry, technological momentum and application diversity. Typically, there would be two such windows in the lifetime of a particular technology or systems concept during which prohibitions or significant limitations could be achieved.

   The first window would open after development had proceeded successfully to the point at which the characteristics of the system were clearly enough defined to permit its strategic significance to be baubed and a detailed assessment of arms limitation possibilities to be made, but before either side's development program had reached the point at which one side, but not the other, was ready to produce and deploy the system.

   This window might in some cases be open for a long time, e.g., when a development program makes little headway or stalls, due either to inability to solve a technical challenge (e.g., ABM in the 1960s/early 1970s) or lack of military interest/financial support (cruise missiles in the early 70s). But in other cases, this window may only open extremely briefly, as was the case with MIRV, which moved quickly through a successful development program to a point at which the system was ready to be deployed.

   The second window would open after both sides have mastered the technology, but before full-scale deployment has been completed. Since at this point the military demand for the system would generally be real, the most likely arms limitation options would be for fairly permissive numerical limitations on deployments, though stricter limits, effective prohibitions or even complete prohibitions would still theoretically be possible.

4. A thorough process of net strategic and technical assessment is essential to the evaluation of arms limitation possibilities. This process would be both conceptually and bureaucratically more balanced than the existing arms control impact statement process and would, in addition, represent a vehicle for gauging both arms limitation proposals and defense procurements in relation to the statement of national

> strategy and objectives contained in the Defense Guidance document. The process would involve the use of various techniques of analysis and technology forecasting to define and evaluate, in the light of specified U.S. and Soviet strategic objectives, the U.S./Soviet strategic relationships which would occur at different times in the future and under different arms limitation regimes (including a no-arms limitation regime). The cases studied suggested that the absense of such an assessment in the past was a distinct liability. (30)

At the same time, studies still continue designed to take advantage of technological assymetries in the U.S./USSR weapons competition. (31)

The question of reduction of military R&D expenditure in particular (as distinct from military expenditure in general has been raised only in one occasion. In 1972 targets for monetary aid to developing countries, specifically related to research and development, were established in the United Nations as part of the World Plan of Action for the Second Development Decade. There were three separate financial targets, the third of which was the stipulation that five percent of R&D expenditure of developed nations be devoted to the R&D problems of developing nations. (32) At the time some six nations — the USA, USSR, UK, France, Germany and China — spent over 80 percent of world military expenditure, and by the only estimate then available, some 98 percent of total world military R&D expenditure. (33) It was pointed out that "the proposed 5 percent target was approximately 12,5 percent of this sum, and could easily be met by a small and gradual decrease of military research during the Decade". (34)

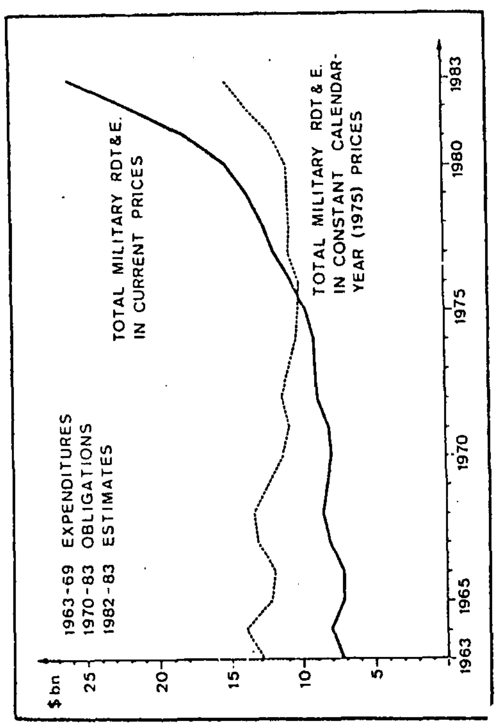
The US and USSR spent the great majority of this sum, and for these two countries military R&D expenditure came to half or more of their total R&D expenditure. The USSR resisted the suggestion that the five percent goal should be taken from all R&D expenditure of the postulated donor nations, and insisted that it be assessed only from their <u>non-military</u> R&D expenditure. (35)

Of course the goals were not met in any case, and military expenditure was unaffected. In the years 1971-1976, when US military expenditure did drop in real terms for autonomous reasons, there was some concomitant reduction in military R&D expenditure (36). (See table below)

US military research and development: DoD direct and indirect funding and atomic energy defence activities, FYs[a] 1963–83

	$ million, expenditures						$ million, obligations													Estimates		% change
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[a]	1977[a]	1978	1979	1980	1981	1982	1983	1980–83
:t funding of RDT&E							7 387	6 984	7 161	7 945	8 000	8 009	8 572	9 212	10 522	11 085	12 021	13 475	15 910	19 872	23 784	
rect RDT&E[b]	415	407	387	416	439	340	300	367	339	362	393	401	429	417	417	434	441	468	585	681	685	
) military RDT&E							7 687	7 351	7 501	8307	8 394	8 409	9 001	9 629	10 940	11 520	12 463	13 943	16 494	20 553	24 469	+75
elated atomic DT&E activities[c]	482	571	556	524	534	609	669	629	609	594	608	607	678	801	924	1 063	1 131	1 132	1 347	1 504	1 684	+49
tary RDT&E: rices[d]	7 273	8 000	7 179	7 200	8 134	8 593	8 356	7 981	8 110	8 902	9 002	9 016	9 679	10 430	11 864	12 583	13 594	15 075	17 841	22 057	26 153	+73
calendar year A[e]	12 839	13 901	12 251	11 970	13 108	13 353	12 398	11 249	10 864	11 398	10 985	10 263	10 109	10 165	10 800	10 711	10 698	10 894	11 882	13 691	15 314	+41
es B[f]											11 236	10 619	10 297	9 984	10 186	10 106	10 074	10 107	10 597			

US military RDT&E: DoD direct and indirect funding and atomic energy defence activities, 1963–83



Source: Table

Source: World Armaments and Disarmament, SIPRI Yearbook 1983, pp 201-203.

All notes for the table have been omitted here.

What is the plausibility of the selective reduction of military R&D expenditure? The experience of the 1970's that was described earlier, both for the US and the USSR, certainly gives one no hope of the political feasibility of such a suggestion. Some argue — on logical grounds — that the hardest element to pry loose from the military services will be that "farthest back" from deployment — which is R&D. In addition, it is difficult to produce a legislative debate on military R&D appropriations, except in particular circumstance described below which do not deal with arms control. Otherwise such appropriations are relatively neutral and very few argue against them. For just the opposite reasons, however, one might assume that it would be politically easier to cut R&D than to cut procurement and deployment. The latter are far more tangible, and R&D has to be argued for in the budgetary process in terms of more provisional "threats" farther off in the future. In fact, for somewhat related reasons, many people in favor of serious arms control and disarmament have traditionally felt that it would be much more significant to stop procurement and let R&D go. Either the R&D could then be "afforded", politically and economically, or it would suffer a sort of retrograde degeneration. It is the weapons procured and deplyed that are more dangerous, and that preempt political decisions, and not R&D.

The instances in which military R&D funds have been frequently cut, either by the Dept. of Defense or by various congressional committees, are those cases in which a weapon development program promises to be obsolete, far too expensive, or will not meet technical performance requirements. There have been a great many such cases: Dyna-Soar, MOL, The Navaho cruise missile, Cheyenne helicopter, B-70 bomber; the Blue Streak and Sky-Bolt missiles, etc. However, none of these programs were cut for arms control reasons. In a very rare instance, the chairman of the subcommittee on military R&D of the US Senate Armed Services Committee, Sen. Thomas McIntyre, was able to obtain the deletion of R&D funds for greater SLBM accuracy during the years 1973-75, on the grounds that administration statements at the time claimed that it was not official policy to seek such accuracy improvements.

In the USSR the greater portion (and possibly even the total) of military R&D expenditure is funded from the "science budget", and is not included in reports of military expenditure at all. This obviously complicates the problem enormously, certainly under any proposed arms-control regime.

The final suggestion, of Harvey Brooks — the unilateral action of scientists as a world wide community to withhold their services from military research and development — has been reflected to a slight degree in various marginal activities in the post-war years. To the knowledge of the author, they have occured primarily in the United States. In an extremely unusual case Norbert Wiener, an eminent mathematician who had been involved in U WWII military R&D programs, wrote an open letter to the government refusing any further participation in military research. (37) A substantial group of scientists that had been involved in the nuclear weapon program during WWII also resigned from further participation in the program at the war end, and there were at least a few such cases in the United Kingdom as well. There were two very substantial efforts by the US scientific community in particular to petition the government in relation to particular weapon programs. The first of these was the Pauling petition (named after Nobel Laureate Linus Pauling) in 1957-1958, asking that the government cease nuclear weapon testing, which can be considered an R&D program. The second case involved an operational program, the use by the United States of herbicidal and chemical warfare agents in Vietnam, and was thus not a protest against an R&D program. The Pauling petition gained some 1800 signatures but did not have any substantial impact on the nuclear weapon testing program other than to add to the pressures which led to the initiation of underground testing of nuclear weapons. In the second case some 22 scientists — including 7 Nobel Prize winners — wrote a public letter at the end of 1966 to President Lyndon Johnson condemning the use of defoliants by the United States in Vietnam. By February, 1967, this letter had gained the signatures of more than 5.000 scientists, including 17 Nobel winners and 129 members of the National Academy of Sciences. Together with international diplomatic pressure in the United Nations this protest did succeed in forcing the cancellation of the program. As a result of opposition to the prosecution of the war in Vietnam there also developed opposition on major American college and university campuses against large scale defense research programs that were affiliated with particular universities — the Massachusetts Institute of Technology and the Lincoln Laboratory, the University of California/Berkeley and the Lawrence Livermore laboratory, programs at Stanford University and elsewhere. There was some effort to dissociate these from their university affiliation, and there was also an effort to curtail classified — that is, secret — research, performed under contract to the Dept. of Defense in academic institutions. (38)

Second to the attempt to curtail military R&D as a component of arms control agreements with the USSR, the most significant development (at least as initially hoped) was the initiation of Arms Control Impact Statements — ACIS — in the United States in the mid-1970's. As early as 1962 Bernard Feld had written:

> The problem seems to be in developing reasonably accurate projections of the effects and dangers of a new discovery rather than imposing restraints on the research leading to the discovery. For this purpose, openness would seem a desirable end to pursue. (39)

The point was the same as Panofsky's in 1971, and the 1969 papers of Franklin Long had also called for a process that paralleled "technology assessment" or environmental impact statements for major weapon systems. Perry had made a similar argument, not perhaps from the point of view of arms control, but rather from that of a more rational weapons acquisition process that took account of a far wider range of national goals by way of criteria for major policy decisions and acquisition choices. He argued that the lesson

> ... derived from this quick overview of the past, is that more thorough-going analysis of possible consequences should be conducted as part of a decision process that involves weapons selection. The influence of weapons choice on strategy, tactics, and level of violence is far too important to be subordinated to questions of technical feasibility, general "weapons requirements, definitions, or institutional preferences. If national goals are to be dependent on weapons choices, then the interrelationship of the two must be properly acknowledged. Whatever the intentions or inclinations of military commanders, at any level, they are inhibited in their strategy and tactics alike by the necessity of employing the weapons they have on hand. If such weapons are suited only to a narrow range of applications, strategy and tactics alike will be limited. Technology alone, or its failure, has not yet been decisively important to the outcome of a war — an accident that promises nothing for the future. A faulty reconciliation of technology with strategic goals, or disrespect for the strategy implications of weapons decisions, could have catastrophic effects. (40)

All of these assessments, by Feld, Perry, Long — and finally that of the Congress — saw secrecy in weapons decision making and the antecedent R&D process as an impediment to a more competent and wide ranging assessment, which might also include arms control goals. In the summer of 1969, as an aftermath of the significant Congressional debate on the acquisition of a US ABM system and in an effort to possibly stave off MIRV deployment, there had been a Congressional Hearing entitled Diplomatic and Strategic Impact of Multiple Warhead Missiles which to some degree served as a model of what was desired. (41)

In the environment of the SALT agreements the US Congress legislated an Arms Control Impact process for all nuclear weapon programs, and for other major weapon development programs that exceeded certain financial criteria. In late 1975, the Arms Control and Disarmament Act was amended to require that the executive branch submit (arms control impact statements to the Congress with requests for) authorization or appropriation. The new provisions required that

> "a complete statement analyzing the impact ... on arms control and disarmament policy and negotiations" accompany requests to the Congress for authorization or appropriations for the following programs:
>
> - Programs of research, development, testing, engineering, construction, deployment, or modernization with respect to nuclear armaments, nuclear implements of war, military facilities, or military vehicles designed or intended primarily for delivery of nuclear weapons.
> - Programs of research, development, testing, engineering, construction, deployment or modernization with respect to armaments, implements of war, or military facilities having an estimated total program cost in excess of $250 million or an estimated annual program cost in excess of $50 million.
> - Any other program involving weapons systems or technology which the National Security Council believes, upon the advice and recommendation of the Director of ACDA, may have significant impact on arms control policy or negotiations.
>
> The new section also required that the Director of ACDA be given "on a continuing basis ... full and timely access to detailed information" with respect to such programs that require arms control impact statements.
>
> ....
>
> The underlying assumption of this new requirement was that the arms control implications of military programs, whether positive or negative, should be considered together with the merits of the programs' defense capabilities. Specifically, arms control impact statements were intended to tell how a given program might enhance or detract from attaining the primary objectives of arms control. According to ACDA, these objectives are to reduce the likelihood of armed conflicts, their severity and violence if they should occur, and the economic burden of military programs. (42)

Opposition to the act was severe within the administration even before it came into law. Four of the six executive agencies concerned requested President Ford to veto the bill, and the Dept. of Defense drafted a veto message for the President to sign. (43) Nevertheless, President Ford did sign the legislation.

The Ford administration did not however comply with the law. The first arms control impact statements, submitted to the Congress in August 1976 as part of the fiscal year 1977 authorization/appropriation process, were a disaster. (44)

The statements were too few in number, too sparse in content, and too late to be of any use in Congressional deliberations over the funding of major defense programs. Of an estimated 70 Defense programs that legally required statements, only 16 were submitted. Most statements were not more than a single paragraph and discussed overwhelmingly the positive aspects of the programs. The statements were submitted after the Congress had authorized the Defense budget for fiscal year 1977 and just before the final vote on military appropriations. Other objections were that the statements lacked analysis, dealt only at the shallowest level with the impact on arms control and disarmament negotiations, and not at all with the impact on policy. Following the letter of the law the Congress could have postponed any vote on the defense appropriation, but that was not done. The Congressional response must however be considered to have been unusually strong. The Chairmen of the two respective Congressional committees wrote to the President's Assistent for National Security that

> We were frankly appalled at the statements... The 16 statements are not, in any sense, complete. They certainly are not analytical. They dealt only at the shallowest level with impact on arms control and disarmament negotiations and they do not deal at all with impact on policy. (45)

Senators Sparkman and Case in correspondence addressed to Defense Secretary Rumsfeld and ERDA Administrator Seamans were a bit more to the point in their language

> The statements provided do not comply with the law and are unacceptable. Accordingly, on behalf of the Committee on Foreign Relations, we request that you take immediate steps to resubmit comprehensive statements meeting the requirements of law on each of the ... programs covered in the initial submissions. (46)

However the results were only slightly improved.

> Analysis implies an examination of such matters as causes, effects, purposes, accompanying circumstances, alternatives, reasons in favor or against, costs versus benefits, and historical evolution. To put it in other ways, an analysis of impact might explore historical, political, economic and military factors, or it could be concerned with long-range, or medium and short-term elements. These are some categories of information, among others, that are necessary for Congress to make its own appraisals and to participate meaningfully in formulation of arms control policy.
>
> ....
>
> Most of the elements of analysis just mentioned are not reflected in the statements submitted. From the viewpoint of their completeness and analytical quality it is difficult to understand how Congress could rely upon them exclusively or even largely to make its own independent appraisal or for assistance in making a Constitutional input to foreign policy relating to arms control.
>
> ....

> We conclude that the latest statements still do not comply with the law and are unacceptable as a model for future submissions. The submitted statements are neither complete nor adequately analytical. They do not deal in any comprehensive way with the impact of the programs covered upon arms control policy and negotiations. They clearly have not served the purpose envisioned in the legislation of being an integral part of the decisionmaking process within the executive branch, nor could they be of particular value to the Congress in making its own appraisals and in participating in the formulation of arms control policy.
>
> A further problem with the statements is that of secrecy. When classification is necessary for full and detailed discussion, as we noted in our response to the first submissions, specific statements should be provided in classified and unclassified form. Every effort should be made to provide unclassified information to the fullest extent possible. (47)

The Congressional committees published seven model impact statements of their own, prepared by the Congressional Research Service, and the incoming Carter administration promised to do a more thorough job.

In the succeeding years the Arms Control Impact Statements (ACIS) have been issued in a substantial annual volume — but to no real effect. (48) They require a considerable amount of staff and time, but are in essence a separate excercise to comply with the law — a "sideshow" alongside the real decisionmaking process. Perhaps it would be more accurate to say an afterimage following that process. Though much more competently written, in all cases they justified administration decisions already taken. Having been produced within the administration, it was impossible that there could be intraagency consensus on a document disagreeing with or being sceptical of administration policy in any significant way. Even if the ACIS had been written by the Arms Control and Disarmament Agency alone, without any intraagency review, it is inconceivable that it — or any other executive agency — would openly take on the role of contesting another agencies policies — in this case the Dept. of Defense before the Congress. Hence the ACIS were never critical enough of weapons programs to form a basis for Congressional questioning or opposition to programs. There was no evidence that they impacted on internal administration decision making, or for that matter, on that of the Congress. In three particular examples during this period which were very problematical weapon development programs either on technical or political/arms control grounds, or both, the ACIS had no discernable effect on administration or Congressional decisions. Secrecy deletions remained a problem, particularly with politically sensitive programs such as ASAT. There was no impact on R&D whatsoever.

It remained for several other Congressional organizations that were responsible for their mandate and their operations only to the Congress to provide more substantial analysis and critiques of US Dept. of Defense weapons programs:

- the Congressional Budget Office, in broadly based routine reports wich do not however usually deal with an individual weapon system
- the Comptroller General, otherwise known as the General Accounting Office
- and most recently the Office of Technology Assessment, which has recently prepared several very substantial, detailed and probing studies of major weapon programs with far more impact on Congressional assessment. One of these dealt with the MX ICBM and the second with space based directed energy ABM defense. (49)

In short, the Arms Control Impact Statements have not succeeded to date in their intended purpose, and they are not likely to. It would appear that such restrictions as exist in the various bilateral or multilateral arms control treaties (see the tables which follow regarding SALT qualitative restrictions) have been the only substantial restraints — if at all — on military R&D.

REFERENCES

1. Solly Zuckerman, Nuclear Illusion and Reality, London, Collins, 1982 pp. 103, 105.

Ulrich Albrecht has written the most explicit position diametrically opposed to that of Zuckerman:

> Two other groupings which have little or no influence in forming the basic patterns of interaction that recreate the military R&D establishment may be neglected. They are the R&D community at large, which has little or nothing to say about military affairs or about the national ministries for scientific research and development, and the scientific and technical personnel within military R&D.

Ulrich Albrecht, "Military R&D Communities", International Social Science Journal, 35:1,(1983): 7-23

2. Ettiene Bauer, "Irresistable, Irrational, Indomitable Military Technology", Bulletin of the Atomic Scientists, 40:5 (May 1984) 4-5.

Another author, Gerard Piel (the editor of the journal Scientific American) attempted by a great exageration to exonerate "science" by placing all of weapon development in "technology" and establishing a distinction between the two."Science is concerned with the discovery of the unknown. Technology is the exploitation of the already known... Contemporary weaponeering is essentially a process of miniaturization, of packing more devastation into a smaller and more portable warhead... This is not Science. It is Technology of a high order, and it is exploiting whole regions of knowledge only recently won from the unknown...
(Quoted by Philip Noel-Baker, in "Science and Disarmament", Impact, 15:4 (1965): 221. In contrast a major proponent of military R&D argued the exact opposite,(C.S.Draper, "Interdependence of Civilian and Military Science", in Annals of the New York Academy of Sciences, 485-489) but in a second article was not above another kind of gross obfuscation. In a description of the laboratory that he headed, the Instrumentation Laboratory of the Massachusetts Institute of Technology, which produced the inertial navigation guidance systems for many American strategic missiles and space systems, he wrote "The primary function of the laboratory is education." (C.S.Draper, "The Inertial Gyro - An Example of Basic and Applied Research", American Scientist, 48:1, (March 1960): 9-19.

3. Kosta Tsipis, "The Building Blocks of Weapons Development", Bulletin of The Atomic Scientists, 33:4 (April 1977), 41

This was a brief editorial commentary to a series of articles on Military R&D which Tsipis had edited for the Bulletin . In its entirety the series consisted of the following articles:

- Kosta Tsipis, "Science and the Military, Bulletin of the Atomic Scientists, 33:1 (January 1977): 10-11.
- H.F.York and G.A. Greb , "Military Research and Development: A Postwar History", Bulletin of the Atomic Scientists, 33:1 (January 1977): 13-26.
- M.A.Milshtein and L.S.Semeyko, "US Military R&D Through Soviet Eyes", Bulletin of the Atomic Scientists, 33:2 (February 1977): 32-38.

LIMITS ON FREEDOM TO EXPLOIT TECHNOLOGY ACCEPTED BY THE U.S.S.R. IN SALT AGREEMENTS

Article & Paragraph	Agreed Statement	Common Understanding	Limitation	TYPE OF LIMITATION: System upgrade	System ban	Design/commonality	Testing practices	Operational practices	EFFECTS OF LIMITATION: U.S. most constrained	USSR most constrained	About equal	Little effect
			SALT I - ABM TREATY									
V.1			No development, testing, or deployment of sea-based, air-based, space-based, or mobile land-based ABM systems or components		●						●	(b)
		D	Definition of mobile system: radars or launchers are not permanent, fixed types			●				●		
V.2			No development, testing, or deployment of multiple ABM launchers or rapid reload launch systems		●						●	(b)
	F		No development, testing, or deployment of multiple warhead ABM missiles		●						●	●
VI a			No upgrade to ABM capability of non-ABM missiles, launchers, or radars, and no testing in an ABM mode	●			●				●	
VI b			No BMEW radars except on periphery of territory and oriented outward	●				●			●	
	D		No other non-ABM large phased array radars except for space-track and ICIM purpose		●						●	
	C	B	ABM deployment areas for NCA and ICBM defense to be separated by at least 1300km					●			●	
	E		If future ABM systems based on other physical principles developed, limitations will be subject to negotiation and agreement	●							●	
XII.2			No interference with NTM					● ●		●		
XII.3			No deliberate concealment which impeded NTM				●	●			●	
			SALT I - INTERIM AGREEMENT									
II			No conversion of launchers for light or older ICBMs into launchers for modern heavy ICBMs	●						●		● (a)
	J		No significant increase in ICBM silo dimensions	●						●		● (a)
		A	Definition of significant increase: 10-15%	●			●			●		● (a)
	L		No conversion of test range launchers for purposes other than testing and training				●	●		●		? a
V.2 V.3			Same limitations on interference with deliberate concealment from NTM as in ABM Treaty									
				1	2	3	4	5	6	7	8	9

KEY: (a) Imprecision or loopholes in limitations.

(b) Lack of technological momentum, i.e., no active program in being or systems obsolescence

NOTE: For a complete listing of all SALT II provisions, agreed statements, and common understandings, including quantitative and other restrictions not directly affecting technology exploitation, see Sauerwein et al A Study of the Impacts on U.S. Strategic Weapon Systems of the SALT II Treaty, SAI, 31 March 1980, Volume I, Appendix A.

LIMITS ON FREEDOM TO EXPLOIT TECHNOLOGY ACCEPTED BY THE U.S.S.R. IN SALT AGREEMENTS (continued)

Article & Paragraph	Agreed Statement	Common Understanding		Type of Limitation: 1 System upgrade	2 System ban	3 Design/commonality	4 Testing practices	5 Operational practices	Effect of Limitation: 6 U.S. most constrained	7 USSR most constrained	8 About equal	9 Little effect
III.4			Type rule: All ASBM carriers credited with maximum number of ASBMs for which type equipped	•		•	•				•	• b
IV.3			Same ban on conversion of light and older ICBM launchers to modern heavy ICBM launchers as in SALT II.A									
IV.4			Increases in volume of ICBM silos limited to 32%	•							•	• a
IV.5			No rapid reload capabilities for ICBM launchers and no excess missiles at launch sites or deployment areas			•		•		•		? a
IV.7			Upper limit on launch-weight and throw-weight of heavy ICBMs, i.e. those of SS-18	•						•		? b
IV.8			No conversion of non-ICBM launchers to ICBM launchers	•						•		? b
		1	No production, testing or deployment of the Soviet SS-16 ICBM		•	•				•		? b
IV.9			Each side limited to one new type of light ICBM		•					•		
	1	1	Definition: new type differs from an existing type in number of stages, type of propellant, or more than 5% in length, diameter, launch-weight or throw-weight	•		•				•	•	?(a b
	2	2,3,4	Limits on changes to permitted new type and other "non-new" ICBMs during flight-testing				•				•	? a
IV.10			No increase in maximum number of RVs on existing types of ICBMs	•						•		
		1	U.S. Minuteman III limited to 3 RVs	•					•			• b
	2		Simulated RV release procedures count as RVs	•			•				•	
	3		Restrictions on reducing weights of RVs and PBVs	•							•	
IV.11	1,2		Maximum number of RVs on permitted new type of ICBM limited to 10, with no increase permitted after 25th launch or deployment if smaller number of RVs is selected	•		•					•	
IV.12	1,2		Max. number of RVs on an SLBM limited to 14, with same rules on changes, simulations as above	•		•		•		•		
IV.13	1		Max. number of RVs on an ASBM limited to 10, with same restrictions on changes, simulations			•	•			•		•
IV.14			Average number of ALCMs per carrier limited to 28			•			•			

LIMITS ON FREEDOM TO EXPLOIT TECHNOLOGY ACCEPTED BY THE U.S.S.R. IN SALT AGREEMENTS
(continued)

				TYPE OF LIMITATION					EFFECT OF LIMITATION			
Article & Paragraph	Agreed Statement	Common Understanding		1 System upgrade	2 System ban	3 Design/commonality	4 Testing practices	5 Operational practices	6 U.S. most constrained	7 USSR most constrained	8 About equal	9 Little effect
II.2	1	2	Type rule: All launchers of a type developed and tested for ICBMs count as ICBM launchers	•		•				•		
		1	"Contains or launches" equals "developed and tested"				•				•	
II.3	4		Heavy bomber type rule, including ALCM and ASBM carriers, with exceptions for airplanes with FRODs and ODs	•		•					•	
		1	Definition: FRODs are observable differences indicating whether or not airplanes can perform specific missions			•					•	
		2	FRODs required on Bison tankers	•		•		•		•		• b
II.5	1	2	Type rule: All launchers of a type developed and tested for MIRVed ICBMs or SLBMs count as MIRV launchers	•		•				•		
		1	"Contains or launches" equals "developed and tested"				•				•	
	2		One flight-test with MIRVs makes an ICBM or SLBM a MIRVed type, other payloads not withstanding			•	•			•		
		4	All Soviet ICBM launchers at Derazhnya and Pervomaysk count as MIRVed			•				•		•
		5	ODs required for future MIRVed ICBM launchers and for submarines with MIRV launchers			•					•	• a
II.6	1		One flight-test with MIRVs makes an ASBM a MIRVed type, other payloads not withstanding			•	•				•	• b
II.7 II.5	1 3		Definition: heavy ICBMs are ICBMs having launch-weight or throw-weight greater than that of the heaviest existing light ICBM, i.e. the SS-19	•							•	
II.8	1		Type rule for counting cruise missiles with ranges >600km	•		•					•	
		1	One flight-test >600km equals cruise missile with range >600km			•	•				•	
		2	ODs required for cruise missiles with ranges <600km			•					•	• a
	2		Definition of cruise missile range			•	•				•	• a
	3		Type rule for counting armed cruise missiles	•		•					•	
		3	ODs required for unarmed pilotless guided missiles			•					•	• a
		4	No conversion from unarmed to armed or vice versa			•					•	? b
		5	Advance notification required if a Party intends to flight-test or deploy an unarmed, pilotless, guided vehicle with ranges >600km on aircraft, except for target drones			•					•	

LIMITS ON FREEDOM TO EXPLOIT TECHNOLOGY ACCEPTED BY THE U.S.S.R. IN SALT AGREEMENTS
(continued)

Article & Paragraph	Agreed Statement	Common Understanding		TYPE OF LIMITATION: System upgrade (1)	System ban (2)	Design/commonality (3)	Testing practices (4)	Operational practices (5)	EFFECT OF LIMITATION: U.S. most constrained (6)	USSR most constrained (7)	About equal (8)	Little effect (9)
	1		Type rule: All ALCM carriers credited with maximum number for which type equipped	•		•					•	
	2		Limit of 20 ALCMs per existing type of heavy bomber (including B-1)			•			•			? b
V.4	1		Type rule for MIRV ASBM carriers crediting all with max. number for which type equipped	•		•					•	• b
V.6	1	1	Removal of systems from MIRV/ALCM carrier aggregates required D&D or other agreed procedures			•					•	
VIII.1,2	1	3	No conversion of non-bombers into heavy bombers or carriers of ASBMs or cruise missiles with ranges > 600km, except for up to 16 ALCM or ASBM testbeds having FRODs	•		•	•				•	
IV.1			No development, testing, or deployment of:									
			(a) ballistic missiles with ranges > 600km on surface ships		•						•	• b
			(b) bottom-mounted or crawling underwater missiles		•						•	• b
			(c) orbital or fractional-orbital nuclear weapon systems		•					•		• b
			(d) mobile launchers or heavy ICBMs		•					•	•	? b
			(e) and (f) heavy SLBMs or ASBMs		•						•	• b
IX.2			No development, testing, or deployment of ALCMs with multiple warheads		•						•	• b
XV.2 XV.3		1	Same limitations on interference with and deliberate concealment from NTM as in SALT I ABM treaty, except to specify that prohibited concealment measures include those associated with testing.									
XV.3		2	No deliberate denial, including by encryption, of telemetry during testing when it impedes verification				•			•		
		3	No shelters which impede verification over ICBM silos				•	•			•	
XVI.1		1,2	Advance notification of ICBM test launches outside territory, and of multiple ICBM launches				•				•	

SALT II — PROTOCOL (until 31 December 1981)

Article & Paragraph	Agreed Statement	Common Understanding		System upgrade (1)	System ban (2)	Design/commonality (3)	Testing practices (4)	Operational practices (5)	U.S. most constrained (6)	USSR most constrained (7)	About equal (8)	Little effect (9)
I			No deployment of mobile ICBM launchers and no flight-testing of ICBMs from such launchers		•						•	
II.1			No deployment of SLCM or GLCM with ranges 600km		•						•	
II.2			No flight-testing of SLCM or GLCM with multiple warheads		•						•	

SALT II — SOVIET BACKFIRE STATEMENT

Article & Paragraph	Agreed Statement	Common Understanding		System upgrade (1)	System ban (2)	Design/commonality (3)	Testing practices (4)	Operational practices (5)	U.S. most constrained (6)	USSR most constrained (7)	About equal (8)	Little effect (9)
			No increase in radius of Soviet Backfire bomber, including by refueling, which would "enable it to strike targets on the territory of the USA.	•						•		? a b

42

Limitations on the Application of Technology Accepted or Rejected by the Soviet Union in SALT

In addition to the major cases reviewed by the study, a larger list of cases in which the Soviets eventually accepted limitations on technology applications during the SALT negotiations was compiled. This list is shown in Figure 3.2. Many of these limitations were introduced into the negotiations primarily to close theoretical, but in practice unattractive, means to circumvent the intent of the major limitations. Acceptance of them represented little more than a willingness to accept the logical consequences of the major limitations.

More interesting, perhaps, are several cases in which the Soviets rejected limitations on the application of technology. The most important of these are discussed below.

- Ban on deployment of land-mobile ICBM launchers. Proposed by the United States at a time when the Soviets were developing, but not yet flight-testing, land-mobile ICBMs, the Soviets rejected the proposal, arguing that limiting mobile ICBMs should be a subject for discussion in a future negotiation. This position reflected the fact that the SS-16/SS-20 was in an advanced state of development, but not yet in the testing phase. The technology involved in making a mobile missile was not profound, however. The United States already had one -- the Pershing -- and Soviet momentum was well beyond the threshold. Nevertheless, the Soviets did in the end accept an effective delay in the deployment of a Soviet land-mobile ICBM by agreeing to Article IV.8 of the SALT II agreement, which prohibited the deployment of the SS-16 and to Article I of the Protocol, which prohibited flight-testing and deployment of mobile ICBMs until December 1981, though the precise reasons for this decision (whether unhappiness with the system or a real sacrifice made in order to reach an agreement) are unclear.

- Ban on deployment of "Exotic" ABM systems. Proposed by the United States in 1971, the Soviets argued that it was not appropriate or reasonable to include provisions on undefined systems, and that the provisions for ABM Treaty review and amendment were sufficient. Since many of these prospective technologies were not even paper, ere was a strong incentive to reject limits. However, in 1972, this issue (to the extent that Articles I and II of the Treaty leave i which is debatable) was resolved to some degree in Statement D, which called for discussion and agreem specific limitations on systems based on "other pl principles".

- Ban on flight-testing and deployment of intercont cruise missiles (ICCMs). Proposed by the United Sta 1970, along with the proposal to limit SLCM launch those most currently deployed, the Soviets claimed th ban was irrelevant because all of those systems obsolete. The proposal was dropped when the Soviets c their proposals to limit FBS. Soviet representation c issue appears to be straightforward. This tends to s the earlier contention that there was little interest Soviet Union in cruise missiles at this time; intere sparked only by the seriousness the U.S. program took c later.

- Ban on testing and deployment of MIRVed heavy ICBMs. posed by the United States in 1973-74, it was re because the Soviets were developing, but had not yet f tested a MIRVed version of the SS-18.

- Ban on development, testing, and deployment of new ty ICBMs. Proposed by the United States as part of March package, and subsequently proposed for the limited per the Protocol. The Soviets countered initially with a pr to ban any new MIRVed missiles, and then to ban any new except for one new non-MIRV type. The Soviets state they wished to replace some obsolete light ICBMs single RVs (presumably SS-11s) with a more modern no system. As the U.S. commitment to the MX grew stronge Soviets proposed (in May 1978) a ban on any new ICBM f entire treaty period, but the United States reject When the IOC date for MX slipped to 1986, the United proposed in July 1978, a ban on the deployment, b testing, of any new ICBM for the entire treaty period. their follow-on ICBM evidently nearer to deploymen this, the Soviets rejected the U.S. proposal. The sid agreed to permit flight-testing and deployment of c type of light ICBM, either MIRVed or non-MIRVed. The S sought to limit the number of RVs on a MIRVed type to s number on their light SS-19, but accepted 10, corres to their SS-18 and the U.S. MX, when the United insisted.

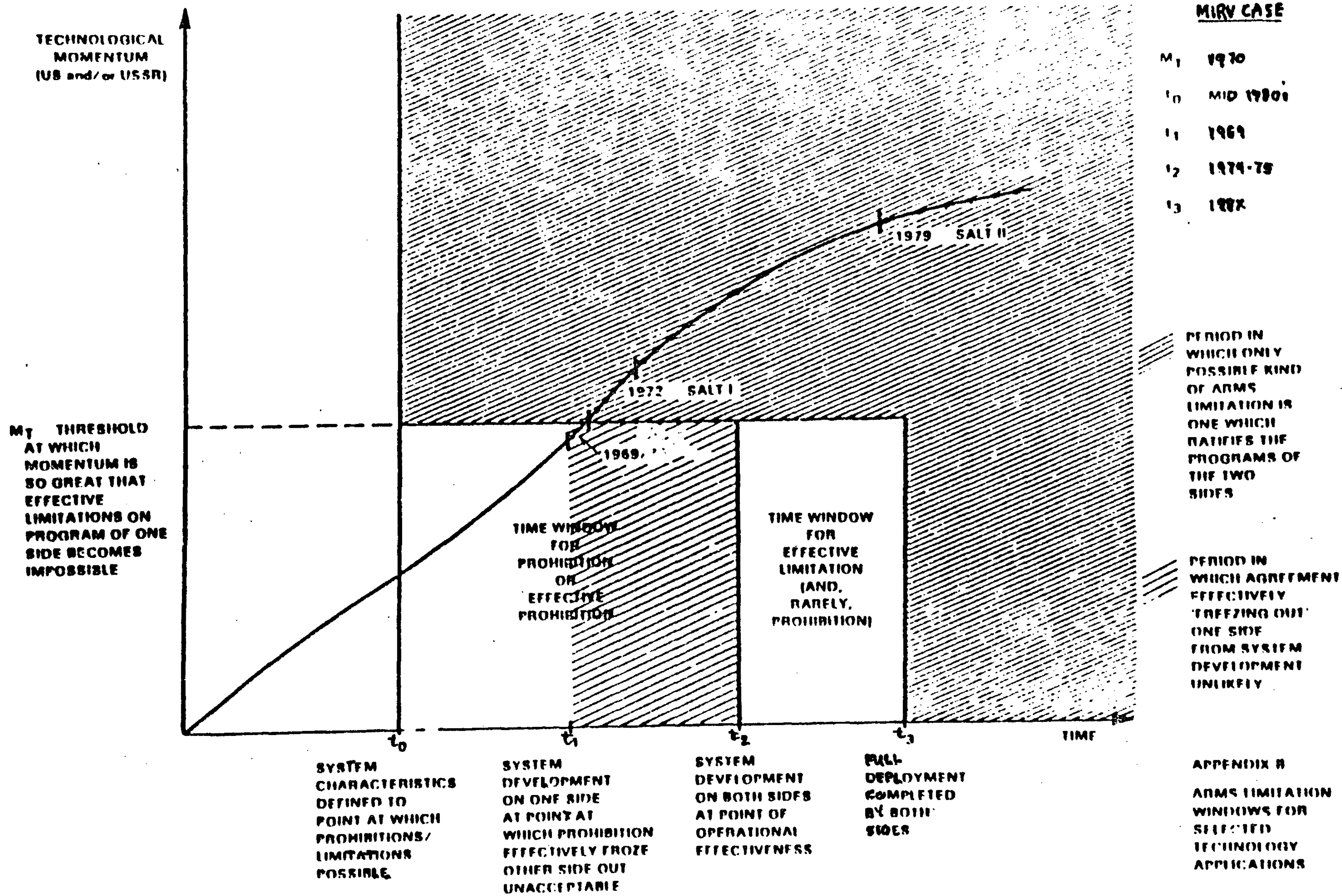


FIGURE B.1 TIME WINDOWS FOR ARMS LIMITATIONS INVOLVING PROHIBITIONS, EFFECTIVE PROHIBITIONS AND EFFECTIVE LIMITATIONS **MIRV CASE**

(44)

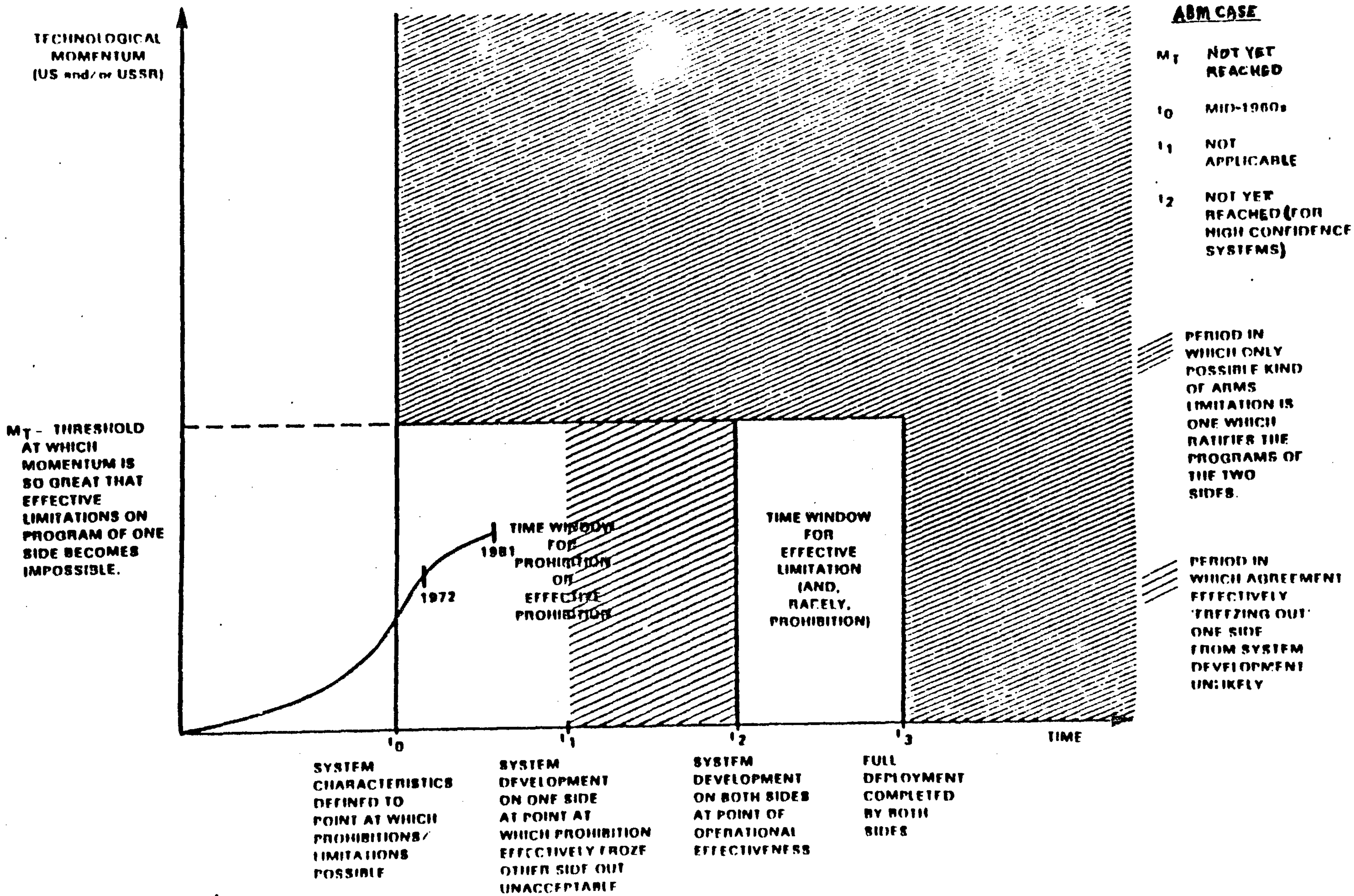


FIGURE B.2 TIME WINDOWS FOR ARMS LIMITATIONS INVOLVING PROHIBITIONS, EFFECTIVE PROHIBITIONS AND EFFECTIVE LIMITATIONS: **ABM CASE**

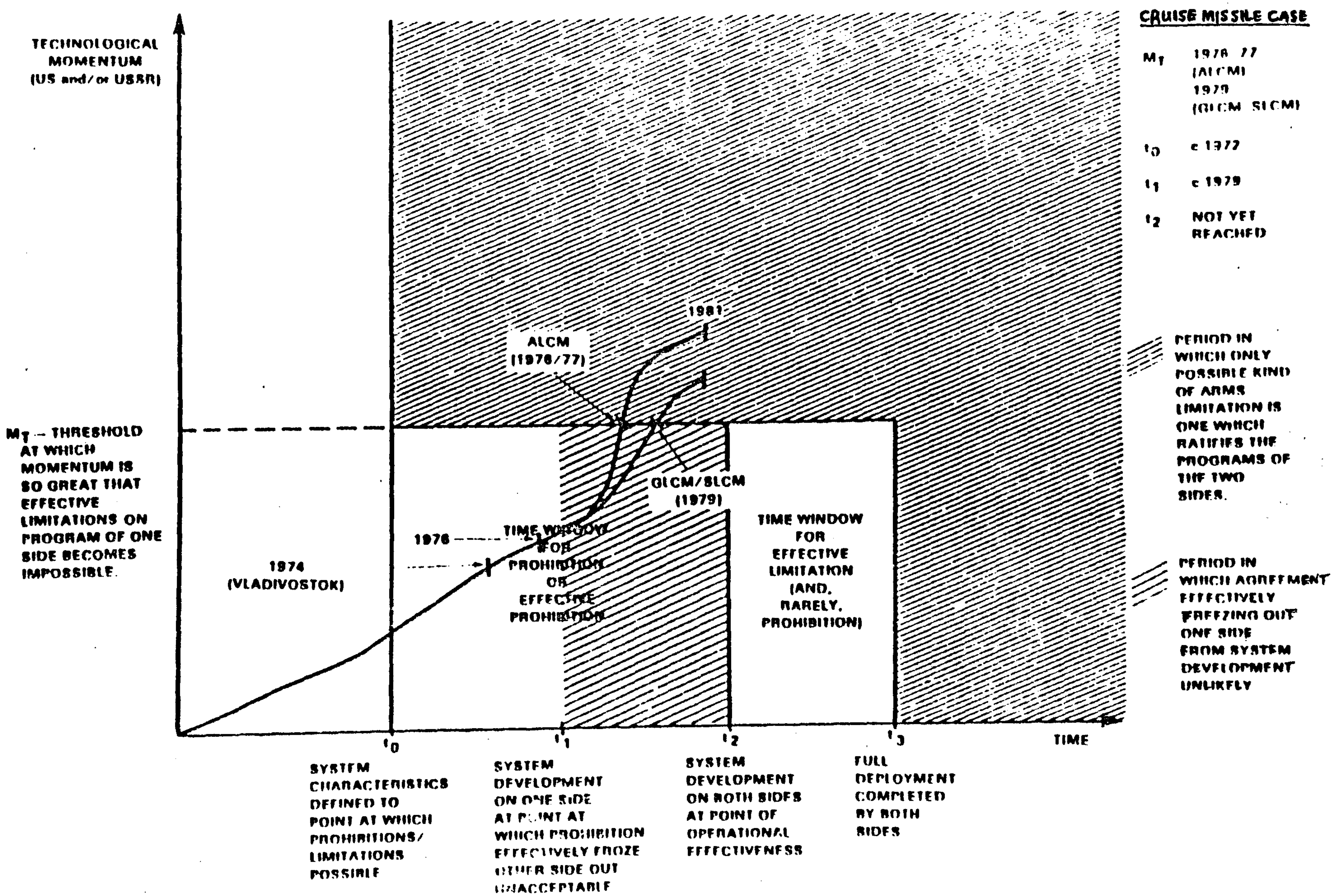


FIGURE B.3. TIME WINDOWS FOR ARMS LIMITATIONS INVOLVING PROHIBITIONS, EFFECTIVE PROHIBITIONS AND EFFECTIVE LIMITATIONS: CRUISE MISSILE CASE

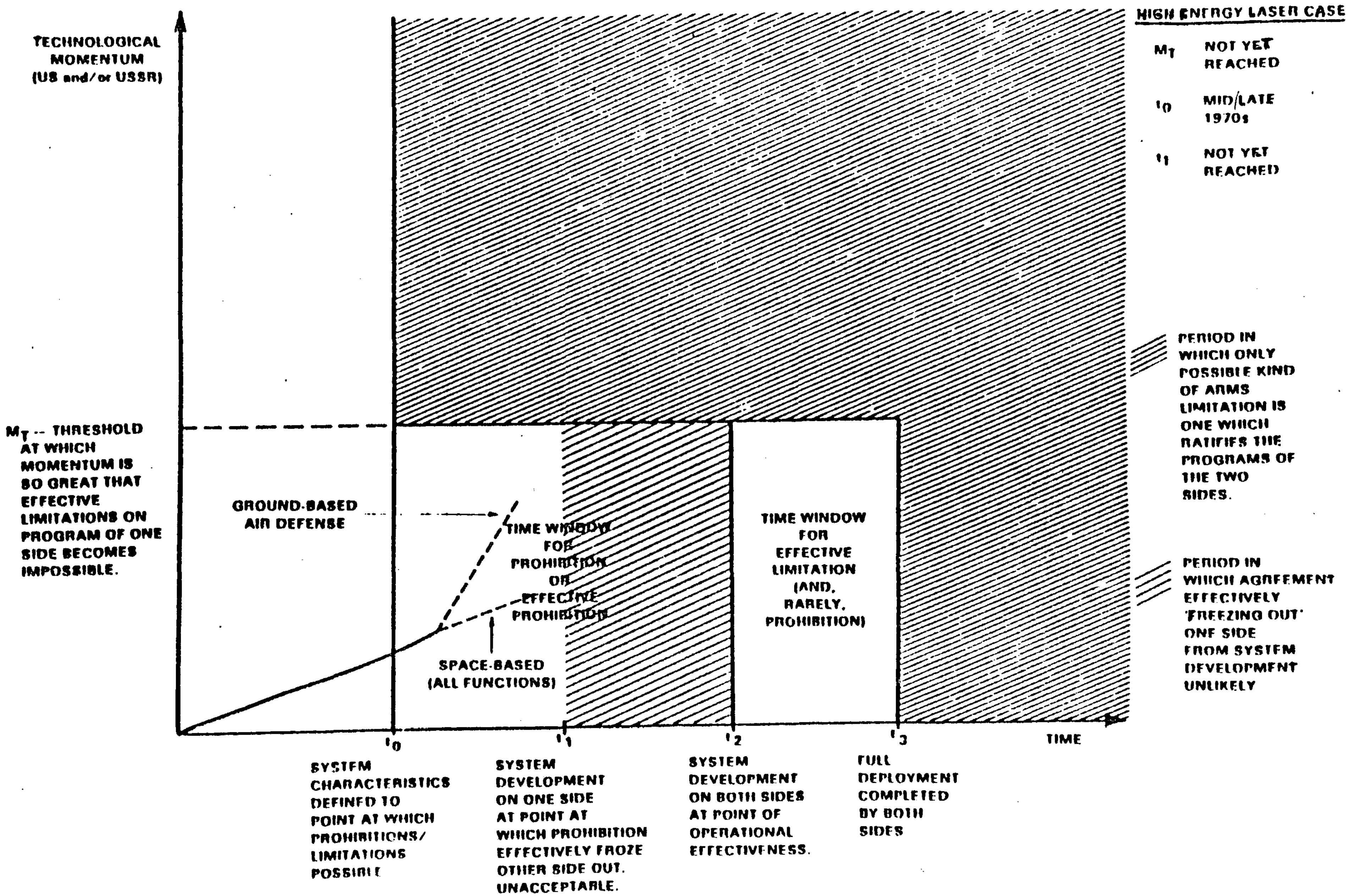


FIGURE B.4. TIME WINDOWS FOR ARMS LIMITATIONS INVOLVING PROHIBITIONS, EFFECTIVE PROHIBITIONS AND EFFECTIVE LIMITATIONS: HIGH ENERGY LASER CASE