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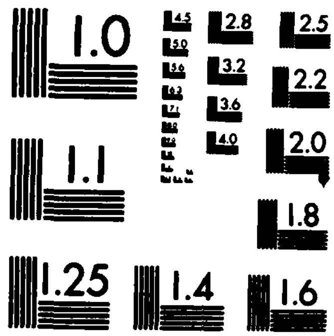

MICROCOPY RESOLUTION TEST CHART
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STUDENT REPORT

MANAGING SCIENCE AND TECHNOLOGY AS A CORPORATE INVESTMENT

MAJOR THOMAS J. HALL 87-1055

"insights into tomorrow"

REPORT NUMBER 87-1055

TITLE MANAGING SCIENCE AND TECHNOLOGY AS A CORPORATE INVESTMENT

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PREFACE

In recent years many have expressed concern that our once undisputed lead in technology over the Soviet Union is slipping. Several factors have contributed to this, and inadequate funding has played a major role. The Air Force needs a way for its top leaders to prevent any unintentional erosion of funding for science and technology and reverse the trend toward technological parity with the Soviets. Several people within the Air Force science and technology community have proposed that we manage science and technology as an investment account, with funding established as a percentage of the total Air Force budget, to help ensure that a proper overall emphasis is placed on our science and technology program. The purpose of this report was to examine this proposal.

Most of the ideas expressed in this report are not original to the author, but have been drawn from ideas expressed by many senior Air Force leaders involved in science and technology over the past few years. Some of the more specific recommendations concerning implementation of the above proposal resulted from countless discussions in 1985 and 1986 between the author and both Mr Michael Flynn and Col Joe Bianco, whose help is gratefully acknowledged.

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REPORT NUMBER 87-1550

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TITLE MANAGING SCIENCE AND TECHNOLOGY AS A CORPORATE INVESTMENT

I. <u>Purpose:</u> To show the need to restore science and technology investments to a healthy level, and prevent erosion of funding by managing it as an investment account.

II. <u>Problem:</u> In recent years there has been concern expressed by top DoD officials that our once undisputed lead in technology over the Soviet Union is slipping. Although several factors have contributed to the closing gap in technology, inadequate funding has been a major player. The Air Force needs a way for its top leaders to prevent any unintentional erosion of funding for science and technology and reverse the trend toward technological parity with the Soviets. It has been proposed that managing science and technology as an investment account, with funding established as a percentage of the total Air Force budget, would accomplish this.

III. <u>Data:</u> Technology assessments show that the Soviet Union is gaining ground on the United States in many key areas of military technology. Some believe that the trend, if unchecked, could result eventually in the U.S. being in a position of inferiority. There are several factors which contributed to this. First, it is believed that the Soviets are outspending us in science and technology. In addition, they have put a greater emphasis on science and engineering education, today graduating 300,000 engineers per year

Chapter 1

INTRODUCTION

> Our current U.S. defense strategy . . . is based on the premise that the U.S. will rely on superior technology and ability to apply that technology as the primary means of offsetting the numerical superiority (both personnel and systems) of our potential adversaries, primarily the Soviet Union and the Warsaw Pact. . . . This strategy can work only if U.S. technology and application are indeed superior (5:46).

This statement by Dr Edith W. Martin, former Undersecretary of Defense for Research and Engineering, underscores the reliance that the U.S. has placed on technology to prevail in future conflicts. Indeed, the Air Force's basic doctrine stresses the importance of technology to our future war fighting capability by stating that "the capability to win tomorrow's war demands that Air Force research and development efforts must not only exploit new technologies, they must also push the limits of technology to discovery and breakthrough" (9:4-9). Whether this strategy is the best one or not is certainly debatable. However, as Dr Martin warns, if this is our strategy, and it is, then the U.S. defense establishment must ensure that we do in fact maintain technological superiority, or our strategy will fail.

Unfortunately, our once undisputed technology lead over the rest of the world is being challenged on several fronts. The Under Secretary of Defense for Research and Engineering, indicates that while the U.S. is still equal to or ahead of the Soviet Union in most key technology areas, our lead is slipping (12:II-11). Why has this happened? According to Dr Martin, "the gap between U.S. and Soviet military technology capabilities has narrowed significantly during the last decade as a result of inadequate research funding . . ." (5:47). This theme was also sounded in 1984 by the departing Commander of Air Force Systems Command, Gen Robert T. Marsh, and his successor, Gen Lawrence A. Skantze who emphasized "the 'central importance' of restoring the growth of the science and technology program to a healthy level" (6:53). To help solve the problem, they advocated that the Air Force "restore investments in the science and technology area to the traditional level of about two percent of TOA (total

Chapter 2

SCIENCE AND TECHNOLOGY FUNDING TRENDS

To examine the proposal to manage science and technology as a corporate investment, the essential first step is to look at the funding trends in the Air Force science and technology program. An examination of these trends over the past quarter century shows that the Air Force has decreased its emphasis on science and technology.

To determine the emphasis the Air Force puts on science and technology, it is instructive to look at what share of the total Air Force budget (TOA) is allocated to it. Figure 1 shows Air Force science and technology funding as a percent of the total Air Force budget (15:--). In these terms, it is clear that the relative emphasis on science and technology has decreased markedly from a high of about 3.25 percent in 1963 to about 1.3 percent in 1985. It shows that over most of that period, science and technology accounted for about two percent of the total budget, on the average. It also shows that since 1979, science and technology funding emphasis has sharply declined.

A similar conclusion is reached when looking at real spending for science and technology over the same period. Figure 2 shows Air Force science and technology funding in FY 1986 constant dollars (15:--). Again, the early 1960s saw more real funding for science and technology than today, ranging from around $2.0 billion in the early 1960s to an average of about $1.2 billion over the late 1960s to the present. It also shows that, since 1974, the Air Force science and technology program funding has experienced modest real growth.

Although real funding has increased modestly since 1974, this has been offset by several factors which have tended to decrease the purchasing power of these funds. The Air Force laboratories have experienced increases in the cost of doing business that have offset this modest growth. For example, Figure 3 demonstrates the rapid growth in the cost of scientific and engineering man-hours for Air Force Wright Aeronautical Laboratories. Over the period of FY 1978 to 1984, the average contract cost of a man-year of effort rose from about $91,000 per year to about $113,000, an increase of

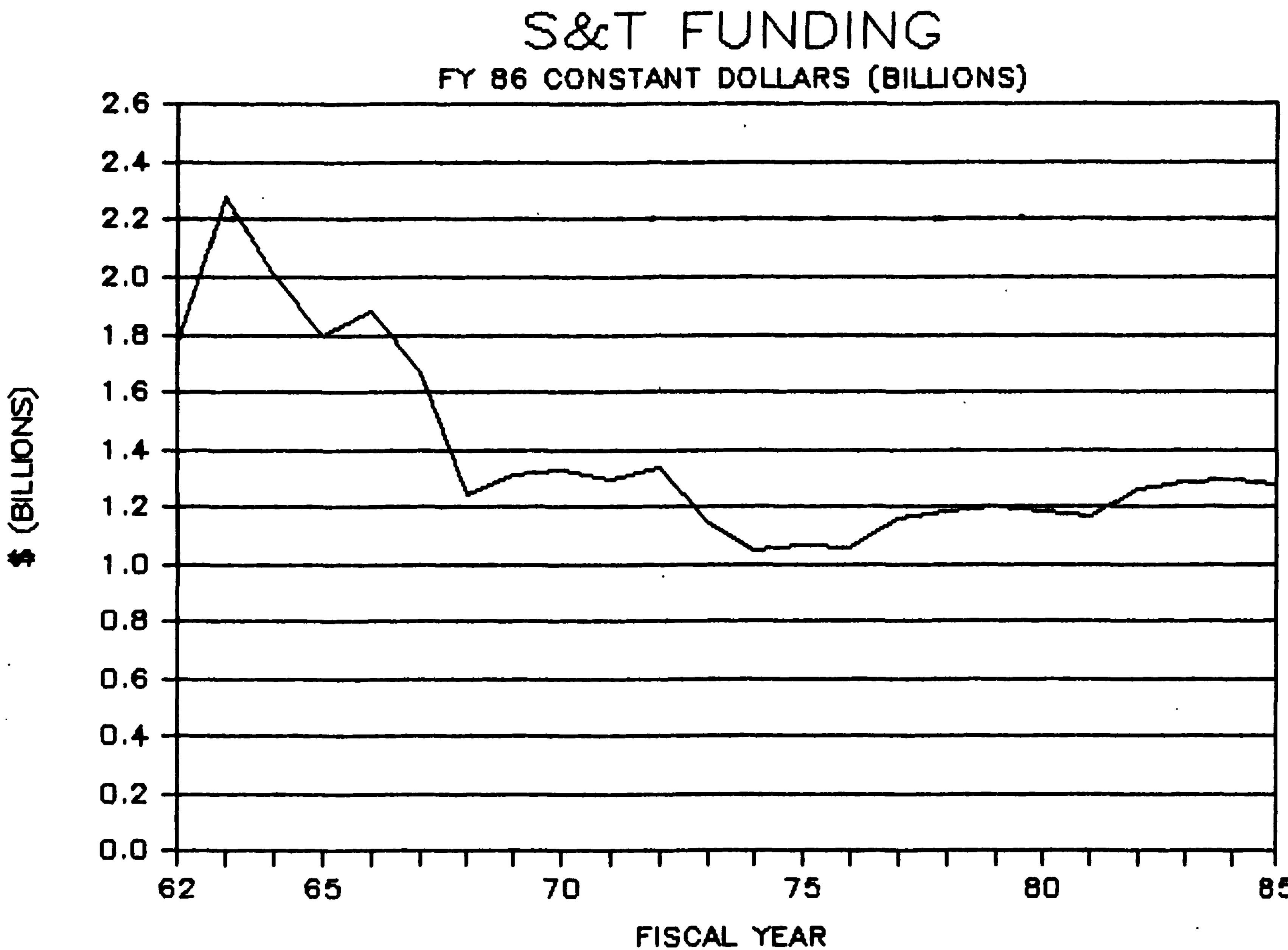
S&T FUNDING
FY 86 CONSTANT DOLLARS (BILLIONS)
$ (BILLIONS)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
62
65
70
75
80
85
FISCAL YEAR

FIGURE 2

about 24 percent. Overall science and technology funding increased about the same amount over that period of time, resulting in about zero net growth in contract purchasing power. Another area of increased cost of doing business is in flight testing. Figure 4 shows the very dramatic rise in the cost charged to the science and technology account for flight testing, approximately doubling from 1979 to 1984 (15:--). The result of these kinds of increases in costs has been to negate the modest growth experienced since 1974.

The impact of Department of Defense (DOD) Instruction 5000.1, issued in 1971, has caused additional shrinkage in Air Force science and technology dollars. As a result of DODI 5001.1,

> massive changes in program funding, schedules, and plans for testing were introduced to provide independent operational testing of all weapon systems planned for production and to assure that all costs associated with production and testing of such articles were paid for by appropriate Research, Development, Test, and Evaluation (RDT&E) funding. . . . The adverse impact of these policies has been severe because little or no fiscal adjustment has been provided for the RDT&E account to accommodate the resulting large increase in financial burden (2:86).

Although no Air Force figures are available, the Navy has estimated that, as a result of actions taken to implement DODI 5000.1, "approximately 20 percent of the RDT&E account is now associated with support and procurement tasks not allocated to RDT&E 15 years ago" (2:87). How did this impact science and technology funding (which is included in the RDT&E account)? The result was that "previous categories of development activity have been forced downward" into the science and technology program (2:90). The Navy estimated in 1984 that more that 15 percent of their technology base program now supports programs that were once paid for by other funding sources (2:90). It is reasonable to assume that some small erosion of the Air Force science and technology program has also taken place over the same period for the same reason.

Any fair treatment of trends in Air Force science and technology funding should take into account the impact of funding by the other Services (Army and Navy) and agencies such as the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), and the Strategic Defense Initiative Organization (SDIO). To be sure, these organizations have a tremendous impact on America's overall technology posture and often support Air Force needs and missions. However, several factors need to be considered in assessing their impact.

First, as Dr Martin pointed out, the problem of inadequate research funding is not unique to the Air Force, but affects all of DOD. Thus, we can not count on the other Services and DOD agencies to take up our slack.

Second, although there is undoubtedly some duplication of effort within DOD, for the most part this is necessary to maintain expertise within the different services and agencies in the various technology areas.

Third, the relative contribution of other organizations to Air Force interests has not changed significantly over time. This is shown by looking at the amount of money the other services and agencies have given to the Air Force for various technology developments. Over the period of 1973 to 1981, the only time when the Air Force kept comprehensive records of this, the funding provided by others for Air Force execution remained constant, accounting for about eight percent of the program (15:--). Thus, the money other services and agencies provided the Air Force did not have an affect on the downward trend in the overall science and technology program.

The President's Strategic Defense Initiative is an important program that will help stimulate technological progress in many areas. However, at this point, it has an uncertain future, being intimately linked to strategic arms negotiations and to an administration with only two years to go. Furthermore, it does not address the full spectrum of technology needs that support traditional Air Force missions. Although tempting to do so, it would not be prudent for the Air Force to continue to neglect its own technology needs because of the existence of a large technology program such as SDI.

The bottom line of the preceding discussion is this: Air Force emphasis on science and technology funding has declined over the past 25 years both in absolute terms and as a percent of the total budget. By itself, this would not necessarily be either bad or good. What matters, in terms of U.S. national strategy for waging war, is how this affects the technology lead over our potential adversaries. The next chapter will show that, over the same period in which less emphasis has been placed on science and technology, this technology lead has slipped. In this context, the decline of science and technology funding is indeed an alarming trend.

However, as Collins points out,

> America's temporary purchase [i.e., temporary lead based on past investments], however, is no cause for complacency. The US lead is solid in only slightly more than half of those cases (13 out of 24). Opposing scientists, who are closing the gap in 11, protect Soviet primacy in every instance. Relative US/Soviet ranks would reverse if straight-line projections of those trends continued (1:105).

The result of that straight-line projection is the following (1:106):

<u>Projected Status</u>

United States Superior		Soviet Union Superior	
Present Lead Solid	13	Present Lead Solid	14
Subsequent Gain	0	Subsequent Gain	11
	--		--
Total	13		25

Looking at applied technology presents an even more ominous picture of our relative position, as shown below (1:106):

<u>Present Status</u>

United States Superior		Soviet Union Superior	
Lead Solid	18	Lead Solid	23
Lead Shaky	17	Lead Shaky	5
	--		--
Total	35		28

Again, the U.S. holds an advantage for the present. But if the present trend continues, we could expect the following result eventually (1:106):

<u>Projected Status</u>

United States Superior		Soviet Union Superior	
Present Lead Solid	18	Present Lead Solid	23
Subsequent Gain	5	Subsequent Gain	17
	--		--
Total	23		40

Whether or not this type of analysis is valid can be honestly debated. However, it does seem clear that the overall trend is that the Soviets are indeed closing the technology gap. More recent assessments by DOD seem to

Chapter 4

CAUSES OF THE TECHNOLOGY GAP

Up to this point, we have seen that over the same period of time in which our emphasis on science and technology funding declined, the Soviets closed the technology gap between our two countries. The purpose of this chapter is to examine the factors which led to the decline in our technology lead. These include the Soviet investment in science and technology, the Soviet emphasis on science and engineering education, technology transfer from the West, and our own investment in science and technology. While all these factors have an affect, our science and technology investment is the factor over which we have the most control.

The Soviet Union has stressed science and technology as a primary element of their defense strategy for a long time. In 1965, General B.A. Schriever, Commander of AFSC, said:

> But one thing is clear--technology is not only a source of comfort and convenience; it is also a source of power. No one is more aware of this fact than our opponents. Every Communist leader since 1917 has stressed the importance of science and technology in the Communist drive for world domination (17:292).

In February 1986, this point was further underscored by our Under Secretary of Defense for Research and Engineering, when he told Congress the following:

> The USSR has recognized that leadership in science and technology plays a key role in maintaining world leadership--industrially, economically, militarily and politically. . . . The Soviets' strategy for the achievement of their R&D goals includes a high and steadily increasing level of resource investment, and encompasses essentially two approaches: (1) the maintenance of a large indigenous technology base to support military and industrial development, and (2) the acquisition and assimilation of Western technologies to reduce the time, cost and risk involved in new programs. The Soviet military RDT&E program is characterized by stability in

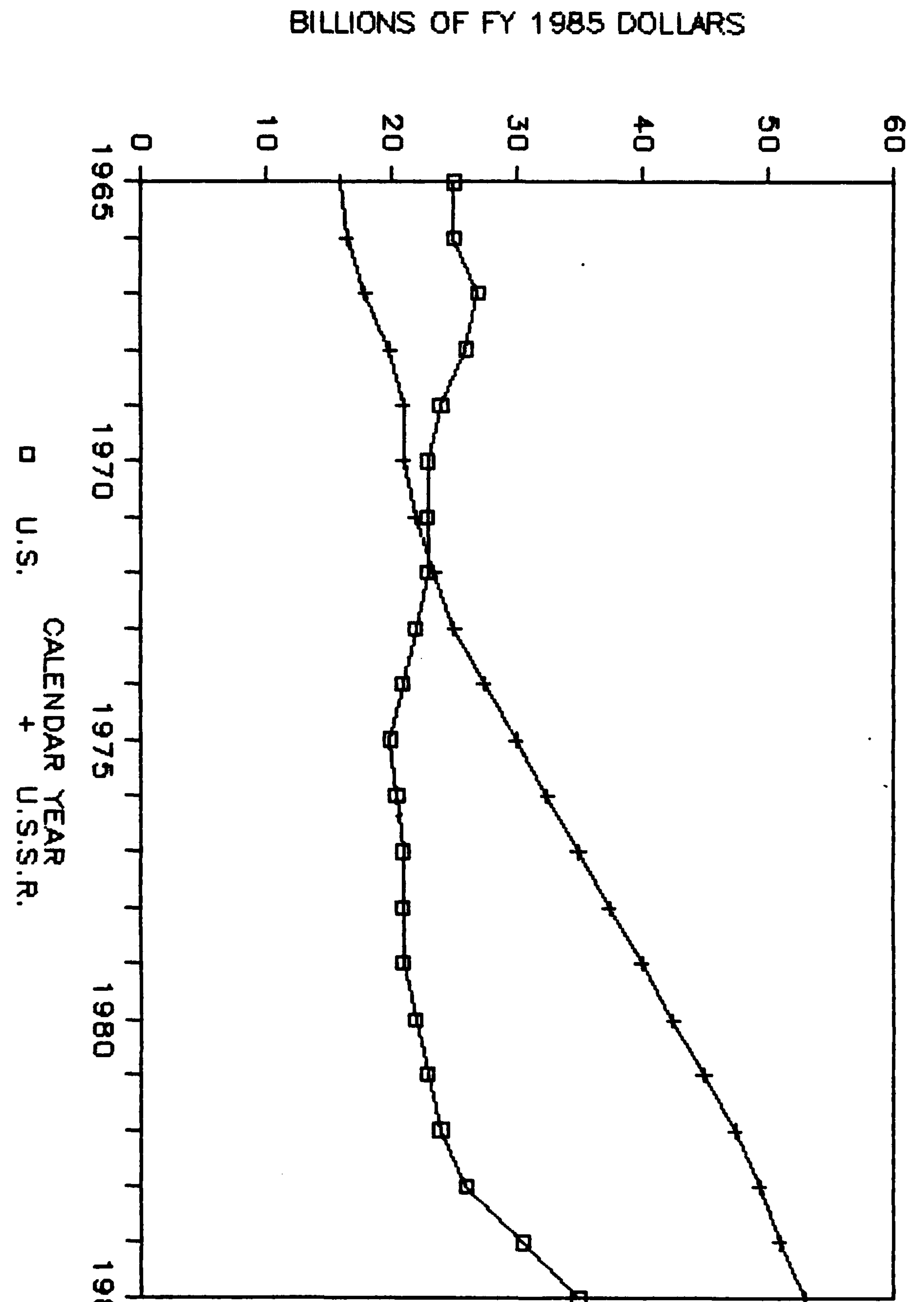
MILITARY RDT&E COMPARISON
BILLIONS OF FY 1985 DOLLARS
0
10
20
30
40
50
60
1965
1970
1975
1980
1985
CALENDAR YEAR
□ U.S.
+ U.S.S.R.

FIGURE 5

It is difficult to determine which position is correct. From the private sector's point of view, restrictions on exports of technology only hurt the U.S. defense industry. However, Secretary Weinberger has stated that U.S. trade policies toward the Soviets and their surrogates should not be determined by "private market forces" alone but should "take into account our larger strategic interests" (14:II-30). In any event, prevention of this transfer of technology to the Soviets has been a major concern of the DOD for a number of years. Recent export control policy changes are apparently having success in restricting the flow of technology to the Soviets (12:II-18). But past technology transfer has evidently helped the Soviets close the technology gap, to some extent at least.

Finally, our own decreased investment in science and technology has allowed the Soviets to gain ground on us. Dr Martin wrote in 1985,

> But, ironically, in the past decade the S&T [science and technology] program has received attention but not funding, interest but not emphasis. Our survival in the 1980s is based on important technical strides made in the early 1960s. This technological prowess resulted from earlier decisions to fund and educate for the future. But now it is clear we will suffer markedly in the 1990s, as a result of very different decisions made in the 1970s and 1980s - decisions that have inhibited progress and technical development (5:46).

A similar conclusion is supported by a recent report of the White House Science Council's Panel on the Health of U.S. Colleges and Universities.

> The panel's charge was to examine and make necessary recommendations for revising the principles underlying the relationship between the federal government and the universities, especially as they affect the U.S.'s ability to create the scientific and technical talent and to conduct the research needed to sustain America's leadership in industry and defense. . . . The report attributes the present ill health of the university research community to the 'long period of stasis and decay' in federal funding for university R&D that commenced in 1970 and lasted for the entire decade. 'Since universities conduct more than 60 percent of the basic research performed in this country, the absence of growth was reflected in significant deterioration in this nation's ability to promote technological advances' (7:23).

Admittedly, our science and technology program consists of more than just university research, but the basic science and

Chapter 5

MANAGING AS A CORPORATE INVESTMENT

What does it mean to manage science and technology as a corporate investment? How does that differ from the way the Air Force manages it today? How could this be implemented? This chapter will attempt to answer these questions and look at some of the implications of managing our science and technology program as an investment account.

Simply stated, to manage as a corporate investment means that the Air Force leadership would make a conscious decision to invest a certain portion of their total budget on science and technology. For example, the Air Force could decide that it wishes to spend two percent of its TOA over the next ten years on science and technology. This would be a top down decision that is made with careful consideration of all of Air Force needs and requirements. It would represent a high level policy decision that focuses on how much the Air Force can and should spend on science and technology as a whole, in relation to our many other requirements.

This is a considerably different approach from the way that science and technology is funded today, where individual programs compete for funding on their own individual merits. While this sounds eminently sensible, it has nevertheless resulted in an overall decline in science and technology funding. The Air Force programs funds through a bottom up process culminating in our Program Objectives Memorandum (POM). In this process, the Air Force Board structure performs a rigorous review and scrub-down of individual Air Force programs and projects to determine which should be funded. Because the funding requests always exceed available funds, only the highest priority programs survive. The POM process has proven to be an excellent tool for ensuring that critical Air Force programs are funded and that our budget request represents a proper balance of all our needs. However, because of their relatively low dollar amounts and lack of well defined near term payoff, science and technology programs have failed to compete well against more urgent,

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

It is now time to return to the original thesis of this paper. In Chapter 1, we set out to look at several factors to determine if the Air Force should adopt the proposal to manage its science and technology program as a corporate investment, with the Air Force establishing the investment level as a percentage of its total budget by a conscious decision. It was shown in Chapter 2 that over the past 25 years, the Air Force has reduced its real funding and emphasis on science and technology. Next, Chapter 3 demonstrated that over the same period of time in which the Air Force, and the nation, decreased funding for science and technology, the Soviet Union was able to significantly close the technology gap between our two countries. Chapter 4 then examined the factors that allowed the Soviets to close the technology gap. It was shown that although several factors were instrumental, our own failure to adequately fund science and technology played a major role, and that we have more control over funding for science and technology than the other factors. Finally, Chapter 5 discussed what it means to manage as a corporate invesment and told how the Air Force might implement such a proposal.

If the analysis of this report is valid, it is logical that we could most easily reverse this trend toward loss of technological leadership by increasing the amount of funding for science and technology. And there is the rub. In an era of tight budgets and more immediate threats to our national security, increasing our emphasis on anything is extremely difficult. Yet, the trends are clear. If we do not reverse the slide toward technological inferiority by increasing our investment in science and technology, we will bankrupt our national defense strategy, which counts on superior technology to overcome superior numbers of the Soviet bloc.

No one would purposely allow themselves to fall into a position of inferiority. As indicated in Chapter 5, the reason we are where we are today is not the result of a conscious decision to allow our science and technology base to decay. Rather, we reached this point gradually by innumerable individual budget trade-offs within the annual budget cycles. When hard decisions had to be made about

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