The Strategy of Technology: Winning the Decisive War

Stefan T. Possony, Ph.D, Jerry E. Pournelle, Ph.D,
and Francis X. Kane, Ph.D. (Col., USAF Ret.)

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Preface

A Disquisition on the Strategy of Technology, originally in View 30.

It is probably worth keeping a bit closer to the book.

I mentioned Strategy of Technology in a recent letter to subscribers, and discovered that some had never heard of it. That goes to show that this web site is more complicated than it ought to be, and suggests that I need to do more work on organization to let people know what's here. Herewith a short explanation:

Fair warning: this is done informally and from memory, and I may have one or two details wrong.

Strategy of Technology was written in the 60's and published in 1970. The authors of record were Stefan T. Possony and Jerry Pournelle, and the book, long out of print, was published by Dunellen The University Press of Cambridge, Mass., which no longer exists. There was in fact a third author, Francis X. Kane, Ph.D., (Col. USAF, Ret'd) then the Director of Plans for USAF Systems Command.

The book was a success d' estime: that is, it was quite influential, but sold something under 20,000 copies, and went out of print when the publisher vanished. For a while it was a textbook in all three Service Academies and remained so for several years at the Air Force Academy in Colorado Springs. It was also used at the Air War College in Alabama and the National War College, and it's my understanding that Xerox copies are used (with our permission) in some classes at the war colleges to this day. Strategy of Technology was very much a book for the Seventy Years War (or Cold War if you like); although the principles remain true and important, all the examples are pretty well drawn from that conflict and specifics are directed to weaknesses in the nomenklatura system that governed the USSR in those times.

Over the years we rewrote some of the chapters and published them in various places including my own THERE WILL BE WAR series (books that were about 3/4 science fiction but which contained significant non-fiction essays on military history and principles). Dr. Possony had a disabling stroke in the mid-1980's and died shortly after the Cold War ended; he was lucid enough to know that the USSR was brought down, and that he had been a key player in that game. As one of the authors of the seminal THE PROTRACTED CONFLICT (with Robert Strausz-Hupe and William Kintner) as well as STRATEGY OF TECHNOLOGY, and in countless other ways, he had a major influence in winning the Seventy Years War. In my judgment we would not have won the Cold War without him; he was one of the great men of this century although few have heard of him today.

The book has been out of print for years, and when this web site began I was urged to make copies available here, which I did. I have posted the "revised" edition, which contains most of the first edition, prefaces, and some extensively reworked chapters done mostly by Kane and myself, although Stefan had a hand in some of the earlier revision, and we did discuss the later ones with him. After his stroke he remained aware but had great difficulty in communication, which produced extreme frustration as he tried to convey important thoughts that came out incoherently; a very painful situation for all concerned.

The html code which presents the book with extensive notes was done by professionals working as volunteers, and has some minor flaws, (I would be grateful to anyone who can correct them) but the book can be read here. I have been urged to make it available in Acrobat pdf format, but I have never had the time to do so. Perhaps one day.

When we put it up here we called it an experiment in shareware, and I asked that if you read the book you send me a dollar; a dollar bill in an envelope will do. Some have also added a couple of dollars to checks sent as subscriptions to this web site. Over the years that has amounted to a couple of hundred dollars, and at his birthday party a week or so ago Dr. Kane and I agreed that rather than divide this small sum, I'll just send it all to Dr. Possony's widow, who still lives in Mountain View.

Regina Possony was a survivor of Stalin's prison camps (they met in the United States after both had fled). She was born in Berlin and her father was an influential Communist politician who fled with his family to the USSR on the rise of Hitler; they were of course put into a labor camp. As both Jews and Communists they would hardly have survived in Berlin, so a Russian camp was a stark but better alternative to remaining in Nazi Germany. As a young girl Mrs. Possony had met Albert Einstein on a family visit to the United States, and from the USSR prison camp wrote him a letter addressed to "Dr. Albert Einstein, United States of America". The US Post Office delivered it to him at Princeton University. Einstein was gracious enough to reply, and even to send a small package of food and hygienic goods, which raised her status somewhat in Stalin's estimation. After Stefan's stroke she singlehandedly kept him alive for a decade when no one expected him to live a month.

Stefan T. Possony was a Senior Fellow of the Hoover Institution until he died. He had formerly been a Professor of Political Science at Georgetown University, and a Pentagon intelligence officer for the United States. Prior to the invasion of France in 1940 he was an intelligence officer in the French Air Ministry, to which he came from the Air Ministry of Czechoslovakia. His escape from France during the confusion of the Fall of France was a fascinating story; at one point he contemplated using a kayak to paddle to Spain, but managed to get one of the last tickets to Oran.

He had fled Czechoslovakia during the Nazi invasion. He had come to Prague from Vienna, where he obtained his Ph.D. at the University of Vienna and joined the Schusschnigg ministry opposing the Anschluss with Germany; he was on the Gestapo's wanted list, and left for Czechoslovakia as the Wehrmacht rode in. He used to say that the Gestapo got his library three times, in Vienna, Prague, and Paris. In the 70's and early 80's Stefan was quietly influential, directing several Pentagon studies of Soviet leadership and strategy. His biography of Lenin is still about the best tool for understanding the founder of the USSR. Alas it is long out of print.

Stefan Possony was perhaps the single most important member of my Citizens Advisory Council on National Space Policy which among other duties assisted Dr. Kane in writing Transition Team papers on space and military policy for the incoming Reagan Administration. Possony was one of the major architects of the Strategic Defense Initiative. Strategy of Technology introduced the notion of a strategy of "assured survival" in contrast to "assured destruction" and Assured Survival is the title of one chapter of that book.

Dr. Kane and I would like to revise the book and get it back in print, since the principles seem even more important now than they were when it was written. We're both getting old enough that we wonder if that will happen, but it should. As written it's still worth reading (in my judgment), and several War College students have used it as part of their advanced degree work. Revising it was going to be the project of one USAF officer at the post graduate school, but he was needed as director of a weapons lab and left the school before that could be done. Meanwhile, the book exists here.

Jerry Pournelle

Studio City, CA

Saturday, January 09, 1999

> "A gigantic technological race is in progress between interception and penetration and each time capacity for interception makes progress it is answered by a new advance in capacity for penetration. Thus a new form of strategy is developing in peacetime, a strategy of which the phrase 'arms race' used prior to the old great conflicts is hardly more than a faint reflection.
> There are no battles in this strategy; each side is merely trying to outdo in performance the equipment of the other. It has been termed 'logistic strategy'. Its tactics are industrial, technical, and financial. It is a form of indirect attrition; instead of destroying enemy resources, its object is to make them obsolete, thereby forcing on him an enormous expenditure...
> A silent and apparently peaceful war is therefore in progress, but it could well be a war which of itself could be decisive."
> –General d'Armee Andre Beaufre

0.1 Preface to the Electronic Edition 1997

The quotation above opened the original edition of this book; it was clearly prophetic. The silent and apparently peaceful war was decisive.

This book was originally written in 1968 to 1970, a time when the Cold War was real and the outcome still very much in doubt; it will be recalled that Nixon's Secretary of State Henry Kissinger, convinced that the Cold War was lost, hoped to negotiate détente and come to terms with Soviet International communism; and it was widely assumed in 1975 that the United States had been dealt a major defeat in Viet Nam.

In 1991, just before the collapse of the Soviet Union ended the Seventy Years War, we attempted to edit this work into a form suitable for publication in an electronic medium. This was well before the popularity of the world wide web, and before electronic publishing tools were readily available.

The end of the Seventy Years War brought other problems. The senior author, Dr. Stefan Possony, lived to see the victory which he had done so much to bring about, but died shortly after the collapse of international communism. Dr. Kane and Dr. Pournelle were involved in the development of the space program, and particularly the renewal of the X projects which had been canceled by McNamara in the name of Arms Control (because they were so successful at generating new military technology. New technology wasn't wanted by those enamored of Arms Control strategies.)

For those and other reasons, this book languished for six years with little or no work done.

A generation of students used this book, but a new generation can't find it; the copies still in use in the War College are Xeroxes, the book long being out of print. Meanwhile, new threats loom on the horizon. The Seventy Years War is over; the Technological War continues relentlessly. It is possible that this book is needed now more than ever.

Most of the examples in this book were chosen for their impact on thoughts about the Cold War and the threat of Soviet communism. They are now historical rather than current, and a proper revision of this book would use examples from current threats; alas we haven't time to do that; nor have we time to do a proper chapter on space and space weapons. You will find THOR and SDI in these pages, but they aren't given their proper emphasis. No matter. The principles in this book remain as true today as when they were written; we find little that needs explaining, and nothing that requires an apology.

Jerry Pournelle Studio City, California 1997

0.2 Preface to the Electronic Edition 1991

When this book was originally published, the Cold War was very real. The United States was winding down the agony of Viet Nam, and one heard calls for "one, two, three, many Viet Nams" to bring the United States to her knees.

The threat of nuclear war was quite real, although it was not everywhere taken quite as seriously as it should have been.

The Soviet Union was not seen as an evil empire, but as the representative of the wave of the future.

The result was that the early portion of the book was devoted to convincing the readers that the threat was real, and imparting an understanding of the nature of that threat. That was needed then. It is less needed now; yet some of the early material also introduces the concepts of strategic analysis and the technological war, and those concepts are vital to understanding the principles we try to explain in this book.

A full rewrite of STRATEGY OF TECHNOLOGY would go through and pare away those portions written to respond to the threat of the 70's and would add new examples and analyses to fit the threat of the 90's. Alas, we have not time to do this; our choices are a 'quick fix' or not to publish for some years.

[That paragraph was itself written in 1991; what we did then was essentially nothing. It is clearly time to get this published in electronic form, whatever else we do.]

STRATEGY OF TECHNOLOGY was a textbook in the Service Academies for several years, and off and on has been a textbook in the Air and National Defense War Colleges. We have reason to believe that its arguments were useful in bringing about adoption of a high tech strategy for the US Armed Forces. That such a strategy was adopted is self evident from the victory in Iraq and the collapse of the Soviet empire. How much was due to this book can be debated, but we can at least claim that this book explains the principles of technological strategy.

Some day we will revise the examples. However, the principles haven't changed, and the rapid changes in the Soviet Union as well as the Iraq victory can be explained as consequences of an earlier victory in the 'silent and apparently peaceful conflict which may be decisive' which we called The Technological War.

From time to time we have inserted comments made at times later than the first publication. Those are marked with brackets and dated. We find we haven't had to do much revision of the book, and none of the principles espoused needed changing. We have pointed up new examples of the application of those principles.

Portions of this revised text have from time to time been published in different volumes of THERE WILL BE WAR, an anthology series edited by Jerry Pournelle.

Chapter 1

The Technological War

> *There are at least two kinds of games. One should be called finite, the other infinite. A finite game is played for the purpose of winning, an infinite game for the purpose of continuing the game.*
> –James P. Carse, *Finite and Infinite Games*

The United States is at war. Whether we consider this to be the Protracted Conflict initiated in 1917 by the Bolsheviks or something new brought about by the march of technology, the war cannot be escaped. The field of engagement is not everywhere bloody. Except for financial sacrifices, many citizens of the West and subjects of Communism may be unaware of the conflict until the decisive moment, if it ever comes, is upon them. For all that, the dynamic Technological War is most real, and we must understand its nature, for it is decisive. Our very survival depends on our constantly winning this battle.

The Technological War has been raging since World War II. That war marked the end of the era in which decisive military power grew exclusively from the products of the original Industrial Revolution. In the new era, power grows largely – sometimes exclusively – from products based on applied science.

The Technological War is dynamic. There are dramatic peaks in activities as rates of change suddenly accelerate. The theater of operations can change in bewildering ways: recent (1989) events in Europe are a prime example. Ruling classes come and go, alliances are made and dissolved; but the Technological War remains. For the West, the Technological War is an infinite game; victory in one battle, or in an entire theater of conflict, does not end the conflict.

The Technological War is seemingly impersonal because of its new and unexpected sources of change and its global impact. Even so, the Technological War, like all conflicts, is driven by human ingenuity responding to basic challenges and aspirations.

For many years the most basic challenge of the Technological War has been the threat to U.S. security caused by the enmity of the Soviet Union, specifically a small group within the ruling elite of the U.S.S.R. That group within the nomenklatura Footnote 15deliberately chose the U.S. as its enemy after the close of World War II, and renewed the Protracted Conflict against the rest of the world. That conflict has lasted for over seventy years.

The true nature of the Soviet nomenklatura is not fully understood in the West even today. As a first approximation, they may be thought of as the "state engineers" whose emergence under socialism was predicted by Bakunin, and who were first described in popular literature in Milorad Djilas's The New Class. This privileged political-scientific class was the actual government of the U.S.S.R. It arose during the Stalinist purges of the 30's, gained strength shortly after World War II, and consolidated its hold on the U.S.S.R. from the time of Stalin's death until the rise of Gorbachev.

The nomenklatura were the true owners of the U.S.S.R., for not only was the population at large excluded from the political process (except for ritualistic purposes), but also the rank and file of the Communist Party, some 18 million in number, were reduced to executors of the nomenklatura's will. The nomenklatura held the Soviet Union in ownership every whit as much as had feudal landlords; it's position can best be given in the words of Karl Marx, who spoke of the post-1830 monarchy in France as " 'a company for the exploitation of the French national wealth,' of which the king was the director, and whose dividends were distributed among the ministers, parliamentary deputies, and 240,000 enfranchised citizens."

nomenklatura has two meanings: a list of the most important offices, appointment to which requires approval by the Secretariat; and the roster of the personnel who either hold those offices or are eligible for promotion to them. The numbers and names of the nomenklatura remain state secrets. In 1989 Esther Dyson was shown a copy of the Leningrad edition for 1987: a small red book consisting of about 5,000 names and addresses, with no title other than a document number and date.

Although the nomenklatura exists within the Soviet Union, it is independent of the nation in that it owes no allegiance to the country or the people; its major goal, like that of many oligarchies, is to retain its power and privileges.

This power structure has undergone dramatic changes in the Gorbachev era. It has not been abolished, and it is unlikely that it will be abolished in any short period of time. Gorbachev's official view is that the basic structure of the U.S.S.R. is sound, as was Lenin's view of the world situation; the Revolution was betrayed, but the Marxist analysis of history remains sound. In today's Soviet Union the old nomenklatura is the enemy of glasnost and peristroika, and must be replaced. The result is likely to be faces among the nomenklatura, and a new basis for its selection – possibly a structure independent of and antithetical to the Communist Party. Even so, the phenomenon will remain, nor should anyone familiar with political history be surprised by that. Michels's Iron Law Of Oligarchy was written well before the Russian Revolution. Replacement of the nomenklatura would require fundamental changes in Soviet economic organization and structure, and so far those are not only not contemplated, but vigorously denounced by Gorbachev as well as by his enemies within the Party.

Thus, despite changes in Soviet structure, the basic conflict remains; and so does the Technological War. Indeed, glasnost and perestroika , by allowing the new Soviet leadership to abandon obsolete weapons systems, can release new resources which can be committed to the struggle. Military commanders are usually reluctant to reduce the numbers of troops they command; but in fact in the Technological War it is often better to have smaller numbers of highly effective forces than to use one's scarce technical resources to maintain obsolete equipment. For all the talk of a new era in the Cold War, the U.S.S.R. has not noticeably slowed its production of modern weapons, and is not likely to.

In addition to the Soviet threat, there is a second challenge: the threat to the U.S. economy from our erstwhile allies, who, under the shelter of the U.S. military umbrella, have exploited technology to challenge U.S. economic leadership. While purely commercial competition is outside the scope of this book, there is a strong interaction between military and economic national technological strategies. A rational strategy of technology will not neglect the means for expanding the technological base from which military technology is derived. We will return to this point later.

During the 1990's, the major conflict will be between the United States and the U.S.S.R. The natures of both technology and the enemy dictate that this will a be state of Technological War. For all the Gorbachev reforms, the U.S.S.R. is a power-oriented dictatorship, whose official doctrine is Communism: That is, a chiliastic movement which claims inevitable dominance over the entire earth. It is not necessary for all of the individual leaders of the U.S.S.R. to be true believers in this doctrine, and in fact most may not. Since the Soviet Union is a dictatorship, the usual dynamics of dictatorship apply.

The government of the Soviet Union is divided among the Army, KGB, and Party. The Party and KGB appear to be under the near total domination of the nomenklatura. The Army may not be, but military promotions are largely under the control of the Party and therefore the nomenklatura. The relation between Gorbachev and the nomenklatura is also unclear. One thing is certain: glasnost and peristroika cannot be implemented without using the existing power structure, and that includes the nomenklatura.

One fundamental fact of dictatorship is that losing factions within its ruling structure forever lose their positions and power. They may retain their lives – the nomenklatura generally do – but they retain little else, and sometimes they do not survive. Thus, such rulers, whether sincere or cynical, have a powerful incentive to conform to the official ideology or line of the top man or group. Moreover, they compete with each other for power. If a powerful faction counsels aggressive expansion – whether out of sincere belief in the ideology, because expansion creates more opportunities for advancement, or because it expects aggression to prop up a tottering regime – failure is the only way through which its influence will be reduced. Every successful aggressive action increases the influence of those who counsel aggression.

If aggressive moves encounter stern opposition, so that the ruling faction is not only not rewarded for its expansionist policies, but finds its national power decreased, changes in the official policy may take place. Such failures, consequent punishment, and resultant troubles for the dictatorship may serve to place in power a more cautious group dedicated to defense of the empire and the status quo.

This was dramatically illustrated by the Soviet failure in Afghanistan. It is possible that the nomenklatura, faced with rising opposition from both ethnic minorities and even the Russian people, has veered its policy toward one of imperial defense. If so, this will mark an important turning point in history; but we cannot bet the survival of freedom on what may be a temporary policy shift based largely on the life of one man.

Moreover, if there has been a change in policy, it is due largely to the failure of the previous leaders to induce the United States to abandon the conflict entirely. Nearly twenty years ago we argued that the best way to change Soviet policy was to negotiate from strength; we believe the Reagan era has proved that.

There have been profound changes in Soviet leadership and policy since we wrote the first edition of this book. Much of the Soviet leadership has become disillusioned with the inevitability of world victory. At the same time, there is no ideological justification to the rule of the Party – and behind that the nomenklatura – except Communism.

glasnost and perestroika may be genuine; they may even work; but these changes will not and cannot remove all the incentives for expansionism, particular if expansion looks easy.

Moreover, aggressive actions may occur because of internal pressures, especially in a period when faith in Communism as an ideological system is declining, and it is possible, although unlikely, that aggressive initiatives will be taken by non-Communist states.

The international situation is complex; and despite all complications the U.S.S.R. is the single most important and strongest opponent of the United States. If the USSR leadership believes it can eliminate the United States, the temptation to do that will be severe. Consequently, American strategists must primarily be concerned with Soviet strategy and the threat posed by the U.S.S.R..Footnote 1

This does not mean that the economic threat to the U.S. technological base can be neglected. Other nations pursue an aggressive strategy of technological competition, often guided, as with the Japanese Ministry of Trade and Industry, from the highest government levels. International technological competition can sometimes reach levels best described as economic warfare, and the outcomes of these competitive struggles can have surprisingly long range effects on the decisive military Technological War.

The nature of technology also dictates that there will be conflict. This will be discussed in greater detail in later chapters. For the moment, we can say that although technology can and should be driven by an active strategy, there is also a sense in which technology flows on without regard for human intentions, and each technological breakthrough offers the possibility for decisive advantages to the side that first exploits it. Such advantages will be fleeting, for although the weaker side does not have weapons based on the new technology yet, it is certain that it will have them in the near future. In such circumstances, failure to exploit the capability advantage is treason to the Communist cause.

It must be emphasized that to the committed Communist, there are no ideological reasons for not exploiting advantages over the capitalists. The only possible objections are operational. No communist can admit that a capitalist government is legitimate; thus there can be no "mercy" to a vulnerable capitalist regime.

Therefore, capability combines with ideology to produce a powerful effect on intentions, which, be they ever so pure before the advantage was obtained, cannot fail to change with the increasing capabilities: if capabilities grow, intentions become more ambitious.

Thus, it is futile and dangerous to base modern strategy on an analysis of the intentions of the enemy. The modern strategist must be concerned with the present and future capabilities of his opponent, not with hopes and dreams about his goals. The dynamics of dictatorship provide a continuing source of ambitious advisors who will counsel the rulers of the Soviet Union toward aggressive action, and only through continuous engagement in the Technological War can the United States ensure peace and survival.

Because the goals of the United States and the U.S.S.R. are asymmetric, the strategies each employ in the Technological War necessarily are different. The United States is dedicated to a strategy of stability. We are a stabilizing rather than a disturbing power and our goal is preserving the status quo and the balance of power rather than seeking conquest and the final solution to the problems of international conflict through occupation or extermination of all opponents. In a word, the U.S. sees the Technological War as an infinite game, one played for the sake of continuing to play, rather than for the sake of "victory" in the narrow sense.

The U.S.S.R. is expansionist; aggressive; a disturber power which officially states that the only true peace is that of world Communism. Marxist theory would make the Technological War a finite game, to be ended with a clean win.

The United States has conceded the initiative in the Protracted Conflict, and is to a great extent bound to a policy of reacting to Communist advances, rather than seeking the initiative in undermining Communist power. Because we have conceded the initiative in the phase of the Protracted Conflict which deals with control of territory and people, Footnote 2we must not abandon the initiative in the Technological War. We are engaged in a war, not a race, although it may appear to be a race to many of us. But it is a race in which we must stay ahead, because if we ever fall behind, the opponent will blow up the bridges before our runners can cross them.

Given the opportunity, the Soviets will deny us access to the tools of the Technological War exactly as they have denied access to their territory, which they call the "peace zone" in distinction to the rest of the world which is the "war zone". If we are to be on the defensive in the Protracted Conflict, survival demands that we retain the initiative and advantage in the Technological War. We know that U.S. supremacy does not bring on global war, let alone a war of conquest; we held an absolute mastery during our nuclear monopoly. We can be certain that the Soviets would not be passive were they to gain supremacy.

The Technological War is the decisive struggle in the Protracted Conflict. Victory in the Technological War gives supremacy in all other phases of the conflict, to be exploited either by thermonuclear annihilation of the opponent, or simply demanding and obtaining his surrender. The Technological War creates the resources to be employed in all other parts of the Protracted Conflict. It governs the range of strategies that can be adapted in actual or hot war. Without the proper and superior technology our strategy of deterrence would be meaningless. Without technological advantages, we could never fight and win a small war thousands of miles from our homeland, or prevent the occupation of Europe and Japan.

Up to the present moment, technological warfare has largely been confined to pre-hot war conflict. It has been a silent and apparently peaceful war, and engagement in the Technological War is generally compatible with the strong desires of most of our people for "peace". The temporary winner of the Technological War can, if he chooses, preserve peace and order, act as a stabilizer of international affairs, and prevent shooting wars – continue the Technological War as an infinite game.

There could be a different outcome. If the side possessing a decisive advantage sees the game as finite, the victor can choose to end the game on his own terms. The loser has no choice but to accept the conditions of the victor, or to engage in a shooting war which he has already lost.

Technological War can be carried on simultaneously with any other forms of military conflict, diplomatic maneuvers, peace offensives, trade agreements, detente, and debacle. It is the source of the advanced weapons and equipment for use in all forms of warfare. It renders cold war activities credible and effective. Technological warfare combined with psychosocial operations can lead to a position of strategic dominance.

This new form of warfare has its roots in the past, but it is a product of the current environment. World War II was the last war of industrial power and mobilization, but it was also the first war of applied science. The new war is one of the directed use of science. The manner of its use is shown by the changing nature of warfare. Wars of the past were wars of attrition of the military power which was a shield to the civilian population and the will to resist. The new technology has created weapons to be applied directly and suddenly to the national will, soon with the speed of light.

1.1 Definition of Technological Warfare

Technological warfare is the direct and purposeful application of the national technological base Footnote 3and of specific advances generated by that base to attain strategic and tactical objectives. It is employed in concert with other forms of national power. The aims of this kind of warfare, as of all forms of warfare, are to enforce the national will on enemy powers; to cause them to modify their goals, strategies, tactics, and operations; to attain a position of security or dominance which assists or supports other forms of conflict techniques; to promote and capitalize on advances in technology to reach superior military power; to prevent open warfare; and to allow the arts of peace to flourish in order to satisfy the constructive objectives of society.

Each decade since World War II has seen a dramatic, sometimes sudden acceleration of the application of science to defense. In the 1950's nuclear weapons technology led to a complete revision of strategy and force structures. In the 1960's, missiles and space technology shrank the globe. In the 1970's electronics led to "force multipliers" by increasing the possible accuracies of weapons systems from short to intercontinental ranges. In the 1980's the era of "computational plenty" arrived. In the 1990's we will see an explosion in sensors, in optics, and space exploitation, in laser and other beam technologies, and many other fields, all of which will contribute to active defense against ballistic missiles.

The emergence of this relatively new form of war is a direct consequence of the dynamic and rapidly advancing character of the technologies of the two superpowers and of certain of the U.S. allies. Its most startling application to date has been the Soviet and American penetration of space and the highly sophisticated articulation of specific technical achievements in other aspects of modern conflict – psychological, political, and military. In one generation space went from the realm of science fiction to become the hallmark of Superpower status.

The foremost characteristics of the Technological War are dynamism and flexibility, while surprise is its main strategic utility. World powers can expand their technologies and employ them unhindered by actions short of all-out war. The nature of the technological process reinforces the uncertainty of war and of the enemy's course of action. The indicators of success in maintaining a position of dominance are vague and inconclusive because of dynamism, variability, and uncertainty; thus, unless this form of warfare is well understood, it is possible to lose it while maintaining to the last the illusion of winning.

The importance of this new form of conflict lies in the challenge it poses to the continued national existence of the participants. Just as the Romans deliberately increased their national power by adding seapower to landpower, and just as the major nations of the world added increased their power by adding airpower to their surface power, the U.S.S.R. is adding technological power to its existing capabilities.[1]

[1]The above section (1.1) was written in 1968. It is now (1991) possible to see the effects of Soviet adoption of a technological strategy. They have an entire new line of intercontinental missiles with accuracies sufficient to threaten the entire US land-based missile force; and they have gone into space in a big way, so that they have far more experience in manned space operations than we do. They have also built a full line of naval vessels, including nuclear ballistic missile submarines, attack submarines, and cruisers.

The threat of Soviet technological power is much greater now than when we wrote this book; and our time for meaningful response is much shorter. There is still time, more

1.2 Foundations of the Technological War

1.2.1 Fundamentals of Technology Strategy

There are four overall aspects to technological strategy. Enumerating them does not constitute a strategy but merely sets forth certain criteria with which to judge the conduct of the conflict. They are:

- Forces In Being
- Modernization of Weapons
- Modernization of the Technological Base
- Operational Capability to Use New Technology

A power that does not intend to end the Technological War by destroying the enemy must constantly maintain superiority and continuously modernize its forces. At all times, the defending nation in the Protracted Conflict must maintain sufficient forces in being to assure that the enemy does not end the conflict by coup de main, or an overwhelming surprise blow. These forces must have the modern weapons they require, and must know how to use them; must have operational familiarity with them.[2]

given the renewed internal struggles in the U.S.S.R., but we have little to waste. The pace of the Technological War has not slowed at all.

Technological advances can produce a small number of weapons with a decisive capability, as illustrated by the atomic bomb. Since some technological changes can occur unobtrusively and yet be decisive, the real power situations are never transparent and never fully understood, so that the power of the opponent, as well as one's own power, remains partially unknown.

This unavoidable ignorance is the source of direct challenge to the security and existence of the participants in the Technological War. Technology itself does not automatically confer military advantages. Blind faith in technology alone can lead to disaster. Like all wars, the Technological War requires a deliberate strategy, and it must be conducted by commanders who understand fully the objectives they have been instructed to reach.

The Technological War is not synonymous with technological research. The instruments of technological research and development are required for successful participation in the Technological War, but their existence does not ensure their proper use. Research itself does not create technology but is merely one of technology's major prerequisites; and technology by itself cannot guarantee national survival

[2]Note that the Iraqi War was fought with weapons already in inventory when the war began. Some key weapons systems were rushed into the theatre and used experimentally, but in general the war had to be fought with what we had: what the troops already knew how to use. Fortunately that inventory included smart weapons despite the opposition of many critics. JEP, 1991

The result is a highly dynamic process, requiring careful judgment. We certainly cannot depend on our former strategy of industrial mobilization, relying on overseas allies to bear the initial brunt of the war while we convert from a peace to a war economy. We must have a force in being which cannot be destroyed by the enemy, and which can quickly move to counter the enemy's aggressive actions.[3]

Secondly, the force in being must be a **modern** force. It is unimportant if we surpass the enemy in capability to conduct horse-cavalry conduct, or even guerrilla war, if we do not have a force that can fight successfully with modern high-energy weapons. The situation is not symmetrical; if we possess superiority or supremacy, we need not end the conflict by destroying the enemy, and will not do so because of our essentially defensive grand strategy. However, we cannot afford to allow the enemy superiority or supremacy, because he could use it to force so many concessions – particularly from our then-unprotected allies – that the contest would be decided in his favor even if he did not employ his decisive weapons to destroy us.

Finally, we must assure that the technological base from which our forces in being are derived is truly modern and creative. We must be certain that we have missed no decisive bets in the Technological War, that we have abandoned no leads which the enemy could exploit for a decisive advantage over us. For every capability he has, we must have a counter, either through defending against the weapon or riposte against him if he uses it. Footnote 11More important, we must keep a sufficient technological base to allow us to generate the capability to counter any new weapons he constructs or may suddenly invent; and we must stay sufficiently current to allow us to seize the technological initiative when the enemy poses new threats.

1.3 Dimesnions of the Technological War

The dimensions of the Technological War range farther than any conflict previously known in human history. They include the aerospace, from ground-level to trans-lunar space; the ground and the underground deep within the earth; and the surface of the seas and the underwater world we call inner space. The battlegrounds of the Technological War could include every con-

[3]A recent example is the Falkland Islands conflict; Britain had sufficient forces in being to reverse the initial advantages held by Argentina. Had Britain scrapped its nuclear submarines and surface ships [as was indeed planned for the following year] then there would have been no possible response to the Argentine occupation of the Falklands; certainly no response short of all-out war and actions against the Argentine homelands. This could have been very dangerous. The Iraqi war is another obvious example.

ceivable area in which military conflict can occur. Yet, this is merely the endgame aspect of the Technological War. Actual military battle may never take place. The dimensions of the war also include the nonmilitary struggles, psycho-political warfare, ideological warfare, economics and trade, and the educational process. A college campus with students shrilly screaming obscenities at the police, and a quiet laboratory populated with soft-spoken men armed with chalk and blackboards are equally important battlegrounds.

Technological Warfare in its decisive phase will aim at bypassing the other forms of military conflict and striking directly at the will to resist. Military power may be used, and thermonuclear warfare may be necessary to consolidate the victory, but the true aim of the Technological War is the denial, paralysis, and negation of all forms of hostile military power. Often this may be achieved through psycho-political pressure employing tactics of demonstration, terror, despair, and surprise, conducted in concert perhaps with other forms of warfare. Specifically, genuine Technological War aims at reducing the use of firepower in all forms to a minimum.

1.4 An Overview of the Nature of Technology

Before we examine the strategy of Technological War, it is necessary to understand the nature of technology. Contrary to what people have often been encouraged to believe, it is not necessary to be a scientist or technologist to comprehend the general nature of technology, or to employ technology in a strategic contest. Indeed, sometimes specialization on one aspect of technology and strategy prevents understanding of technology in its broader sense.

The following discussion is a nontechnical introduction to the general nature of technology and strategy. Later sections of this book develop each of these themes more fully, but because of the interdependence of strategy and technology in modern warfare, it is not possible to organize this book into discrete sections and chapters. Modern Technological Warfare is a mixture of strategy and technology, and their interrelationships.

The primary fact about technology in the twentieth century is that it has a momentum of its own. Although the technological stream can to some extent be directed, it is impossible to dam it; the stream flows on endlessly. This leaves only three choices. You may swim with the stream, exploiting every aspect of technology to its fullest; you may attempt to crawl out on the bank and watch the rest of the world go past; or you can attempt to swim against the stream and "put the genii back in the bottle".

Since nearly every nation, and certainly both superpowers, swim in more or less the same technological stream, only the first course of action makes sense. To continue the analogy for a moment, there is a fog over the surface of the water, so that you cannot know exactly what and how your opponents – open enemies, or economic competitors – are doing. An opponent may tell you he has crawled out on the bank and is enjoying the view, while in fact he is either treading water or racing away from you. If you do not intend to lose, you have little choice but to swim with the current as long and as hard as you can.

The nature of technology makes meaningless the gunpowder era phrase 'arms race'. It is fashionable at present to speak of the action-reaction arms race, in which each power constructs weapons for fear that the other has done so. According to this theory, Footnote 4the primary reason nations arm themselves is that they react to others.

The newest catch phrases are "arms race stability" and "assured stability". These slogans are essentially undefined by their authors, who advocate that the U.S. simply opt out of a Technological War we can't afford. The Soviet Union, under this notion, will also see the advantages of "arms race stability" and likewise abandon the struggle. The money saved by both sides can be invested in social programs and increased consumption.

We make no doubt that there will be other such catch phrases and buzz words, and that they will also remain undefined and only loosely coupled with reality.

In fact, in the Technological War, opposing powers essentially react to the seemingly impersonal stream that carries them along. They really have no choice and never will have so long as the current flows and there is asymmetry of information between them. The technology stream exists independent of the will of those who create technology. The direction and pace, however, are more amenable to control by strategists.

To continue our analogy, the fog over the technological battlefield is made denser by confusion caused partly by deliberate deception and partly by self-deceptions. Only when the Communist states have transformed themselves into open societies and there is a complete exchange of information – that is, when the fog has lifted from the stream of technology – can meaningful efforts to arrange the contest on a more economical and less risky basis be successful. Until that time we must engage in the Technological War. Footnote 13

It is fairly obvious that rationalization of the Technological War will not come in our lifetimes. glasnost may be genuinely desired by Mikhael Gorbachev and most subjects of the Soviet empire, but its permanence as a policy is not guaranteed. glasnost is especially fragile if the USSR is faced with the opportunity for a decisive win. Finally, we would do well to expect that even if the U.S.S.R. were to change its character, other threats might

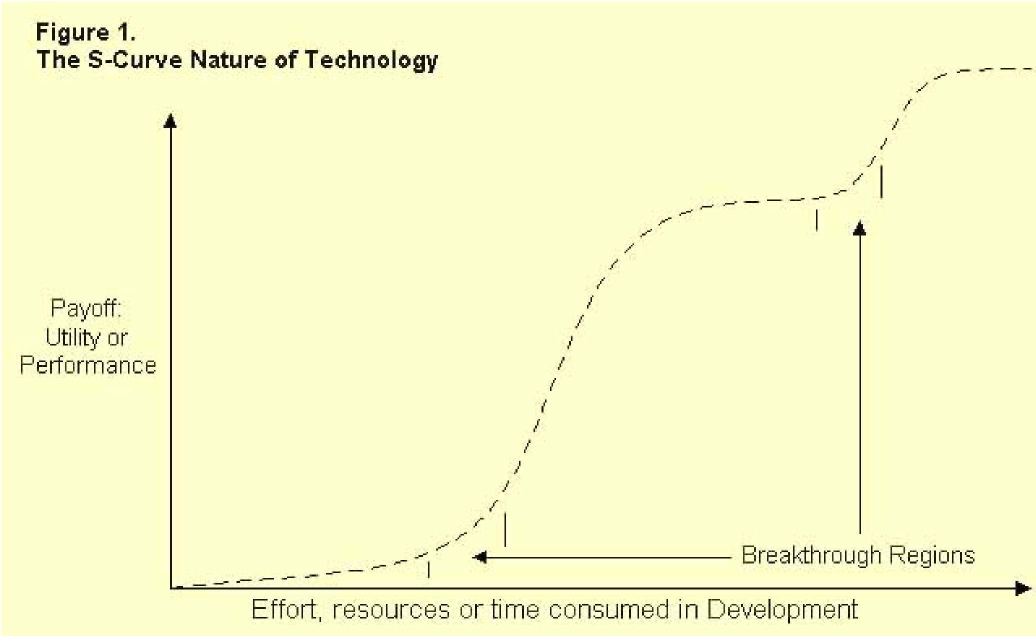

Figure 1.1: The S-Curve Nature of Technology

arise in its stead.

Arms races in the nuclear era differ from those in the gunpowder era in one fundamental way: they are qualitative rather than quantitative. In the gunpowder era, numbers of divisions, tanks, battleships, and aircraft gave rough estimates of the strength of the possessor and his capability to defend himself. It was possible to overcome an enemy by sheer numbers of weapons alone. In the nuclear era, numbers remain important, of course, but the primary strength lies in quality of weapons and their survivability. Nuclear weapons can destroy an enemy's entire military power in one strike if the attacker possess sufficient qualitative superiority. Space technology gives the promise of negating the ICBM as a deterrent to a first strike. This too is a result of the nature of modern technology.

One of the most easily observed phenomena of technology is that it moves by "S" curves, as illustrated in Figure One. Take for example speed; for centuries the speed of military operations increased only slightly as each side developed better horses. Then came the internal combustion engine. Speed rose sharply for a while. Eventually, though, it flattened out again, and each increase took longer and longer to achieve.

To illustrate the S-curve concept, consider the development of aircraft, and in particular their speed. For many years after the Wright brothers, aircraft speeds crawled slowly forward. In 1940, they were still quite slow.

Suddenly, each airplane designed was faster, until the limits of subsonic flight were reached. At that point, we were on a new S-curve. Again, the effort to reach transsonic flight consumed many resources and much time, but then the breakthrough was made. In a short time, aircraft were traveling at multiples of the speed of sound, at speeds nearly two orders of magnitude greater than those achieved shortly before World War II.Footnote 5

Note that the top of one S curve may – in fact usually will – be the base of another following it. Although the stream moves on inexorably, it is possible to exploit one or another aspect of technology at will. Which aspect to exploit will depend on several factors, the most important being your goals and your position on the S-curve.

Technology is interdependent: advances in one sector of technology soon influence areas which might naively have been believed unrelated. For example, the development of molecular chemistry techniques led to the art of microminiaturization, which allows development of computer technology beyond the expectations of only a few years ago. The revolution in computer sciences has made possible the development of on-board computers for missile guidance, and thus of accuracies not previously predicted. Increased accuracy has made possible the destruction of missile silos with much greater ease and smaller warheads.

Nuclear research, meanwhile, had developed smaller and lighter warheads; this coupled with increased accuracy has led to the development of Multiple Independently Targetable Re-Entry Vehicles (MIRV), each one of which uses on-board guidance computers. The increased kill capability stimulated research into silo hardening techniques, which led directly to what were called "hard rock silo" designs. That development made it possible to conduct certain mining operations that were previously financially infeasible. Examples of interdependence can be given without limit. Footnote 12

Thus, technology influences nearly every aspect of national life. In particular, technology influences strategy, forcing strategic revolutions at frequent intervals. There are those who say that strategy never changes. If they mean literally what they say, they have never appreciated the effects of the airplane and the ICBM, the possibilities for surprise attack created by these radical new weapons delivery systems coupled with thermonuclear explosives, and the effect they have on ground battles. If, however, they mean that the principles of strategy have not changed, they are more nearly correct, as we will discuss below.

The important fact is that technology paces strategy to a great extent, and forces the development of new military strategies which take the new technology into account. As we will show, it is dangerous to regard this relationship as one-sided. Technology and strategy are interrelated, and strategy can and should also pace technology.

This is well illustrated by the SDI program. President Reagan was convinced that the U.S. needed a new strategy. That strategy was impossible without new technology. His call for technology to make possible a strategy of 'assured survival' stimulated a dozen technology development programs. It is important to note that most of them worked, and some worked much better than we had supposed they would.

We have not always done badly in this race. Despite the opposition of a number of scientists, the feasibility and potentially decisive advantages of ballistic missiles were early recognized, and a program to develop and deploy these weapons was undertaken. The Thor IRBM was designed, developed, and ready to deploy in just over three years. Submarine launched missiles were developed in parallel. The IRBM was soon followed by the ICBM. Meanwhile, missile research led to capabilities in space technology.

Shortly before the first edition of this book was written, the major computer companies of the world decided that the United States would need no more than a dozen computers, none of them more powerful than the equipment that now sits on desktops in small businesses. The demands for further accuracy in missiles led to developments in miniaturization of components, including on-board guidance computers; the result became a full revolution in computer technology. That revolution's full extent cannot yet be measured.

Despite some spectacular successes, technology appears to many of our national leaders, and most of the Congress, to be an impersonal force. Although America is the leading technological power – perhaps because we are the leading technological power – many of our leaders do not really comprehend technology. As a consequence, technology remains largely a matter of individual initiative. Sometimes we do well. The first edition of this book contained lengthy analyses of our faults. Many have since been corrected.

Unfortunately, we still have no comprehensive strategy for winning the Technological War.

1.5 The Decisive War

The technological contest is a war. It is not a game against an impersonal force, it is a deadly conflict with an intelligent and implacable enemy. We do not suppose that a military commander who conducted his battles as they occurred, understanding neither the terrain nor the enemy and preparing only for the battle that he had already fought, would be properly performing his task. Yet, too often this is precisely what happens in the Technological War, which may be the most decisive engagement in the history of mankind. Technology has grown into the driving force, dictating to strategy; and strategy is conceived of as employment of systems already created by the technologists; that is, strategy is confined to operational decisions. This is akin to allowing the recruiting and supply officers to decide the conduct of a traditional land war.

The danger in the Technological War is that it is closely coupled with the Protracted Conflict, and a decisive lead in the Technological War can be converted into a decisive advantage in military weapons. Note that military power and technological power are coupled, but are not identical; military technology is not in and of itself a weapon system, but it can be used to create weapons systems. Thus a commanding lead in the Technological War can be achieved before a corresponding lead in military technology has been obtained.

As an example, the Soviet Union could, through the development of strategic nuclear defense technology, obtain a decisive lead in the Technological War at a time when the United States still possessed a clear superiority in deliverable weapons. This technology could then be used to create defense systems, and if the United States took no countermeasures during the deployment of those defensive systems, we would find ourselves in an inferior military position.

This is an especial danger if the numbers of strategic offensive weapons has been limited by arms reduction treaties and the Soviets then "break out" of the defensive and offensive limits imposed by the ABM Treaty and SALT. The closed nature of Soviet society makes planning for breakouts rather simple; the open nature of the US makes that nearly impossible. Note that the USSR used the breakout strategy following the 'gentleman's agreement' Test Ban.

During the 1970's the Soviet Union achieved (entirely predictable) spectacular gains in achievable accuracies, and also built large new missiles capable of carrying a dozen and more warheads over intercontinental distances. The United States relied on Arms Control negotiations for security; when these failed, we found ourselves facing a "window of vulnerability" – that is, a period of time during which, if we do not act promptly and intelligently, the Soviet Union could construct a first strike capability. The Soviets continued to deploy ICBM's in large numbers. The "window of vulnerability" has not entirely been overcome as of 1988, although President Reagan's strategic force modernization program took away much of the danger.

Glasnost and peristroika promise a new era in strategic conflict; they have not eliminated the technological war.

In addition, the USSR has undertaken serious research into strategic defense systems, not merely building on the single system permitted under the ABM Treaty, but also investigating entirely new concepts. When the US began its own strategic defense investigation in 1983, the Soviet Union redoubled its efforts, including construction of large components such as the radar system at Krasnyarsk.

None of this was decisive. Victory in the Technological War is achieved when a finite game participant (ie, one who wishes to bring the game to an end by winning it) has a technological lead so far advanced that his opponent cannot overcome it until after the leader has converted his technology into decisive weapons systems. The loser may know that he has lost, and know it for quite a long time, yet be unable to do anything about it. To continue the above example, if the Soviet Union were able to develop the technology in time to deploy ballistic missile defense systems of his own before ours could be installed and operational, we would be beaten, even though the U.S.S.R. might spend several years in deployment of his own system. Our only choices would be the development of a penetration system that his defenses could not counter (such as manned bombers of very high capabilities), Footnote 6surrender, or preventive war.

Now, in the late 1980's, many believe that development of space laser battle stations will be a decisive move in the technological war. The laser battle station could, at least in theory, destroy an entire ICBM force in flight, then burn down the enemy's bomber fleet for encore. Such a station once in place could give a decisive lead to its owner.

In practice a space laser battle station would require auxiliary equipment for its own defense, since there are many ways to attack such a system; on the other hand, it is likely that such escort systems would be deployed by any power constructing a large space laser battle station.

The Soviets have raised the specter that other space weapons which they call "space strike weapons" are being developed as part of the US Strategic Defense Initiative. The fact that the Soviets emphasize such a threat at a time when the US has no concepts, let alone a technology which could produce them, raises the concern that the Soviets are developing them, because the Soviets often accuse the US of developing and deploying weapons which they themselves are developing.

Several years after the initial Soviet assertions that SDI raised the spectre of such weapons, the Soviets defined them for Ambassador Henry Cooper, head of the US negotiating team on defense and space talks, as : 1) Ground to space weapons, 2) Space to space weapons; and 3) Space to ground weapons. The U.S.S.R. has demonstrated all three: Galosh interceptors against satellites; co-orbital ASATs; and FOBs, which are bombs in orbit.

If space and ground based ICBM defenses could give us a decisive advantage, they would confer no less advantage on the Soviets if we allow our enemies to develop them without any counter on our part.

This is the unique feature of the Technological War. Military superiority or even supremacy is not permanent, and never ends the conflict unless it is used. The United States considers the Technological War as an infinite game: one which is not played out to a decisive victory. We are committed to a grand strategy of defense, and will never employ a decisive advantage to end the conflict by destroying our enemies. Consequently, we must maintain not only military superiority but technological supremacy. **The race is an alternative to destructive war, not the cause of military conflict.**

In summary, proper conduct of the Technological War requires that strategy drive technology most forcefully; that there be an overall strategy of the Technological War, allocating resources according to well-defined objectives and an operational plan, not merely strategic elements which make operational use of the products of technology. Instead of the supply officer and the munitions designer controlling the conduct of this decisive war, command must be placed in the hands of those who understand the Technological War; and this requires that they first understand the nature of war.

Lest the reader be confused, we do not advocate that the Technological War be given over to the control of the scientists, or that scientists should somehow create a strategy of technological development. We mean that an understanding of the art of war is more important than familiarity with one or another of the specialties of technology. It is a rare scientist who makes a good strategist; and the generals of the Technological War need not be scientists any more than the generals of the past needed to be good riflemen or railroad engineers.

Like all wars, the Technological War must be conducted by a commander who operates with a strategy. It is precisely the lack of such a strategy that brought the United States to the 1970's low point in prestige and power, with her ships seized across the world, her Strategic Offensive Forces (SOF) threatened by the growing Soviet SOF – and with the United States perplexed by as simple a question as whether to attempt to defend her people from enemy thermonuclear bombs, and unable to win a lesser war in South East Asia.Footnote 7

We had neither generals nor strategy, and muddled through the most decisive conflict in our national history.

Much of this changed in 1981. President Reagan's 1983 call for SDI was in response to strategic analyses presented by General Daniel O. Graham and others.

There always were exceptions to this unsatisfactory record of American performance. General Bernard Schriever created a military organization for strategic analysis which was responsible for our early commanding lead over the Soviets in ballistic missiles, despite the fact that the U.S. had allowed the U.S.S.R. many years' head start in missile development after World War II.Footnote 8 The Air Force's Project Forecast and later Project 75, was an attempt to let strategy react to, then drive, technology; these, too, were creations of General Schriever's.

In the Navy there have also been notable attempts to allow strategy to influence technology and produce truly modern weapons systems.

1.6 The Elements of Strategy

1.6.1 What is Strategy

Because there seems to be little understanding of strategy and its effect on the Technological War, we will briefly review some general principles of strategy and warfare. Our purpose is not to teach the elements of strategy, which would require another book, but rather to make the reader aware of strategy and some of its complexities.

According to the traditional concept of military strategy it should mean the art of employing military forces to achieve the ends set by political policy. This definition was formulated by [Sir Basil Henry] Liddell Hart in 1929 and it hardly differs from that of Clausewitz. Raymond Aron follows it almost word for word. France's leading strategist of the 60's commented:

"In my view this definition is too restrictive because it deals with military forces only. I would put it as follows: the art of applying force so that it makes the most effective contribution towards achieving the ends set by political policy...

"In my view the essence of strategy is the abstract interplay which, to use Foch's phrase, springs from the clash between two opposing wills. It is the art which enables a man, no matter what the techniques employed, to master the problems set by any clash between two opposing wills. It is the art which enables a man, no matter what the techniques employed, to master the problems set by any clash of wills and as a result to employ the techniques available with maximum efficiency. it is therefore the art of the dialectic of force, or, more precisely, the art of the dialectic of two opposing wills using force to resolve their dispute.Footnote 9

In our judgment it would be hard to better the above definition provided that we understand force to include the broader concept of power and force. Examining the definition shows us several important aspects of the Technological War and its strategy.

First, we see that strategy involves two opposing wills. This in itself sets the Technological War apart from the simple development of technology.

The development of technology is a game against nature, which may be uncooperative, but which never deceives or actively conspires to prevent your success. The Technology War is a contest with an intelligent opponent who seeks to divert you from seeing his purpose, and to surprise you with his results.

Secondly, strategy involves the use of power and force. In the Technological War, the more power is extant, the less often force needs to be used in the primary or decisive mode of the conflict. In the place of battles, the Technological War general disposes his own resources so as to maximize the power he holds and at the same time compel the enemy to make maximum dispersal of his. To make the enemy counter each move you make, and dance to your tune, is the aim of a Technological War strategy. In the ideal, if the enemy were required continually to build purely defensive weapons which might protect him from your weapons but could not possibly harm you, you could be said to have won a major engagement in the Technological War. In the contest between wills, seizing and holding the initiative is of importance; as indeed it has been for a long, long time:

You hear that Phillip is in the Chersonese, and you vote an expedition there; you hear that he is in Thessaly, and you vote one there. You march the length and breadth of Greece at his invitation, and you take your marching orders from him.Footnote 10

But if the power ratio is ambiguous, the decision as to who is the stronger will be made by force, which is the application of power in battle. Other things being equal, battles are won by superior technology. But clearly superior technology prevents battle.

1.7 The Principles of War

War is an art; it is not an exact science, although the Soviet Union considers it to be so. Precisely because there is an intelligent opponent, there are real uncertainties about war, not merely statistical uncertainties which may be measurable. Every attempt to reduce war to an exact science has ended in a dismal failure. The advent of the computer and systems analysis, useful as both may be, has not changed this fact, although it has often been forgotten.

Part of the traditional method of learning the art of war is studying the principles of war. These principles are a set of general concepts, like holds in wrestling, and no exact group of principles is universally recognized. Some strategists combine several into one or divide one of those we show into several. The following list will serve well enough for our purpose:

- The Principle of the Objective

- The Principle of the Initiative
- The Principle of Surprise
- The Principle of the Unity of Command
- The Principle of Mass (Concentration of Force)
- The Principle of Economy of Forces
- The Principle of Mobility
- The Principle of Security
- The Principle of Pursuit

It will be noted that some of these principles, if carried to their extremes, would be contradictory. They are intended to serve not as a formula for the planning of a battle, but rather as a set of guides or a checklist which the planner ignores only with peril. They are as applicable to the Technological War as to any other war. At first glance, it might seem that one principle or another might be more directly applicable to the Technological War than the others, but in fact none can be disregarded if success is to be achieved. We will have occasion to refer to them from time to time in the analysis below.

1.8 Strategy and Technology

The United States today has no technological strategy as we define it. However, as the philosophers have noted, "Everyone has a metaphysics, including those who deny it." The same applies to a technological strategy.

Instead of an integrated strategy of technology, we have a series of independent and often uncorrelated decisions on specific problems of technology. This is hardly a strategy. A technological strategy would involve the setting of national goals and objectives by political leaders; it would be integrated with other aspects of our national strategy, both military and nonmilitary (Initiative, Objective, and Unity of Command); it would include a broad plan for conducting the Technological War that provided for surprising the enemy, pursuing our advantage (Pursuit), guarding against being surprised (Security), allocating resources effectively (Economy of Forces), setting milestones and building the technological base (Objective), and so forth. Lesser conflicts such as that in Vietnam would be governed by a broad strategic doctrine instead of being considered isolated and treated as crises.

In our national strategy, far too much attention has been given to current affairs and to specific conflict situations at particular times and places. There has been no serious attempt to integrate the individual decisions, or relate them to a comprehensive grand strategy that is adequate to overcome the challenges. The few attempts we have made to manage technological decisions properly were disastrous; examples are the ludicrous "saving" achieved through the TFX and the equally dismal saving through over-management of the C5A program. We have confused a strategy of technology with centralized interference in the design or production of specific weapons and the imposition of a "standard management plan".

Micromanagement, whether by Congress or the Pentagon, is no substitute for a genuine strategy.

The results of our neglecting technological strategy are easily seen. Our performance in Vietnam was disastrous. We failed to exploit our superior technology to grasp a commanding lead in either inner space or outer space. Our merchant marine where it exists at all flies the proud flag of Panama or Liberia. Meanwhile, many of our young men are sent to fight overseas with weapons that make use of principles discovered by Roger Bacon in the thirteenth century.[4]

The reasons for this dismal performance are complex; it is not necessary to understand all of them and it is not germane to blame anyone. Events caught up with us, the stream of technology swept us along, and only recently did we begin to realize the nature of the Technological War. In fact, one reason we have no strategy of technology is that not everyone realizes we are at war; but perhaps the most important reason is the basic failure to understand the nature of technology itself, and particularly the problems of lead time which produce a crisis-oriented design process.

Our opponents created crises, and we have had to meet them. Decision makers at the national level concentrate on fighting today's fire, partly because they hope that the current trouble will be the last but mostly because of the long lead time involved in technology. A President called upon to spend money in any fiscal year actually is spending money to solve the problems

[4]Alas, we see no reason to revise the above after over twenty years. Our failure to understand what the Viet Nam War was about cost us all the blood and treasure we had previously invested; the Soviets have surpassed us in manned space exploitation and ICBM deployment, and are keeping up in missile defense technology; and we were unable to use our technology or military power in the Iranian hostage crisis. Our attempts to remedy this situation have generally made things worse. Endless reviews and meaningless analyses have driven lead times to inordinate lengths. Whereas in 1941-44 we were able to conceive, design, build, and deploy large numbers of new military aircraft within three years, this is inconceivable today (1991).

of a President two terms later. But even if we try to find comfort in expenditures for research and development, we must understand that these are oriented to specific projects and tasks and do not result from technological strategy.[5]

Our misunderstanding of the Technological War is illustrated by our failure to build an organization for conducting technological warfare. The review of the annual budget and of individual projects in basic research, in applied research, in development, and in procurement is the only process by which our technological development is controlled directly. Other influences such as the statements of requirements and the evaluation of military worth are felt only at the level of individual projects. Overall evaluation of the research and development effort and of its relations to strategy is rudimentary.

An example of how irrelevant factors influence our efforts, and perhaps one of the decisive signs of the times: the January 20, 1969 issue of Aviation Week and Space Technology, the most influential journal in the aerospace field, included a report entitled "Viet Lull Advances New Weapons". The article makes clear that the budgetary funding level of many advanced new weapons systems, including research and development, basic technology, and actual system procurement, is largely dependent on the continuation of a "lull" in the Vietnam war. Given a proper strategy for the Technological War and proper command of our efforts, the title should read "Advanced New Weapons End Vietnam War".

1.8.1 1988

Perhaps the most glaring examples of our failure to grasp the fundamentals of a technological strategy are found in our failure to build on the Apollo program to create a space station and build systems for rapid and assured access to the space environment; to develop defenses against ballistic missiles; and to make the transition from aerospace power to space power. Such failures are clear illustrations of that a strategy of technology should be. The goal of this book is to try to prevent future errors of this kind.

[5]During the 1970's, the expenditures in research and development were cut back; the result was that high technology exports became less valuable than agriculture in our balance of payments. SDI refocussed U.S. efforts and halted what had been a continuous erosion of our technological base. Fortunately the Soviets have their problems too, caused by their generally bad management practices; but do note that the Soviet military economy is run on an entirely different basis from their notoriously inefficient civilian economy. Meanwhile, as the Soviet threat to Europe abates, the Technological War does not, for many of our erstwhile allies, now freed from fear of the Soviets, can put even more of their resources into that war – and we have yet to examine the potential of Eastern Europe.

1.8.2 1997

We cannot emphasize this too strongly. The Seventy Years War which began in St. Petersburg in 1917 effectively came to an end with the destruction of the Berlin Wall, leaving the United States of America as the only Superpower. Victory in the Seventy Years War, sometimes (in our judgment mistakenly) called The Cold War, did not bring "the end of history" as was naively prophesied by Francis Fukuyama and others.

Fukuyama's thesis was that with the end of the Cold War all nations would now embrace liberal democracy; and liberal democracies do not make war on each other. Therefore, while mankind would now prevail, there would be no more history, which is the record of change, often by violence.

By now it should be clear that all the nations of the Earth have not embraced liberal democracy. It is not inevitable that the United States itself will be governed by what we understand as liberal democracy much beyond the end of this Millenium. Being the only Superpower carries with it the danger of a fundamental transformation from democracy to Empire, and there are powerful forces pushing the United States toward Imperium if not Empire. In any event, there are plenty of regimes motivated by religious fervor, nationalism and tribalism, and ruled by elites or dictators.

The end of the Seventy Years War has not brought lasting peace, nor has it ended the Technological War; indeed, the stakes are now much higher, and the price of entry into the Technological War is far lower; with only one Superpower in the game, a potential Superpower has only one competitor, and that a somewhat complacent one that cannot believe anyone can possibly catch up.

Unfortunately, catching up is quite possible. Just as the threat of a strategic sidestep into space negated much of the USSR's vast missile establishment and threatened the USSR with economic ruin, a real move into space–a real conquest of the High Frontier, if you will–would put the United States in a vulnerable position.

This is not the place to generate scenarios of potential conflicts over the next fifty years; suffice it to say that there remain a number of powers with unsatisfied ambitions and both territorial and economic claims. Some, like China and Indonesia have large populations, an educated elite, high industrial potential, and no great experience with, or desire for, liberal democracy.

The world remains a dangerous place, and a Strategy of Technology remains the most prudent course for the United States; and it is a course we are not properly following.

Chapter 2

An Overview Of The Recent History of the Technological War

We have called the Technological War the decisive war, and have stated that the United States has not always done well in its conduct of that war. The reasons for our repeated failure in technological warfare – despite the fact that we are far and away the most advanced technological power and have expended far more money, manpower, time and resources on military technology than all other nations combined – require careful study. There is no reason why the United States cannot maintain a decisive advantage in the Technological War, and, moreover, do so with the expenditure of no more resources than are now being used up in our present wasteful efforts.Footnote 1

In our national strategy far too much attention has been paid to current affairs and specific conflict situations. Instead of a real technological strategy we have a series of unrelated decisions on specific problems. There have been attempts to integrate the individual decisions, but these attempts have often resulted in even more waste and inefficiency. Examples abound. Consider, for example, the fanciful expectations about the TFX (FB-111), the joint service fighter aircraft program; and the Sergeant York missile, which, originally a reasonable idea, was micromismanaged, given impossible goals to meet, and eventually cancelled.

The fact is, we had no mechanism for generating a strategy of technology. The Joint Chiefs of Staff have been an inter-service negotiating board; and since the officers who serve the Joint Chiefs must depend on boards of officers drawn from their own branch of service for promotion, there has been little chance that anyone will or can develop loyalty to the Joint Chiefs as an institution.

In the late 1980's, the situation began to change. Under the urging of the Reagan Administration, the Commanders in Chief (CINC's) of the major operating forces (SAC, EURCOM, PACOM, SOUTHCOM, SOFCOM, and SPACECOM) were given responsibility for generating requirements and for both advocating and defending programs. The struggle within the Joint Chiefs thus became one of struggle among the CINC's for resources with the JCS, and especially the Vice Chairman, being the adjustors. The Services started to become responsible solely for personnel, research and development, logistics, and budget, and their role within operations began to disappear. However, there is no technological CINC, and no clear career path for the developing technological strategist within any branch of service.

2.1 Organization of This Chapter

In the pages below we open with an overview of Soviet technological strategy as it contrasts with ours. We will then give examples of U.S. successes and failures in four periods:

- 1950's: ICBM and the nuclear powered airplane
- 1960's: SSBM, Apollo, space techology and satellites, and TFX
- 1970's: MIRV, new fighters, and the Shuttle
- 1980's: B-1; SDI; cruise missiles; MX, and C3/I; B2

We follow with more examples of Soviet achievements during the same time periods:

- 1950's: H-bomb; ICBM/IRBM, Space boosters
- 1960's: Nuclear powered submarines, advanced fighters, tanks
- 1970's: Manned space program; MIRV
- 1980's: Mobile ICBM

We will then examine the lessons learned from these examples.

2.2 Soviet Technological Strategy

Although the Soviet Union begins from a lower technological and industrial base, some of their achievements in the Technoloigcal War have been impressive.

In contrast to the diffusion of effort, centralization of decision making, and micromanagement which characterize American technological strategy, the Soviets have a strategy of focusing their efforts, including basic and applied research. Central direction and control are key aspects of their use of technology. This means that discovery must be on schedule. The motivation of Soviet scientists has been an important factor in meeting goals, but sanctions and punishment are also an important part of the Soviet system. By focusing their efforts the Soviets allow to atrophy those areas which they do not consider important to their strategy.

The Soviet priority system places military technology and fundamental industry a long way ahead of any other aspects of technology. In part this neglect of other technology is then compensated for by purchase of nonstrategic goods and technical processes from the West; scientific exchange programs; industrial espionage and piracy; and general exploitation of Western achievements.

Arms negotiations to slow down the U.S. technological challenge by eliminating key weapons and technologies have always been a key part of the Soviet strategy of technology. The INF is a prime example of this. The Soviets naturally seek to negotiate the elimination of technologies in which they are weak, and to retain those where they are strong.

The INF treaty is a prime example. Under INF an entire class of weapons – nuclear and non-nuclear – was eliminated. Not only were the nuclear tipped IRBM's destroyed, but the non-nuclear systems, while not destroyed, cannot be improved by new technologies. The result was to increase, not decrease, the strategic imbalance in Europe, because the U.S.S.R. has no great need of IRBM systems, while the U.S. and NATO do not have a good substitute.

The Soviet commanders of the Technological War can afford to wait for consumer technology and goods, and concentrate their efforts on winning the decisive war. This remains true during the era of glasnost; although there is an emphasis on decentralization of the civilian technology and the production of consumer goods, there has been little noticeable decrease in military spending; this remains true in late 1989, even after the fall of the Berlin Wall. Given that there will be cuts in the overall Soviet military budget, it is highly likely that there will be little to no decrease in military R&D.

The Soviets concentrate their technical and engineering talent on the decision and design phases of technology for those systems which are most important to their strategic goals.Footnote 2 This permits them to weigh the relative merits of alternative technical approaches to their strategic goals and use what they have learned from Western technology to aid the production process. Their strategy facilitates finding a near-optimum approach to a variety of goals, and is designed to compensate for their inferiority in overall technical resources. The point is, despite the enormous Western superiority in total quantity of technological resources, the U.S.S.R. has been able to concentrate more effort than we have on selected portions of weapons technology and to gain superiority in many phases of military technology driven by strategy.

In their designs the Soviets make simplicity an important criterion for both production and operation. Success in achieving simplicity leads to low costs of production and, importantly, to high reliability of operation. Simplicity also allows them to operate the systems with personnel who have only rudimentary training and skills, and to reserve their limited supply of highly skilled technicians for R&D.

Because their deadlines are self-imposed, the Soviets can take their time about selecting designs. This was the pattern they followed in military computer technology. After making a survey of Western advances on a variety of fronts, they chose an optimum path to follow.

The West has a defensive strategy. Although we would welcome the disintegration of the Soviet Empire, we strive mostly to preserve the status quo. This imposes few deadlines on the Soviets, who can afford to take their time. Western achievements in the Technological War are not threats to Soviet national existence. The defensive strategy nature of the West prevents us from fully exploiting our advantages. However, there are ways in which we can force the Soviets to react to our initiatives.

Recently, through programs like SDI and high-precision weapons to target command posts, we have started to find ways to exploit our strengths and Soviet weaknesses. The new [1988] buzz word for the concept is "competitive strategies." The result has had spectacular success in recent weeks.[1]

The Soviet strategy in the Technological War would not be an optimum strategy for the West, precisely because neither motives nor resources are

[1]This may be the place to note that the first edition of this book was written at a time when the US was NOT doing well in the technological war. That changed, partly – some would say in large part – due to this book's employment as a text in the military academies and War Colleges. Things change so quickly now that we cannot rewrite everything; there will of necessity be residual elements of our older polemic against US policy. The fact is, though, that much of what we advocate was adopted in the Reagan era. Alas, not everything; which is the purpose of this second edition.

symmetrical. The West has vastly superior resources, and can afford non-specific research to find unsuspected technological advantages. The West can afford to decentralize a part of its decision-making process and employ a variety of technological approaches, particularly during the scientific and advanced engineering research phases of the technological discovery process. Whereas the Soviet Union can afford only one "center of gravity" for their efforts, we can afford several.Footnote 3

As a consequence of the asymmetries of motive and resources, it would be foolish to copy the Soviet strategy for the Technological War. We can afford a more sophisticated strategy, and will have a far higher probability of success. What we cannot afford is the luxury of having no strategy at all.

2.3 The U.S. Conduct of the Technological War

By contrast with the Soviet strategy of focusing effort on the development of specific technological achievements, working on each problem until it is solved, and concentrating their technological forces as may be directed by a carefully-chosen center of gravity, the United States has had a number of projects, some successful and some not; there has been little or no overall technical strategy.

Our technological decision-making process is scattered throughout a number of agencies and departments of the government, most of which are not under the control of the Secretary of Defense and many of which are not represented on the National Security Council. For example, even though it may be supported by appropriations our civil space program under NASA has rarely been coordinated with military requirements, and can hardly be governed by our nonexistent strategy of technology.[2]

[2] When we wrote those words in 1969 it was all too true that there was no technological strategy. During the Reagan era that changed somewhat. Although there never was implemented a full reorganization that would create a technological war plan, at least the subject was taken seriously. General Daniel O. Graham's analysis of moving to space as a "strategic side step" spoke in explicit strategic terms, and had considerable influence on strategic thinking. After the low ebb of the McNamara era there was renewed interest in an overall strategy of technology. The decisive moment came in Iceland when Gorbachev pleaded with Reagan to abandon SDI and strategic defenses; Reagan refused, and thereby brought about the collapse of the Soviet Union, although it was not apparent at the time that this would happen so quickly.

The USSR was at that time spending far more of its national budget on weapons (hardly 'defense') than was admitted by the CIA or Department of State. Possony, Pournelle, and Kane, along with General Graham, continued to insist that the USSR was spending some

2.4 The 1950s Era

2.4.1 The Nuclear Powered Airplane

The history of nuclear-propulsion aircraft illustrates the problems inherent in the present system.Footnote 4 In an effort to advance nuclear technology while living within budget limitations, the military tried to play scientific politics. Because of the need to justify funds on the basis of practical systems rather than their contribution to the Technological War, at times the military tried to set up requirements for nuclear-propulsion aircraft systems. These requirements were beyond the realm of technological possibility and resulted in opposition from the scientific community. At other times, the military justified funds on the basis of scientific experiment.Footnote 5 Here the generals subjected themselves to the inevitable arguments and divisions among scientists. The decision fell to the timid.

There was never an attempt to analyze the problem in its strategic context, or even to consider it historically, such as comparing it to the invention and development of the jet engine. If Whittle's work had been subjected to an experience similar to that of the nuclear engine, we would not have jet aircraft today. In addition to the arguments about technical feasibility, moreover, the question was raised, What can the nuclear aircraft do that the jet aircraft cannot do cheaper and faster? Inasmuch as there were no nuclear-propulsion aircraft and its ultimate capabilities were unknown, this question was hardly intelligent; and although its detractors admitted that the nuclear aircraft could stay aloft for long periods, the significance of this characteristic for our defensive strategy was not understood. More importantly, the far-reaching consequences of practical development of nuclear propulsion were never seriously analyzed.

A further difficulty was that some members of the military never quite understood the problem and some were ready to sacrifice the overall project for systems that could be made available earlier. Others wanted immediately an airplane with performance characteristics superior to those of our most modern jets – as though an entirely new technology does not require lead time and as though a mature chicken jumps out of the egg.

The scientists should not really have mixed in the strategic debate, but they were in fact the only ones who argued the question. They broke up in several small groups, opposing or rejecting nuclear aircraft, nuclear-rocket propulsion, or nuclear ramjets, or dismissing nuclear propulsion altogether.

30% of GNP on weapons and military power. We privately suspected that it was more (and in fact it was), but official opposition to our 30% estimate was surprisingly hostile. The official US estimate was under 20%.

The scientists who have had the greatest impact on the negative decisions affecting the nuclear-propulsion aircraft are the graduates of one laboratory which always was opposed to this program – for good or bad reasons. While they were instrumental in killing the plane they did not appreciably advance the cause of the nuclear ramjet or rocket that they were in charge of developing and that they claimed was a more promising approach.

The politicians didn't understand the problem, either. One Secretary of Defense called the nuclear-propulsion aircraft "a shitepoke which could barely get off the ground."

As a result there were innumerable stop-and-go decisions. While it is true that about $1 billion was spent, at least one half was spent on waste motion. It is said that we have nothing to show, but this is not true. We do have the know-how to fly low-speed, experimental and test aircraft. This is precisely the one type of aircraft we could be flying now, and which someone will one day develop.

This experiment should have been the signal for the military to face up to the technological age, especially to prepare a technological strategy to meet the new Soviet challenge and to organize better ways and implement such a strategy.

In 1988 almost nothing remains of the nuclear propulsion experiments; and although nuclear aircraft may never play a role in the technological war, nuclear propulsion could in future be decisive in space. Unfortunately, the nuclear rocket programs, such as NERVA and DUMBO, were also mired in internecine warfare, and eventually closed down as well.

The mismanagement of the nuclear airplane project is a text-book example of how not to conduct a program.

2.4.2 The ICBM

By contrast, the IRBM and ICBM programs were well developed and well managed in the 1950's. As an example, the Thor IRBM was brought from conception to operational capability in just over three years. (Thor follow-on rockets are used for satellite launches to this day.) Instead of programs designed by scientists to investigate a technology, IRBM and ICBM systems were designed, fielded, and operational in a very short time period, largely because General Schriever instituted dramatically new management procedures, including concurrent development of the components and subsystems.

2.4.3 SLBM

In this period Admiral Red Raborn married the nuclear submarine and ballistic missile in a "special project" which produced the Polaris, and later the Poseidon and Trident boats and Submarine Launched Ballistic Missiles.

The program was important not only because of its direct effect on strategic deterrence, but on its adoption of new management principles, and the demonstration that it was still possible to produce strategic weapons systems in a timely and cost-effective manor without micromanagement from the Pentagon.

2.5 The 1960s Era

2.5.1 Apollo

The Apollo program of manned exploration of the Moon was certainly the outstanding achievement of this Century. It is a landmark of what the U.S. could achieve given a challenge to the scientific and engineering community.

The Apollo program was also the most complex action ever undertaken by the human race. It is interesting to note that the second most complex activity in history was Overlord, the Allied invasion of Normandy in 1944. Although Apollo was accomplished outside the Department of Defense, it was no accident that many of the key leaders, such as General Sam Phillips, were highly experienced managers of advanced military technology programs.

The Apollo program was mission oriented. Its management structure closely resembled a military organization. Instead of micro-management from the top, there was delegation of authority. Tasks were narrowly defined, and responsibility for achieving them was spelled out in detail. As with the ICBM program, parallel processes were set up to investigate alternate ways of achieving critical tasks.

The result was that technology was produced on demand and on schedule. Setbacks and even tragedies such as the capsule fire did not halt the program. On 20 July, 1969, the Eagle landed on the Moon, a little more than eight years after President Kennedy began a task which much of the scientific community said could not be accomplished in two decades.

2.5.2 Military Aircraft

In 1962 Project Forecast identified a requirement for new military aircraft. Systems designs began shortly thereafter.

Unlike the Apollo program, both the fighter and bomber programs were micromanaged from the top. There were endless reviews and appeals.

As a result, the first of the new generation of fighter aircraft was not rolled out until the mid-70's, and were not in the operational inventory in numbers until considerably later; and both the Navy and Air Force are now flying aircraft whose basic designs are twenty years old.

The B-1 fared even worse. Not only was there micromanagement, review, and appeal, but the program itself was cancelled by political authorities. The first operational B-1 was delivered in 1983; we now have a full inventory of 100 B-1 bombers.

The B-1 bomber and the F-14, F-15, F-16, and F-18 fighters are probably the most advanced aircraft of their kind in the world; but the contrast between the 8 years from conception to operation of Apollo, and the 16 and more years from design to operation of these aircraft, is worth noting; particularly when contrasted with the rapid development and deployment of the P-51 and P-47 aircraft during World War II. Recall that the P-51, then the world's most advanced fighter, went from drawing board to combat operation in under a year.

Note also that the reviews and delays characterizing the development and procurement of the B-1 and the new fighters did not save money. The total program costs were considerably higher than they would have been had we set up a management structure similiar to Apollo; indeed, the total costs of these programs exceeded that of Apollo, which was brought in on time and under budget.

2.6 The 1970s Era

2.6.1 MIRV

The major technological developments with stategic implications for the 1970's were new techniques for increasing ICBM accuracy, and the capability for deploying Multiple Independently Retargetable Re-entry Vehicles (MIRV).

These capabilities stimulated spirited debate between the advocates of security through Arms Control and the military services.

Arms control advocates said that MIRV was inherently destabilizing: that is, if each missile had the capability for destroying a large number of enemy missiles, then there would be a military incentive to launch first in crisis situations.

Strategic analysis gave a different answer: given the limited size of the

U.S. missile force, any increase in numbers of Soviet systems would pose an increasing threat to the U.S. SOF, especially since it was known that the Soviet Union was developing new techniques for increasing the accuracy of its missiles. The threat to the SOF could be countered by three different means:

1. Increase the numbers of missiles in the US SOF
2. Increase the survivability of the SOF
   - 2.1. Hardening silos or other passive means
   - 2.2. Active defense
3. Increase the effectiveness of U.S. missiles that survived a Soviet first strike.

Of these options, (1) was declared politically undesirable; (2.1) was extremely expensive and given increased Soviet accuracies would soon be impossible; and (2.2) was rejected on political grounds. There remained only (3), which in practice meant MIRV.

The MIRV system was accordingly built, and once the decision was acutally made was reasonably well implemented. However, we should note that the Senate Armed Services Committee tried to prevent the Minuteman III MIRV from becoming accurate enough to attack Soviet missile silos. These efforts delayed the deployment of accurate MIRV by several years.

2.6.2 Shuttle

The most spectacular program of the 70's was the Space Transportation System, popularly known as the Shuttle.

By 1968 it was clear that the Apollo program would perform its mission on schedule. At the same time, the Viet Nam war had created a budget crisis, leading to considerable opposition to the space program. NASA, concerned about retaining its large army of development scientists recruited for the Apollo program, searched for new missions to keep them on the payroll.

The original proposal for the Shuttle was as a large reusable general purpose system for putting heavy payloads into orbit. Simultaneously, the military needed a much smaller and more maneuverable system along the lines of the Dyna-Soar concept.

In order to obtain funds for the Shuttle, NASA combined these incompatible missions, and set out to kill all competing programs. Not only were the remaining fully operational and man-rated Saturn rockets laid on their sides as lawn ornaments, but all Saturn facilities were closed, and even the plans for the Saturn were ordered destroyed as "useless archives." NASA officials conducted a campaign to discredit all possible opposition to Shuttle.

The Shuttle became the "National Space Transportation System", able to meet all possible space missions. The Air FOrce had previously studied a mission in which an orbital surveillance vehicle would be launched in polar orbit from Vandenberg; overfly the Soviet Union; then reenter and land at Edwards AFB after one orbit. It was not a mission that inspired USAF enthusiasm, but the Air Force was bullied into supporting Shuttle, and this looked as good as anything.

Unfortunately, the specified mission requires atmospheric maneuvering, and dictated that the Shuttle would have wings. The wings dictated horizontal landings. They also greatly complicated the system design. A smaller vehicle intended for this mission could have been built, but NASA insisted that Shuttle could do the entire job. Wings plus Shuttle's large payload requirements dictated increasingly large rocket engines to get the craft into orbit.

There were other design changes. The original concept of a spacecraft that would be "reusable like an airplane" disappeared; instead there would be a lengthy refurbishing period whose cost could only be estimated.

The original design for a reusable vehicle proposed liquid fueled booster engines as well as a liquid fueled main engine. The alternative was solid fuel boosters. Developing the liquid booster engines would have cost more money to begin with, but would make for great savings in operational costs; NASA chose to argue for the lower up-front costs, on the theory that once the committment was made, Congress would have no choice but to appropriate the additional funds for Shuttle operation.

The solid fuel engines could have been designed in one piece; however, except for barges on the Intercoastal Waterway, there was no transportation system for shipping such large objects filled with high explosives. The only plant on the coastal waterway system capable of building the one piece engines was Michoud in Louisana. That plant had been closed, and re-opening it would require up-front money. There were also political considerations. The result was that the boosters were designed to be built in segments and made in Utah.

The Congress, partly in reaction to NASA's constant inability to meet either budgets or schedules, imposed funding limits and budget stretchouts. Since delaying a program never saves money, the overall costs grew accordingly. However, this was not the only reason for runaway costs in the program, as NASA continued to make design changes at every stage of the development process.

Shuttle program expenses grew until each Shuttle craft cost more than $2 billion. The first Shuttle flew on April 12, 1981, more than three years after it had originally been scheduled. During that time we lost Skylab, an operational space station, which could have been rescued had we retained the Saturn rockets which NASA deliberately destroyed.

No Shuttle ever met its design criteria for payload weight or refurbishing costs. Shuttle Challenger was destroyed by the failure of the joints in one of the segmented solid booster rockets.

2.7 The 1980s Era

2.7.1 B-1

The Reagan administration ordered the ressurection of the B-1 program which had been cancelled by President Carter. The procurement was turned over to a slimmed-down organization, and, with little interference from above, the full inventory of 100 aircraft was delivered on time and under budget, in under four years.

2.7.2 SDI

During the 1980's, the Strategic Defense program has clearly been the dominant area of competition in the Technological War. When the decade began, most scientists and miitary strategists believed that defense against the ICBM was impossible. How could you hit a bullet with a bullet?

Nevertheless, on March 23, 1983, President Reagan challenged the scientific community to develop a meaningful ballistic missile defense system. As happened with the ICBM and Apollo programs, the response was nearly incredible. Within two years a range of new applications of technology in the areas of propulsion, sensors, guidance, and even production were generated. By 1988 there were a number of alternate systems which could meet the challenge.

We will draw the lessons to be learned from these examples in later sections and chapters. First, we should examine the way technological planning is now conducted.

2.8 The Present Assumptions Governing U.S. Conduct of the Technological War

The assumptions that appear to govern our conduct of the Technological War are shown on Chart 3. They derive from a misunderstanding of the nature of war and from a failure to appreciate the nature of technology. Because these assumptions are based on an improper appreciation of the real world, it is no surprise that despite our enormous expenditures the United States has failed to exploit its advantages to take a commanding lead in the Technological War.Footnote 7

As of 1988 there remains a window of vulnerability: new advances in both defense and offense technologies now make it possible for the U.S.S.R to develop a Full First-Strike Capability unless we act swiftly and skillfully.Footnote 7a

Fortunately, the Soviets under Brezhnev were unable fully to exploit their opportunity; even so, they were able to construct a highly threatening ICBM force, and their lead in strategic nuclear forces continued to grow during the Brezhnev regime and beyond. Meanwhile, the Soviets began an extensive program of R&D into missile defense systems, and deployed some long term components of a working continental missile defense system.

Although the present U.S. assumptions are based on a false picture of strategic and technological reality, they are all the assumptions we have, and they generate what little strategic direction our efforts are given. The assumptions, and the various directives which can be derived from them, therefore merit a great deal more study than has been given to them in the past.

CHART THREE: Assumptions Governing U.S. Technological Strategy

- The United States is the Superior Technological Power, and thus, inevitably, the Superior Military Power.
- We are not engaged in Technological War, and if we were, we would inevitably win.
- The United States has the potential of making any desired advance or application of technology to military power whenever it is needed.
- Incompatible missions can be combined, with a resulting saving of money.
- Technological education benefits defense, regardless of where, and in what field, it is obtained.
- The Time Factor is on our side, or at worst, neutral.
- The Soviets also wish to halt the Technological War.
- Technological War can be (or already has been) halted by Agreements and Treaties.
- The "Technological Explosion" relieves us of the necessity for making decisions in the Technological War.
- A Defensive Strategy is synonymous with Not Taking The Initiative; rather it implies Avoiding The Initiative in most aspects of national power. Defense means reacting to Soviet Initiatives.
- Defense is incompatible with Deterrence.
- All technological decisions should be made by civilian scientists, and technological research vital to military power should be carried out under civilian supervision, and preferably by civilian agencies such as NASA.
- The military should fight battles, but not prepare for or prevent them.
- The military principles of Surprise and Pursuit are not applicable to the Technological War.

Other postulates, derived from the assumptions on Chart 3, include the proposition that since we are not at war, we do not need an overall technological strategy and should not seek technological surprise even if it is possible to obtain it; that since the U.S.S.R. is also interested in stabilizing the "arms race," we should not exploit our advantage by engaging in technological ppursuit even if we could so exploit them; and that since we can do anything we imagine and the technological explosion will inevitably produce anything we need, there is no necessity for an orderly accumulation of the building blocks to expand our military technological base.

If these propositions were put to the managers of our military technology in the explicit form given here, it is likely that many of them would disagree. Yet, an examination of the history of our technological management indicates that each of these factors is at work.

For example, the exploration of space, probably the most important military medium of the future, has been given to civilian agencies that are often unresponsive to military requirements. Worse is the artificial distinction imposed on development of space technology in the National Space Act of 1959. This Act creates a civil space agency, NASA, exclusively for "peaceful purposes" in space. The effect was to constrain the use of space for military missions.

NASA by law is not supposed to respond to military requirements for space systems. Admittedly, various pragmatic expedients have been followed to coordinate the separate civil and military program requirements, such as the Aeronautics and Astronautics Coordinating Board, and the Space Task Group of 1969, but those efforts could never produce an integrated national space program to execute a national technological strategy for space applications. Footnote 15 We have yet to establish environmental laboratories in space to develop the basic building blocks for making the use of space the routine operation that a military mission must be.

Similarly, the National Defense Education Act doles out money for technological training with no regard to whether those who have received it will participate in or will hinder national defense.Footnote

Many decisions on military technology have been centered in the office of the Director of Defense Research and Engineering, who is sometimes a scientist with no military training. When we have achieved advances or breakthroughs in military technology, we often halted short of exploiting them and attempted to negotiate with the Soviet Union to put them back in the bottle.Footnote 9 In general there has been little planning for technological surprise, no integrated strategy of technology, and no understanding of the meaning of technological pursuit.

The above analysis was written in 1970. By 1989 the situation had changed, although not as much as it should. Our educational establishments have so deteriorated that normative scores on both the Scholastic Aptitude Test and the Stanford-Binet IQ Test have been lowered; our space program was cut back to a single Shuttle system which was then mismanaged, delayed, and stretched out; and our manned space program was non-existent through the last part of the 70's. Then, when the Shuttle Challenger was lost, instead of rethinking the situation and generating new means for routine access to space, we spent more than two years redesigning new launch vehicles. By late 1989 the consequences of the 1983 SDI decision, coupled with the sheer weight of US economic power and the total incompetence of the Soviet economic system, brought about heavy pressures for change within the Soviet system. This has not changed the fundamentals of technological warfare. It has bought the West a respite. [1989]

The respite was followed by the collapse of the USSR, giving the US a chance to rethink our strategy of technology. We are not making good use of this opportunity. The US is at present the only 'superpower' but this situation need not be permanent. TECHNOLOGY HAS A WAY OF EQUALIZING vast disparities. The Dreadnought made obsolete much of the naval establishment of 1900. Space weapons can do the same in the year 2000. [1997]

2.9 The Abandonment of the Initiave

Of the present assumptions, probably the most dangerous is that it is sufficient simply to react to Soviet initiatives in the Technological War. By failing to seize the initiative, we place ourselves in a clearly impossible situation: either we must maintain such decisive superiority over the Soviets at any possible point of breakthrough so that we can concede to them a long lead time and still be able to counter their new weapons; or we must abandon superiority to them whenever we fail to do so.

Wealthy as we are, with enormous reserve power in the form of our industries and laboratories, we cannot keep this posture forever. The abandonment of the initiative is probably the most expensive mistake we have made in the Technological War.

Until SDI there was little conscious effort to use the initiative to drive the U.S.S.R. to decisions which add to our security. For example, we have announced that we will develop penetration aids for our missiles, and deploy those as needed to overcome the Soviet missile defense system. This strategy presupposes high confidence in our estimates of the characteristics and limits of their system, which is a dangerous assumption because the U.S.S.R. is a secretive society about which it is difficult to obtain reliable technological information; but that is not the only hazard. Since the Soviets proceed to exploit defense technology while we merely study endlessly whether or not to pursue what needs to be done, the chances are that they will understand defense far better than we; and understanding defense technology is at least as important to the designers of our penetration systems as it is to our defense systems designers. For lack of a sophisticated understanding of the nature of defense technology, we may fail to understand Soviet defense capabilities and limits.

By contrast, we could have deployed a series of penetration aids, some of which are quite inexpensive, forcing the Soviet Union to adapt their defenses to our offense. As they made such an adaptation, we could change the nature of our offensive weapons, engaging in technological pursuit and forcing them to waste their resources reacting to our initiative. Admittedly this kind of strategy is not simple, but the point is that it was not seriously considered.

In fact, though, we did nothing of the kind, but once again relied on negotiations and treaties. Under the 1972 Anti Ballistic Missile (ABM) Treaty, both the United States and the Soviet Union agreed to build no more than one ballistic missile defense system; and that system was supposed to protect missiles or the national command. The Soviets chose to protect the missiles near Moscow; we soon abandoned our defensive systems entirely.

> Fortunately, this policy was reversed after 1983; but it is instructive to understand the situation prior to the SDI effort. Most of this analysis was written prior to 1980.

Under the ABM Treaty, neither side was to build battle management defensive radars, or to test certain ballistic missile intercept systems. The Soviet phased array radar near Abilokovo is clearly in violation of that treaty; so was teh Kraskyarsk radar (by their own admission). As of 1989 the United States has not begun construction of the radars and other auxiliary equipment needed for a large-scale ballistic missile defense system, nor have we made any other move to seize the initiative in this phase of the Technological War.

We did announce our new policy of SDI. This will be discussed in more detail in a later chapter; for the moment, it is sufficient to note that although strategic defenses cand be decisive in the Technological War, SDI is formally defined as a program of pure research, and is not integrated with any scheme for deployment. The United States remains utterly defenseless against nuclear ballistic missile attack.

We also could be devoting some of our technology to making life difficult for the U.S.S.R. in other theaters and areas of the world. It is unlikely to do any great harm if we manufacture small, short-range handguns of extremely inexpensive design and either scatter them broadside in Cuba or threaten to do so. This would, of course, be a diversionary move intended to force some kind of reaction from the other side and cause them to waste their resources. It has no great merit other than as an example; but nothing like it has even been discussed.

We have taken few military initiatives in space. The list of Soviet 'first' in space is long. Footnote 14 Our manned space program was in trouble long before the Challenger disaster. Skylab, the world's first operational space station, was launched (without crew) on May 14, 1973. Key elements of the environmental control system failed to deploy, but on May 25 the first Skylab crew arrived and soon managed to make the space station operational. On November 16, 1973, Skylab 4 carried Jerry Carr, Ed Gibson, and Bill Pogue to the space station, where they remained for 84 days. That was the last mission to Skylab, and the last American manned mission until the flight of the Shuttle Columbia in 1981. On December 18, 1973, the Soviet Union launched Soyuz 13. The crew remained in orbit only 7 days; but over the next fifteen years, the Soviets sent up Soyuz flights of increasing duration, until on February 19, 1986, they launched their MIR space station, and on March 13, Soyuz T-13 docked with MIR and placed a crew aboard. There have been many crew changes since, but MIR has been continuously manned from 1983 to present.

Skylab was not visited again after the February, 1984 return of Carr, Gibson, and Pogue. Manned space was utterly neglected during the Carter Administration. On June 11, 1979, the space station's orbit decayed the Skylab burned up in the atmosphere.

In 1982 in a speech at Edwards AFB, President Reagan announced an intention to "look aggressively to the future by demonstrating the potential of the shuttle and establishing a more permanent presence in space." On January 25, 1984, in his State of the Union address, President Reagan directed NASA to develop a permanently manned space station within a decade. After the initial excitement, it became known as "The Incredible Shrinking Space Station"; every year it was redesigned to have fewer capabilities while costing additional billions of dollars. The present design calls for a station smaller than Skylab.

Meanwhile, our efforts to investigate the military potential of man in space continue to languish. We have no serious program for making space a theater of military operations; instead, we require the military to describe their mission requirements in detail before they are given a chance to explore the space environment and discover its potential. Because they cannot solve this dilemma, we do not capitalize on the military potential of space.

This unfortunate state of affairs continues in the 80's, with the added new wrinkle that space installations are now said to be too expensive and too vulnerable. This will be discussed in detail in the chapter on space systems.

Our missile programs have not yet been designed to maximize the variety of threats and missions inherent in using the aerospace, so that the Soviets have had to do little in the way of wasting resources to be ready for what we might do. By abandoning the initiative we give the enemy the chance to concentrate upon his strategic plans entirely unmolested by the options that we do not take up; and where, by accident, we do achieve a breakthrough ahead of the Soviets, we do not develop the new technology at all.

Yet, a defensive strategy does not imply abandoning the initiative. Properly conducted, a defensive strategy can be stronger than the offensive, particularly if the defender enjoys resources superior to those of his opponent – as we do. The essence of a good defense is not so much a good offense as planning for surprise – which requires that the defender exercise initiative and ingenuity.

2.10 Surprise[3]

The foremost characteristic of a good defense is timing. The side which first achieves a new advance can gain advantage can gain significant advantages in the Technological War by exploiting it to the fullest, keeping the opponent uncertain of what may be developed and how it might threaten him, and forcing him always to guard against surprise. A major goal of strategy should always be to achieve surprise, regardless of whether the strategy is offensive or defensive. Weapons systems and scientific research programs should be designed not only for minimum cost, technological elegance, and logistic ease, but also to create maximum uncertainty in the mind of the opponent. Surprise may result from the proper use of technology, but its main impact is upon the enemy's mind.

Surprise may be achieved through the sudden unveiling of a secret weapon. It is more often achieved through the novel use of a familiar system, as in the use of the B-52 against the guerrillas in Vietnam. Surprise is still more often

[3]Current examples are space, ABM, MIRV, and the use of deep underwater technology for military purposes.

achieved by taking an action the enemy did not consider because, although he knew perfectly well you were capable of performing it, it was completely outside the doctrines he thought governed your actions. This miscalculation may result in a paralysis of thought, because now the enemy has no idea of what to expect next. If you were capable of doing that, what else might you do?

The first bombardment of North Vietnam could have been used to create such a state in the minds of the enemy, had we not gone to such pains to make him aware of just what limits we placed on our future actions. A classic example of surprise is Guderian's thrust through the Ardennes followed by deep penetration of France, producing the collapse of the "finest army in Europe".

Another common method of achieving surprise is through the exploitation of small advantages. Sometimes very small technological differences can be decisive; for example, in air combat during World War II, a speed differential of 20 miles per hour was crucial, even though it was only a small percentage of the total speed of the two airplanes involved. A 10 percent performance advantage in a radar can work a similar result. In war, there are very few prizes for having the second best equipment, even if it is almost as good as the enemy's; if before the combat you thought yours was better, the resulting surprise could be as disastrous as the actual inferiority.

Sometimes surprise can be achieved by deliberate manipulation of the expectations of the enemy, through the design of military equipment to maximize certain crucial variables at the expense of others. The Spitfire was designed to have a faster rate of climb and more firepower than the Messerschmitt, yet it was inferior in most other respects. It was then employed in an operational environment which made use of its advantages and minimized its disadvantages. The result was the disaster to the Luftwaffe that we call the Battle of Britain. Yet, to an aeronautical engineer or an aerodynamics scientist, the Messerschmitt was clearly the better airplane. German scientists and pilots alike were victims of a deliberate policy of technological surprise.

The above example is worth studying. In particular, it should be noted that victory was produced by the combination of aircraft design and strategy, which required careful analysis of far more than aerodynamics and engineering. The victory was won by military decisions, not scientific theories.

2.11 Science Is No Substitute for Military Judgment[4]

The Spitfire example is illustrative of the principle that science, computers, and systems analysis cannot make military decisions, although they can be greatly useful. It was not merely the Spitfire's advantages but the strategy which used them effectively that gave victory in the Battle of Britain. The art of war is the art not only of using your advantages to best account but also of creating advantages you did not previously have by inducing the opponent to make mistakes. It is rather difficult to simulate this on a computer.

2.12 Systems Analysis and Military Decisions: The TFX

The current miraculous substitute for military judgment and creativity is called systems analysis. The authors are familiar with the techniques of systems analysis and often employ them for certain limited purposes. When, however, these techniques are used as a substitute for strategic analysis the results are usually disappointing. One outstanding example is the TFX.

The problem of the TFX (FB-111) is not that it will not fly. Although its crashes have received spectacular publicity, as this is written (1970) the aircraft has in fact a better safety record, for this stage of introduction into the force and number of hours flown, than any attack bomber in recent history. The difficulty of the TFX is that it is not the best airplane for any mission it can fly, and was deliberately designed that way.

This difficulty is the result of trying to save money by designing the plane to do reasonably well at many different missions, at the sacrifice of performance in all. Thus we have an airplane which is a very good second best to the new MiG in the air superiority mission; and although useful in other missions, it is not as good as the aircraft we could have for those roles, yet it is costing more than the optimum plane for any single mission would.

In the first edition we did not argue against the continued introduction of the TFX into the force. If called the A-111 and used for the attack-interdiction mission, it remains a good airplane. During the bombing of North Vietnam, the FB-111 was so clearly superior to anything else we had

[4]For an early discussion of this subject, see Colonel Francis X. Kane, U.S.A.F., "Security Is Too Important To Be Left To Computers," Fortune, April 1964. Reprinted in Barnen, Mott, and Neff, Peace and War in the Modern Age (Garden City, N.Y.: Doubleday Anchor, 1965).

that a sortie by three TFX gave results equivalent to strikes by up to 40 other aircraft, and at far less cost. (FB-111 was also effective in the strikes against Libya.) This illustrates the well-known principle that in general the most technologically advanced system is the cheapest system when it must actually be employed in war.

However, the TFX is not an optimum attack bomber. It costs far more than the attack bomber we should have built and must build in the 1990's. It suffers from design defects directly traceable to the effort to make it useful for other missions, and these defects contributed greatly to the much-publicized crash record of the TFX. For a lot less money we could have had not only a better attack bomber but a second airplane to give close support of ground troops – something the TFX was also supposed to do but for which it was so badly designed that it was never attempted. It was also supposed to be able to fly from aircraft carriers; that too was never attempted, but the requirement delayed the aircraft and influenced its design.

Analysis of the TFX is compounded by the political interference with the military source selection boards, and the awarding of the production – over the objection of eleven military boards – to a Texas company instead of the greatly-favored Boeing, of Seattle. This was not, however, the crucial decision in the TFX mess. Given proper design, almost any competent airplane company can build a good airplane, although some will have more difficulties and charge more than others. The critical problem of the TFX was in the systems analysis-spawned concept of the airplane, not in the subsequent efforts of the engineers to build an airplane to a set of impossible specifications.

The original concept of the TFX was born during a visit by then President Kennedy to an aircraft carrier. The Navy, in a misguided attempt to impress the Commander In Chief, landed a variety of aircraft on the carrier, prompting Kennedy to ask Secretary of Defense McNamara why there were so many different kinds of military planes. McNamara did not know, and after a few moments of thought decided there was no reasonable cause, and that a great deal of money could be saved by building general purpose machines. Then, in a burst of insight, he promised the President that not only would there be a reduction in the number of kinds of aircraft, but that both the Navy and the Air Force could use it, thus reducing costs still further.

The interservice airplane was itself a questionable concept, inasmuch as the missions and roles of the two services differ greatly. However, it would be possible to create such an aircraft, provided that its purposes and intended missions were not impossibly contradictory. It would be highly difficult to do so, and an aircraft required to take off and land on carriers would almost inevitable have more performance restrictions than airplanes designed for use from Air Force land bases; but the savings in costs of construction, stores, inventories, etc., might be sufficient to justify degrading the performance of, say, an attack bomber or close-support airplane.

The really crucial decision came when Secretary McNamara decided that the TFX should be both an air superiority fighter and an attack bomber. Once these roles and missions were mixed, the airplane was doomed. Such a multi-mission aircraft looks extremely good to the budget-minded. By assigning proper numerical values to various levels of performance on different missions, adding them up, and calling that effectiveness, you get a figure which – compared with the cost of producing several different types of airplanes each of which is optimum for a mission – makes it the best airplane you could ever buy. The TFX will remain a wonderful general-purpose craft until it fights the airplane that takes first place in the air superiority mission. In war, there is no prize for second place.

In fact, the TFX was intended to perform not two but four incompatible missions, and to do so for both the Air Force and the Navy. In its original conception, the TFX was intended to be: (1) our general-purpose all-weather air-superiority (or dogfighting) fighter, with the possibility of being a continental defense interceptor as well, (2) a reconnaissance-strike attack bomber, (3) a long-range, deep-interdiction attack bomber for all-weather missions, and (4) a close-support, attack-weapons delivery platform for missions in combination with ground troops. We note here that the TFX is not a strategic bomber and was never intended to be one; attempts to call it that were for the political purpose of hiding the fact that our bomber force was approaching obsolescence in the 1970's.

TFX designers were therefore called upon to do the impossible. The requirements for missions 2 and 3 above are not completely incompatible, and cost considerations may well dictate a single airplane for these two purposes; at the moment, the TFX could have been the best craft in the force for either of these missions. However, each of these two missions is incompatible with the air-superiority mission, so that after years of delay the Congress approved the design and construction of the F-14, F-15, and F-16. Because of the long lead times involved in airplane development, before the F-15 was operational the Soviets had will have at least one generation of fighters superior to anything we could put in the sky.

The TFX was not the best airplane we could have had for missions 2 and 3. It is too expensive, for a start. The compromises made in its design to make it useful as a fighter and a close-support weapons platform not only degrade its performance as an attack bomber but are extremely expensive. For a lot less money we could have an attack bomber as superior to the TFX as the TFX is to the older planes that are still the mainstay of the tactical air force.

Despite the incompatibility of missions, the proposed TFX designs were evaluated on the basis of a single number: the effectiveness of the proposed airplane for all four missions. This is similar to the point system for determining the winner of the Olympic Decathlon or the Modern Military Pentathlon, by which the winner of a single event may be ranked behind the man who has taken second or third place in all contests of the decathlon. A second criterion employed was the degree of commonality between the Air Force and Navy versions of the plane, that is, the percentage of parts the two versions had in common. This criterion compromised the aircraft design, and eventually was worse than useless because the completed airplane could not land on carrier decks. The Navy finally canceled its orders for TFX and began design of an aircraft suited to the Navy mission environment.

Thus, instead of bringing the heralded savings of billions of dollars, the completed aircraft cost more than would three separate airplanes optimized for individual missions; the Navy got no attack bomber at all; and the Air Force finds itself with an airplane useful only for the attack bomber mission, and not optimal for that. Finally, because of political interference in the selection of an airplane producer, the TFX was built by a company that had a reputation for delivering aircraft late and with high cost-overruns. At this time (1970), the airplane is grounded until studies can reveal the cause of the latest crashes. Instead of having a splendid general-purpose aircraft, the services are presently fighting a war with airplanes that were in the inventory when the TFX was designed.

Fortunately, the United States was never required to fight new Soviet MiG aircraft with the TFX.

2.13 The Limits of Scientific Military Analysis

The use of numbers to calculate effectiveness – that is, taking a number of different missions or parameters and adding or otherwise combining them to get a single criterion measure – was once known in engineering as the figure of merit fallacy. In the McNamara era and after, the civilian leaders in the Pentagon promoted the figure of merit fallacy to the major principle by which we chose new weapons. Most Congressional staffer continue to operate this way.

If the weapons are to be chosen by scientists through scientific means, some such figures of merit will be necessary. Used properly, they are quite useful because they are not inherently misleading. What is misleading is the fallacy that military decisions can be made by scientific means.

The problem with scientific criteria and analyses is not that they are false or useless, but that they are incomplete. It is simply not enough to use cost-effectiveness or "most bang for the buck" as the means of choosing weapons. (One of the authors can remember when he was designing a small missile for use in defeating an enemy field army near friendly inhabitants. The nuclear physicist working with him was near to tears when he discovered that he had to design a very clean weapon with a rather low yield. "Why, for that much fissionable material and weight," he said, "I could give you a megaton." It took some patience to explain that a megaton delivered near the city would defeat the purpose of the weapon system.)

In other words, some systems that are militarily best are not necessarily the scientifically most elegant, as the Spitfire was hardly the "best" aircraft to the aerodynamicist, or the new MiG to the TFX systems analyst. It is the nature of the military decision that it has to take into account a large number of factors, most of them uncertain and in no way amenable to mathematical modeling.

In some cases, of course, scientific calculations are of immense value. If you are trying to discover how many missiles you must aim at the enemy to achieve a given probability of killing a target of (assumed) hardness, given an enemy attack of (assumed) effectiveness which will knock out a given portion of your force (surviving force to be calculated from assumptions), the systems analyst can be of great help in telling you how many more missiles you have to aim at the target because your own birds have a given reliability (calculated from insufficient testing data).

He can tell you what improvement you must make in this theoretical reliability to knock out the target system with the force you already have. He can even construct a little cost-effectiveness model in which he analyzes whether it is better to spend your money on improving the reliability of your present force or buying new missiles. His calculations will, of course, be based on assumptions about what the reliability improvement research will cost, and he will probably ignore Pournelle's Law of Costs and Schedules in the calculation[5] but he will come up with a recommendation which at least has the merit of letting you see where it came from and on what it is based. What systems analysis cannot do is tell the commander if it might be better to not use this force against a particular target at all, but rather attempt to

[5] Pournelle's Law of Costs and Schedules states that "Everything takes longer and costs more." It was independently discovered by J. E. Pournelle and Poul Anderson in the early 1950s.

achieve surprise or in some other way defeat the will of the opponent rather than his forces.

Strategy in the Technological War must be based on strategic analysis, not systems analysis. The decision process must employ an appreciation of the enemy, the operational environment now and in the future and the principles of the art of war. It cannot simply be based on a highly artificial figure of merit.

2.14 Other Fallacies

Before we take up the nature of the technological decision process, it will be helpful to discuss some additional common fallacies. These are important not because they are common today but because they seem to be attractive to technological planners. A list of common fallacies, not exhaustive but illustrative of the more attractive errors, is shown on Chart 4. Some of these have been touched upon above and require no detailed analysis.

CHART FOUR: Common Fallacies About Technology

- The march of technology can be halted by agreement.
- The centralized decision is the best decision.
- Centralized decision making = strategy
- Small advantages are not decisive, and probably not important.
- Symmetry of motives or actions.
  - The enemy won't do what we won't do. ("Why should he do that?")
  - The enemy is not doing what he is in fact doing. ("He can't be that stupid, and it isn't cost/effective.")
- Overkill
- If it's been constructed, it's obsolete.
- Technological advances in the military arts are automatic.

2.15 Technological Process

The first and last of the fallacies shown on the chart may seem to be self-canceling; that is, it may at first appear that no one could hold both simultaneously without being aware of the contradiction. This is in fact not true. It is possible to believe that technological progress can be halted through treaties and agreements, and yet also to imagine that advances are automatic; moreover, in our judgment, much of the technological policy of the past ten years has been based on these twin delusions.

The belief that technological progress can somehow be halted comes, we believe, from an imperfect understanding of the nature of technology, and in particular from failure to consider the interdependence of technological discoveries. There is no possibility of halting all scientific research or engineering development; yet you cannot predict in advance what the results of a particular discovery will be. For example, modern computer science, plus the development of complex mathematical models of the laws governing the combinations of particular molecules to form atoms, have made it possible for the chemist to make "dry lab" experiments with new chemical processes, discover new compounds, and determine much about their nature, all without soiling a single test tube. The research is carried on entirely by computer simulation. This technique is adaptable to weapons technology for the discovery of propellants, war gases, nonlethal incapacitation agents, "psychological" gases, and dozens of other militarily useful agents. As nuclear forces are better understood, most weapons tests may be conducted in the same way. An agreement by all governments to halt research and development in military chemistry or nuclear physics simply cannot be enforced, even if the governments actively strive to do so.[6]

Other examples of the interdependence of technology include the following: the utility of various fiberglassing techniques, developed for automobiles and boats, in rocketry and space warfare; the great increase in the accuracy of the ICBM from 1964 to 1968, not as a result of deliberate application of technology but merely through the reduction of International Geophysical Year data, which gave a better understanding of gravitational anomalies and thus reduced the largest single factor in the ICBM error budget; the military communications revolution brought on by the civilian invention of the transistor, which was also the prerequisite of the Minuteman. Unless you are determined to halt all technological progress – which is inherently impossible – you cannot stop the progress of military technology. No agreement

[6] Such simulated tests will never be effective in competition with real tests, of course. The point is that no agreement or inspection can halt research. Agreements can slow it down – but at the risk of the enemy making discoveries through his use of ingenuity.

can bind, because the stream of technology will flow on despite any effort to swim upstream.

Information about technological progress in the United States and the Soviet Union is not symmetrical. Despite the expenditure of billions of dollars for intelligence, the United States has incomplete knowledge about the state of Soviet technology in many military fields. If we are determined not to exploit our technological advances, we can not be sure the Soviets are not exploiting theirs; soon enough, we may find that they have been doing so, and that their exploitation has given them a decisive advantage.

2.16 Centralized Decisions

We have mentioned above that centralized decision making is no substitute for a strategy. Indeed, in the absence of a strategy centralization of the decision process is the worst mistake possible because it suppresses innovation in discovery and application. The military services cannot themselves generate a technological strategy, cannot orchestrate our technological research, development, and procurement into a grand design; but they can pursue rational substrategies which may be the best we can obtain. Until we have a workable mechanism for making use of military inputs and conducting strategic analysis to generate workable policy guidelines for achieving a strategy of technology, decentralization is probably the best protection against paralysis at the top of the decision pyramid.

Even when strategic analysis is conducted regularly and a national strategy for the Technological War is generated, over-centralization of technological decision making is useless at best and can be disastrous. In World War II (The Great Patriotic War, according to the U.S.S.R.), the major weakness of the Soviet army was the tendency to make all decisions at the top, the generals going so far as to order the placement and deployment of individual companies. This is not strategy.

A strategy provides subordinate commanders with the information they need to make intelligent choices and trusts them to carry them out. The strategist may well be unable to determine the best approach to a particular technical problem, just as a brilliant staff officer may not be able to place a company of soldiers for maximum defensive effectiveness. Even though the strategist may know better how to command a rifle company than its present commander, the strategist is not there. He cannot know the peculiar problems and strengths of this particular company; he cannot know that Privates Roe and Doe are individually worthless but nearly unbeatable in combination. The same is true of technological decisions. The human element of scientific management counts at least as much as the human element in military management. There is little to be said for the kind of centralization which centers all decisions at the top, saying in effect to those who must carry out the orders that they are untrustworthy; and there is much to be said against it, especially that over-centralization burdens the top.

2.17 Small Advantages

The notion that small advantages cannot be decisive stems from an imperfect understanding of the military arts. There is no prize for second place in combat. A system that is second best in each of ten areas is excellent until the moment it must be used in combat; then it is nearly worthless. Many examples of small decisive advantages come to mind: for example, in an air battle conducted with air-to-air missiles at long ranges, a two-mile difference in radar ranges can result in one side being destroyed before it even detects the other. Small percentage improvements in missile accuracy can result in enormous increases in target kill probabilities. Moreover, if you have misgauged your position on the technological S-curve (see the section on the nature of the technological process), what is expected to be a marginal improvement may in reality be quite a large one. Refusal to make small improvements usually stems from lack of desire to improve the force at all; that is, from failure to conduct technological pursuit and exploit your advantages to leave the enemy well behind.

2.18 Symmetry of Motives

Failure to exploit advantages, through technological pursuit or through a deliberate effort to achieve surprise, is often caused by the assumption of symmetry of motives and behavior. We are all too prone to believe the enemy will never do what we ourselves would not do, and if it is suggested that he would, we cannot understand why. This is the result of faulty intelligence and imperfect understanding of the enemy's objectives and philosophy. Similarly, we may be overconfident in our own analyses, believing that certain technological enterprises are worthless. We then refuse to believe the intelligence we do obtain when it shows the enemy is doing something we would not do. For years there was hard evidence of Soviet deployment of Anti-Ballistic Missile (ABM) systems; actual photographs showed installations employing radars not remotely useful for air defense and oriented such that they could only be part of an ABM system; yet the official word from the top was that they were air defenses or else mere sham. It had been proved that ABM was technologically impossible, thus the Soviet Union would not build them: ergo, they were something else.

The trouble with that kind of analysis is that the enemy may know something we don't. The Soviet operational tests of nuclear-tipped ABM systems in which they shot down several incoming RVs (reentry vehicles) and destroyed one of their Cosmos satellites with a nuclear interceptor may well have given them information which we could never gain because shortly after their operational tests they induced us to sign the Treaty of Moscow (atmospheric test ban). If, for example, nuclear weapons in outer space have much greater kill effects than we think, and operate at longer ranges than we have postulated, Soviet deployment of ABM systems would be quite justified. Several physicists have attempted to prove to the authors (on purely theoretical grounds, since the United States never conducted any real tests designed to get empirical data on the effective range of nuclear weapons in space), that the ranges could not be greater than we have postulated. The scientists eventually conceded that something might be achieved in exotic ways, but then contended that the Soviets could not know about them and certainly could not have tested them. Yet, the U.S.S.R. has continued to pour concrete and build an ABM system which we knew could not work. It would appear, from our present efforts, that the ABM effort is worthwhile after all; our blind refusal to believe the obvious cost us several years.

Incidentally, the Soviet ABM system, from its location and orientation, is obviously directed against the United States, not China; anyone familiar with the principles involved would know this. U.S. theorists simply cannot conceive that the U.S.S.R. might be willing to build a less-than-perfect defense system; therefore certain members of the technological community, finally convinced that the U.S.S.R. was in fact deploying ABM, decided to explain these efforts as China-oriented. Self-deception, once begun, can continue to absurd lengths.

> The above was written in 1969. It has since become clear that there are numerous ways to intercept ballistic missiles. Regardless of what the Soviets knew then, they continued not only to search for, but to prepare for technological breakthroughs. We did not being serious research into new ABM technologies until 1983, and in 1988 we have yet to do serious preparation for implementing what the laboratories have discovered.

2.19 Overkill [7]

The "overkill" argument appears to us to be self-contradictory, especially when presented by an advocate of Mutual Assured Destruction. On the one hand, the greater the forces in the inventories on each side, the greater the destructiveness of war if it does occur – something surely known to the leaders in both Washington and Moscow. Thus it is unlikely that anyone would deliberately engage in thermonuclear strikes against another's homeland. On the other hand, it is when one or both sides have more weapons than targets that wars can begin. Furthermore, the technological race inevitably makes previously invulnerable forces quite vulnerable as time goes on. Reliabilities of aged equipment are lower than those of new.

The best protection against losing one's second-strike force to an enemy first strike is constant updating of the force; but the second best protection is to keep in the inventory numbers that seem superfluously large, so that some marginal improvement in the enemy's counterforce will not result in a decisive advantage. The more weapons in inventory, the larger the surviving number of weapons, no matter what the respective percentages of kill may be; the larger the surviving force, the less likely the enemy is to strike in the first place.

Overkill is a good phrase, but, unless one assumes that military planners and political leaders are moral monsters and strategic idiots, it is unlikely that weapons of mass destruction will be accumulated simply for their own sake. To those who believe that motives of the services are in fact tinged with moral imbecility, no analytical work is likely to appeal.

2.20 Fear of Obsolescence

A common argument against investment in technological weapons systems is the engineering maxim "If it works, it's obsolete." This is a hangover from the mobilization strategy of the thirties, and stems from misunderstanding the nature of the technological revolution in war. It is true that whatever system one deploys, it is likely that if one had waited a few years, a better one could have been constructed. If this were carried to its extreme, nothing would ever be built.

Technology is dynamic by nature. Whenever a new field of technology opens up, the people who will use it must learn how. They must be trained,

[7] The Secretary of Defense's heavy emphasis on numerical data from Viet Nam often dictated inappropriate military tactics and strategies. As one operations officer explained, the goal wasn't to kill targets, it was to fly sorties.

and become operationally effective. In the case of aircraft there must be pilots. For space systems there must be satellite controllers.

Because of the long lag between generations of military bombers, the U.S. pilots of the B-1 and B-2 must be retrained. Because we have neglected manned space for years, military astronauts will have to be trained from scratch.

Had we waited until third-generation missiles were available before we constructed any (and had we also left the bomber force as it was), the world would not be as safe as it is today. A time comes when systems must be built, even though we know they will be obsolete in future years. Proper technological strategy will plan for such obsolescence, will seek systems of maximum salvage value, flexible enough for refit with the latest advances in technology. A proper strategy also forces the enemy to react to what you have done, so that he too must deploy hardware to avoid losing the Technological War.

The fallacy that prototypes and research are all that are needed should have been laid to rest by the experience of the French in 1939. The French army had – and had possessed for quite a long time – prototypes of aircraft, armor, and antitank weapons far better than those of the German army. The French did not have these weapons in their inventory because still better ones were coming. While they waited for the best weapons, they lost their country.

Military action must be routine; it cannot be extraordinary, planned months in advance like a space spectacular. Operational experience with a weapons system is required before operational employment doctrines can be perfected. Troops must be trained, logistics bases developed, maintenance routines learned, idiosyncrasies – and modern technological gadgetry is full of them – must be discovered. This cannot be done if the latest technology is confined to the drawing board or laboratory.

Clearly, all the above arguments doubly apply in the space era. Military space missions can only be routine when we have personnel experienced in performing them.

2.21 We Don't Need to Do Anything

Finally, we come to the quaint notion that since the stream of technology moves on inexorably there is no point in wasting resources on developing military technology. It will come of itself, without effort. This is, of course, nonsense. It is true that technology has a momentum which cannot be halted; but the direction and timing can be changed drastically. The interdependence of technology will eventually produce improvements in weapons whether you want them or not; but it does not guarantee sufficient improvement when the enemy has been devoting considerable effort to his own improvements while you have been waiting for what will come inevitably. In keeping with our analogy of the stream, those who simply drift with it will be carried along with little effort but those who swim with the current will be far ahead.

A force is at work that produces technological advances without regard to our intentions, but major specific advances in military capabilities result from deliberate human action. Technological discoveries may be self-generating in their own due time, but the timing can be speeded up. Advances not resulting from planned action cannot be fitted into an overall strategy, and often are not even recognized as militarily useful until long after they have been discovered. Although other advances are uncontrolled, their use is not.

2.22 An Illustrative Case History:

Initial deployment of GPS NAVSTAR took place in the late 1970's with partial operational capability to become available in the early 1990's, and full capability later in the decade. Dr. Francis X. Kane, Col. USAF (ret.) was one of the original planners of GPS, and closely followed its career.

First, we must note that the GPS NAVSTAR satellite navigation system will revolutionize the way the world lives and operates. Although its applications are just beginning to be understood by the world at large, they have been known and forecast by strategic analysts for more than a quarter of a century. The reasons why it has taken so long to bring about the happy marriage of concept and technology provide a case history of how hard it is to introduce advanced technology into our military forces, and indeed into our society.

Any strategy of technology has to cope with the brakes on innovation applied through ignorance, bias, prejudice, lack of foresight, and short-term special interests. The planner's task is to overcome ignorance, bias, prejudice, and lack of foresight, and to fight special interests. Only by perseverance can he capitalize on the potential of new technology. History is replete with examples of this problem. GPS NAVSTAR is only one of them: but it is the one which may yet show that the problem can be solved.

In 1963-64, under General Bernard Schriever's leadership, USAF planners conducted a top-down analysis of the relationships between strategy, policy, military requirements, and advanced technology. The study was called Space Policy and Doctrine (SPAD).[8] They studied the relationships between military functions: offensive and defensive systems, communications, weather,

[8]We did deploy the GPS navigation system, which we discuss elsewhere.

reconnaissance, surveillance, and navigation, on the one hand, and advanced space-based technologies and programs on the other. They soon found that our space-development program was not giving sufficient attention to space-based navigation, which, it appeared, could serve an almost infinite variety of military and civilian uses.

True, at that time the U.S. did have an operational satellite system: TRANSIT, which had been developed for the Navy by the researchers at Johns Hopkins Laboratory. The system did a good job of meeting the Navy's stated requirement: to determine the positions and locations of ships and submarines. Today, hundreds of thousands of agencies, units, and individuals, both civilian and military, use TRANSIT. The ships are from all countries, including the U.S.S.R. (to whom we provided a limited number of satellite receiver sets).

However, because of its design and performance, TRANSIT cannot be used by many others who need precise position- location information. Obviously, TRANSIT is independent of the weather. Navigators do not need to have clear weather in order to take sightings, but they do need several minutes to receive signals from the satellite and calculate position locations. Moreover, TRANSIT does not provide instantaneous read-outs (for example, for pilots of high-speed aircraft), and the calculations are too complex for a tank driver or a jeep driver to make, especially in rough terrain or under fire. These 'dynamic' users need a different type of system.

To overcome some of these problems, in the sixties the Navy developed a technology program called TIMATION. The objective was to develop and test orbiting clocks of unprecedented accuracy. That technology was supported by the Office of the Secretary of Defense.

At the same time, the USAF planners at Space Division together with Aerospace Corporation had developed and analyzed a new concept for a system called NAVSAT. This called for a constellation of four satellites at near geostationary orbit over the United States. One satellite was to be geostationary and the other three were to be in slightly inclined orbits, so that viewed from the ground, the three outer satellites appeared to rotate about the one at the center. These four satellites would be available at all times to navigators on the surface or in the air over the U.S.

The revolutionary aspect of NAVSAT was that the user, wherever he was, would be able to receive signals from the four satellites nearly simultaneously. He could then correlate the four signals and compute his position with unprecedented accuracy. Predictions at the time were for position-location accuracy on the order of 10 meters.

Extensive analysis was conducted to determine the number of users and examine the revolutionary effect of NAVSAT on military operations. The range of applications covered low-level bombing by fighter aircraft; high-level bombing; reconnaissance of targets with precise location known; strikes by aircraft or missiles; missile launches; anti-submarine warfare (ASW); surface-ship location; submarine navigation; amphibious landings, perhaps in remote regions; operation of aircraft from austere bases; en-route navigation by civil and military aircraft; helicopter operations; tank navigation; jeep and foot-soldier position-location; mapping; range operations; and even navigation by other satellites. There are thousands of potential users.

The NAVSTAR planners were certain that the world would unite to make a reality of that potential. Instead, the list of nay-sayers was as long as that of the users who stood to benefit from the system. The nay- sayers fell neatly into the four categories that are all too familiar to innovators:

1. Who needs it?

2. It won't work!

3. It costs too much!

4. Even if it does work and doesn't cost as much as I thought, I still don't want it.

In the Air Force's Research and Development Program, the budget for new concepts and new technologies was very small. However, a long internal struggle, characterized by numerous reviews and demands for more data, finally resulted in a funded program called simply "621B." This was a competition for concept formulation to cover military requirements, technical analyses, costs, program formulation, and organizational development – all simultaneously.

The Air Force spent several million dollars on operational and systems analyses in order to determine the military requirements the system would have to meet. Almost every conceivable military operation was considered. Aircraft operations (weapons delivery and air defense) were high on the list. Among the ground targets were bridges, airfields, transportation, and hardened bunkers. The war in Vietnam provided data on types of targets and on force effectiveness in such operations. For example, the many nearly futile attacks on the Paul Doumer Bridge dramatically illustrated the effects of inaccurate weapons-delivery systems, in spite of the efforts of experienced and dedicated airmen. The accuracy that a global positioning satellite (GPS) system would have provided would have let the pilots "drop the spans" in only a few attacks with few weapons.

Similarly, more accurate artillery fire, made possible through precise location of the Fire Control Center and individual pieces in the battery, could have produced dramatic improvements in "fire for effect."

Air refueling, rendezvous at sea, and concentration of ground forces and close air support demonstrated the utility of operating in a "common grid" and with very precise timing; reconnaissance and surveillance for tactical target location and eventual mapping with extreme accuracy would have provided that common grid.

Anti-submarine operations using a variety of sensors would have permitted accurate delivery of weapons by aircraft, surface ships, or submarines.

A virtually unique application was the potential use of the GPS system for air operations from austere bases, particularly bases in remote areas. If an airfield wasn't equipped with navigation and landing aids, GPS transponders located next to its runways would provide "differential navigation" with accuracy on the order of a few feet. This application would be equally useful for small civil airfields.

Precision location of satellites on orbit and ballistic missiles on test ranges would also be possible. In brief, knowledge of precise location and time would permeate all aspects of military operations and have equally dramatic civil applications.

It seemed strange, then, that with so many potential beneficiaries, the answer to the question "Who needs it?" was "No one." No program, whether it was the F-15 or the F-16 or a satellite system, wanted to sponsor any project that would disrupt its own plans, increase its costs, and (worst of all) give anyone else a free ride. Like many public programs which in theory belong to everybody, in practice the NAVSAT program belonged to no one. In fact, 621B was a rival for funds and a potential threat to every existing R&D and operational navigation project.

In the end, after many different lengthy field tests of NAVSAT technology, the individual and combined opposition of the services was overruled by the Office of the Secretary of Defense.

In the technical analysis, the story was much the same. The challenges were numerous. "It won't work because of ionospheric effects." "It won't work because you're in the wrong frequency band." Various distinguished groups agonized over such issues. They usually reached the same conclusion: "The theoretical analysis appears sound but there are very few data to support it. At no time did anyone say "I know the answer to the ionospheric effects" or "You should be in 'L' band because..."

The only sensible answer to these objections was the one that prevailed: to conduct tests and to collect data on technical performance and military effectiveness. Even that process was a slow one that met with constant opposition. Finally, though, R&D satellites were approved and developed; twelve were launched into orbit. Prototype receivers were built for a limited set of users: a fighter-bomber, a helicopter, a ship, and an individual foot-soldier. Literally hundreds of tests were conducted, their time and duration being determined by the four satellites' presence in the proper locations.

Satellite positions were a problem because the birds were in low earth orbit rather than geostationary orbit. If the original system design had been followed, four satellites would have been constantly "in view" over the U.S., and the tests could have been run whenever the user platforms were available. That option might have accelerated the program; nevertheless, a different constellation was used for a number of reasons, primarily survivability and power required for transmission of signals at lower altitudes.

The original NAVSAT study identified nearly 30,000 potential military users. The total number of military and civil users was and is in the hundreds of thousands. The users were classified according to their level of performance, and thus according to the kinds of electronics they needed. Obviously, high-speed aircraft, particularly fighters, had the most stringent requirements. It became clear early in the technical design phase that a combination of inertial navigation systems, GPS receivers, and computers would work in concert to meet pilots' needs. At the other end of the requirement scale were the surface users: trucks, tanks, and foot soldiers. Instead of the signals from at least four satellites, the low-speed users could do very well with the signals from three or even two of them.

Because the system was to be a global one, the users and satellites had to be linked by a ground network that would control the satellites and keep them in position. A prototype was built at Vandenberg Air Force Base. The user tests were conducted principally at the Yuma Test Range, but ships in the San Diego area were also involved. The results proved conclusively the technical nay-sayers were dead wrong.

Perhaps the biggest brake on the development and deployment of the GPS system was its overall cost. The cry "It costs too much!" went on for years. In fact, principally at the insistence of the Congress, a novel control mechanism was imposed on the program. The Congressional budget legislation stipulated that GPS had to show that it would cost no more than the money saved by phasing out other navigation aids (LORAN, OMEGA, and TRANSIT). Naturally, the sponsors of these programs had no intention of letting them be de-activated in order to pay for the GPS system. In the end, however, such a schedule was drawn up.

That Congressional constraint was followed by another, which proved almost fatal to the program: make the non-DoD users pay. A scheme was developed that involved designing an integrated circuit (microchip) that contained the essential codes. The chip would be changed periodically; in order to use the system, users would have to buy updated chips. The impracticality of this idea fortunately led to its demise.

Finally, there were the nay-sayers whose attitude was "Even if it works and I can afford it and it improves my operations, I still don't want it." Their argument was that satellites would always be vulnerable, and therefore the GPS system could operate only in peacetime. They had no intention of depending on it for military operations. To meet this objection, the constellation was changed so that the satellites were deployed in six planes, with three satellites per plane and three others on orbit. The satellites would be hardened to resist the effects of radiation. Last, three other satellites were to be procured to replace any birds that were lost for any reason, including hostilities or direct attacks.

Another set of objections came from the "guidance mafia": the people who make inertial guidance systems for ballistic missiles. Typical is a dialogue with an internationally renowned scientist who chaired an adversary group. His comment was: "Don't develop the GPS system; spend the money on inertial guidance." That resistance still remains.

The most discouraging attitude, however, was that of some of the principal users. During the early phase of the program, NAVSTAR planners made an extensive analysis of air operations in Vietnam, comparing the actual performance of weapons-delivery systems in a large number of raids with the improvement in effects which would result from GPS-level accuracy. The analysis showed not only more target destruction, but also lower aircraft and crew losses, and an overall cost reduction. When the results were released, the reaction was "You don't understand the war. We're not destroying targets. We're flying sorties and dropping bombs."[9]

Furthermore, the GPS system fell victim to the "18-month rule," of the Viet Nam War, which was our counterpart of the British "ten-year rule" that had prevailed in the thirties: There will be no war for ten years; therefore if this program takes more than ten years to develop, we can well afford to wait. The same approach held in Vietnam: If it takes more than 18 months to field the system, we won't need it. Obviously GPS would have taken more than 18 months to implement; therefore...

[9]Meanwhile, the Strategic Arms Limitation Treaty requires the U.S. to use "national technical means" for verification of Soviet compliance with the treaty. According to the London International Institute for Strategic Studies, this means observation satellites, particularly the large "Keyhole" systems. The special needs of these systems are also imposed onto the design of space systems, and apparently influenced the shuttle design. The result is one more conflicting set of requirements, and leaves the design of purely military systems up in the air, or to agencies not responsive to military planners.

The long struggle to deploy the NAVSTAR GPS system culminated in another bureaucratic innovation: multi-year procurement of the entire constellation of 24 satellites. Just as it seemed the positioning revolution would finally begin, the program met another setback. The satellites were scheduled to be launched into orbit by the Shuttle. The Challenger disaster and the resulting hiatus in launches have delayed those operations for at least two years. Nevertheless, the revolution will still begin in the 1990's when the full constellation has been placed in orbit and thousands of receivers will be in the hands of the operating military forces. Civilian applications such as surveying, oil exploration, and navigation will be commonplace. Before the end of the century NAVSTAR will have affected everyone's life, perhaps in ways we can still only guess at.

NAVSTAR illustrates both the positive benefits of strategic analysis – the system was invented that way – and the difficulties that bog down or halt the actual deployment of systems relevant to a strategy of technology.[10]

Most of these difficulties stem from insufficient study of the technological process. We turn now to a description of the march of technology.

[10] The "overkill" argument goes in and out of fashion. In 1969 it was very much "in". In 1988 it appears to be less so, but it will probably rise again.

Chapter 3

The Nature of the Technological Process

Today's revolution in space and weapon systems technology is a result of the revolution in science, notably in physics, of a century ago. The first step was an intellectual breakthrough made during the period when Maxwell, Hertz, and Mach were making their discoveries and led to Einstein's Theory of Special Relativity. These intellectual advances were a breakthrough because they eliminated some of the restrictions imposed on scientific thought by classical principles. By proposing new theories, individual scientists established a new era in science. Several characteristics of this revolution are noted on Chart 5.

CHART 5: The Intellectual Breakthrough

- Work of men of genius.
- Required two generations before science accepted and understood the implications of their work.
- The basic advances were made over 100 years ago.
- The discoveries were in the realm of pure science.
- The time of the breakthrough was unpredictable.

The second step is a process of translating theory into a device that appears to have some usefulness. The essence of invention is the instinctive or intuitive confidence that something should work and the first rough test of whether it will in fact work. We note several characteristics of this step on Chart 6.

CHART 6: Characteristics of Invention

- A creative art.
- Exploits science, and may support science as well.
- Invention is in the realm of technology, not pure science.
- Invention can be a lengthy process.

The third step toward a breakthrough results from a decision made at the management level, be it in industry or in the military. Such a decision is based on recognition of the potential importance of the invention. The essence of the decision is to allocate resources to translate an invention into a product that is materially useful. In the military this is usually a weapon system, a major component, or a piece of equipment.

The purpose of the decision is to gain an advantage in time or strength over competitors – in the market in the case of an industrial breakthrough or over potential enemies in the case of a military breakthrough. The decisions and actions of the enemy have an effect on the decision makers who seek to achieve a breakthrough. The characteristics of this third step are shown on Chart 7.

CHART 7: The Management Breakthrough

- A decision is made based on recognition of the importance of a scientific principle or invention.
- The choice has major implications for future capabilities.
- The time required for decision is shorter than the time needed for invention.
- The decision allocates resources, and usually leads to a production decision.

In the last step the invention chosen by management is developed as a system and produced in appropriate numbers. An essential part of the engineering breakthrough is the advanced development or prototype. The construction of a pilot plant by industry provides the bridge between the breadboard model and full-scale production. The military have taken several approaches to this aspect of the engineering breakthrough. We have built prototypes of aircraft prior to production. In our development of missiles we telescoped the construction of the prototype and production into a single phase under the concurrency principle. In our space effort we had planned to create building blocks such as Dyna-Soar and Titan III booster before the manned military space program was shut down. The distinction is further blurred by development of one-time, unique systems, such as our command, control, communications, and intelligence systems, which have been evolutionary as new devices and systems have been introduced into ongoing networks and command centers. The characteristics of this fourth step are shown on Chart 8.

CHART 8: The Engineering Breakthrough

- Exploits the realm of engineering and technology, not science.
- It is a deliberate product of technology with a useful purpose in mind.
- Success in this stage is the only real addition to capability.
- Requires a shorter period than scientific discovery or invention.

This division into steps, into bits and pieces, is for illustrative purposes only. We should recognize that scientists sometimes take on the role of technologists, that technologists have made scientific discoveries, that production may require invention, and that scientists, engineers, and managers participate in the decision process. It would be misleading to try to summarize all the many activities of a multitude of individuals in complex technological relationships in four simple steps. Historical experience is complex and the four steps we have discussed are only indicative of broad areas of human activity.

Also, there is no uniformity in this process. At times, individuals have tried to stimulate closer ties between science and technology; Galileo and Newton, for instance, tried to cross-fertilize these two fields. Diesel's attempt to apply the law of thermodynamics (made possible by the high pressure steam engine) led to the invention of the Diesel engine, but the forecast that it would be the best engine for aircraft was clearly wrong.

However, our interest is in the use of science and technology as elements of strategy and conflict. Let us look at these four steps in this context. The revolution in physics that began with Maxwell and Mach led to new theories, which in turn led to independent work by Fermi and others. By contrast, the atomic bomb was the result of determined effort. The policy breakthrough in this historical example was the decision by the president to spend the large sums of money required to construct a useful weapon. It was based on recognition by the scientific community, notably by Einstein, Wigner, Szilard, and Fermi, of the practical implications of an advance in basic science.

In the case of the ballistic missile the direct relationship between science and weapon is not quite as dramatic and clear-cut as in the example of the atomic bomb, partly because war rockets are ancient. However, Goddard's initial investigations of rocket propulsion and Oberth's theoretical calculations played key roles in the German development of the V-1 pulse-jets and V-2 rockets. Here is an example of an invention being recognized and resources being allocated for an engineering breakthrough. The Germans made this decision in 1932, and chose two different approaches, rockets and jets. The first V-1 and V-2 flew about ten years later.

The German engineering work played a significant role in Russian rocket development and in our own as well. For example, both the Redstone and the Russian T-1 and T-2 used oxygen and alcohol. However, the technical paths diverged at this point. The Russian strategy was to pursue an engineering approach to missile development. We, on the other hand, chose to await an invention in nuclear weaponry to give us a lightweight, high-yield, nuclear bomb. Once this invention had been realized, we made the decision to allocate resources to our missile program and sponsored the many engineering breakthroughs in guidance, airframe construction, and reentry technology required for operational missiles.

In summary, then, we see that the atomic bomb followed the four-step pattern; however, in the missile field the division is not so clear-cut, notably because the policy breakthrough came so late that technology from other areas of research had caught up with missile technology.

In its broadest sense the term technological breakthrough applies to the entire process when it results in advances that thrust us into a new era of military capabilities. However, the term is used also in connection with limited parts of the process. A new theory may be described by scientists as a breakthrough. An inventor may describe his work as a breakthrough. The engineers working on a specific part of the problem of production may describe an advance they make as a breakthrough. This is most likely to occur when an invention is necessary for production; use of the term breakthrough has some validity because without the invention, production would not be feasible or efficient.

The key step in the process is step three, the policy breakthrough. A decision in the realm of the engineering breakthrough cannot be considered in isolation from effort allocated to steps one and two. The importance of the policy breakthrough cannot be overemphasized.

In attempting to bring order and control to the technological breakthrough, we have in the past concentrated on steps three and four in the process. We have studied management and decision procedures in more detail than the intellectual breakthrough and invention. We have brought a great effort to bear on production so that systems are made realities in a minimum of time. We consider it a major breakthrough when the time covered by steps three and four is reduced from eight years to five years. We have not made a similar effort to reduce the total time covered by the entire process.

At present, the period covered by the intellectual breakthrough and the invention cannot be reduced. This is an unavoidable consequence of our scientific and technological effort, partly because steps one and two lie outside the military sector. In their broadest sense steps one and two are the consequence of our society, and our contemporary society has not organized an effort to influence these steps. The way we approach invention has changed: in the past, invention was usually the work of an individual; today, we are making an institutionalized effort to stimulate inventions. But this change is not always productive, because it may stifle the loner and out-of-step creativity.

Once again there is much to be said for both sides of this argument. The team approach is not always superior to an individual approach to an invention. Some creative individuals cannot work as members of a team; others function best as part of a team. Furthermore, some parts of science notably chemistry, seem to require a team effort to make advances; but in the field of physics and mechanical engineering, more advances seem to be made by the individual working alone. On the other hand, there is the difficult task of interdisciplinary work. Regardless of the approach followed, it appears difficult to reduce the time necessary for intellectual breakthroughs or inventions and it is unpromising to organize according to pat formulas.

It may well be that recognition and acceptance of new theories and inventions will always require a period of mellowing, testing, and evaluation. Early dissemination of the new idea would help – provided its significance is recognized. Some say that new ideas never win by persuasion; they merely take over as their opponents die off. In any event, a new theory usually has little impact within one and often even two decades. This brings us to another aspect of the breakthrough.

From the point of view of technological strategy, our principal concern is in the time when such advances occur. The invention of a new jet engine today would not produce a new era in military capabilities as did the first jet produced by Whittle. Conversely, the invention tomorrow of a practical way of using focused energy beams as weapons would alter radically the whole sphere of military activities. Time is especially crucial in technological maneuver.

Whether the breakthrough is a surprise to the enemy or is an advance that he anticipates but cannot counter, the side making the breakthrough should plan for technological pursuit to maximize the gain made possible by the new advantage. Pursuit has proved difficult in warfare. The losses sustained in winning the battle frequently have reduced the momentum of the winner. Also, uncertainty about the conditions of the loser has made the winner act with caution.

In technological conflict pursuit is facilitated by the circumstances surrounding the breakthrough. Rather than causing losses, the technological success increases the power of the side making the advance, and success often heightens morale. The breakthrough can reduce the amount of uncertainty about the enemy's technology position.

These circumstances point out clearly that significant technical advances must be exploited. The concept of pursuit has a valid role in technological conflict. This is well-illustrated by Soviet space activities. Once they achieved a clear advantage over us in space they engaged in a form of pursuit to negate our attempts to make any advances in this new arena of conflict.

Moreover, this advance was used as the basis for maneuvers in other forms of conflict. In 1961 the Soviets broke the "gentleman's agreement" on testing nuclear weapons in the atmosphere, and then prevented the "neutral" powers from criticizing them. This advantage in another aspect of the technological conflict is an example of technological pursuit.

The full consequences of the Soviet decision to ignore the spirit of the 1972 ABM Treaty and go ahead with ballistic missile defenses while simultaneously improving their ICBM force and greatly increasing its numbers, were not recognized until 1983. The expansion of Soviet ICBM capability may have been one of the most crucial moves of this century. After 1983 the US began the painful process of catching up, but we have not yet done so.

Pursuit is not the exclusive province of the aggressor. The defender should plan on pursuit when he has acquired an advantage over the aggressor. Up to the present, we have yet to engage in pursuit to overcome the Soviets. On the contrary, we have halted short of using our superiority in aeronautics, nuclear weapons, computers, or missiles to cause the Soviets to modify their goals, strategy, or operations.

As the side on the defensive, we have one advantage which comes not from our technological strategy but from our resources. That advantage is mobility. We can change the priorities of our efforts and counter new threats as they appear. The richness of our technology makes this mobility possible.

(This was amply illustrated in the SDI program, where we were able to investigate a number of alternate approaches to ICBM defense. Unfortunately, we have not done as much to exploit these advances as we might.)

The crucial problem is to meet the threat on time. This is especially vital for us because we are on the defensive, have never tried to achieve surprise, and have never engaged in technological pursuit. The Soviets need not be as concerned about the time dimension of technological conflict, since they know that our goal is to maintain the geopolitical status quo and not to overthrow the Soviet *nomenklatura.* Thus, our advances pose threats only to their near-term goals abroad, and never to their security at home.

3.1 U.S. Policies and Technological Progress

As we stated in the last chapter, the United States has no overall policies with regard to technological development. In part this is due to the decentralization of technological resources in independent private industries, and is a benefit to our overall progress. Unfortunately, we have no policy or strategy at the governmental level, although paradoxically we do suffer there from overcentralization of the decision process. However, our central decision makers are not guided by strategic considerations and projects are related to each other mainly through budgetary actions. Various projects have their goals and we make extensive efforts to relate projects to each other, but the relationships do not come from a felt need to execute strategy. Without strategy, there is no mechanism for integrating goals, tasks, and priorities, and there is no criterion for the weighing of risks and costs.

Our technological effort is guided to some degree by conflicting policies. For example, we assert frequently that we are advancing along a board front. Also, we minimize direction and control, for in that way we assist progress. Consequently, innovation and invention are where we find them; we abhor invention on schedule. From the point of view of Protracted Conflict, however, we do not have an integrated technological strategy.

We do have budgetary controls. Each project is made to compete for funds, generally on the basis of the skill of its managers in playing financial and political games and the persuasiveness of its supporters. This is probably inevitable in a democratic society, but the results are sometimes bizarre. Projects are often assigned to different regions for purely political purposes. At one time the U.S. Air Force found its technological resources scattered from Boston (electronics) to San Bernardino, California (ballistic systems), and managers of crucial Air Force space projects still spend as much time on airplanes as they do at work.

These are some of the major restraints we face in regaining the commanding lead we once held. There are others. Some lie in our technology itself: although technological research can be directed and certain lines of research emphasized, there are limits. The first jet could never have been produced in 1900 nor the first atomic bomb in 1915.

Another restraint is the technology base. The space systems now in operation are an outgrowth of our missile technology. We have, in the past 20 years since the first edition of this book, begun to recognize the importance of technological building blocks, and have constructed some of the necessary facilities such as environmental laboratories on earth and underseas, although, except for the very temporary Skylab we failed to build a manned orbital laboratory.

Considerations of strategy impose still another restraint. We must have at all times the in-being force necessary to win wars. This means being ready for operations at every moment in the foreseeable future while providing simultaneously the foundations for major advances in future capabilities. These are requirements that compete for resources. Our in-being capability is not static; we cannot allow it to dwindle or become obsolete. Thus, modernization of our forces must be continuous but it cannot detract from having sufficient power at any given time.

This restraint is compounded by a third restraint, which is financial. There is an upper limit on what we can expend to advance technology in general and on what we can allocate to develop specific systems. For example, no amount of money spent in 1935 would have given us our first ICBM. Unlimited resources in 1950 would not have give us Apollo 11. In attempting to achieve a technological breakthrough we must reckon with restraints imposed by funding.

These restraints have their greatest impact on step three. In the policy breakthrough, the attitude toward technology plays an important role. If decision makers are convinced that advances occur automatically, if they believe that contemporary technology can give us at any moment an unexpected but major advance in military capability, they will be restrained from taking effective action. Such an attitude makes them reluctant to choose a weapon or warfare system to be developed and produced because a breakthrough would make it obsolete and unnecessary.

A belief in millennium tomorrow is based on the unstated assumption that advances come automatically because of the nature of our present environment. From a cursory glance at past breakthroughs it should be apparent that they are the result of deliberate human action, that is, a combination of goals and work to attain goals. Nevertheless, the result of this attitude is a belief that choices are unnecessary because advances are spontaneous.

Another aspect of this step is a seeming paradox. The decision maker, while awaiting a technological breakthrough at any given time, feels he is suffering from an embarrassment of riches. As he faces the choice of a course of action he sees so many ways to proceed that he finds it difficult to choose any one of them. Furthermore, the rate of advance makes him hesitate. For if he chooses, he may soon find that the system selected has been made obsolete before it is usable.

These aspects have important repercussions. The first is that they delay decisions. Secondly, the decision makers press the military planners to examine minutely the entailed decisions which spring from the courses of action possible. Additionally, they press them to forecast with certainty these anticipated effects. A recourse to science is the planner's response to such impossible demands.

Here we should note another paradox in this process. The scientist and technologist are responsible for advances in knowledge and in applications. Authority in these fields does not per se provide insight into what is either commercially or militarily useful. The management level in industry uses scientists for technical advice but does not depend on them for managerial decisions. However, in the military, management procedures are designed to have scientists participate; thus while individual scientists can initiate an advance other scientists can restrain the project.

Past attempts to put more objectivity into our decision making by considering cost-effectiveness and by using computers for war games had only a limited validity. They contain an inherent danger because the results are inevitably biassed, even forced, by the assumptions governing the game. If the simulation designers do not recognize crucial factors, those factors will have no effect on the game results. The main decision is still that of a choice of strategy which, in turn, must reflect an assessment of the enemy's strategy.

Many strategic considerations do not lend themselves to computer simulation, because they cannot take into account all the relevant factors. As an example, in the computerized war game situation the surprise element is usually not considered and, therefore, a basic distortion may be introduced. Modern computers are useful to determine patterns and to help in visualization, but they don't substitute for the strategist.

The challenge is to create and execute a technological strategy. Technology should be the servant of the strategist, who must be a thorough student of strategy and its history.

The weapon system as such is not the goal of technology. The weapon system is the tool of the soldier or of the man carrying out a selected strategy. This is true even of push-button weapons. Conflict occurs between men or between societies.

3.2 Technology and the Economic Base

Technology develops faster than the economic base. This elementary fact prevents us from taking advantage of all technological possibilities. Technology grows according to geometric progression, whereas the resource base grows, at best, according to an algebraic progression. Sometimes it even retrogresses. Included in this resource base is the human factor, and that may not grow at all.

The heart of the matter is not just a question of inventiveness and organization of the scientists or the scientific base. It is the optimal utilization of economic resources and the proper integration of the technological, economic, and strategic resources. This integration is essentially a two-way street. The strategist must be able to request technological solutions for his problems, which can range from space warfare to propaganda. But in turn the technologist must tell the strategist what the potentials and limitations of his strategy will be.

3.3 The Technological War General

In technological warfare, generalship is the key to success, as it always has been in every conflict. The difference today is that generalship on the battlefield is perhaps less important than generalship exercised many years before a battle is joined. This is especially true of the generalship that goes into the design and development of weapon systems. The general who wins the battle is usually the man who held decisive control ten years before the fighting started and who, at the moment of battle, is either dead or retired.

Note that this applies equally to Commanders in Chief, and behind them to the Congress. Andrei Gromyko has met fourteen American Secretaries of State during his tenure as Soviet Foreign Minister. Cyril Korolov commanded the Soviet space program for a considerable period of time. The Soviet tyranny, by its nature, has the advantage of being able to make and keep long range plans. An American President, by contrast, must spend money and make unpopular decisions that bring results during the administration of his successors. The temptation to let the future take care of itself is intense.

Technological generalship must anticipate strategy, tactics, and technological trends. It must develop weapons, equipment and crews. Such developments must be anticipated in advance of trends.

Generalship in battle still is of great significance, especially because of the surprise element in modern war. Here the general must be the man who can get the maximum performance out of the systems he actually possesses.

He must have an inventive mind, to carry out modifications that become desirable. If he cannot overcome a technological lead by the opponent he must be able to devise tactics or stratagems to carry out his mission despite technological inferiority. While not necessarily a battle leader – although battle leaders are still required – he must be a great thinker. He must have full knowledge of his weapons systems and those of the opponents. Finally, he must be able to think through the lessons of the battle, even as the battle is being fought.

Implicit in this description of generalship is the assumption that the leader is striving to reach selected goals and that he is using initiative in his actions. Our technological strategy of the future must try to take the initiative in a selected field and to defeat the Soviets clearly on as many occasions as possible. For example, there is no reason why guerrilla warfare and counterinsurgency should be their exclusive domain. Technology can make it possible for us to contain them in these forms of conflict as well as in nuclear war. Fortunately, as the lessons of Vietnam were learned we have devoted some attention to the technology of people's war.

3.4 Conclusion

The U.S. goal is to make the Technogical War remain an infinite game; one which will never be "won" in the sense that one side eliminates the other through armed conflict, especially nuclear war.

The challenge is clear. We are engaged in a conflict for technological dominance. The center of our power position is threatened by the Soviet drive to surpass us and become superior. While the relative technological position is important to political, economic, diplomatic, and psychosocial struggle, it is vital to military conflict.

Superiority in military technology is the prerequisite of strategic success. This is especially true in the era of aerospace nuclear warfare, when a surprise attack made possible by an unexpected technological advance could lead to sudden defeat of the seemingly strongest power. The danger is especially acute in the current period when expanding technology can be used to implement aggressive ideology. In spite of the richness of U.S. resources, two resources are neutral: time and will. The time advantage goes to the one who has the will to grasp the initiative.

In order to use time successfully, we need an integrated technological strategy. Such a strategy will require basic changes in American organization and decision-making processes. To survive, we have no choice but to pioneer.

THIS PRINCIPLE HAS NOT CHANGED. [1997]

Chapter 4

Strategic Analysis

In war, the morale is to the physical as three is to one.
–Napoleon Bonaparte

In Technological War, organization and leadership is to the morale as six is to three.
–Possony, Pournelle, and Kane.

The starting point for strategy must not be that which is possible; we must discover what is necessary and try to achieve it.
–General d'Armee Andre Beaufre

Note to the Second Edition: The first edition of this book was part text and part polemic: the strategic situation in 1969 was at a low ebb, and the threat from the Communist Empire was large and growing. Since that time there have been some beneficial changes. The United States began to take seriously the Technological War. Although the Soviet Union continued to engage in Technological War, the US stayed just far enough ahead to prevent a decisive advantage. The Reagan Administration shuttered the Communist 'window of opportunity', while internal stresses within the Communist Empire continued to grow.

The small computer, itself a fall-out benefit from military research and development (for on-board missile guidance systems), had a near decisive impact: a power without computational resources in an era of "computational plenty" suffered a great handicap. On the other hand, it was impossible for the Soviet Union to introduce the small computer and maintain the management and control of information. Arthur Koestler pointed out in 1946 that the necessary and sufficient condition for the end of totalitarian tyranny was the free flow of information and ideas within the totalitarian society. The small computer, as the ultimate instrument of samizdat, makes information control impossible.

The Soviet Union was thus presented with an impossible set of choices: introduce modern technology, and thus inform the Soviet population of the true conditions both abroad and within the Empire; or suppress that technology, and forfeit its benefits.

Brezhnev chose the latter course. Andropov and his protégé Gorbachev, possibly because as KGB officials they were acutely aware of the internal problems of the Empire, chose the former. The repercussions of that decision are nowhere near over: as we write this, there are riots in Bohemia, and a new Prague Spring – if not a new Defenstration of Prague – appears likely.

The other key decision was the U.S. venture into SDI: that is, a decision to open a 'second front' in the Technological War. This intensified the dilemma described above.

As a consequence of these changes in world circumstances, much of the specific analysis in this and other chapters is no longer applicable. On the other hand, the principles on which that analysis was based have not changed one whit. Winning the Technological War is as vital as ever: we must not forget that perestroika and glasnost are not acts of kindness, but strategic decisions which allow the Soviet Union to continue its efforts in the Technological War.

We have partially revised the text in this chapter, but much of it remains as it was written in 1968-69. We wish to repeat: circumstances change, but principles do not; and if some of our text now appears to rail against problems already solved, we hope the reader will recall that this book played its part in solving them. STP, JEP, & FXK, Fall, 1989

As we have repeatedly stated, the Technological War must be fought as are other wars; that is, it must be fought according to a strategy. A general who simply muddles through, overcoming each obstacle as it comes to him, fighting battles at the dictation of the enemy, and preparing only for battles already fought would soon lose the war. Yet, too often it is thought that the Technological War, which may be the most decisive engagement in the history of mankind, can be fought with precisely this technique. Technology is made the driving force, dictating to strategy; and strategy is conceived of as the employment of systems already created by the technologists, that is, strategy is confined to operational decisions. This is akin to allowing the munitions manufacturer to decide the conduct of the war.

Proper conduct of the Technological War requires that strategy drive technology; that there be an overall strategy of technology, not merely strategic elements which make use of the products of technology. Instead of the munitions designer controlling the conduct of the war, it must be in the hands of those who understand technological warfare; and this requires that they first understand the nature of war.

Lest we be misunderstood, we wish to underscore the following point most forcefully: we do not say that scientists must somehow create a strategy for technological development. Nor do we advocate turning over the conduct of the Technological War to the average flag officer or captain of industry.

This is in fact the source of one of the major weaknesses of the West in the Protracted Conflict: there are very few experts in technological warfare. It is hardly surprising, for there are few senior people in the United States who have ever studied strategy, and fewer of those have turned their attention to a strategy of technology.

The first edition of this book was used as a text in the War Colleges and two of the service Academies, so that at least some of the officer corps has been exposed to the concept of a technological strategy; but there are no universities teaching technological strategy or the essentials of it, and there are few apprenticeship programs.

A Brookings Institution study recognized a facet of this problem, pointing out that the senior service schools were teaching officers how to "manage' but not how to understand, let alone develop, strategies and fight wars. This is being partly overcome by programs such as the USAF "Warrior" and the National Defense University computerized war games, but we have a long way to go.

One of the problems of the United States is our quaint belief in the administrator, our belief that a man capable of governing a large automobile company will be a good strategist and can safely be entrusted not only with the titular leadership of the services but with a dictatorial power over them extending to the silencing of all verbal opposition. We have coupled this promotion of administrators or executives with a tendency to centralize all decision processes, particularly those involving budgets and funding. These beliefs were the major architects of our defeat in Viet Nam. The problem is not trivial.

4.1 The Creation of Technological Strategy

To illustrate what is meant by a strategy of technology, we will trace the steps in the creation of military technology; and we mean by military technology those systems which are used in the Technological War, not merely weapons. Laboratories are an obvious example of tools of the Technological War that are not weapons. Others could include logistics systems; civilian hardware useful for the nation building mission; irrigation systems and sea water conversion plants; agricultural techniques and equipment. The list is endless.

We also wish to emphasize something very strongly: we are not proposing the creation of new layers in the decision process. We do not intend this analysis of organizations for rehumanizing strategy and generating a strategy for the Technological War to be taken as recommendations for creating new organizations for solving the wrong problems, and new structures to be added to the old.

What is needed is a fundamental restructuring of the entire decision process to allow government of the Technological War according to a strategy, rather than by a series of independent technological or scientific decisions. Once strategy governs the decision process, many of the present delays are likely to vanish. They must be made to do so. Time is the most important dimension of the Technological War, both to maintain the necessary lead and to save money.[1]

4.2 The Elements of Technological Strategy: An Overview

The elements of technological strategy are shown on Chart 9. It will be seen that the heart of the process is something we call strategic analysis. In other times this was called War Plans; for the Technological War the scope of analytical work must be broader than that of the old War Plans division of the European General Staffs. Strategic analysis is a process which generates a plan: it seeks the proper use of available and future weapons of the Technological War, orchestrates them, and produces the actual engagements. These may take the form of research plans, hardware construction, intelligence operations, or even military battles. The latter are unlikely in a Technological War until one side has achieved a decisive advantage.

At the top of the structure is the political leadership of the nation. This element makes resources available, particularly funding. It sets the grand strategy of the nation – that is, whether the nation is to go on the offensive or defensive, be expansionist or static, be interventionist or isolationist, and so forth. In addition, the political leaders must support the personnel engaged in

[1]The first edition of this book proposed a number of changes in decision structure. Some of those were made in the 1980's.

Table 4.1: CHART 9: Strategic Analysis

Strategic Analysis	Government Support	Technology
	• Leadership • Budget • Grand Strategic Decision Process • Public Morale	• Science • Research • Engineering • Production • Management • Procurement • System Analysis
	Non Military Conflict	**Military Arts**
	• Psychological Operations • Economics • Trade • Diplomacy • Internal Security	• Strategy • Intelligence • Counterintelligence • Logistics • Operations • Command • Military Analysis • Non Violent Warfare

the Technological War. It must be concerned not only with the morale of the technological soldiers but with the nation at large, justifying the necessary expenditures, explaining the purposes of each approach taken, and combating indifference and defeatism. Unless the political leaders properly perform their mission, the Technological War cannot be won.

The second major element in the creation of a strategy of technology is what is called the military arts. This includes subelements such as commander, strategists, and intelligence personnel. They must understand the significance of the moves made by the enemy in the Technological War, and formulate strategies for overcoming them. For example, if the enemy decides to engage in warfare, open or covert, at a level of hostility where the United States is weak, the military strategists must have available contingency plans for changing the nature of the war, either through controlled escalation or otherwise, to a kind of war in which we dominate. The military strategist must have an appreciation of our capabilities and limits as well as those of the enemy, and he must continually revise his estimates of what modern technology can accomplish.[2]

[2]This process has in part been implemented since the first edition of this book. The result is known as competitive strategies.

nologists, both scientists and engineers, obviously are essential to the Technological War at this point. Through independent research, they create new technology which may or may not be useful in the conduct of the technological conflict. They discover scientific laws and principles which may be exploitable as military or nonmilitary weapons. They should be guided in their research by the requirements of the military, by the military roles and missions that require improvements or that have been conceived of but cannot as yet be performed.

Others will be engaged in pure research which may or may not be useful in the Technological War but is beyond the charter of the strategist to direct or control. However, while we recognize the value of pure research, such as that carried out by Einstein and Fermi, we note that the creation of military technology from their physical principles was the result of a directed effort. We do not advocate over-control and micro-management of the research process and scientists in projects funded by DOD; however, some direction and control is necessary.

Modern technology is fluid; often specific items of technology can be created on demand through focusing of effort. The Soviet Union employs this method consistently to preserve resources, and has achieved many notable successes despite a paucity of reserouces compared to the West. In the United States the development of the hydrogen bomb, a key event in preserving the freedom of Western Civilization, was largely the creation of a focussed effort despite the fact that it was unwanted by many scientists, some of whom believed it unfeasible.

We want to be understood clearly: scientific research and discovery are in large measure products of free inquiry and human freedom. This fundamental point has been confirmed in a dramatic manner by the performance of the U.S.S.R., which depends to a surprisingly large extent upon the pure science produced in the Free World, but which, within the limits of its capabilities, has had an astonishingly good performance in the military applications of scientific discovery.

No one can predict the ultimate use of any research in any of the pure sciences. Except for navigation, astronomy was of no military use before the space age. Yet the mathematical techniques developed by the astronomers to solve the four-body problem helped to overcome one of the greatest difficulties in antiaircraft defense. Therefore, as a general principle, no scientific investigations should be starved, let alone suppressed. However, those researches that appear to have no strategic utility and most probably will not be useful for several decades surely need not be accelerated or be given priorities – even though they may be of extreme utility in the next century. It would be entirely sufficient to allow such work to proceed at a normal pace.[3]

s that many lines of basic research can be safely regarded as of great strategic importance, even though we may be unable to predict specific applications. For example, the steady exploration of atomic particles may, in the end, yield no strategic value, but the overwhelming odds are that a better understanding of the structure of matter will result in entirely new tools and materials. Discoveries in medicine, biology, psychology, and agriculture could have massive impacts on strategy.

Hence we believe this to be a matter of common sense: first, to support particularly those lines of pure research which promise an early strategic payoff; second, to regard technology as a task and end-product of all sciences; and third, to devote far more time and resources to analyzing research discoveries from the point of view of their possible strategic utility. In other words: do not hamper any research; support heavily research that has a predictable payoff; and reduce uncertainty concerning the military and strategic usability of scientific discoveries.

Note that the ordering of priorities is itself a strategic decision. When the threat is small and waning, one wished to allocate resources to technologies which may not mature for many years; when the threat is large and growing, technologies of more immediate application are needed. These are not scientific decisions.

The technological community has several duties. These will be discussed in more detail in later sections. For the moment, they can be summarized as shown on Chart 10.

The final major source of technological strategy is the nonmilitary conflict expert. The traditional elements of this community, namely, the diplomatic corps, foreign aid experts, propaganda and psychological warfare experts, and economic warfare practitioners, have a self-explanatory role. The important point is that this group cannot be ignored; and perhaps even more important, they cannot operate in isolation. Trade agreements, diplomatic negotiations, and political alliances are extremely important facets of Technological War, and the efforts of those engaged in these aspects of the Protracted Conflict must be coordinated according to a strategy. It cannot be stated too strongly that the Treaty of Moscow and the whole test-ban affair was a great Technological War victory for the U.S.S.R. To a lesser extent, U.S. trade policies have also been Soviet victories in the Technological War, in that they have allowed the Soviets to concentrate their scarce technological talent on mili-

[3]Times change, of course; what was 'far out' in 1969 became vital in 1980. In the chapter "Assured Survival" this book in 1969 advocated strongly focused efforts into 'beam technologies'. That research paid off handsomely after 1983; but note that beam technology is only one of the means for constructing viable missile defense systems.

tary systems in the confident expectation that the West will sell to them the technology and technological products the rest of their economy requires.[4]

This section has been an overview of the creation of technological strategy. In the following sections, we turn to each contributor in detail and trace the development of new weapons systems.

CHART 10: Duties of the Technological Community

- Providing Strategic Analysis with new possibilities.
- Developing specific systems from military requirements.
- Creating technology on demand.
- Creating technology from pure research.
- Discovering new fields of technology.

4.3 The Creation of Military Technology

In this analysis we have divided the creation of technology into three phases but we caution the reader that their linear form is in part illusory. Many of these functions are carried out simultaneously, and it is not necessarily true that all systems will pass through all stages we have shown. However, it will be helpful to trace all steps in the process, keeping in mind that this is not intended to be a recommendation for new delays in decision making. We do not insist that each technological creation go through these steps in succession.

In the discussion that follows we are attempting to show the kind of analysis which should be followed in order to coordinate technology with strategic planning. This is in no way a description of the actual steps taken in present

[4]This situation is essentially unchanged in 1989; the USSR expects glasnost and perestroika to produce internal changes, but also to induce the West to loosen up restrictions on both strategic goods and credit. While it is important to "give Gorbachev a chance" it is also vital that we don't preserve and increase Soviet military power. In the 1990's Trade policy has become the key front for the Protracted Conflict. [1987]

The decisive moment was when Reagan refused to abandon SDI at Gorbachev's request. This threatened to make obsolete the extremely expensive missile establishment of the USSR; the cost of refurbishing that system to make it viable in an era of strategic defense was unthinkably high for USSR planners. The alternative of using it before it became obsolete was no more attractive due to NATO readiness (although there certainly were advocates of a 'take Europe now' policy within the PolitBuro.)

weapon system design; indeed, as demonstrated in earlier chapters, we argue that at present there is no automatic review of technology to determine its relationship to the overall plan of action in the Technological War. Instead, decisions are made at present on the basis of technological or scientific factors, and usually by scientists.

> Circumstances change: in 1989 this is no longer true. Now decisions are made largely on the basis of cost, with a heavy dose of political pork barreling from the Congress. There is, however, some appreciation of the need for a technological strategy, and to that extent the situation is much better now than in 1969.

4.4 Phase 1

The first phase of the creation of military technology is shown on Chart 11. It begins with a strategic appreciation. This was once part of the intelligence process. In the 1960's and 70's the intelligence community was largely confined to the provision of data and descriptions of foreign technology to policy makers. The policy makers were generally civilians with little experience in the conduct of war, and rely on staff assistants for advice. The reorganization of the services divorced the top military staffs from direct participation in the operation of the services themselves, which are organized into commands and function as nearly self-contained structures under the direct orders of the Secretary of Defense. During the McNamara era the Plans and Doctrines departments of the various military service headquarters were thus required to compete for the attention of the civilian policy makers who alone have the authority to implement changes in the organization and structure of military forces.

For much of the 60's and 70's there was thus no organization in the United States whose mission was to prepare a strategic appreciation. This serious defect in our national policy machinery, but was not likely to be observed by the average civilian official because strategic appreciation had nearly become a lost art; and one does not feel the need for something he has never seen or known about.

Prior to the McNamara Era, the JCS had the responsibility for strategic assessment, but that role was eliminated by the civilian 'Whiz kids' he brought into the Pentagon. The role is being restored under the Goldwater Act.

All military technology should begin with strategic appreciation. Unlike an intelligence report, an appreciation takes into account our own resources

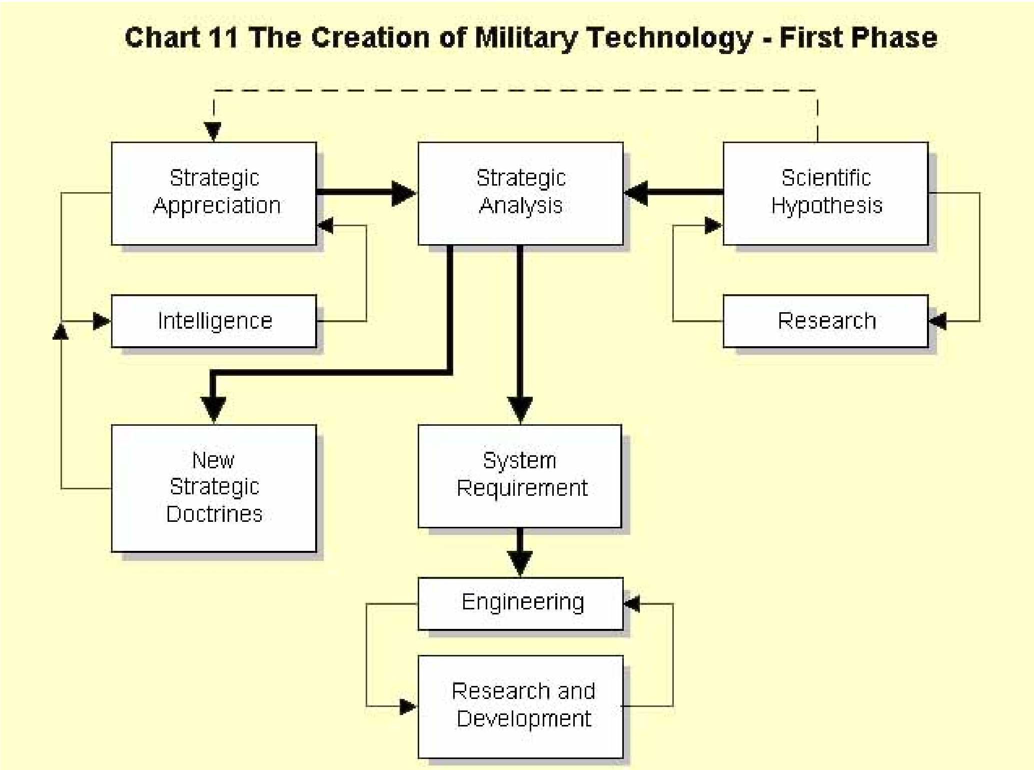
Chart 11 The Creation of Military Technology - First Phase
Strategic Appreciation
Strategic Analysis
Scientific Hypothesis
Intelligence
Research
New Strategic Doctrines
System Requirement
Engineering
Research and Development

and weaknesses, enemy objectives and intentions, our own goals and policies, and alternatives available to us. It provides an estimate of the situation, and a prediction of the outcome of the engagement if existing trends continue.

As are all military assessments and decisions, strategic appreciation is an art. It is more than what an economist or physicist would call an analysis or evaluation. Strategic appreciation requires a feel for events and trends which can be gained only from historical knowledge and experience of the proper kind; and that experience must include living in an environment in which one is constantly aware of the opposition of an intelligent enemy. Business and scientific expertise are not enough; almost every skilled generator of strategic appreciation is a military officer of long service, although not every senior officer is capable of an appreciation of the situation in the Technological War. One excellent example of an officer who possessed the talents required for this work was General Bernard Schriever, whose work in generating Project Forecast and Project 75 has been noted throughout this book.[5]

The strategic appreciation provides the strategist with an estimate of the probable outcome of present trends, and allows him to form judgments about the future requirements and capabilities for military technology. It thus forms the first element of strategic analysis, but by itself it is insufficient. The second element comes from the scientific and engineering communities in the form of possible or probable developments in the world of technology.

It is important to note that scientists and engineers will in general produce fundamentally different kinds of inputs. Scientists' reports will generally be given as scientific hypotheses, and insight and experience on the part of the strategist are required to see the implications in terms of new weapons systems capabilities.

Engineering reports are generally more concerned with short term prob-

[5] The era of computational plenty has had many beneficial effects, but it has one major drawback: if not careful, one can easily exaggerate the accuracy of computer predictions. The output of a computer analysis is really no better than the understanding of the programmer who built the analytical model; and since even today's computers can't understand history and economics and leadership personalities, they output of a computer simulation isn't likely to be an accurate prediction of world events. As an example, a popular computer game called "Balance of Power" is often used in university classes on foreign relations, and has been used in the Foreign Service schools. This game ignores economics and trade, and is largely "won" if the U.S. player pursues a policy of appeasement vis-à-vis the 'implacable' Soviet Union. Nothing the U.S. player can do will make fundamental changes within the structure of the Soviet player's empire. Balance of Power is an amusing game, but it is a pernicious instructor in real-politik. [1989]

We note that had the US followed the precepts of that game—which was based on the principles then taught by the Department of State—the Seventy Years War or Cold War would still continue. [1997]

lems, costs, and schedules. The technologies they advocate will have less scientific uncertainty – you can be fairly sure they can build what they say they can – but will also tend to be less imaginative if more immediately practical. Determining wheter to invest resources in science or in engineering development is one of the key decisions of the technological war. For example: the scientific work of Arthur Kantrowitz at the Avco/Everett Research Center, was crucial to the development of the continuous wave laser. Kantrowitz was dismissed as a dreamer by many in the aerospace community, who claimed in 1960 that lasers would never be practical military weapons because they could never be made more than 5

Technology will have two distinct impacts on military systems: it will identify new uses for our own systems and suggest new capabilities that would be desirable for the force; it will also postulate potentially new enemy capabilities against our force, generating new requirements for ourselves and changing the predicted outcome of future battles.

4.5 MIRV: An Historical Example

Note to Second Edition: After extensive debate, the United States under Nixon decided to deploy MIRV, Multiple Independently Retargetable Reentry Vehicles. This was a key event in the Technological War. In 1969 when the following was written, that decision had not been made, and there were strong advocates against MIRV deployment: that it should either be left as a pure R&D effort, or abandoned altogether.

Fortunately the U.S. continued MIRV development and actual deployment. If we had not done so the consequences would have been extremely serious.

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Fortunately the U.S. continued MIRV development and actual deployment. If we had not done so the consequences would have been extremely serious.

As an example, the implications of MIRV have an impact on both offensive and defensive systems. If MIRV is installed only in offensive weapons, this technological development can allow the utter destruction of a second strike force before it is launched, without the attacker having to deploy any new missiles. An aggressor could thus construct a full first-strike capability in his territory without doing anything observable by satellites or radar. As no intelligence organization in the world can guarantee that a potential aggressor is not altering the warheads of its existing force to take advantage of MIRV technology, MIRV poses a distinct new threat to U.S. missiles, and thus to the survival of the nation.

MIRV also has the effect of multiplying the capability of the surviving boosters in a second-strike force, by allowing each surviving missile to destroy more than one enemy target. It could, therefore, aid the defense as well as the offense. The actual changes in the strategic equation are dependent on additional factors, in particular the improvements of the yield-to-weight ratio of nuclear weapons (lighter weapons with a bigger bang allow installation of more MIRVs in a given booster), and improvements in accuracy (the more accurate the MIRV, the better chance that the second-strike force will be destroyed completely). In contrast to MIRV, extremely high accuracy of intercontinental missiles chiefly aids the offense: that is, great accuracy is not needed to destroy a city, but accuracy improvements allow the first strike to eliminate a greater proportion of the defender before he can launch a counter blow.

A current example would be the debate over strategic defenses. SDI forces both sides to stretch their technological resources to the limit. This is clearly advantageous to the U.S. because we have more technological resources: SDI deployment at the very least forces the USSR to spend its resources refurbishing its Strategic Offensive Forces rather than adding new capability to the SOF. They probably cannot afford to do this, which forces the Soviet leadership to decide whether a large and expensive SOF is needed at all. (1987) It is now clear that the above analysis was correct. (1997)

The strategic analyst must understand the implications of new technology, and the uses to which they may be put in both the Technological War and the Protracted Conflict. His analysis must extend beyond such obvious areas as improvements in missile guidance and accuracy to more subtle developments based on new scientific principles. He must also be ready to exploit fallout benefits, such as small computers.

The strategic analyst also uses the strategic appreciation to guide research efforts. From military requirements for underseas warfare capabilities, the technological community may be encouraged to do research in oceanology, particle propagation in dense media, measurement of cosmic ray backscattering, or examination of surface phenomena. Research budgets will to a great extent be controlled by the priorities for new technology set by the strategic appreciation.

However, it bears repeating: only a fool would so trust his own judgments as to cut off lines of research sponsored by competent scientists who believe themselves on the threshold of new principles or new fields of scientific endeavor. Research programs must always hedge against improper judgment or faulty analysis, but they must not be allowed simply to proliferate according to the specialties of the scientists who happen to be employed.

In fine, a technological "center of gravity" must be chosen, and research priorities allocated around it, so that most of the programs contribute to, or are designed to make use of, the advances in the chosen field of emphasis. Research in unrelated fields is good insurance, and should be carried out; but no one spends the major part of his budget on insurance to the detriment of his own plans.

The strategic appreciation and the technological state of the art are then analyzed in the light of the requirements of the other members of the Technological War community. Restraints imposed by political authority and diplomatic necessity must be considered, while, equally importantly, the effects of those restraints on the Technological War must be made clear to policy makers. There are times when diplomatic policies can be overcome only through enormous technological effort, such as in the case of the Test Ban; in these instances, policy makers should at least be made aware of the problems involved in the policy so that they will know their true costs to national security as well as their benefits.

When the restraints have been set and the requirements for the force understood, a technological strategy can be generated. It must plan for maximum strategic surprise, and incorporate planning for technological pursuit. It must plan for real options as well as paper options – that is, for systems that can be built and deployed as well as those that are only theoretical possibilities dependent upon the success of high-risk research and development. The strategic plan must provide for flexible systems which can incorporate new technological developments expected in the near future, and for defense against possible enemy capability improvements.

This analysis will generate a set of military system requirements. These will be brief descriptions such as "a general-purpose offense-defense missile system capable of using many elements in common for both missions. The offense system should have intercontinental range, and the defense system should be capable of interceptions in either the upper atmosphere or mid-course flight at ranges of at least 800 miles from the interceptor launch site."

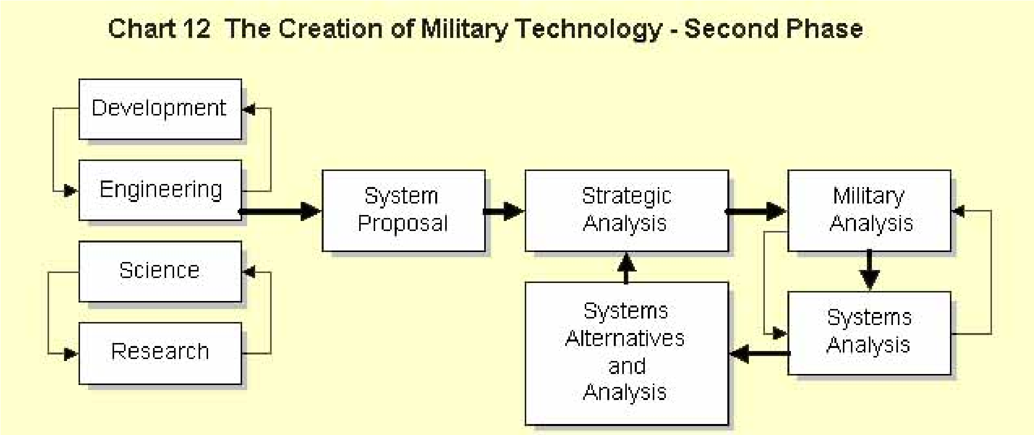
It is, in other words, a strategic system concept. In a real world case, the performance requirements would be defined more rigorously but not in detail. The strategic analyst is concerned with establishing a requirement, not with the actual design of technology.

> We understand that the requirements process is more complex than this. The requirements game is also used as a primary way to suppress promising lines of research and development.

The system design description is turned over to the engineers and technologists for implementation. Some performance features can be implemented with off-the-shelf hardware. Others require new developments in technology. Research will be required to provide a system design. This, however, is directed research to solve specific problems and provide specific technology building blocks to achieve the desired system performance. The engineering design team will also generate a series of estimates of system performance traded off against time and money; that is, an estimate of how long and what cost will be required to achieve each of several different levels of performance. Often this will be accompanied by proposals for alternative approaches to solve the technical problems. These estimates are returned to the technological strategist for decisions.

The decision as to which of several competing technical approaches should be used, or whether to spend the time and effort to achieve a particular level of performance instead of using cheaper methods to build systems of less value, will be one of the most important decisions in the life of the weapon system. Such decisions should be made with due regard to strategic necessities, not merely their scientific elegance. For example, a strategist may require an operational system within a certain period to assure national survival; the possibility that a greatly superior system will be available at a later date may be interesting, but it is irrelevant. He may also be able to restructure his existing forces to provide a stop-gap defense which will carry him over to the period in which the more advanced system will be available, or even decide to abandon the system altogether in favor of a different method of achieving security. The point is, those are strategic decisions, in which technologists and scientists participate only as generators of information, not as part of the policy-making process.

Decisions at this stage must often be referred to political authorities at the highest level. When this is done, the strategic analyst must be able to provide them not only with an understanding of the cost-performance tradeoffs but also an appreciation of the strategic necessity of various performance levels and an estimate of the magnitude of future demands for resources.



In any event, such crucial decisions should be made at a level where there is likely to be an understanding of problems of national security, not, as was the case in the McNamara era, by low-level civilian scientists who have never been faced with real military decisions. The economist in the Pentagon who wants everything reduced to a set of numerical values so that he can pick the minimax strategy has already confessed his ignorance of strategic realities, which cannot be given in numerical form.

In 1989 the decision maker is likely to be a Member of Congress, or, even more likely, a Congressional Staffer, whose expertise is more likely to be in political than strategic analysis. Micro-management and pork barreling by Congress has replaced the systems analysis by Whiz Kids in the Pentagon.

4.6 Phase 2

The decision as to system performance expectations and the technical approach to be employed begins the second phase of system development (see Chart 12). The systems engineers will work with the scientific community, seeking technological developments that may be useful to the system design and requesting assistance in research programs. Eventually, a systems proposal is generated.

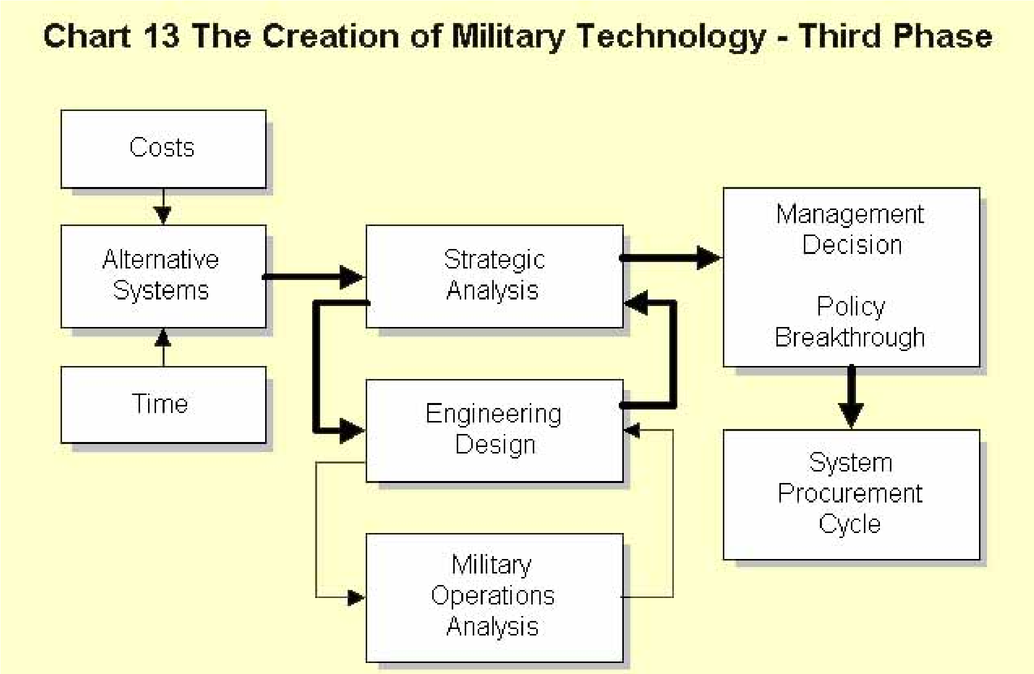
At this time, the specific system appears in a recognizable form. It is no longer simply a requirement for a particular mission but a hardware concept, employing radars and interceptor vehicles, warheads and guidance systems, ICBM stages and nosecones, bases and operating personnel. It is for the first time something that can be discussed by the general public, the Congress, and the average civilian official.

Note that, while this stage is usually the beginning in our present method of creating military technology, it is in fact quite late in the process. Systems proposals are expensive in terms of money and technological resources, and should not be generated merely to satisfy curiosity or because they can now be designed. They should conform to a recognizable need identified by strategic analysis.

The concept must then be examined by the military professionals who will use the system. However, if the first phase has been carried out properly, the new system will come as no surprise to the military process. We show military analysis as a separate step because it is at this stage that the system should receive a thoroughgoing review by field commanders to be sure it conforms with such realities as missions, existing installations, manpower availability, operation with other weapons, maintainability, etc. In addition, the impact of the system on force doctrines must be ascertained, and either the system adjusted to the doctrine, or the doctrines changed in time for adjustment to the system. Proper military analysis at this stage prevents the strategist from surprising his own troops – which has happened more than once in the past – and thus allows time to develop new employment doctrines in keeping with new capabilities.

This review may once again force a modification of the system design, and require that the system be submitted again to engineering and development, then back to the military analyst. Because of the delays inherent in this kind of process, it is obvious that the strategic analyst should be familiar with the operation of the forces, not merely be an armchair theorist, so that the first phase will identify and correct the major operational limits imposed on a new system design.

The second phase will thus evolve a system proposal that stands up. The first phase has ensured that it will be strategically useful. Military analysis ensures that it is militarily sound and will conform to the best technological data we have available. It is at this point, and not really earlier, that the systems analyst is useful. He performs tradeoff studies on performance, mission, and cost, to generate a series of alternative systems design possibilities and to compare this systems proposal with other possible ways of completing the mission. He hopes to show the effect of adopting one or another of a family of systems. Eventually a series of proposed alternative systems, not all of which have any assurance of being deployable, and an analysis of cost-performance tradeoffs are returned to the strategic analyst.



4.7 Phase 3

The strategic analyst must now exercise his own analytical judgment in consultation with the engineering and military operations experts (see Chart 13). He cannot base it simply on numerical analysis and statistics, but must take account of strategic principles and real uncertainties. Using his strategic knowledge he will reach a decision. He will select the system that offers the best strategic possibilities, including the capability to achieve surprise and pursuit, etc. There has been a policy breakthrough.

If the proper analyses have been carried out, and in particular if the first phase has been given the attention it deserves, the decision should not take long to make and will not be difficult to defend before strategically alert critics. Many project decisions can be made by relating them to the overall strategy of conduct of the Technological War. Others may require revision in the national strategy. The main point is that once a definite policy and strategy is accepted at the highest levels, project decisions concerning weapons systems will not be impossible for lower level commanders and can safely be entrusted to them. It is only when the top generals do not themselves know what they or their civilian superiors want done that the colonels and majors must submit even the smallest decisions to the top staff.

The system design then goes into the procurement cycle. This function is the best understood of all phases of technological development, and it is the least difficult (although the most expensive) step in the creation of military technology. In the past, procurement managers have been hampered in their work by an excess of management from the top, but to some extent this has been solved by placing a public relations expert in ostensible charge of the program, leaving the real manager (now second in command in the table of organization) to get on with the job while the "Director" uses up his time and that of his superiors in endless briefings. This strategem is more successful than might naively be assumed.

Because the procurement cycle is the best understood and most discussed of the phases of military technology, we will not discuss it here. For a brief discussion of the problems and work of the program manager, the reader is referred to a well known article by then Colonel Lawrence Skantze of the United States Air Force. The opening paragraphs are particularly worthwhile.[6]

> Alas, since the above was written, there has been considerable change in the procurement process; due to micro management by Congress and a proliferation of regulations, procurement has become much more expensive, and takes a very great deal longer, than in 1969. Reform of the procurement process is somewhat beyond the scope of this book; but we do note that it is a major problem for the Technological War.

During the past ten years, the evolution of research and development (R&D) in the Department of Defense might be characterized by two significant achievements:

The development, test, and acquisition of a substantial number of highly sophisticated, expensive weapon systems.

The development of an equally substantial number of R&D management systems, techniques, and tools.

Since the latter is a direct outcome of the former, one might assume that the errors these tools and techniques were designed to overcome have been eliminated. In the real world of R&D management, however, this is not always the case. Such tools as System Engineering, Configuration Management, Scheduling, Cost Programming and Control, etc., are most worthwhile. But the craftsman's skill determines the true effectiveness of the tool. Tools have been oversold to the extent that professional R&D management-course curricula and most trade-journal articles create the impression that R&D management is a science. The implication is that applying all of these tools

[6] Colonel Lawrence A. Skantze, U.S.A.F., "The Art of the Program Manager," Air Force-Space Digest, LII, 11 (November 1969), p. 78.

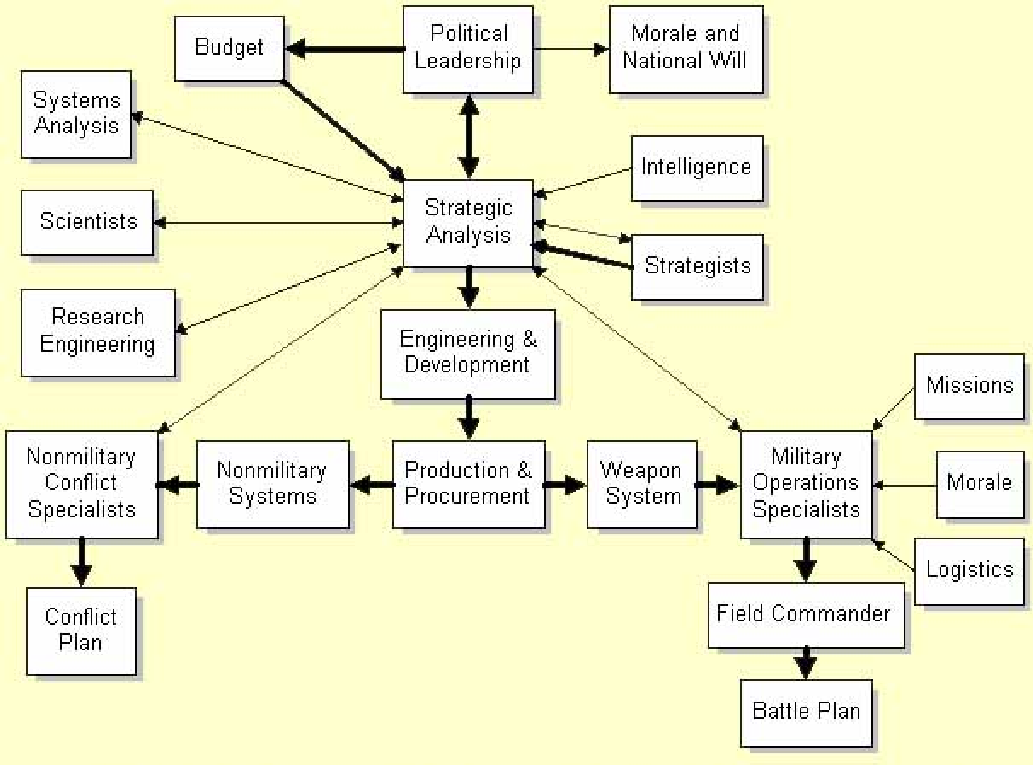


Chart 14 The Development of Technical Strategy and Strategic Weapons

as doctrinaire formula assures successful program management. This is simply not so. Program management remains more an art than a science, and anyone who believes differently should take a second look.

4.8 Leadership in Technological Warfare

The general decision path for leadership in Technological Warfare is shown on Chart 14. At present the U.S. defense decision process is not organized as shown on this chart, which represents our judgment of what would constitute a proper organizational structure for the creation of technological strategy and weapons systems.

4.9 Political Decision Makers

The task of the political decision maker – the civilian control of the military we hear so much about – is to set policy and see that the grand strategy of the United States is carried out, not to function as general officers in mufti and interfere with the proper operation of the services. Civilian control of the military is important; and it is basically guaranteed in the section of the Constitution which makes the President the Commander-in-Chief of the armed services, as well as in those specifying the functions of the Congress and forbidding appropriations for the Army for more than two years. It is not civilian control to place untrained political appointees at every level of the services and require military professionals to submit all decisions to them before implementation. Such a system of political commissars was tried by the USSR with such disastrous results that we are unable to understand why the United States should institute something along those lines in our military development and procurement commands; yet that is precisely what has been done.

Secretary McNamara's "whiz kids" believed themselves competent to make almost every military decision, and to do so while also holding the privilege of disassociating themselves from the resulting disasters they had produced. Civilian management of the Vietnam War should be sufficient example for anyone, but if more examples are needed the TFX and C5A debacles are also illuminating. In 1968-69 we witnessed a shortage of military fliers caused by the civilian decision to close the schools for pilots, the lack of iron bombs in Vietnam despite the recommendations of the services, and the provision of our combat troops with more than enough turkey on Thanksgiving but not enough helicopter gun ships. Civilian control of the military is a Constitutional requirement; civilian command of the military arts is not.

The chief role of the political leader is to frame basic national goals and policies. These include such factors as whether the nation will be a stabilizer or a disturber; aggressive or defensive; isolationist or interventionist. It is also to be hoped (although from previous performance not expected) that the basic national goals will at least be consistent with each other. The President as head of the National Security Council, with consultation with the Congress as representative of the people, is the only proper level at which such broad and basic decisions can be made; and it is vital that these fundamental goals be set, for without them the strategist is helpless.

Political decisions of this kind cannot, of course, be made independently of the strategist and the technologist. Until the political authorities know what alternatives are open they cannot decide between them; the principle is that a strategy or policy should not be adopted unless it is based on real capabilities. There is no point in considering a strategy of rollback if the means for implementing it are not available and cannot be made available; and there is no point in adopting a strategy of containment if Communism cannot in fact be contained. You cannot opt for Fortress America if defense cannot be built, and you cannot be a world policeman without an effective police force. The statesman must be made aware of the options actually and potentially available and the costs and consequences of each.

There must also be hedges against a changed strategic environment. Even if national authority is convinced that the rulers of the USSR have mellowed, simple prudence requires that there be some insurance against renewed radicalism in Soviet leadership. After all, not even the highest authorities in the USSR can be absolutely sure who will be in control in years to come, or even what the structure of government will be. There must be preplanned alternatives in the event of technological surprise, whether the surprise comes from our own laboratories or in the form of enemy weapons. The one generalization that can be made with certainty about our scientific era is that it will remain uncertain; that the rapid stream of technology will bring new weapons we did not predict. A prudent national strategy will realize this elementary fact and retain sufficient flexibility to allow adjustments.

Another important but recently neglected duty of the political authorities is leadership in solidifying national morale. The political leader must understand the doctrine of Just War and be able to transmit it to the nation. Where sacrifices are called for, the statesman must make the population understand their purpose and necessity. Precisely because we are faced with a dictatorial enemy who does not need to consult his subjects before making strategic decisions, the leaders of the West must continually make clear to the people exactly what is at stake. If freedom is to survive the Technological War, this task is at least as important as the civilian control of our own military.

4.10 Budget

The budgetary process is inseparable from the political machinery of government; the concept of scientific management of the disbursement of billions of dollars extracted from the taxpayers is a myth. Indeed, the control of governmental finances is one of the most important of political decisions, and some theorists have gone so far as to say that it is the essence of politics.

In financial decisions as well as in others, the political authorities must be guided by sound strategic advice, and the strategist should have access to fiscal officials in order to determine priorities. However, strategy does not consist merely of giving the strategist all he asks for, and certainly we do not argue that the defense of the United States requires that the services be given a blank check. Civilian expenditures are obviously relevant. Then, too, military budgets are no longer sensible, and indeed are deliberately inflated. This is not because duplicity is inherent in the military services but because it has become traditional to inflate budget requests so that political officers can take credit for cutting them to trim off the fat.

The problem with this negotiatory method of arriving at budgets is that the political authorities are aware that the budget is inflated. They then seek to make cuts below the sum the military would have requested had they been presenting an honest budget. In many cases they are perfectly justified in doing so, but how can anyone be sure? Service chiefs are generally not aware of their real requirements because their own subordinates have often inflated their requests, anticipating a general trim at the chief of staff and service secretary level. The upshot is that no one is really sure which programs are vital to national security and which are not.

This kind of problem will continue in our republic, and we are hardly foolish enough to believe that we have a solution to it. So long as democratic politics exist, various stratagems must be employed by its servants. We do point out, however, that it is much easier to solve budgetary problems as part of an overall strategy than to control hundreds and thousands of individual programs; and furthermore, that there will be less need for centralized control of the myriad programs that make up defense research, development, and procurement if there is a strategy. Games and debates will continue as always, but if top-level decision makers first decide on strategic centers of gravity they will find that many of the details that plague them today will take care of themselves.

4.11 Intelligence

The intelligence function is one of the most important in the Technological War. Since this is a work on technological strategy, not on intelligence, we do not provide a lengthy discussion of the details of this vital function.

The intelligence community provides inputs to the strategic analyst as well as to political decision makers. It is of vital importance that this intelligence be reliable; indeed, it is often better to be less complete, but more reliable, than to indulge in theories. In particular, the intelligence community cannot be certain about enemy intentions, which are subject to rapid changes. The strategist must work mostly with capabilities and technological trends, and he must have a flexible general understanding of who the opponent is and will be, what the range of his intentions might be, and what he probably will not do. And he must have detailed knowledge of the opponent's operational doctrine.

Intelligence cannot ensure against technological surprise, although the United States has certainly been surprised by enemy actions that were easily predictable. Technological surprise in particular can bring about near-disasters, not the least of which is brought about by psychological effects on the population: people either despair or demand overreaction in a particular field that causes improper utilization of resources.

4.12 Strategists

As General Beaufre has pointed out, the strategist must not limit himself to what is possible; he must find ways to do what is necessary. Wishing for a technological capability will not necessarily give us one, but the history of technological development, particularly of weapons, leads us to believe that identification of a technological requirement increases the likelihood of fulfilling it.

In any research program, there will be alternatives. There is usually more than one way to reach a technological goal, and several competing principles may be involved.

Choices have to be made, and it seems to us far more reasonable to make them on the basis of strategic necessity than simple technological elegance. Cooperation between strategists, technologists, and politicians will solve almost any problem, given the resources of the United States; hostility between these groups precludes the solution even of simple problems.

Strategists are almost never found in universities, or indeed in civilian life. These rare birds will generally have had a long career of working with military officers and military problems. Most strategists are, of course, military officers of reasonably high rank and long service. The converse is not true; many high ranking officers of long service have no conception of strategy – this is not intended as a criticism. The vast majority of military assignments involve the implementation of a strategic plan rather than its generation. Leadership of men, technical proficiency, courage, stamina, and careful attention to detail are all required of the successful field officer; yet nearly all these qualities may be lacking in a good strategist.

The strategist is, above all, an intellectual, but he is an intellectual of a different order from the scientist and engineer, or the average university professor. The strategist, unlike the scientist, deals with a world of secrecy, incomplete information, and real uncertainties which cannot be measured by statistical procedures. He lives in a world of intelligent opponents who seek to thwart him at every turn. He is concerned with the generation of plans which will be carried out by others, and he makes use of principles rather than scientific laws.

Strategists may in fact be unable to carry out their own plans. Many great strategists have lacked the vital qualities of leadership required of great military captains. Some have suffered from severe personality defects which prevented them from convincing anyone of the soundness of their plans. Consequently, strategists are not necessarily carried to the top of the military services unless they have been diligently sought and carefully chaperoned during their careers.

The U.S. armed services are not organized to locate and promote strategists, and originality in strategy has never been plentiful during out history. American military history shows rather the reverse: in all our wars, we have generally started with poor strategists in command and had to muddle through until we found strategic competence – e.g., Lincoln's difficulties in locating a general who could take advantage of the peculiar strengths and weaknesses of the Union Army.

Consequently, we will not generate a strategy of technology simply by giving technological autonomy to the services, particularly as they are presently organized. Our problems are much more difficult than that; in fact, the misconception that the usual military chief of staff is a strategist may be responsible for many of our present difficulties. In the past, civilian authorities have tended to defer to the military whenever they desired support for national security; the discovery that infallibility had not been conferred with the third star initiated a train of consequences that ended with the fallacious policies of McNamara, who regarded the military as incapable of making proper decisions.

The fact of the matter is that the U.S. armed services are commanded by men of great skill and competence, but this is not the same as saying that they are strategists. There are numerous strategists and potential strategists in the military services, but they are not usually found in positions of command. We do not advocate that command of the forces be given to strategists; as we have pointed out, good strategists are not always good leaders. But certain high-level positions must be filled by strategic minds.

What we must do is encourage strategic thought, particularly among younger officers, and ensure promotion for officers who show genuine strategic talents. This nation has always been fearful of a general staff, falsely identifying this useful military instrument with Prussia and Nazi Germany and supposing it to be incompatible with democratic institutions. When the structure of a general staff corps is explained, not one American in a thousand recognizes what it is; yet he no longer fears it when he does understand it. There may be good reasons for rejecting the general staff concept, but we venture to suggest that it be rejected for something better than a pipe dream such as that which was brought to an end by the historic event at Kitty Hawk.

In fact, the general staff corps concept is this: at an early stage in their careers, certain young officers are selected as potential strategists, intelligence experts, and staff officers. Management of their careers is then given to the general staff; they are posted to staff assignments and schools where they study war, strategy, tactics, military doctrine, and history. School assignments are alternated with service in the field and with such special arms as artillery, infantry, and armor. They remain in the general staff corps until they are thought to be unsuitable for it, whereupon they can either be transferred to one of the line services or retired.

During their careers in the corps, the selected officers alternate between appointments to general staff headquarters and its specialized branches – such as logistics, and attache duties – and appointments in the field, where they serve as chiefs of staff to the field commanders of successively larger units. Thus, commanders learn to command and staff officers learn the functions of staff work. Commanders and staff officers each have their own paths of promotion, and are not in competition with each other until they come to the highest positions. Even there, competition may be kept to a minimum because staff officers often make good commanders above the corps level.

This, in brief, is the general staff corps system. It produces officers who have considerable knowledge of strategy; it requires them to be familiar with the operations of the military services and the tactics of the field forces; and it encourages them to think in intellectual rather than command terms. The system has been proved to be effective, although it is subject to improvements.

Whether it be through the general staff concept or some other, we must find ways of selecting, training, promoting, and rewarding strategic talent and placing it in positions where it would be able to formulate successful strategy. Without strategists we will have no strategy. Yet it is strategy that is our greatest need in the Technological War.

4.13 Military Operations Specialists

The military operations specialist is a uniformed service officer, as is the strategist. However, whereas there are few strategists in the higher ranks of the military, tacticians and men experienced in leadership of troops are found there. No restructuring of the military services is required to bring them to the higher ranks. On the other hand, as we will discuss below, the systematic study of tactics is sadly neglected in U.S. military education.

Although there are a few civilian strategists, there are almost no civilian military operations specialists. [Now there are too many.] Academic students of tactics generally lack experience in leading troops and actually employing military equipment. The officers assigned to strategic planning must be selected for their leadership ability and field ingenuity. In particular, they must be able to get along with men they dislike, particularly with scientists and technologists, and to defend their point of view in intelligent debate. Although these qualities are not as rare as strategic talent, they are not exactly common in the military. The problem is compounded by the lack of academic training of military officers, so that the twin qualities of leadership ability and theoretical understanding are more rare than they ought to be.

Since the military arts and military education are not within the scope of this book we note the following in passing, for the student of the art of war.

First, the relationship between tactics and strategy is complex; the failure of the British to understand the tactical value of the tank led to failure to provide strategy for armored employment in World War I and thus prolonged that conflict. Second, civilian operations analysts have in the past been highly successful as advisors in restructuring tactics and battle plans, and have often been heeded because of the faults in military education.

Good tactics can sometimes compensate for poor strategy. On the other hand, the finest military forces in the world can be destroyed when their leaders employ them with poor strategies or no strategy at all. In military combat, neither tactics nor strategy can be ignored.

We cannot neglect the training of men who will employ the weapons of the Technological war in actual combat; however, in the Technological War the pressing need is for strategy and strategic thought.

4.14 Scientists

It is tempting to allow the scientist to dominate the field of strategic analysis and the management of the Technological War. He is the chief weapon in the war, and without him nothing could be accomplished. However, to give the scientist control of the process is an error of grave consequence. The qualities that make a good scientist are not those that produce a good engineer, let alone a strategic analyst. The scientist understands technology; indeed, he creates technology. However, he is often a specialist who is quite helpless outside of his own field. In general, he must be a specialist to make a reputation as a scientist, and without that reputation he will never achieve a position of management.

There is a major difference in mental attitude between a scientist and a strategist. The scientist must deal with facts and scientific laws. By contrast, the strategist must deal with futures which cannot possibly be factual because the events have not occurred. The scientist deals with repetitive events and laws of nature; the strategist is virtually always confronted by a unique situation in which the opponent will try to do the unexpected. The strategist must always make decisions based on inadequate data; scientists must not jump to conclusions. The strategist's primary skill is to be able to reason like the opponent and stay ahead of him, while the primary skill of the scientist is to produce and package knowledge.

Just as men can be divided into athletes and nonathletes, they can be divided into scientists and nonscientists. But if a man is an athlete, he is not necessarily a good athlete; if he is a good one, he may only be good at baseball or boxing. Scientists, too, have very pronounced qualitative differences. There are broad distinctions between creative scientists, scientists who work best as assistants and experimenters, and scientific administrators. Many a scientific reputation rests upon one particular discovery. Other reputations are derived from a long series of creative contributions. When we are talking about scientists it is quite important to keep these distinctions in mind.

But this is not the end of the story. The history of science is replete with examples of scientists who were grievously wrong. Scientists have believed firmly in weird theories and have instituted veritable inquisitions against nonbelievers. Scientists often refuse to accept evidence, and they sometimes go to rather comical lengths to defend their own theories.

There is no such thing as a fully rational scientist. There are only men who have scientific training, and this scientific training has not eliminated their emotions, hopes, and other human features as indeed it should not. The trouble is, however, that scientists are often inclined to transfer to themselves as individuals the objectivity of the scientific approach and to consider themselves to be far more objective than they are. They tend to identify their brain with a computer and become emotional if the security of an established theory is threatened.

So far as their contributions are concerned, scientists can be seen as falling into three categories. One group is made up of those who are good at anticipating the scientific future and visualizing new possibilities and opportunities. In sharp contrast are those who are opposed to the future, who in essence want to stop technological advance and, if possible, bury technological innovations so that no one ever finds them again. In a middle group are those who would like to return to the past but realize this cannot be done; they also view the future with concern, would like to slow down technological progress, and frequently raise either genuine or spurious doubts about the feasibility of new ideas.

It must be realized that technological innovations usually call for new approaches. While some of these approaches may be practical, nevertheless none can be proved until much experimentation has been carried out. If doubts are raised about the feasibility of an approach, investigation can be prevented, misdirected, or financed on such a low level that five years later it can be claimed that "this approach has proved disappointing."

Scientists of the middle group, resigned but resistant about the future, have sometimes had a strong influence on U.S. technological activity. This has frequently proved unfortunate. Some of the scientists who have been most influential in American security programs have not quite grasped the fact that today the stream of technological progress flows fast and wide. Some have believed that floating with the current and even occasionally swimming upstream would be the right type of action. Some have had the notion that it is possible to get out of the current and watch the spectacle from the river bank. In some areas, notably in nuclear physics, scientists advising on U.S. weapons have argued that everything worth discovering has already been discovered. The effect such attitudes tend to have on technological progress is obvious.

By contrast, scientists who are future oriented – who understand the need to swim faster than the current and who are able to propose technologies and new ideas – although they may also sit in the councils of government, often have had less influence than might be desirable. And, scientists of the remaining category, who want to bury new technology, have seemed to grow more influential with time, especially at the highest levels.

Responsibility for our deficiencies in technological strategy must rest ultimately with the military. They have the continuing responsibility for our security, but they have been slow in understanding the need for technological strategies and in adapting to this innovation in conflict.

There is no obvious solution to this dilemma, which is essentially that all humans are fallible. The military have placed increasing emphasis on scientific education of qualified officers, but since these officers also must fulfill the professional obligations of the services they cannot possibly become scientists. There is little evidence that scientists, including those who make a profession of advising the Pentagon, ever school themselves systematically in the history of war, military technology, and current strategic and tactical problems. Thus, we have had two groups talking to one other on the basis of different backgrounds, different problems, and even different languages. It should surprise no one that there is no meeting of the minds. The problem may not be entirely soluble but it certainly can be alleviated – for example, by introducing pertinent courses on military problems in the various institutes of technology and universities and by offering such courses in service schools to scientists who want to qualify as military advisors. Our military services have been laggard in teaching military history, yet in the Continental general staffs the teaching of military history was often regarded as a major staff function, and members of the history department participated in military planning. Our services could easily perform this function, and might add a staff section on the history of military technology, members of which would participate in technological planning. There cannot be any panaceas in this field but it is inadmissible that year in and year out obvious fallacies are allowed to influence strategic planning. It should be possible to eliminate recurrent error from what is supposed to be a rational and objective administrative procedure.

4.15 Engineering and Development

The usual engineer is fundamentally different from the scientist, and is given less deference and respect. However, he is far more likely that the scientist to become the president of a large technological company, and is more likely to be useful for strategic analysis. The engineer is oriented toward the use of technology rather than its creation. He is also skilled in taking basic concepts and turning them into workable devices. He is indispensable to the war of technology, but is usually not a proper choice for its overall management because of his limited familiarity with strategy and his frequent inability to comprehend the importance of nonmaterial factors.

Napoleon said, "In war, the morale is to the materiel as three is to one." In the modern age, organizational leadership is to morale, and morale is to the materiel, as six is to three is to one. It is precisely the hardheaded preoccupation with the physical factors that makes the engineer successful that often disqualifies him from successful management of the Technological War.

4.16 Procurement and Production

The production specialist is usually an engineer. His function is highly important, as he must take the designs and concepts from the engineering and development cycles and turn them into actual hardware. In the United States, the production specialist is usually found outside the government process. Unless he closely works with engineering at all stages of weapons design, production is often delayed. In a pure war of attrition with static technology, the production specialist is often the proper manager of the entire effort;

for technological warfare, he is usually an improper choice.

4.17 Nonmilitary Warfare

The expert in nonmilitary warfare is the strategist of nonmilitary operations. He may be a scientist, although he often is not. His advice is of great importance to the strategic analysis function, since he must discover and describe the alternatives to military action for achieving the goals set by political authority. He is also important in the exploitation of new technology and the proper design of research programs, educational processes, etc.

There are functions within the nonmilitary warfare specialty, many of which are themselves specialties. Examples range from the inventor of a plow capable of turning jungle into arable farms, thus truly allowing his nation to give land to the landless, to the early space-spectacular enthusiasts, psychological warfare experts, economists and trade strategists, etc.

The nonmilitary warfare expert may or may not manage the nonmilitary systems produced through the strategic analysis process. The important factor in his role, and one which is usually forgotten is that the expert on nonviolence must fit his inputs into a strategy. If his efforts are independent of those of the military they may be ineffective or even counterproductive. Few nations can afford several independent or contradictory commitments of force in the Technological War, any more than armies can afford independent and uncoordinated efforts by divided forces.

4.18 Systems Analysis

The systems analysis function is analyzing tradeoffs between technological possibilities, budgetary constraints, and system effectiveness requirements and presenting the analysis to the decision maker with a series of possible choices or options. He is generally incapable of distinguishing a real option from a theoretical one, although he may attempt to obtain a statement of probability of success of a particular technological innovation from its designer. Because most inventors are fond of their brainchildren they assign high probabilities to their own systems and low probabilities to those of others. The life of the systems analyst is thus not an easy one.

However, the systems analyst must not, as he often does, make the mistake of thinking himself either a strategist or a political decision maker. He can do this consciously or unconsciously. There is sufficient ambiguity in prediction of technological success, costs, schedules, risks, etc., that the analyst is always capable of removing any given system from serious consideration, provided that he wants to do so (and he may want to because of his political assumptions or his own strategic assessments). He may favor one system over another simply by his choice of assumptions about the environment in which the system will operate.

Thus, the strategic analyst must not rely entirely on the systems analysis process to make his decisions. Systems analysis can show why a decision has been made, by making explicit the analytical assumptions involved – although it has lately failed to provide this service – but it cannot substitute for proper judgment until such time as all the variables, including the enemy's objectives and intentions, are quantifiable.

4.19 Strategic Analysis

The strategic analysis function is the most important component of the design process. It is the final decision in the weapons system process, and thus belongs to the civilian officer responsible to the political decision maker. This was in the past the Director of Defense Research and Engineering or even the Secretary of Defense.

The strategic analyst must trade off the demands of the several services. He must implement the basic policies set by the top political decision maker, and do so within the constraints of the budget. He must allocate research and development money and resources among competing scientists, each of whom is honestly convinced that his project will save the country – or possibly the world. He must constantly keep in mind the limits of systems analysis and not allow the mechanical computer processes employed by systems analysis to substitute for the final decision making power. He must understand that there are real uncertainties in this world in contrast with probabilistic or statistical uncertainties which can at least be quantified. He must understand that since an intelligent enemy opposes him, probabilities may not apply at all. Game theory cannot always guide him, for some real world games can be played but once. He must constantly strive to be the surpriser and not the surprised.

In doing all this, he must understand the possible futures the technologists dream up. He must balance off the hardheaded attitude of the engineer, who prefers to work with known technologies to produce something he knows will work, against the more visionary glimpses of the future by the scientist, particularly if the scientist foresees a technology that will make obsolete or useless the system the engineer "knows will work." He must also understand production limitations.

Finally, but most important, the strategic analyst must understand strategy. He must be able to communicate effectively with the strategists and military operations specialists, who will sometimes be in conflict with each other. Beyond strategy, he must understand war. If war is too important to be left to the generals, the strategic analyst in an era of technological warfare is the man beyond the general. His decisions will decide the character of the next war.

Modern war is often won by men who are retired or dead at the time the war is fought. The visible commander must fight with the resources bequeathed to him by others; yet the decision by the strategic analyst, made years before, may have decided the outcome of the war beyond recovery by the most brilliant operational strategist. The strategic analyst can never win the war. Improper operational employment of his designs and systems can waste all his efforts. But he can lose the war. If he has provided future generals with the wrong tools, all their brilliance may be insufficient to prevent defeat.

Thus, this role is almost beyond human talents; yet it must be performed. To some extent, it must be decentralized, so that hedges against wrong decisions can be made. So long as the function is perfectly centralized, even the decision as to what hedges to make is in the hands of one man and perhaps his staff. It is a responsibility that none but a saint or a fool could exercise, and that a saint probably would not want.

Yet there must be a strategic analyst, and he must make final decisions. To some extent, decentralization will protect him, but not entirely. Worse, he must recommend courses of action to his political masters that may result in the unpopularity of the present government because of the cost yet will be vital to the survival of the nation under the successors of the present regime. Indeed, in order for a future regime to survive, it may be necessary for the present one to make decisions that will be so unpopular as to force it out of office.

It is not possible to specify the qualifications of the strategic analyst in any detail, but some stand out. He must have courage; that is, moral courage, the courage to make decisions that may be adverse to his career. He must be willing to give unpopular advice. He must have the courage to say "no," emphatically, to many of the countless men and organizations that demand his precious resources. He must not confuse courage with pigheadedness, however. He must also have the courage to understand that he may be wrong, and to make the appropriate investment of resources in a hedge against this contingency.

He must understand strategy and war, although he need not be a strategist himself. In our judgment, if he is an expert, he should be an expert in strategy rather than technology or science; but specialization in this function is not wanted, and could be disastrous. The strategic analyst must always remember, however, that he is the analyst and decision maker for a strategy – a strategy of technology which could mean the difference to the nation of survival or doom, freedom or slavery. In some senses he is more important that the president, because his decisions will dictate the choices of future presidents. If he fails to make at least some correct decisions, the future president may be helpless.

He must understand technology, although he need not (and often should not) be a technologist. In particular, he must know what the technologists are talking about. He must be a man of vision, yet have a streak of the hard realist within him. He must be a judge of men, capable of knowing which of the scientists are probably advocating research that will pay off and which are merely indulging in fantasies. More, he must be able to judge the engineers and decide which ones are giving him correct advice on what can be done now and which ones simply do not understand the situation.

There are few men with these qualities. Strategic analysis is not a specialty taught in our schools. It is not often learned in business, and it is decidedly not an ability picked up along the road to a Ph.D. degree in economics.

The comforting thought is that if the United States does not have many men with these qualities, the enemy probably does not either. On the other hand, this does not mean that the United States can afford to abandon the search for the proper men, or so structure the organization of technical management that the strategic analysis function is simply not fulfilled.

There is, in fact, no evidence that there are more geniuses in the U.S.S.R. than there are in the United States – rather, the evidence points to the contrary. Yet, the governmental system of the Soviet Union has ensured that strategy is the foremost business of the top echelon, that this top echelon is preoccupied with strategic rather than administrative questions, and that virtually all the participants in the strategic decision-making process have been trained in strategy and tactics. These men have acquired considerable experience in strategic operations, and are counted among the world's foremost experts in strategic planning. Strategy has been the lifelong profession of the Soviet leaders, while in the United States, strategic decision makers are only strategists pro tem and must depend upon on-the-job training. Our American marvels are obligated to make major decisions from their first day in office, before they even know the current American and Soviet battle orders. If Gulliver were to travel to the United States, he probably would report that we are handling security as though we believe that doctors of divinity make good surgeons. Americans pride themselves on their skill in organizing, yet this skill has yet to be applied to security, which is the foremost business of any nation.

Chapter 5

Surprise

It never troubles the wolf how many the sheep be.
–Virgil

Surprise has long been a key aspect of war. The history of surprise has been analyzed from the point of view of the surpriser and the surprised, defender and attacker. Many kinds of surprise have been identified: strategic, tactical, operational, and technological.

One inherent element is warning. Warning results from a combination of intelligence and reason; lack of information about the nature and course of events and lack of time in which to take action after a threat is perceived contribute to the devastating effect of surprise.

Surprise in modern war is vastly different from surprise in the past. At the operational level the ballistic missile with intercontinental range and time of flight in minutes; orbiting bombs of the kind developed by the Soviet Union with times of re-entry measured in minutes; space-based sensors which can detect and report events in seconds; and lasers which have almost instantaneous kill over vast distances all have changed and will continue to change the very nature of surprise in war.

Ballistic missiles and space systems have had a dramatic influence on both tactical and strategic surprise. Combinations of sea-based and land-based intermediate and long range ballistic missiles can be used to confuse sensors and overwhelm the data processing systems of the surprised. Conversely, the data from sensors, especially space based sensors, can be correlated to give much more accurate information of events in real time, and thus provide warning of the tactics being employed by the surpriser.

The responses available include launching many missiles simultaneously to saturate the sensors and prevent accurate intelligence on the number of missiles launched, and maneuvering the re-entry vehicles to deceive the surprised as to the targets being attacked.

Space based systems are essential to prevent strategic surprise. They can report events over a prolonged period so that slow and rapid indicators of changes in normal patterns or operations can be interpreted as opening moves in potentially threatening operations. They provide global coverage but also can be directed to cover specific locations anywhere on the surface, in the oceans, in the atmosphere, and in space.

The surpriser must plan to deceive such space based systems (possibly by destroying them) as well as prevent being surprised himself. These systems are especially important in an era of arms control, because they are generally the only reliable way to verify the opponent's compliance.

Prevention of surprise in the modern era demands access to space; anything which prevents access to space enhances the possibility of surprise.

Technological surprise is in principle much harder to achieve than operational surprise because of the long lead time from concept to discovery through development to eventual military application. However, the accelerating rate of change in electronics makes it possible to retrofit the guidance and data processing elements of existing systems and thus achieve much higher-than-expected performance, as for example in accuracy, and thus contribute to surprise. A more subtle form of advance can also lead to surprise. Passive defense measures, such as hardness, deception, and mobility, which are difficult to detect in the R&D phase can reduce the effectiveness of the attacker.

Unfortunately, defensive surprise, while possibly decisive, is not much use in deterrence of war.

AFTERTHOUGHT FOR THE DAY

Surprise, when it happens to a government, is likely to be a complicated, diffuse, bureaucratic thing. It includes neglect of responsibility, but also responsibility so poorly defined or so ambiguously delegated that action gets lost. It includes gaps in intelligence, but also intelligence that, like a string of pearls too precious to wear, is too sensitive to give to those who need it. It includes the alarm that fails to work but also the alarm that has gone off so often it has been disconnected . . . It includes the contingencies which occur to no one, but also those that everyone assumes that somebody else has taken care of.
–Julian Critchey, *Warning and Response*, 1978

5.1 The Sneak Attack

The popular view of surprise in modern war is identified with a sneak attack, that is, operational surprise. Our experience at Pearl Harbor makes it easy to understand this belief, while the widely-known characteristics of the intercontinental ballistic missile permit us to grasp readily the nature of a future surprise ICBM attack. The missile is the ideal weapon for a rapid sneak attack, not just against one base like Pearl Harbor but against entire countries and continents.

Of the characteristics that make the missile suitable for a sneak attack, the most important is speed. The total flight time of an intercontinental ballistic missile from the USSR to the United States is about 30 minutes. Space-based systems could increase the warning of an attack almost to the total missile flight time; but even if we are given this much warning, the intercontinental ballistic missile has changed the dimension of surprise and has given the aggressor a most potent tool.

Without access to space the United States may well find itself blinded at crucial moments.

Even with warning the US can do little other than launch the force in a classic "use them or lose them" scenario. Lack of adequate defense forces the defending power to a doctrine of launch on warning.[1]

> The alternative is to accept the damage and try to ride out the attack, then retaliate. This may have been a feasible option in the 60's, but by 1975 the Soviet Union had achieved ICBM accuracies of a few hundreds of feet. No passive basing system can protect missiles against nuclear weapons delivered at those accuracies.

A massive intercontinental ballistic missile attack launched by an aggressor is an ever-present danger. Such an attack would come as the culmination of a series of measures, operations, and techniques, orchestrated to achieve

[1] It has always been exceedingly difficult to get arms control advocates to understand this elementary principle: if the retaliatory weapons don't survive, there can be no retaliation; and if the aggressor knows there won't be a retaliation, then deterrence is thin to non-existent. Strategic defenses are stabilizing, not destabilizing, because they are dangerous only to the aggressor.

Strategic defenses make strategic offense weapons obsolete. No one in his right mind believes that strategic defenses can form an 'impenetrable shield' against a modern technological power like the USSR; thus they are not an incentive to a first strike. This point has been made repeatedly in our advocacy of a policy of "Assured Survival" as opposed to the official US Policy of "Assured Destruction", and appears to be taking hold in some part of the armed services, but not in the State Department.

maximum psychological effect on the surprised. The aggressor would have undertaken specialized campaigns in the various elements of conflict – political, psychological, economic, military and, above all, technological.

Once the time is ripe, the attack comes suddenly and catches the defender asleep. But despite the present concentration on the sneak attack, surprise is not the exclusive province of the aggressor. Defenders have used surprise to great effect in the past and should strive to do so in the future. The future security of the United States requires that our strategy include measures to achieve surprise, as well as those to prevent it. The main surprise to aim for is that we won't be surprised.

Before we examine the broader aspects of surprise, let us point up the fundamental aspects of the sneak attack. First, surprise is tactical. Second, this form of surprise is used by the aggressor, not the defender. Third, it will be achieved only with the most advanced weapons. Fourth, prevention of surprise requires use of the most advanced technical means.

5.2 Strategic Surprise

There are also surprises on the strategic level. For illustrative examples, let us look at two of the ways in which the USSR has actually achieved strategic surprise in the decades since World War II: the opening of the space age, and nuclear testing during the test moratorium. As a result, the Soviets obtained a lead over us in space that has only partially been overcome by our massive and expensive NASA spectaculars. They lead in many military phases of space, whereas we are ahead in nonmilitary uses; in near-earth operations their lead may be as much as three years.

> The above was written in 1969. Since that time the U.S. has allowed the Soviets to take a commanding lead in near-Earth space technology. The Soviet Mir space station is fully operational, while the US does not intend even to attempt a space station prior to 1992. As we write this in 1988 the Space Station faces increased Congressional resistance, and its funding is in doubt.
>
> In addition, the Soviets developed and deployed an operational satellite destroyer, which was, because of political opposition, not countered with a US anti-satellite weapon. The US satellite interceptor program was deliberately abandoned, although its feasibility had long been demonstrated. The arguments against development of the US anti-satellite weapon were largely based on the arms control theory that we need space assets more than the Soviets; therefore it would be better if

neither side had anti-satellite weapons. If we don't build ours, we can hope the Soviets won't build more of theirs.

Few now recall when both the US and the Soviet Union engaged in unrestricted nuclear tests. The US was induced to observe a "gentleman's agreement", that is, an informal ban on nuclear testing. Then, suddenly, the Soviets began a massive series of above-ground tests that included the detonation of the largest hydrogen weapon ever exploded; and followed that with the offer of the Treaty of Moscow banning above-ground tests. The result was that the Soviets gathered a great deal of experimental data denied to the West.

The moratorium allowed the Soviets to determine critical effects of nuclear explosions in space. Because we honored the test ban, we let much of our testing capability atrophy, and now the Treaty of Moscow prevents us from finding out just how far behind we are in the application of nuclear weapons in space. The impact of these surprises cannot be calculated with precision but the Soviets gained a considerable time advantage in offensive orbital weaponry and ballistic missile defenses. Note that preparing for strategic surprise must continue over a period of several years.

These two surprises occurred in the technical phase of the Technological War, not in the military phase. They were achieved by an orchestrated strategy that employed several forms of conflict, including intelligence operations, propaganda and psychological warfare, political and diplomatic maneuverings, and a concentrated technical effort. While the goal of the Soviets has been to develop advanced weapon systems, such weapons were not employed militarily in these two surprises; however, military technology was developed, and diplomacy and treaties closed off our access to the means of catching up or at least made it difficult.

The best way to counter surprise is to deploy the most advanced technology possible and continue to modernize the strategic forces. This is not to imply that the technical effort must be devoted exclusively or even oriented primarily to countering potential technical surprise; but as we have insisted, surprise must be made a key element of any technological strategy. Since technology has given a new dimension to surprise in the strategic equation, technology is needed to support our own or prevent enemy surprise in all forms of conflict.

The misconception that surprise aids only the aggressor – a misconception that stems from thinking of surprise only as a 'sneak attack' – is especially harmful in the Technological War. In his classic work on surprise, General Erfuth[2] has shown that there are two parties to the operation, the surpriser

[2]General Waldemar Erfurth, Surprise, S. T. Possony and Daniel Vilfroy, translators.

and the surprised – this is not the same as saying the attacker and the defender. The defender also can employ the technique of surprise, and perhaps more effectively than the attacker.

Furthermore, there is a widespread misunderstanding that surprise refers exclusively to the initiation of war. Some writers consider surprise to be just a more elegant term than sneak attack. To other writers, surprise is tantamount to technological surprise. This is far too restrictive an understanding of surprise and its role in modern war.

5.3 Tactical Surprise

Tactical surprise is essentially surprise in combat. It is used to prevent the enemy from bringing adequate forces into operation in time to counter those used against him. The weapons of the surpriser are used to bypass or neutralize those of the surprised. Without surprise, the attacker would be required to use massive superiority to crush his opponent. The difference is like that between judo and a bare-knuckle fight.

Tactical surprise usually does not lead to the nullification of all of the opponent's armament, but if it is well-conceived and backed by technological improvements and adequate forces tactical surprise can go a long way toward eliminating enemy weapons as a relevant factor. Given the complexity of modern systems, the surprised opponent is faced with considerable delay before he can readjust his tactics; in a fast-moving war such readjustment may not be feasible.

Under modern circumstances time and technology as well as combat procedures are needed to gain tactical surprise. Technology can produce new types of weapons, new weapon effects, improved weapon effects, improvements in delivery systems, combinations of weapon systems, better active defense, and so on. Examples ranging from the "War of the Iron Ramrod" of Frederic the Great to the devastating effect of Lee's rifle pits at Cold Harbor show that technology and its proper tactical use may achieve surprise. With superior armaments or doctrines, and with troops trained in their use, the entire armament of the opponent can be nullified.

While this is the ultimate goal of tactical surprise, it is usually difficult to achieve. This is so because the possibilities of complete technical surprise are limited. Because of time required to develop a new weapon system, opportunities are increased for technical warning and for counterefforts, either technical or operational. Furthermore, excessive secrecy or failure to deploy weapons can result in surprising one's own troops, with disastrous results – as

Harrisburg: Military Service Publishing Co (Stackpole) 1943.

happened with the use of the mitrailleuse by the French in 1871. On the other hand, tactical surprise can be accomplished by a minor weapon improvement that from a technological point of view may be marginal but which today or tomorrow may facilitate victory in battle by creating a decisive advantage.

5.4 Strategic Surprise through Operational Surprise

Surprise can result from operations of the forces available, as well as from technological innovation. To achieve surprise of this type, the commander operates in a way unexpected by his adversary; in the ideal situation the enemy is unable to devise countermeasures in time. The attacker hits the defender where and when he does not expect to be hit.[3] Or, conversely, the defender reacts by hitting with weapons or with performances the attacker did not anticipate and against which he cannot protect himself properly; the defender counterattacks when and where he is not expected.

The number of operational variations is truly infinite, and the details of such operations usually can be planned and prepared with a high degree of secrecy. These variations are possible because of the multiplicity of weapons, the great spectrum of their performance, and the vast number of operational options.

Opportunities to use operational techniques to achieve surprise arise from various combinations of the performance of the carriers of destructive agents and the effects of those destructive agents when they are transported to the target – from the possibilities of multiple routes and methods of attack – from the variety of environments – and from countless other factors and their combinations. In addition, there are the skills of tactics, the principal one of which is to use a military force in a surprising manner. The use of expedients, saturation, and other techniques that cause uncertainty create further possibilities for operational surprise.

[3]One clear example of this kind of surprise was the Fall of France in 1940. Not only did the Germans attack in a place thought totally unsuitable for armor, but they used their armor in unexpected ways, driving deep into the French interior without waiting for the infantry to catch up. They also used their aircraft as long range artillery to neutralize the French artillery which had been placed so as to be out of range of German artillery but able to bombard any attempted river crossing. Once the river was crossed, the French artillery could be engaged by German infantry and light armor.German armor then penetrated deep into the French interior. The result was the the Germans operated inside the French decision cycle: by the time French headquarters had considered the situation and issued orders, their information about the front was obsolete.

5.5 Technology and Surprise

We repeat, surprise is not confined to active combat. Even though hostilities are not occurring now, the battle for tactical advantage and the effort to achieve surprise goes on incessantly. Laboratory is pitted against laboratory to find new advances such as radar techniques for looking over the horizon and for distinguishing between warheads and decoys. The laboratories struggle to compress data so that information, particularly details on attack, can be instantaneously transmitted and presented to decision makers. They search for new concepts that can find expression in hardware and tactics.

In addition, there is the broad area of strategic deception in matters of science. This includes deception about the general state of excellence, the level of progress in a given aspect of science, and the application of science to specific weapon and component development. It seems that behind the Iron Curtain there is a second curtain that conceals the nature of Soviet science.

To conduct this deception, the Soviets release scientific articles and withhold others, thus creating a false impression of their successes, failures, and interests. Another method is to send scientists to international meetings, where they either spread misinformation or are evaluated by their counterparts as not being knowledgeable or as being geniuses. Such evaluations may lead to all kinds of false deductions.

For example, during the test-ban debates we saw arguments that the Soviets did not know anything about decoupling techniques to conduct nuclear tests underground in secrecy. Also, we were told by Soviet leaders that the day of the heavy bomber had passed – which did not deceive us. On the other hand, we were quite surprised when the Soviets sent a man into space, although they had been forewarning us; and their recent exploits in space, including the Mir space station, and the "Red Shuttle" took many of our decision makers by surprise.

5.6 Stratagems to Achieve Surprise

Scientific deception can have a great impact on research and development lead time. The United States has devoted a great deal of effort to reducing the time required to translate a scientific theory, discovery or invention into a practical weapon system. In spite of much study we have not reduced the time interval to less than five years. (Since that was written the procurement time has grown from five years to ten and more.) To develop and produce a weapon in even this lengthy time costs billions of dollars, and the long lead times reduce the prospects of achieving surprise.

Scientific deception aims at keeping the enemy's lead time as long as possible. In this way a significant military advantage may result. This advantage may be crucial at the tactical and operational levels where it could have a direct impact on a strategic decision such as overt aggression.

The ultimate goal is to gain a strategic advantage by acquiring a major new family of weapons while concealing from the enemy that it is being developed. The appearance of a brand new weapon often is termed a breakthrough. When a nation makes a breakthrough of this type, as we did with the atom bomb, the British with radar, the Soviets in space, an entirely new arena for military operations is opened up. If the breakthrough leads to a military advantage that the enemy cannot counter in time, such as domination of the air, space, or deep water, the breakthrough may be decisive.
Strategic surprises can be accomplished in many ways. A few examples are:

- The choice of a strategic concept;
- The selection of weapon systems and their combination;
- The quantitative and qualitative strength of the battle forces;
- The size of the reserves and their degree of invulnerability;
- The choice of the time and manipulation of the circumstances including deception;
- The exploitation of geography such as bases, areas of access, and approach routes;
- The formation of alliances, including secret prewar alliances of the utilization of allied territory to launch an attack from an entirely unexpected direction;
- The proper choice of a center of gravity of the operation; and
- The mounting of diversions, so that the opponent divides his forces.

The major problem is developing techniques to achieve technological surprise. If we assume that the enemy intelligence service watches the development of a weapon system from its early scientific inception to its use by operational forces, deceptive moves we make at any step in the process contribute to the ultimate surprise. For example, in the scientific field we can misinform and disinform to fool the opponent. Scientific misinformation would not be propagated in the form of false formulas which would not survive the first test, but it can be created by cryptic hints about programs and alleged results. Disinformation makes the enemy doubt the accuracy of his findings.

In addition there is secrecy. A classic method of achieving a technological surprise is secretly using foreign know-how. Another widely used method has been making an unobserved modification in a technologically inferior weapon system to give it a massive improvement in performance.

In the period of weapon development, surprise can be achieved through hiding and concealment, by pretended inadvertent showing of weapons and weapon components, by phony orders placed abroad for spares or scarce materials, and through a whole host of such stratagems that are not complex but must be planned into the production cycle.

One of the most effective methods is to start the development of several competing weapons, select one, and then give a great deal of publicity to the weapons that have been rejected and will not go into production. This was used by the Soviets when they exhibited the TU-31, equivalent to our B-36; the TU-31 did not go to production. In addition, rejected test models can be exhibited in operations in such a way that the enemy will be sure to see them and draw erroneous conclusions, while tests of the chosen models are concealed. If this is impossible, erroneous information can be fed into the technical intelligence stream and various red herrings can be used. In brief, the true testing operation can be enveloped in a lot of phony operations.

Another is to develop a weapon system to meet a specific operational requirement, then adapt it for a different operational employment. The Soviet MiG-25 is an example. Developed to counter threats never deployed, the original design was never taken past the prototype stage; it is now used for reconnaissance.

Similar tricks are available to hide production. The weapon system perhaps cannot be hidden, but there are many methods to make it difficult to obtain accurate performance data. As time goes on, several modifications that change the over-all characteristic of the weapon system can be concealed.

Errors contributing to surprise can be induced about the state of training and the precise deployment. In ground war, the effective concealment of a center of gravity is half the battle won. Generally, it is not correct to assume that military forces act consistently. Some nations tend to bluff; the German pre-World War I general staff operated on the principle that one should be considerably stronger than one appears to be. With respect to technological strategy, it is much better to create simultaneously impressions of greater, as well as lesser, capabilities.

5.7 The Basic Purpose of Surprise

The purpose of such maneuvers is to generate uncertainty in the mind of the opponent. Surprise may result from technology, but the actual surprise is not in the weapon system; it is in the mind of the commander and staff that surprise really takes place. Military commanders, not weapons systems, are surprised.

It's probably worth repeating that: Surprise is an event that takes place in the mind of an enemy commander.

The devastating effect of surprise in the past has been caused by the fact that particular commanders and staff have for years conditioned their thinking according to firm expectations of enemy behavior and have carried out all their calculations within that framework. Suddenly, the basic assumptions are proved false by an unfolding operation. The result is a paralysis of thinking which often makes it impossible to carry out even those adaptations which could be accomplished within the time available.

There are a number of rationalizations that facilitate the surprise. For example, the assumption is frequently made that the enemy wouldn't do what we don't do – "Why should he do that?" Another widespread notion is that the enemy would not do what he apparently is doing because, according to his opponent's calculations of the cost-effectiveness of a weapon system, there are cheaper and better ways to achieve the desired result. There are also such common beliefs as that the enemy would not pursue a certain course of action because he would duplicate a strength he already possesses, because he could not afford the expenditures involved, or because he would not be so dastardly.

By contrast, sometimes the enemy makes a spectacular demonstration or diversion for no other reason than to create attention and misdirect the estimator's interest. Then, after losing years in trying to figure out what the military significance of the stunt really was, the estimator arrives at the wrong conclusions.

In a discussion of surprise in a very broad sense, it is often overlooked that surprise about many smaller items has occasionally been truly decisive. If it is true that a major weapon system cannot be hidden, it also remains true that specific performance data can be manipulated in such a way that the enemy makes small errors. These errors may be within the margins usually allowed by statisticians, let us say 5%. In actuality, speed differentials of 10 or 20, let alone 50, miles per hour may spell the difference between victory and defeat in combat. Similarly, such small differentials in, let us say, a radar performance, reliability of communications, or accuracy of missiles can be of the greatest significance.

In missile warfare, the reliability of the birds is crucial. If reliability is 10% higher or lower than estimated, the enemy's strike capability is quite different from what it has been calculated to be. In addition, this reliability must be figured in the time dimension. Reliability can be very high if there are hours to get ready for the launch. If there are only 30 minutes, and if the force must be launched as the attack commences, the figure would change substantially.

When Minuteman II was deployed the reliability of its guidance and control system was about one-sixth of requirement. It took three years to overcome the difficulty, but then performance exceeded specifications. If the Soviets had attacked during this period, we would have been in a fine mess. Since the mishap was widely rumored, the Soviets probably knew about it – fortunately, the U.S.S.R. lacked adequate strength.

5.8 Historical Examples

In 1937, the Germans won an air race in a spectacular manner by stripping down their Messerschmitts while the other nations entered fully-equipped fighters. Presumably the staffs understood this particular trick, but the public, the reporters, and the political decision makers were fooled. This, of course, is an example of combined technological and psychological strategy.

The most intriguing aspect of the history of aerospace war and the role of the surprise is that very professional staffs have been deceived about the most basic elements of this new type of war. At times this has been self-deception; at other times they were deceived through deliberate campaigns.

There was once the notion that the airplane was not really a militarily useful weapon. When this notion was dispelled – it took years – it was believed that the airplane would serve its purposes best by direct support of the ground battle. Consequently, the range of the aircraft was considered to be of no importance and it was thought that the range should rather be short. Later there was a great deal of doubt about the proper targets for strategic bombardment. The effectiveness of strategic air war was a matter of considerable dispute, largely because the interrelationships between industry, battle strength, and time factors involved were not understood. Furthermore, some air warriors overlooked the recuperation factor.

Similarly, during World War II there was a debate about whether the air weapon should be used for only one purpose – against industrial targets. After World War II, similar arguments raged with respect to nuclear weapons, jet aircraft, long-range bombardment versus forward bases (the question was ill-conceived as an either-or proposition), and, of course, space and air bombardment in Vietnam. Few debaters ever look at the whole range of arguments, and non sequiturs usually abound because emotions become involved in the arguments.

Another frequent source of error is that the versatility of the weapon system is underrated. The aircraft obviously is an excellent purveyor of firepower. But often ignored are its uses for demonstration, reconnaissance, the transport of goods and troops, command posts, and damage assessment and its possible employment in big as well as small wars. Some people who know such capabilities only too well, but for political reasons don't want new equipment, put up smoke-screen arguments against it.

The Strategic Defense Initiatives debates are similar. By an odd coincidence, all those who oppose SDI think it will not work. We do not recall one scientist of note who would like to see it deployed but believes it is just too expensive, or too difficult. The result is that what appears to be a technological debate is in fact a political one; but the fact remains that strategic defense offers one of the most decisive opportunities for strategic surprise in all history.

5.9 Breakthroughs

The many facets of developing, acquiring, and operating advanced weapons systems illustrate the need to consider surprise as one of the key elements of technological strategy. Technological warfare includes the anticipated breakthrough, but the breakthrough need not be a surprise.

In fact, it could well be tactical to announce a happy breakthrough that for a while cannot be countered by the enemy. His inability may come from one of two sources – technological inferiority or inferiority in the decision-making process. Naturally, the combination of these two deficiencies would increase the lead of the opposing power. In the end, unless he is defeated, the opponent would catch up with the new technique. The strategic impact of the breakthrough is a function of the duration of the one-sided advantage.

While surprise has its advantages as far as modernization of the force in being is concerned, the breakthrough has the potential of pushing the state of military art into an entirely new field that may lead to clear dominance. This is the role space warfare will play in the future. At present after three decades of space efforts we face an unprecedented situation: a clear military superiority in space potentially can ensure denial of creating a countercapability. There may be a significant novel feature, namely, that even without war such denial could be long-term.

The ability to deny an enemy access to space is essentially the ability to deny him world power status. You cannot be a global power without access to space.

5.10 Exploitation of Surprise

Initiation of war usually is the object of a great deal of surprise planning. Prior to the initiation of war, the planning of the opponent can be rendered ineffective by such techniques as misinformation (the propagation of misleading and false knowledge) and disinformation (the propagation of news designed to induce the enemy to disbelieve existing truthful and reliable information and buy false new information instead). The aggressor can use the time-honored techniques of single and double deception[4] to cloak the steps leading to his attack and induce the opponent to misread his intentions.

To meet deceptions of this sort, the strategic planner by necessity must plan against a war that might come regardless of the probability that it will not. This planning must be based on the enemy's capabilities to strike rather than on his professed intentions. The fact too often ignored is that intentions can change very rapidly, and that implementation of the new intention might require a shorter lead time than improvisation of defense against an attack that was not expected.

Under conditions of nuclear war, the importance of deception techniques is growing ever more rapidly. Arms Control negotiations must necessarily be a part of an aggressive strategy under modern conditions; the aggressor must use deception techniques to bring about disarmament arrangements which reduce the size of hostile forces in being and thus greatly simplify his planning. For example, the reasonableness the Soviets seemingly displayed in the initial SALT talks may denote (a) a turn toward peace, (b) a maneuver to delay U.S. reaction to the missile build-up in the U.S.S.R., and (c) an attempt to gain a safe rear and increase supplies for a Soviet attack on China.

The above was written in 1969. As we look back now we see that the second premise was correct, with the result that the Soviets gained a clear advantage in ICBM numbers and performance, and in military exploitation

[4]Double deception is best explained by the story of the two Jews who met on a train in Russia. Aaron asked Moses, "Where are you going?" Moses answered "To Pinsk." Aaron replied, "You say you are going to Pinsk so that I will believe you are actually going to Misnk, but I happen to know you really are going to Pinsk. So why do you lie?" In military parlance, if A plans an operation he would not try to hide his plan, but would make sure that B assumes this particular plan is being advertised because it will not be implemented. The German deception plan of 1941 that preceded the attack on the Soviet Union was planned as a single deception but actually worked as a double deception.

of space. (The Soviet Union ha a number of 100-kilowatt powered satellite radars in orbit; the US has yet to put up a 10 KW radar.)

Surprise can be achieved through disarmament and arms control arrangements and the use of propaganda and diplomacy, on one hand, and through counterintelligence, introduction of misleading intelligence, and infiltration into intelligence and policy-making staffs, on the other. As an example, before they had completed operational tests of their antimissile system, the Soviets refused to discuss an atmospheric test ban; afterward they rushed to agree before we tested our weapons concept. Other surprise techniques which may be applied could involve the holding of deceptive maneuvers, the building of dummy forces and targets to divert firepower, the employment of electronic equipments that would not be used in war, and electronic deception on a broad scale.

One important technique of surprise of which American writers seem to remain unaware, is provocation[5] This word in English usage denotes the provoking of an opponent into a rash act, but in the Communist dictionary it also means entrapment and instigation of a fight between third parties. Many wars have been started by provocations deliberately engineered by the aggressor; the purpose has frequently been to shift the onus of aggression from the aggressor to the defender.[6]

Other purposes may be to force the defender to make some sort of premature move and thus expose his strategy, or to get him embroiled in a struggle on another front so that he would disperse his forces and lose control. Such an effect could be achieved, for example, by forcing the defender into a limited war in a peripheral theater and gradually cause him to invest ever-greater military strength from his forces in being into this limited operation. Thus, he would expose his main base to effective attack. If he can be induced to use obsolete equipment in the diversionary war, the victim may never develop the kind of weapons that will be used in the decisive combat.

So-called preemptive strikes also may play a great role in surprise. The attacker could proceed by a combination of double deception and provocation to make open preparation for attack and to evacuate his cities. Then by other surprise techniques he could divert the defender's fire to false targets and achieve military superiority. Certainly moves of this sort are extremely risky, because the defender has surprise options of his own and may see through the deception. The risk can be reduced through a first-rate intelligence system, a superb early warning system such as would be provided by deploying even

[5] The Six-Day War in the Middle East has made the concept better known.

[6] As the Russians say, "If I attack you and you don't defend, there will be no war; if I attack you and you defend yourself, there will be war and you caused it."

the most elementary Strategic Defense System, and good penetration of the opponent's military apparatus and inner decision-making cycle.

Strategic planning aims at the exploitation of weaknesses and vulnerabilities, just as the wrestler tries to apply holds that force his opponent to submit. But the strategist has one advantage over the wrestler: he can contribute to the creation of vulnerabilities in the opposing force.

Creating vulnerabilities is an area where the problems of force and budgetary levels become highly significant. They can be created by an opponent who uses political means to achieve surprise. With low budgets there will always be a great tendency to cut corners, and that means that many of the support systems needed to operate weapon systems effectively will be eliminated or reduced to insufficient numbers. Very often it becomes a question of whether it is more advisable to buy firepower and delivery weapons than to harden the missiles or acquire such items as warning systems. Sometimes the choice is between offensive and defensive weapon systems.

If the aggressor can, through the employment of political means, manipulate budgetary and force levels of intended victims in a downward direction, the effectiveness of the opposing forces will be greatly reduced. Fundamentally, with a low budget it is very difficult to maintain alternative weapon systems simultaneously, and even more difficult to maintain forces based on different technologies. It is extremely difficult to provide them with good warning and protective features, to acquire suitable shelters for population and industry, and to bring new systems into being. Consequently, low defense budgets and low force levels aid the attacker in his strategic planning by reducing the complexities of his operations. Political operations in both the economic and diplomatic fields may be used to reinforce the natural tendency of the defender to save money on defense. These operations will have as their twin goals the reduction of strategic complexities through the lowering of the defender's budgets and the achievement of a state of relaxation in the victim. Then, when the attack comes, on the victim's allies and/or on his homeland, he will be unable to believe it has happened and be unprepared to defend himself. In this case, the last phase of the battle may not be a sneak attack at all; the defender may know it is coming and be unable to do anything about it.

To repeat: surprise techniques are available to both the attacker and the defender. Because we are firmly committed to a defensive strategy it is vital that we prevent surprise. We must understand also that capabilities for surprise exist for us and we must emphasize such capabilities.

These come directly from the basis for surprise: uncertainty. Although the attacker has freedom in choosing his surprise moves, the defender can do a great deal to increase the uncertainty in the mind of the attacker.

If the attacker has no uncertainty about the enemy, it is child's play to plan operations that can be decisive. If instead he experiences a great deal of uncertainty, even the planning of surprise operations becomes extremely difficult.

For example, a major purpose of strategic defense is to create uncertainties. If the defender does not have this capability the attacker will be certain that he has a completely free ride. If the defender has active missile defenses and the attacker is in doubt about whether its effectiveness lies between 50 and 90 percent, the attacker's strategic plan is greatly complicated. Suppose he assumes it is 50 percent, but it is actually 90 percent effective. Then he will fail in attack. Suppose he assumes it is 90 percent but it is actually 50 percent. In this instance he may not attack at all. Suppose his experts argue about whether it is 60 or 85 percent. In this case, the decision makers' will may be weakened. By manipulating the attacker's understanding of this situation, the defender may achieve considerable advantages.

The interplay between achieving and preventing surprise is one of the decisive elements of modern war. Speed appears to give the attacker greatly enhanced possibilities of surprise, but the defender is not without his options as well. The key to being the surpriser or the surprised is initiative, which in turn is based upon planning.

5.11 Conclusion

In guarding against technical surprise, it is important to keep its effects in the proper perspective. Technical advances generally and technical surprise in particular are steps to more decisive measures. Technology makes possible tactical, strategic, and timing surprise, and also provides systems for preventing surprise. It contributes to strategic deception, or prevents it. Surprise and deception are most vital when they contribute to or maximize the effectiveness of modern weapons. If our technological advantages are not exploited, while those of the U.S.S.R. are, we will inevitably lose the Technological War. Put differently: we must not be surprised about the fact that this is a Technological War and we must never be deceived about our relative technological standing.

Success in an operational approach based on deception and surprise depends on total orchestration of the types of conflict, not on the effectiveness of each element. Partial successes attained and exploited in many areas will offset the failures that will occur in others. The net result is that overall success is rendered more likely.

If the defender understands this particular aspect of the problem, he can devise many actions through which aggressive stratagems are neutralized. He can maintain force levels, both quantitative and qualitative, that preclude a successful attack. The defender must move constantly during the period of so-called peace, to keep abreast of technical and strategic developments. He must initiate actions to which the attacker must react, using resources that would otherwise be employed against the defender, and must initiate these actions in time to prevent the aggressor from achieving a significant advantage. Success in this game will mean that aggression by nuclear weapons would be unthinkable, simply because the aggressor would remain confined to an incalculable but low probability of success.

The really important point is that war has not become unthinkable simply because weapons of mass destruction have been invented. The prevention of war is just as much a strategic undertaking as preparation for aggression. If the strategy of prevention is effective, the aggressor will be blocked. If, on the other hand, it consists merely of dependence on passive deterrence and on weak retaliation, the strategy of prevention is doomed to failure.

For the Communists, surprise is vital to successful aggression. For our part, through the application of a rehumanized strategy surprise can be our path to the initiatives and maneuvers that suppress aggression.

The only thing that is worse than being taken entirely be surprise is to be taken by surprise after repeated warnings that one is going to be taken by surprise. The former is shocking. The latter is devastating.