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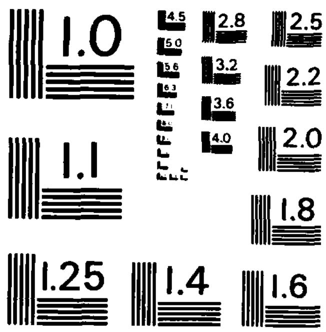

MICROCOPY RESOLUTION TEST CHART
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A MANPOWER, BUDGET, STRUCTURE, SYNERGISM (MBSS) MODEL
FOR THE COMPARISON OF
US-SOVIET MILITARY-SPACE RESEARCH EFFORTS

by

ROLAND DEAN BROWN

BS (Chemistry), Gonzaga University, 1956
MS (Chemistry), Gonzaga University, 1958
MAS, University of Alabama in Huntsville, 1976
MBA, Alabama A&M, 1978

A DISSERTATION

Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Science

SOUTHEASTERN INSTITUTE OF TECHNOLOGY

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ABSTRACT

The objective of the research was to develop an alternative methodology for the comparison of US-Soviet military-space research efforts during the 1970's. A Manpower, Budget, Structure, Synergism (MBSS) model was developed to make a comparison of the effective scientific manpower levels in each of the military-space sectors. The primary advantage to using an MBSS Model is the ability to compare the two national research programs without utilizing published Soviet budgetary data, Soviet monetary conversion rates, or US-developed dollar-ruble index factors. The MBSS Model introduced the concept of Enhancer/Detractor (E/D) Multipliers (greater than or lesser than Unity) which were based upon the unique characteristics of each of the two research systems. Major categories selected for E/D multipliers were: 1) Control of priorities, 2) control of resources and 3) control of adversary conditions.

The major conclusion of the research was that considerations of the quantity and structure of scientific manpower, coupled with an assessment of the synergism of constantly varying nationalistic research organizational structures and research policies has the potential for providing a significantly better method for comparative assessments of US-Soviet military-space research programs than those currently being employed.

This report is DoD funded. The author's tuition was paid by BMDSC. No contract number is involved.
Per Ms. Doris Cornett, Army Missile Comd

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DISCLAIMER

The views of the author do not purport to reflect the position of the Department of Army, the Department of Defense or the US Government.

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CHAPTER 1

NATIONAL MILITARY-SPACE RESEARCH COMPARISONS

INTRODUCTION:

This research effort specifically addresses the development of a methodology to examine and compare US and USSR national defense and space research commitments without the strict requirement to resolve all comparisons to monetary equivalents. A model will be introduced to perform this comparison.

The value of long-range research has been recognized for many years.[1] Within the "weapons for war" context, however, it has only been within the twentieth century that military leaders have been entrusted with dedicated resources with which to plan and conduct research into future battlefield weapons.[2] The introduction of the tank, the airplane and the submarine into the twentieth century battlefield caused the realization that military organizations must become involved in future weapons research in order to prepare for combat roles ten to twenty years in the future.

The extent (in terms of funds and manpower) to which military organizations should be allowed to guide future weapon system developments has been extremely controversial (in most nations) however. For example, the marriage between the airplane and a specially designed surface ship (the combination now known as the aircraft carrier) was one of the leading controversies in the US in the 1930's.

It is probably true that the US industrial sector has an adequate data base (through competitive mechanisms, rates of return, etc.) upon which to judge the appropriate amount of research and development (R&D) to pursue in their particular markets. The US government, on the other hand, has no competition except from foreign governments. Judgments as to the adequacy of governmental R&D (and especially the level of R&D required for national defense) is extremely difficult.[3] The military comes under increased pressure for austerity in weapons research programs during times of national economic depressions. During times of extended conflict military organizations themselves tend to cut back drastically on internal resources for weapons research. The annuals of World War II are replete with examples of instances where short-range battlefield requirements were accorded priority over research efforts which may have ultimately turned the tide of battle had they been given additional (rather than reduced) resources while in the development phase. Examples which readily come to mind are Germany's development programs on the V-2 rocket and the jet engine. Since World War II, the emerging powers (super and near super) have placed increased emphasis upon the rationale for the allocation of dedicated resources to conduct long-range weapons systems research.

Since, as a general rule, the weapons development programs of most nations are judged in comparison to similar programs by nations most likely to be future combatants, it can be assumed that US weapons development programs (and, accordingly, the supporting R&D programs) must be compared against those of the USSR.

It has become increasingly obvious, however (especially in the past few years), that the Congress of the United States is uncomfortable with the testimony which has been presented in regard to US-USSR national defense comparisons, (and by inference national defense research).[4] The viability of budgetary comparisons (the primary method utilized by the US Congress) has been eroded by detailed analyses of the Soviet economy, by "hands on" experience reported by Soviet defectors, and by impressions created by US-USSR scientific exchange programs which occurred in the 1970's. The Central Intelligence Agency (CIA), testified in 1978 to the Joint Economic Committee as follows:

> The estimate for Soviet RDT&E outlays is the least reliable of our estimates. Because the estimate is based on highly aggregated and uncertain data, we cannot speak with confidence, nor in detail, about the allocation of this category of defense spending among the services or among missions.[5]

There is, therefore, an obvious need for an improved methodology for comparison of the national defense and space research efforts of the two nations. Resources, other than monetary, need to be considered. The most obvious alternate choice[6] is a comparison of the dedication of scientific manpower to defense and space research.

SIGNIFICANCE AND ANTICIPATED RESEARCH CONTRIBUTION

The development of additional (alternative) techniques to examine crucial questions of national importance should never be underestimated. The very fact that estimates of Soviet military-space research expenditures have varied by as much as four to one,[7] mandates the exploration of techniques other than monetary. Attempting to resolve all comparisons to dollar equivalents has apparently become a fashionable mode in the United States. This paper presents a new and unique approach toward providing U.S. Legislators with additional data upon which to guide the course of this nation in the years to come. It shall attempt to assist in the resolution of current and future controversies regarding US-USSR research comparisons, attempt to enlighten the R&D community as to the basis upon which many programmatic decisions have been or are being made, and issue a call for synergistic approaches in future comparative analyses.

APPROACH

This research paper will examine the salient differences between the Soviet and the US research and development environments as they apply to the military-space sector. In the early 1970's, "detente" fostered an increased emphasis upon the exchange of ideas and technology between the US and the USSR. Actual exchanges of information began in the mid-decade, the published results of which only became available in the late 1970's. Concurrently, the Soviet Union made many radical changes in their internal (governmental) business practices (especially in the late 1960's and early 1970's), the impact of which were not felt until at least the mid-1970's. Therefore, the primary focus of this research paper was restricted to the period of 1970 to 1979. The impact of earlier (pre-1960) scientific philosophies are considered passe and the impacts of scientific philosophies adopted in the late 1970's are probably too new to evaluate.

The author deliberately chose not to separate military-space activities for this comparison. First of all, the bulk of Soviet Space research is performed by the same research intrastructure that performs military research; and secondly, orbital space is rapidly becoming the "high ground" of the modern battlefield.

LIMITATIONS ON THE RESEARCH SCOPE

In order to narrow the focus of this research paper, certain highly debatable areas shall not be addressed.[8] These are:

1. Judgmental decisions as to the "rights" and "wrongs" of the ideological philosophy between those of the US and the USSR.[9]

2. Comparisons of US versus USSR weapons production statistics, including inventory, annual outputs, etc.[10]

3. Comparisons of US versus USSR "Consumer Products" Sectors.[11]

4. Judgmental decisions on the appropriate size of the US Defense Research Budget (FY 198X).[12]

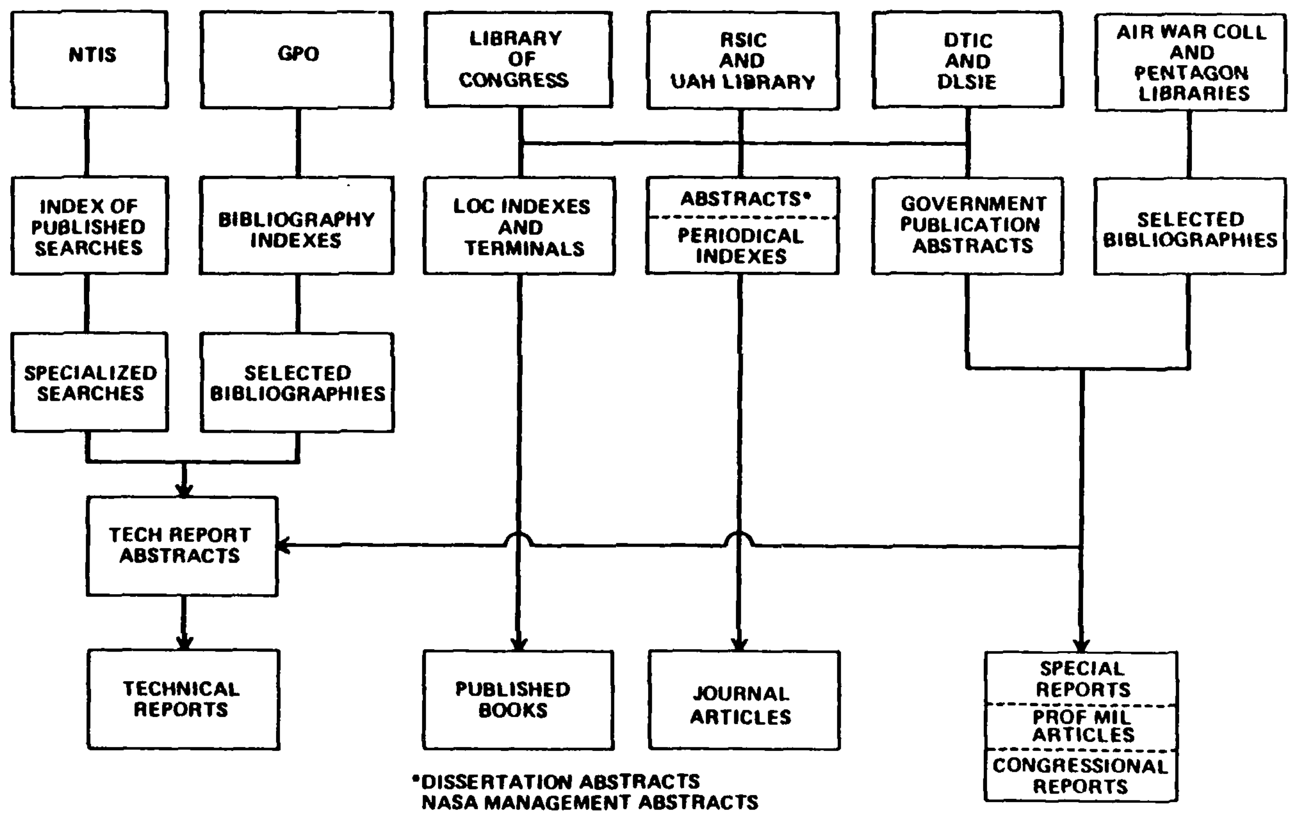
5. Quality versus quantity comparisons of similar weapons systems in a warfighting mode.[13]

SOURCES OF INFORMATION

Establishing the veracity of information took a considerable amount of time. Popular material on the USSR is voluminous, both in the news media and in the professional journals. The congress (especially the Joint Economics Committee) publishes a wealth of economics and other information based upon testimony of experts in the fields.[14] Unfortunately, indepth analyses of the Soviet Research community are relatively sparse and difficult to locate. For this reason a detailed bibliography has been included with this dissertation as well as the location and call number of the more difficult to locate sources.[15] Figure 1-1 reflects the principal libraries and search strategy utilized during the course of the research. Maximum use was made of automated literature search and retrieval methods. A conscious effort was made to assess the reliability of each source, first to reduce the influence of "hysteria publishing" and second to reduce the impact of deliberate

FIGURE 1-1

LITERATURE SEARCH METHODOLOGY



*DISSERTATION ABSTRACTS
NASA MANAGEMENT ABSTRACTS
INTERNATIONAL AEROSPACE ABSTRACTS
AIR UNIVERSITY ABSTRACTS ETC.

"disinformation."[16] Classified documents (and unclassified extracts of classified documents) were totally avoided.

STRUCTURE OF THE RESEARCH PAPER

Chapter 2 contains a synopsis of the current methods for comparison of the military-space research efforts of the two countries. Chapter 3 introduces a new model to compare the two national research programs. Chapters 4 and 5 present the manpower data and a list of enhancer/detractor factors for the USSR and the US, respectively. Occasionally, in Chapters 4 and 5, comparative data will be presented only because in the original source of the data it was presented in this manner.[17] Chapter 6 contains the comparative analysis while Chapter 7 contains a summary and recommendations for further research.

NOTES FOR CHAPTER 1

[1]It has been said that the major invention of Thomas Alva Edison was unpatentable - namely "Organized Research". Edison believed that research breakthroughs could be predicted and produced through organization and concentration of effort. His Menlo Park, NJ team was expected to produce a major invention every thirty days and a minor invention every ten days.

[2]One of the few exceptions was the research effort by the European military organizations into the development of artillery in the eighteenth and ninteenth centuries.

[3]There is a perennial debate in the US Congress regarding the relative merits of Defense expenditures versus those for improving the Quality of Life (i.e., Guns versus Butter).

[4]Congressman Les Aspin (D, Wisc.) is one of the most outspoken critics of current methods (See Congressional Record, 5 Mar 1979 (8), p. E 8511, C-1-1). Senator Proxmire has also questioned the current techiques (See Allocations, 1981 p180). Others include Professor F. Holzman (See "Are the Soviets Really outspending the US on Defense?" International Security Spring, 1980 pp 86-104), Steven Rosenfeld etc.

[5]Estimated Soviet Defense Spending and Trends, Washington, DC, National Foreign Assessment Center, CIA, June 1978 p 11. (SR 78-10121, Pentagon Library UA 770.U584).

[6]Other choices include allocation of research facilities, equipment, information, assessment of priorities etc.

[7]See Chapter 2, Figure 2-9.

[8]These are not considered to be insignificant points, merely areas beyond the scope of this research paper.

[9]Itemization of some of the major differences shall be introduced in Chapter 4, however.

[10]Dedication to procurement of weapons systems is primarily a function of monetary (and facility) commitments, augmented by national desires for specified inventory levels and/or potential Third World sales.

[11]It is the unified opinion of the Western world that the "consumer products sector" of the USSR is extremely neglected.

[12]In Chapter 5, the review process for the Federal Budget shall be summarized.

[13]"Quality versus quantity" attrition effects have been postulated since the days of Napoleon. Lanchester expressed this effect as a series of curves.

[14]See especially the "Allocations of Resources" series published at least annually from 1975 to 1982 by the Joint Economics Committee of the Congress.

[15]It has been the experience of this researcher that the identical document (book) may have different call numbers at the Library of Congress, the Pentagon Library, and local libraries. Whenever difficult to obtain documents or books are cited, the library call number will be contained within the footnote and the bibliography.

[16]Researchers must be very careful of the date of the original sources of Soviet information. The era of "detente" was extremely enlightening to many US analysts as was demonstrated by a dramatic revision of CIA estimates of Soviet Defense expenditures in 1976. "Disinformation" is a term which has been recently coined by the US intelligence community to indicate the deliberate planting by the USSR of false information with the Western news media for purposes of obtaining political advantage.

[17]To deliberately excise single-country data from a comparative chart or figure is considered (by this author) to be a deliberate violation of trust.

CHAPTER 2

SUMMARY OF POPULAR METHODS FOR COMPARISON OF SOVIET AND U.S. DEFENSE AND RESEARCH EXPENDITURES

INTRODUCTION:

The primary medium for comparison of any foreign capability is to equate them to cost in U.S. dollars. Figure 2-1 reflects an overview of the typical methods employed to arrive at estimates of Soviet (USSR) expenditures. Observations are made (generally independently) of the components of Soviet Defense and Soviet National Research. By various techniques these are converted into "Equivalent U.S. Costs" for comparison against "U.S. Costs" during various time frames.

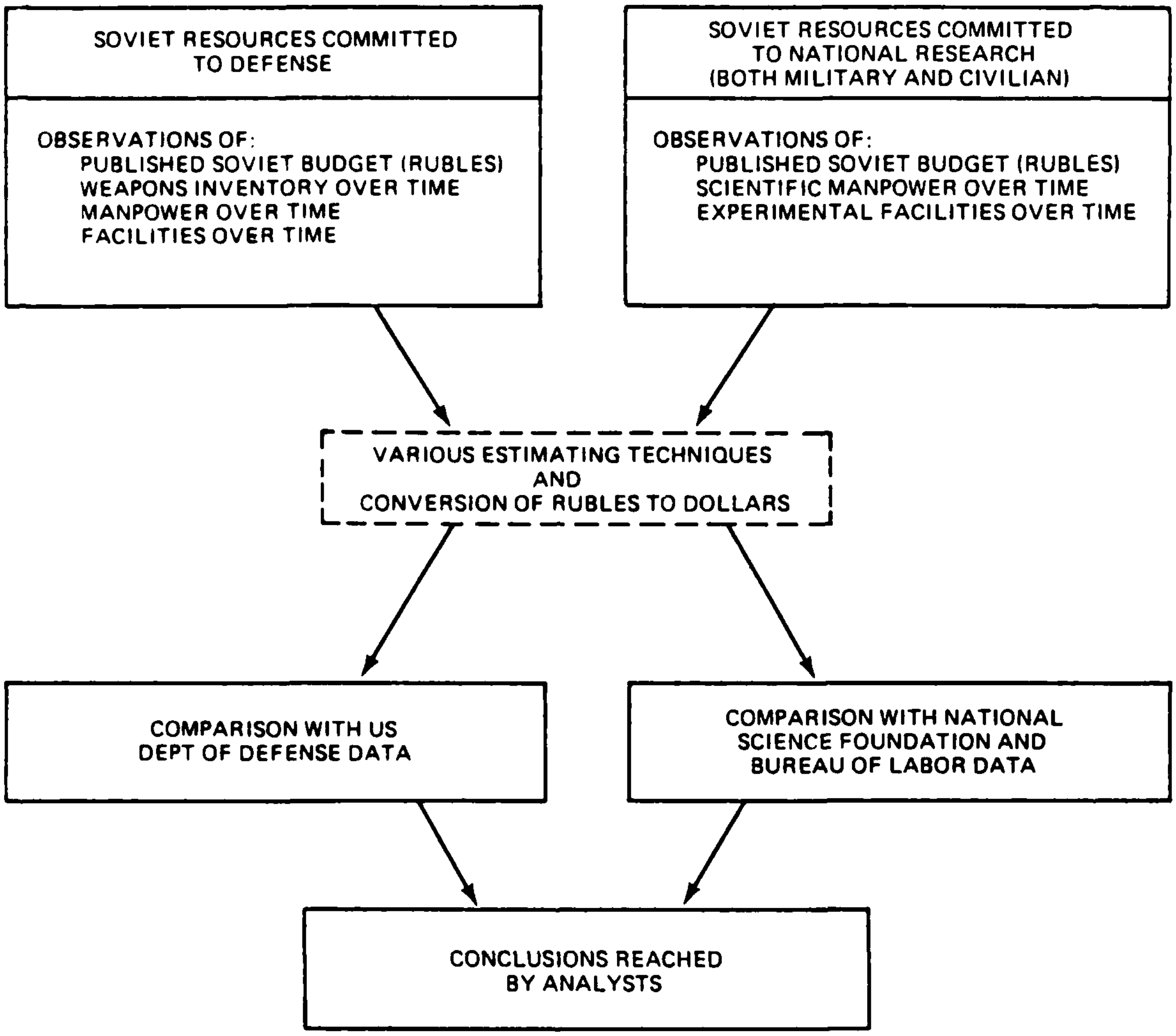
The two major methods for computing Soviet defense expenditures (to compare with U.S. defense expenditures) are as follows:

1. Counting the number of weapons systems, manpower, operations, maintenance, etc., from order of battle and other intelligence information; costing these quantities via cost estimating relationships (CER's) in terms of the expenditures it would require the U.S. Government to obtain a similar item or service; and then comparing these with U.S. expenditures. This latter method is used extensively by the Central Intelligence Agency (CIA) and is commonly referred to as the "Direct Costing" method.

2. Accepting the published Soviet "Defense" and "Science" appropriation and converting these amounts from rubles into dollars for

FIGURE 2-1

USSR DEFENSE & NATIONAL RESEARCH ESTIMATES
(BY US ANALYSTS)



comparison with U.S. expenditures. This method is commonly referred to as the "Budgetary (or Econometric) Approach."

Most professional economists, however, maintain that in order to obtain adequate U.S./USSR comparisons for GNP, defense, and RDTE (or major components thereof), four measurements are required:

1. The Soviet aggregate of goods and services valued in Soviet prices (rubles).

2. The U.S. aggregate of goods and services valued in U.S. prices (dollars).

3. The Soviet aggregate of goods and services valued in U.S. prices (dollars).

4. The U.S. aggregate of goods and services valued in Soviet prices (rubles).

The first two measurements are reasonably well known (with the second being the most accurate). The third is estimated by U.S. analysts using one of several techniques. The fourth measurement, however, is almost completely lacking due to lack of data base upon which to price the procurement and RDTE components of U.S. defense expenditures in rubles.

The reason for the desireability of having all four measures is that a comparison of U.S. and Soviet defense expenditures in dollars tends to exaggerate Soviet defense expenditures relative to those of the U.S.; whereas a comparison in rubles tends to exaggerate U.S. defense expenditures relative to those of the USSR. An "index number effect" is often computed by sectors of each economy to account for these differences. An example of "index number effects" will be presented later. The index number spread tends to account for substantial differences in per capita income, capital/labor ratios, and relative prices of capital and labor between the two nations. In the U.S., the defense effort tends to be capital intensive whereas in the USSR it tends to be more labor intensive. Each nation thus finds the other nation's defense outlays more expensive to reproduce in its own prices. Also, due to this index number effect, annual growth rates measured in dollars will be different from those measured in rubles.

CIA DIRECT COSTING METHOD (FOR SOVIET DEFENSE ACTIVITIES)

The dollar costs of all Soviet defense activities except RDTE are developed by identifying and listing Soviet forces and their support elements.[1] The CIA model contains a description of about 1,100 distinct defense components (ranging from ground force divisions, surface ships, air regiments, etc.) and utilizes their (the CIA's) latest estimates of the Soviet order of battle, manning, equipment inventories, and new equipment purchases for those components.[2]

To these detailed estimates of physical resources, they apply appropriate U.S. prices and wage rates as follows:

1. For procurement, they estimate what it would cost to build equivalent items in the U.S. at prevailing dollar prices for materials and labor, using U.S. production technology and practices and assuming availability of the necessary plants and supplies. Thus, the dollar costs are based on U.S. manufacturing efficiencies.

2. For operation and maintenance, they apply dollar prices to the labor, materials, spare parts, overhead, and utilize estimates required to operate and maintain equipment the way the Soviets do.

3. For military personnel, they first estimate the military rank of the person in the U.S. who would be used to perform the functions of

each Soviet billet and then apply the appropriate U.S. pay and allowance rates to that billet.

The costs of duplicating the Soviet RDTE effort in the U.S. are estimated in the aggregate by converting an estimate of their ruble costs into U.S. dollars. Lee states that this usually consists of taking about two-thirds of the "Science Line" in the published Soviet Budget.[3]

The Soviet counterparts of the U.S. activities shown in Table 2-1 are costed in the above manner. The resulting dollar cost estimates reflect the cost of producing and manning in the U.S. a military force of the same size and weapons inventory as the Soviet force and operating that force in the same manner as the Soviets do. The CIA develops the cost of Soviet Defense activities in rubles by application of ruble-dollar (r/$) ratios to the sectors (in dollars) developed above. According to Lee,[4] there are six basic assumptions underlying the CIA methodology:

1. Production of all weapons systems (from pistols to missiles and support equipment) can be inferred from the Soviet Order of Battle as estimated by the US intelligence community.

2. Estimated dollar prices for weapons systems neither understate nor overstate what it would cost the US to manufacture the same quantities to Soviet specifications.

3. Estimates r/$ ratios applied to the estimated dollar prices of Soviet weapons accurately represent the prices the Soviet Ministry of Defense (MOD) pays for each procurement item at the quantity procured.

4. The preceding assumptions also apply to the estimates of maintenance, operations and construction.

TABLE 2-1

SOVIET COUNTERPART ACTIVITIES COSTED BY THE CIA FOR EVENTUAL COMPARISON WITH U.S. ACTIVITIES

ACTIVITIES INCLUDED:	ACTIVITIES EXCLUDED:
- National security programs funded by the Department of Defense. (RDTE, Investment and Operations).	- Military retirement pay.
	- Soviet space activities that in the United States would be funded by NASA.
- Defense-related nuclear programs funded by the Department of Energy.	- Military assistance and foreign military sales.
- Selective Service activities	- Civil defense programs.
- The defense-related activities of the Coast Guard.	- Veterans' programs.
	- Soviet Internal Security Troops and Soviet Railroad and Construction Troops.

Source: Soviet and U.S. Defense Activities, 1971-80, CIA, SR 81-10005, Jan 81, p 10.

5. "Science" expenditures fund all RDTE -- civilian, military, and space. Military RDTE may be therefore estimated as a share of "Science."

6. Soviet data checks on the direct costing estimate -- total or any component thereof -- are not possible.

CIA COMPARISONS OF SOVIET/US DEFENSE ACTIVITIES:[5]

For Soviet/US comparisons the same items are included and excluded as shown in Table 2-1. Soviet and US defense activities are then compared in terms of the following major resource activities: investment, operating, and RDTE.

The investment category covers the cost of procurement of equipment (including major spare parts) and the construction of facilities. Investment costs represent the flow of equipment and facilities into the defense establishment; they are not an indication of the size of the Soviet Forces in any given year.

The operating category covers the costs associated with operating, training, and maintaining current forces (including personnel costs). The costs are directly related to the size of the Soviet Forces and their level of activity in any given year.

The RDTE category covers a wide variety of activities, including exploring new technologies, developing advanced weapons systems, and improving existing systems.

US data is developed from the Five Year Defense Program (FYDP) and from US Budgets for previous years. The US data are converted from fiscal year to calendar year, and defense-related activities of the Department of Energy, the Coast Guard, and the Selective Service are added. The outlays for each year are converted to constant dollars using detailed price indexes for each type of military expenditure. Because of these adjustments, the US budget figures used in CIA cost comparisons generally differ from published budget US appropriations for the Department of Defense.

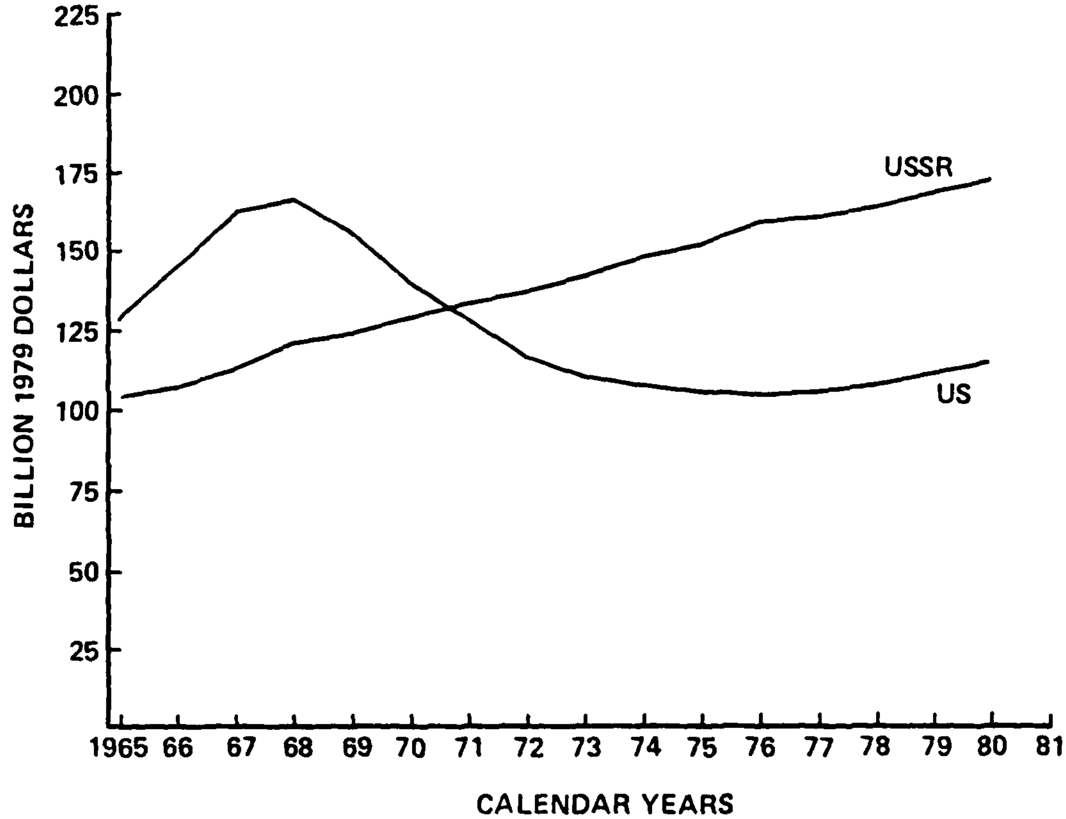
The CIA also makes a highly aggregated estimate of the ruble cost of US Defense expenditures. The reasons for this estimate were previously mentioned and its inherent problems will be discussed later in this chapter.

Figure 2-2 presents the latest (unclassified) cost comparison of US and Soviet Defense activities in constant 1979 dollars. It is to be noted from Figure 2-1 that the Soviets appear to be outspending the US by nearly 50% as of 1980. Figure 2-2 has been widely publicized and is probably the basis for the chart used by President Reagan in his televised Status Report 23 November 1982.

Data developed by the CIA via the direct costing method is used in a wide variety of applications. Figures 2-3 and 2-4 represent two such cases. Table 2-2 represents an analysis of data presented from two additional sources.[6] Due to the remarkably close 1970 ruble to 1979 dollar ratio over the period 1965 to 1980, the most obvious conclusion is that US inflation rates have been imparted to Soviet Defense and Space expenditures. On the other hand, data compiled by Medish[7] on the average monthly salaries of Soviet State employees reflected an escalation rate of only 31% from 1970 to 1978 whereas the US Congress[8] reported to the Executive Office that average US private (non-agricultural) salaries had risen 70% during the same time period. The NSF reported the average S&E salaries in US industry had risen 88% during that same time frame (See Table E-6). Since a major portion of

FIGURE 2-2

TOTAL US AND SOVIET DEFENSE ACTIVITIES



CUMULATIVE COSTS, 1965–80

US 2.015 TRILLION 1979 DOLLARS

USSR 2.235 TRILLION 1979 DOLLARS

Source: SOVIET AND US DEFENSE ACTIVITIES 1971-80, CIA, (SR 81-10005), JAN 1981, p ii.

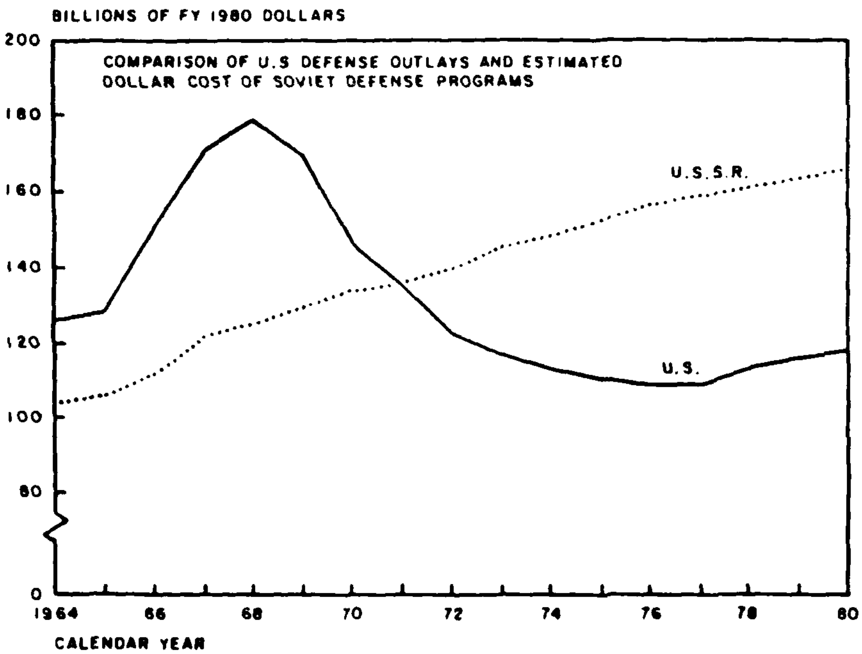
TABLE 2-2

AVERAGE RUBLE-DOLLAR RATIOS
Computed From CIA Estimates of Soviet Defense/Space Expenditures

Calendar Year	Estimated Soviet Defense and Space Expenditures Billions 1970 Rubles (1)	Billions 1979 Dollars (2)	1970 Ruble/ 1979 Dollar Ratio (3)
1965	39.0	105	0.37
1966	40.0	107	0.37
1967	43.0	114	0.38
1968	46.0	121	0.38
1969	47.5	125	0.38
1970	48.5	130	0.37
1971	49.5	134	0.37
1972	51.0	138	0.37
1973	53.0	142	0.37
1974	56.5	149	0.38
1975	57.0	153	0.37
1976	62.5	160	0.39
1977	63.0	162	0.39
1978	64.5	165	0.39
1979	67.0	170	0.39
1980	70.5	175	0.40

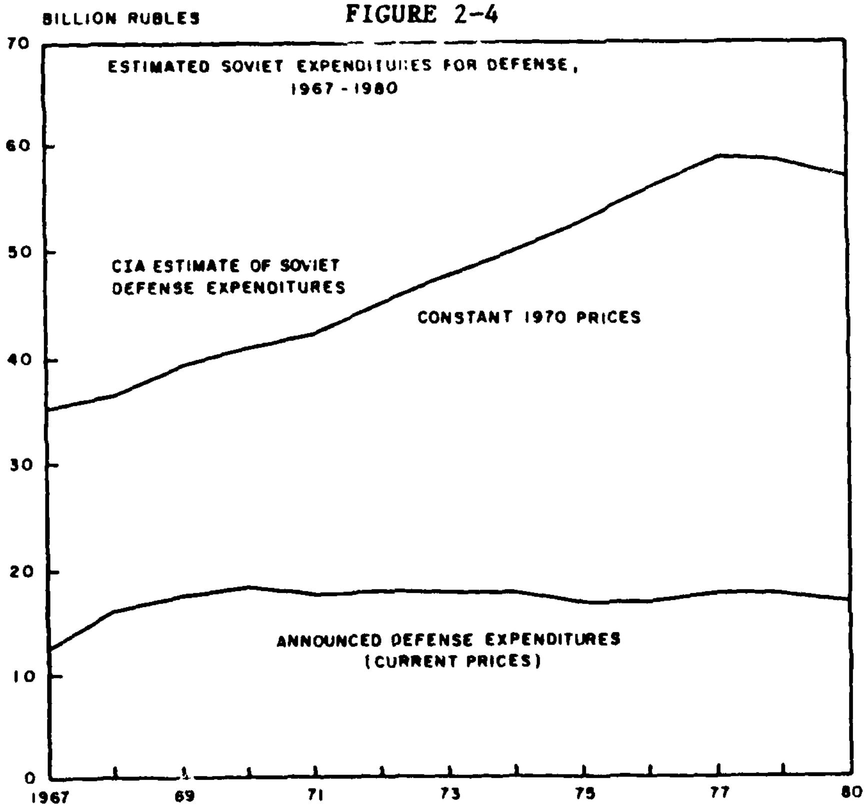
Sources:
Column 1: From statement by Hon. H. Rowen, Chairman National Intelligence council Reprinted in: Allocation of Resources in the Soviet Union and China, Joint Economic Committee Hearings, 8 Jul 1981, p 281 (Average Value) (C-2-10).
Column 2: From Soviet and US Defense Activities, 1971-80, CIA, (Sr 81-10005), Jan 81, p ii (R-6-13).

FIGURE 2-3



Source: FY 81 DoD Annual Report Reproduced in "The Future of the Soviet Defense Burden," Naval War College Review, Jul-Aug 81, p 40.

FIGURE 2-4



Source: FY 81 DoD Annual Report Reproduced in "The Future of the Soviet Defense Burden," Naval War College Review, Jul-Aug 81, p 41.

TABLE 2-3

SOVIET DEFENSE COST CATEGORY MIX

	Percentages	
	Rosenfielde (1)	CIA (2)
Personnel	31.5	35.
O&M	18.0	20.
Procurement	32.5	25.
Construction	4.5	5.
R&D	13.5	15.
	100.0	100.0

Sources:
Column 1. Steven Rosefielde, False Science: Underestimating the Soviet Arms Buildup 1960-1980, chap. 13 (Pentagon Library UA 770.R6 1982). (R-6-32).
Column 2. Soviet and US Defense Activities, 1971-80, CIA (National Foreign Assessment Center), SR 81-10005, January 1981, p 10-11 (R-6-13).

defense-space sector expenses are ultimately for manpower (from the military, to hardware fabrication, to R&D) it does not appear consistent that virtually identical ruble - dollar conversion rates over that period are plausible.

The CIA also prepares estimates of cost category mixes. Table 2-3 presents the 1981 CIA estimate versus an estimate prepared by Rosefielde.[9]

ECONOMETRIC (OR BUDGETARY) METHOD FOR ESTIMATING SOVIET DEFENSE EXPENDITURES

This approach, popularized by Stanford Research Institute (SRI) and especially Stantley Cohn, accepts the Soviet-published "Defense" and "Science" budget allocations as the total USSR outlays for National Security Expenditures (NSE) and civilian R&D.[10] Cohn accepted the "Defense" appropriation as covering all MOD outlays except R&D and assumed that 50 to 100 percent of the budget appropriation to "Science" represented all military and space outlays in the USSR.

There are four basic assumptions to the SRI methodology:[11]

1. The Soviet Ministry of Defense's (MOD's) estimate and the budget appropriation to "Defense" are one and the same.

2. "Defense" covers all pay, maintenance, operations, military construction, and procurement.

3. "Science" expenditures cover all RDTE and space outlays, therefore military RDTE may be derived as a share of "Science."

4. Other than pensions and perhaps some minor education and health services, no MOD funds are buried in other Soviet budget appropriations.

The data on "Defense" and "Science" are then used as inputs to the SRI/WEFA[12] Soviet Econometric Model.[13] The current version of this model (SOVMOD II) is a medium scale econometric model designed to reflect western understanding of Soviet economic institutions and bureaucratic behavior.[14] The system of equations has been fitted to the data for the actual behavior of the Soviet economy for the past 20 years and adapted to carry its existing trends into the future. The model uses western estimates of sector output and Soviet GNP as opposed to Soviet measures of gross value of output.[15] The model was used to evaluate the Soviet 10th Five Year Plan (1976-1980).[16]

The major contribution that the model makes is in the area of examination of the workings of the total Soviet Economy and not in resolving controversies in regarding the amount of Soviet NSE allocated during a particular period of time.

Figure 2-5 summarizes the differences in approaches between the CIA approach and the SRI approach to estimation of Soviet National Security expenditures.

MAJOR PROBLEMS WITH DIRECT COSTING METHODS

The literature dramatically notes that the CIA made a radical change in their estimates of Soviet Defense expenditures in the 1970's. As Hanson states:

> In 1976 the US Central Intelligence Agency announced that it had been getting its measure of the burden of defense spending on the Soviet economy approximately 100% wrong. Hitherto the story had been that in 1970 Soviet policymakers looking at their own current ruble defense expenditure data would have seen a total figure equivalent to 6-8% of their GNP in current established ruble prices. In the light of an unusually large body of new information and of further analysis, the CIA's revised view was that this figure should have been 12-13%. Moreover, in 1970-75, according to the revised view, this spending was increasing at 4-5% a year and not, as previously estimated, at about 3%.[17]

This change is reflected in Figure 2-6. Note that the CIA went back

FIGURE 2-5

TWO CONTRASTING APPROACHES FOR ESTIMATING SOVIET NATIONAL SECURITY EXPENDITURES

	CIA METHOD* (A SYNTHETIC VIEW OF THE KREMLIN)	SRI METHOD (ECONOMETRIC SIMILE)
Sector Estimated		
Procurement	Count Total Weapons Produced, etc.	"Defense" Line Item
Pay & Allowances	Count Operational Personnel, Food, etc.	
Operations & Maintenance	Count Required Inputs	
Military Construction	Count Construction Projects, etc.	
Military RDT&E and Space	2/3 of "Science" Line Item	1/2 of "Science" Line Item
Conversion-Rubles to Dollars	Price Weapons, People, etc. in Dollar Equivalents Convert Dollars to Rubles by R/$ Ratio	Soviet budget data used as inputs to SRI/WEFA Soviet Econometric Model** or SOVMOD II***
Typical Comparisons Made	Soviet Defense Expenditures versus US Defense Expenditures (Both in Constant Dollars) Percentage of Soviet GNP versus Percentage of US GNP (Both in Constant Dollars)	Predicted Impact of Soviet Defense Expenditures upon Soviet economy. Comparisons of predicted sector data with observed data to infer Soviet Defense Expenditures.

*Unclassified results first available 1976, See Lee, The Estimation of Soviet Defense Expenditures: 1955-1975, Chapter 2.

**Became Operational 1975, See Green, The SRI-WEFA Soviet Econometric Model Phase I, p 34.

***Soviet Economy in a new Perspective, GPO, 1977 p 301.

and revised their earlier estimates as well as providing bounds of uncertainty. Also note that (on Figure 2-6) the Official Soviet Defense Line (which is considerably lower than the other estimates) has been retained in current rubles. The reason for this will become obvious later.

There are still at least five problems with direct costing techniques:

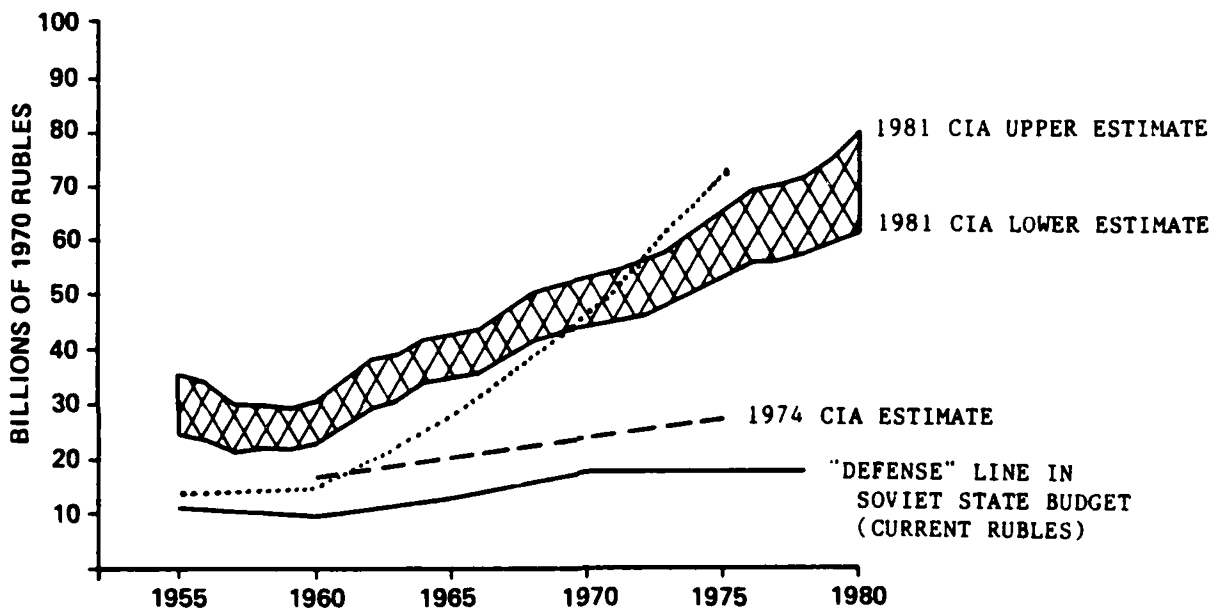
1. Lack of ruble costing of the US establishments.
2. Incomplete Soviet price statistics.
3. Uncertainties in technological paramenters of Soviet equipment.
4. Deliberate manipulation (by the Soviets) of selling prices.
5. Dollar-to-ruble and ruble-to-dollar conversions.

As was noted earlier, in order to obtain adequate US/USSR cost comparisons, four measurements must be made, two in rubles and two in dollars. Dollar and ruble costs of the Soviet Defense effort are estimated in great detail, and US Defense costs are (for the most part) readily available in the open literature. In testimony to the Joint Economics Committee in July 1981, MG Lankin (and others), stated that it would require approximately 5000 man-years of effort to prepare a detailed ruble estimate of US Defense expenditures.[18] Apparently they only devote on the order of three man-years of effort to obtain a highly aggregated estimate. When questioned about the large discrepancy, the witnesses stated that a multimillion unit data base has been developed on Soviet military activities (which can be used to calculate ruble or dollar costs) but that no independent data base on the US military effort exists.

Collins[19] states that price statistics are incomplete or missing for

FIGURE 2-6

ESTIMATES OF SOVIET DEFENSE AND SPACE EXPENDITURES
VERSUS SOVIET - PUBLISHED BUDGET FOR "DEFENSE"



Sources:
1981 CIA Estimates: Allocation of Resources, JEC, 1981, p 281
1974 CIA Estimate: Colby Testimony to JEC, Apr 1974, Cited in Lee, Estimation of Soviet Defense Expenditures, p 136
Soviet Defense Line: Leggett, et al, Soviet Studies, OCT 78, p 557
Dotted Line: Lee's 1977 Estimate (See Text)

at least one-third of all Soviet military items which must be costed.

Cost estimates of Soviet equipment depend primarily upon physical and technological parameters which are not precisely known to the US analysts. Some Soviet weapon systems prove to be less sophisticated and less costly when examined in detail. Others (e.g., ZSU 23-4 AAA Guns, the BMP Infantry Combat Vehicle, etc.) turn out to be much more costly in US dollars than their closest US counterpart.[20]

The Soviets also tend to manipulate selling prices for their own convenience. For example, a truck sold to a Collective Farm may be priced at 40,000 rubles, whereas the same truck sold to other state enterprises may be priced at 10,000 rubles and the same truck sold through foreign exchange may be priced at 4,000 rubles.[21] The intelligence community is uncertain as to how that truck issued to the soviet military should be priced.[22]

In addition to the fact that the ruble is a non-convertible currency (i.e., it is worthless outside the Soviet Union),[23] there are problems of aggregations of commodity sectors into single r/$ ratios. For example, in Table 2-4,[24] the price of sugar in the Soviet Union versus the US may follow the indexes exactly whereas the price of meat (or other foodstuffs) may vary tenfold from the indexes. Disaggregation to the largest extent possible would then seem to be mandatory in order to achieve high fidelity comparisons. This relates back to the reluctance of the intelligence community to disaggregate the US Defense effort and compute ruble costs. Secondly (and perhaps more importantly), when prices of Soviet components of Defense are first computed in US dollar equivalents and then converted to ruble equivalents, it would appear to automatically impart US inflation to the ruble equivalent price. The

TABLE 2-4

SOVIET-US NUMBER EFFECTS, 1976

	USSR/US In Rubles (1)	USSR/US In Dollars (2)	Index Number Spread Dollars (2) - Rubles (1)
GNP	.495	.735	1.49
Consumption	.352	.543	1.54
Food	.596	.723	1.21
Soft Goods	.384	.607	1.58
Consumer Durables	.116	.206	1.77
Household Services	.244	.340	1.39
Health	.256	.814	3.17
Education	.800	1.067	1.33
Investment	1.076	1.403	1.30
Machinery & Equipment	.863	1.414	1.63
Construction	1.025	1.117	1.09
Administration	.571	.602	1.05
Defense and Space	1.292	1.440	1.11
Other	.500	.647	1.29

Source: Imogene Edwards, Margaret Hughes, and James Noren, "U.S. and U.S.S.R: Comparisons of GNP" in Soviet Economy in a Time of Change, Vol 1, Jt. Econ. Comm., Congress of the United States, Washington, Oct 10, 1979, p 378. See also Franklyn Holzman, "Are the Soviets Really Outspending the U.S. on Defense?," International Security, Spring 1980, p 88.

Soviets, on the other hand, vehemently deny suffering from inflation. Most Western observers will agree that the USSR has experienced inflation (or at least price increases on virtually identical items over a period of time), but it is extremely doubtful that the Soviet inflation (or whatever) is in lock-step with US inflation.[25]

AN UNCONVENTIONAL ESTIMATE OF SOVIET NATIONAL SECURITY (NSE)[26] EXPENDITURES

William T. Lee published his unconventional method of estimating Soviet National Security Expenditures in 1977. As an ex-CIA analyst, Lee disagrees with a large number of their methods of computation of NSE (particularly the pre-1976 ones). As Hanson says, "The estimation of procurement is the heart of Lee's study."[27] Lee estimates Soviet NSE[28] as the sum of three components:

1. National security (NS) durables (as defined below);

2. Personnel pay and maintenance, operations and maintenance of the MOD establishments, and military construction;

3. Military and Space RDTE.[29]

Lee defined durables as being dependant upon the final consumer:

1. Producer durables -- trucks, tractors, machine tools, generators, etc. -- allocated to capital investment.

2. Consumer durables -- radios, TV's, sewing machines, etc. -- allocated to private consumption.

3. NS Durables -- tanks, guns, aircraft, ships, missiles, space boosters, spacecraft, etc. -- allocated to the Soviet MOD.

Lee derived "NS durables" by subtracting from the Gross Value of Output (as reported by the Soviet TsSU), intermediate products, exports, and producer and consumer durables. Lee then proceeded to compute values for NS Durables, Pay (plus), and Military-Space RDTE as reflected in Table 2-5.[30]

SUMMARY OF PREVIOUS METHODS FOR ESTIMATING SOVIET RDTE EXPENDITURES BY MOD[31]

Both the direct costing and the econometric techniques for estimating Soviet "Defense" expenditures (at least prior to 1976), used percentages of the reported Soviet "Science" budget for their estimate of "Defense RDTE" (refer back to Figure 2-4). The following are excerpts of CIA reports from 1978 and 1981, respectively:

> "The estimate for Soviet RDT&E outlays is the least reliable of our estimates. Because the estimate is based on highly aggregated and uncertain data, we cannot speak with confidence, nor in detail, about the allocation of this category of defense spending among the services or among missions. Nevertheless, the information on which the estimate is based-published Soviet statistics on science, statements by Soviet authorities on the financing of research, and evidence on particular RDT&E projects-suggests that military RDT&E expenditures are large and growing. We estimate that outlays for RDT&E currently account for almost one-quarter of total Soviet defense spending. As with the investment category, we believe that the growth in Soviet RDT&E spending varied from year to year.[32]

> "We are less confident in our estimate for RDT&E than we are in our estimates for the other categories. Nevertheless, we are confident that the Soviet military RDT&E effort is large and that the resources devoted to it are growing. This assessment is reinforced by evidence on the increases in manpower and facilities devoted to Soviet military RDT&E programs... Over the 1971-80 period, Soviet estimated dollar costs for RDT&E were half again as much as US outlays, and during the late 1970's they were about twice as much.[33]

The first report estimated that approximately 25% of the total defense expenditures were for RDTE, whereas the latter report dropped the estimate back to approximately 15%.[34]

Lee's estimate of Soviet military and space research expenditures was prepared based upon the logic shown in Figure 2-7. It is to be

TABLE 2-5

LEE's COMPUTATION OF SOVIET NSE
(Billions of Current Rubles)

	1970	1971	1972	1973	1974	1975
NS Durables	17.3-18.8	19.2-20.7	22.1-23.8	24.8-26.6	27.3-29.3	31.3-33.4
Pay, O&M, MILCON	17.9	19.3	20.3	22.1	23.1	24.1
RDTE (Military and Space)	7.5-12.4	8.0-13.3	8.4-14.2	9.4-15.8	10.2-17.1	11.3-18.6
NSE	42.7-49.1	46.5-53.3	50.8-58.3	56.3-64.5	60.6-69.5	66.5-76.1
NSE Average	45.9	49.9	54.6	60.4	65.1	71.3

Source: W. T. Lee, The Estimation of Soviet Defense Expenditures, 1955-1975, NY, Praeger Publishers, 1977, Table 4.6.

noted that Lee started from RDTE labor force data,[35] and by subtracting a percentage of the "Science" budget, arrived at a ruble estimate. Lee's basic reconciliation for the much larger numbers which he arrived at (versus those of previous investigators) was primarily due to a difference between "reported" and "unreported" Soviet outlays (see Table 2-6). Lee's basic contention is that Soviet national RDTE (and of course military-space RDTE) are funded from a number of budget appropriations other than "Defense" and "Science."

Nimitz (of Rand) arrived at the conclusion that military-space RDTE consumed approximately 50% of the Soviet published Science budgets in 1960 and 1968.[36] Nimitz's logic and rationale is summarized on Figure 2-8. Nimitz started from total Soviet employment by sector, applied the US analog (S&E to non S&E ratio) to arrive at Soviet diploma level S&E's, and then arrived at the total wage bill for specialized R&D organizations. *Nimitz concluded that the Soviet military R&D sector is* much more efficient than the civilian R&D sector and, therefore, only consumes approximately 50% of the total Soviet "Science" budget. Nimitz, however, admits that the Soviets use a narrower definition of "development" than is used in the US.[37] Table 2-7 presents a recapitulation of Nimitz' data for 1968.

Figure 2-9 portrays Soviet RDTE expenditure estimates provided by the CIA, SRI, Nimitz, and Lee over the period 1955 to 1975. Also shown on Figure 2-9 is the official "Science" budget published by the USSR. As a point of departure, Figure 2-9 also reflects a single point estimate of "total effective science budget" provided by the Soviet scientist Valuyev.[38] Figure 2-9 vividly reflects that there is a large disagreement in the amount of ruble expenditures for Soviet military-

Figure 2-7

LEE'S ESTIMATE OF SOVIET MILITARY AND SPACE R&D EXPENDITURES

STEP 1:

RDTE Labor Force*	x	Average Annual Wage Rate	+	5.8% Social Insurance	=	Wage Bill (in Rubles)**

STEP 2:

Wage Bill (Rubles)	+	R&D Materials*** (Rubles)	+	R&D Investment in Plant (Rubles)	+	R&D Performed by VUZy (Rubles)	=	Total RDTE Outlay (Rubles)

STEP 3:

Total RDTE Outlay (Rubles)	-	75% of "Science" budget (for Civilian Sector) (Rubles)	=	Military and Space RDTE Outlay (in Rubles)

NOTES:

* As calculated by Bronson, and published in JEC Committee Report June 1973.
** According to Lee, this estimate is a minimum estimate.
*** According to Lee, this is the weakest element of his estimate.

Source: William T. Lee, The Estimation of Soviet Defense Expenditures 1955-1975, New York, Praeger, 1977, Tables D-14, D-16.

TABLE 2-6

LEE'S SUMMARY OF FUNDING OF NATIONAL RDTE EFFORTS
(INCLUDING MILITARY - SPACE RDTE)

A. Reported Soviet outlays for RDTE.
   1. Budget appropriations for "Science" and for R&D plant (FNE).
   2. Nonbudget ("Enterprise's Own") funds.

B. Unreported Soviet outlays for RDTE.
   1. Budget appropriations.
      a. Budget appropriations (from FNE) for prototype fabrication.
      b. Budget appropriations (from FNE) for capital investment* relalting to "unique equipment."
      c. Budget appropriation (under "Education") for R&D performed in the VUZy.
      d. Budget appropriation (from FNE?) for transport of prototypes to proving grounds and test ranges.
      e. Budget appropriations (from FNE, "Defense," or both?) for State test and evaluation of prototypes at proving grounds and test ranges (including operations and maintenance).
      f. Budget appropriation (from FNE) for R&D performed in geological survey and hydrometerological organizations.
      g. Budget appropriation from "Defense" for uniformed military personnel engaged in R&D.

   2. Nonbudget funds.
      a. Factory working capital used to fabricate military prototypes.
      b. Unreported enterprise funds; for example, "Fund for Mastering New Products," and probably other enterprise funds formed from retained profits.
      c. Bank credits.

*Capital Investment may also include producer durables such as automotive, machine tools, generators, etc.

Source: Modification of Table in: William T. Lee, The Estimation of Soviet Defense Expenditures, 1955-75, New York, Praeger Publishers, 1977, p 19.

FIGURE 2-8

NIMITZ' METHOD FOR ESTIMATING SOVIET MILITARY-SPACE RDTE

- Soviet Industry was segregated into 28 sectors:*

  10 Non-Industrial
  18 Industrial

- Soviet data on total employment in Sectors, times the percentage of R&D to non R&D in U.S. Industry (i.e., U.S. Analog) to arrive at an estimate of S&E Manpower.

- S&E Manpower in each Sector times Average Employee Wage equals wage Bill for Specialized R&D Organizations.

- Then Diploma level plus Support people in Specs times Average Employee Wage to arrive at ruble expenditures.

- Nimitz concluded that Military R&D Sector is much more efficient than Civilian R&D Sector and only consumes approximately 50% of "Science" Budget.

*Sectors are very similar to the Input-Output Sectors of Treml. (See Appendix D).

TABLE 2-7

SUMMARY OF NIMITZ' DATA ON SOVIET R&D FOR 1968

Machine Building and Metal Working (MBMW)*		
Non R&D Employment		11,275,000
Ratio of S&E's to Non S&E's (US Analog by Subsector)		4.2%**
Estimated S&E's		377,000
Total Employment in R&D Orgs Only		1,526,000
Outlays per Employee (Rubles)		2,789
Total Outlays R&D Orgs Only (Mil Rubles)		4,256
Total Outlays R&D Orgs Plus Enterprises (Mil Rubles)		4,836
Total Outlays Industrial R&D***		5,969
Estimated Share to Defense/Space	2,736-3691	
Total Outlays Non Industrial R&D		1,831
Estimated Share to Defense/Space	305-575	
Total R&D Outlays		7,800
Estimated Share to Defense/Space	3,041-4,266	

* This Sector will be further defined later.

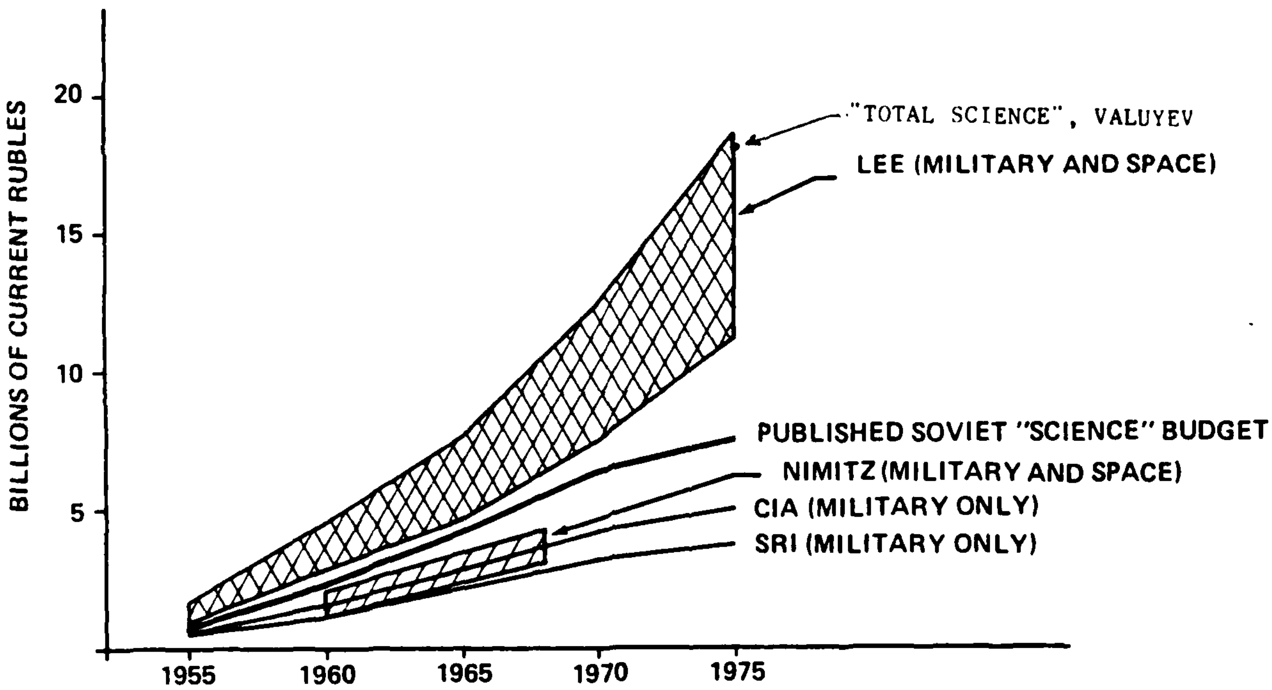
** Excludes employment for repair of machinery; Major subsectors vary from 1.1 to 9.4%, the latter being primarily Defense Industry.

*** It is to be noted that Nimitz calculated the MBMW sector to consume over 80% of the total Soviet Industrial outlays for R&D (4,836 vs 5,969).

Source: Nimitz, The Structure of Soviet Outlays on R&D in 1960 and 1968, Santa Monica, CA, RAND, June 1974, Appendix B.

FIGURE 2-9

VARIOUS ESTIMATES OF
SOVIET MILITARY AND SPACE RESEARCH EXPENDITURES



Sources: See text.

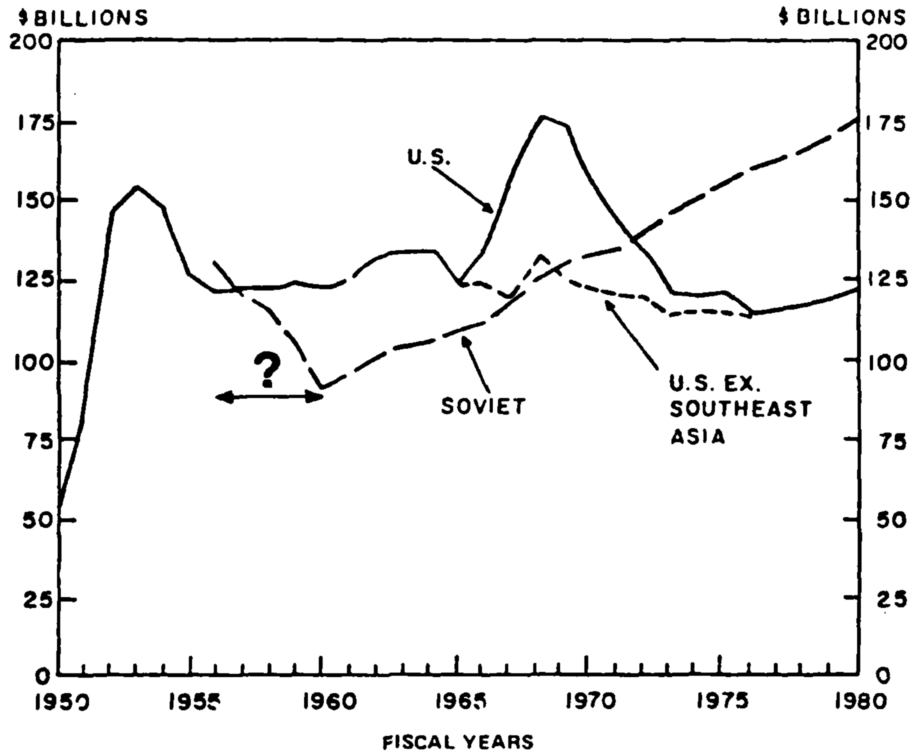
space RDTE activities. The CIA has not recently released (to my knowledge) unclassified figures relating to Soviet military-space R&D, but based upon their dramatic 1976 reevaluation of total Soviet Defense and Space expenditures (refer back to Figure 2-6), it must be anticipated that they have also revised their expenditure timelines reflected on Figure 2-9. One major factor appears to be a considerable lack of commonality in the definition of the term "R&D."

PROBLEMS WITH BUDGETARY COMPARISONS IN GENERAL

Figure 2-10 represents an example comparison of the US and Soviet outlays on an FY 80 constant dollar basis over a 30-year period (1950-1980). Figure 2-11 presents a 10-year representation of the same data except utilizing a constant FY 75 base. Table 2-8 reflects the data presented on Figures 2-10 and 2-11 versus the total obligational authority (TOA) in current year dollars for the Department of Defense. There are obvious inconsistencies between the data presented on Figures 2-10 and 2-11 (e.g., the ACDA data is 12M$ less than the TOA in 1980) yet both charts are replicated frequently throughout the literature. While figures 2-10 and 2-11 have lost a certain amount of fidelity through smoothing for presentation purposes, they are symptomatically representative of another of the problems. It rapidly becomes obvious that the only way to reconcile the differences between the data for US defense outlays presented on the two figures would be to return to the current year data upon which the curves are based and then resolve the differences (i.e., those items which are included and those which are not included). In addition the USSR expenditure curve on Figure 2-10 is based upon international exchange rates whereas the curve in Figure 2-11 has been subjected to sectorized ruble dollar exchange rates and then

FIGURE 2-10

COMPARISON OF U.S. DEFENSE OUTLAYS AND
ESTIMATED DOLLAR COSTS OF SOVIET DEFENSE PROGRAMS
(BILLIONS OF CONSTANT FY 80 DOLLARS)

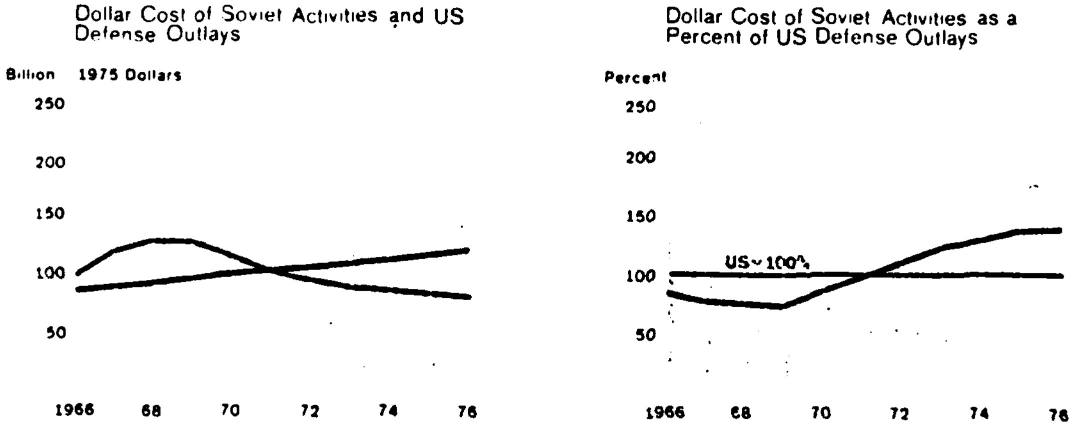


Source: L. J. Korb, "The FY 81-85 Defense Program: Is a Trillion Dollars Enough?" Naval War College Review, Mar-Apr, 1980, p 12 (from Arms Control and Disarmament Agency Report).

FIGURE 2-11

Total Defense Costs 1966-1976 (less pensions)

A Comparison of US Outlays and Estimated Dollar Costs of the Soviet Activities if Duplicated in the US



Source: Allocations of Resources in the Soviet Union and China - 1977, Hearings before the Subcommittee on Priorities and Economy in Govt., JEC, 95th Congress, 1st Session Part 3, 23 and 30 Jun 1977, p 21. (Original Source: A Dollar Cost Comparison of Soviet and U.S. Defense Activities 1966-1976, SR 77-10001U, CIA, Jan, 1977).

TABLE 2-8

COMPARISON OF U.S. DEFENSE EXPENDITURES ON FIGURES 2-10 AND 2-11 VERSUS TOTAL OBLIGATIONAL AUTHORITY

	ACDA Data (Constant FY 80 $) (1)	CIA Data (Constant FY 75 $) (2)	DOD TOA (Current Year $) (3)
1968-69 (Peak	175 Billions	130 Billions	75 Billions
1975	118	89	82
1976	115	88	90
1980	120	(Not Shown)	132

Sources:
Column 1: Figure 2-10; Column 2, Figure 2-11; Column 3, DoD Reports.

inflated (see earlier in text). The entire issue of presenting constant dollar budgetary charts without specifying inflation (or deflation) indices is extremely suspect.

When dealing with budgetary comparisons of US-Soviet RDTE, Campbell[39] (under contract to the NSF) used the ruble-dollar conversion ratios shown in Table 2-9. Campbell's value for construction (0.7) does not appear to compare favorably with the value of 1.025 to 1.117 reflected on Table 2-4. It is not clear whether this means that R&D construction is less expensive than construction in general in the Soviet economy (in spite of the fact that construction tends to labor intensive in the USSR) or if other (unstated) factors have been taken into account.

R&D MANPOWER COMPARISONS

Two of the leading researchers in the field of Research and Development Employment in the Soviet Union are undoubtedly Feshbach and Nolting of the Department of Commerce. Their 1981 report[40] is extremely informative on scientific workers in the USSR. Figure 2-12 presents a graphical summary of the data derived by Nolting and Feshbach. In rough terms the figure reflects that (nation-wide) the USSR had available quantities of S&E personnel equivalent to the US in 1970 and as of 1980 was employing approximately 25% more S&E talent. Later chapters will develop S&E manpower growth patterns for both nations. It must be reemphasized that the data on Figure 2-12 is for R&D at the national level and not R&D dedicated to defense, space, or a summation thereof.

TABLE 2-9

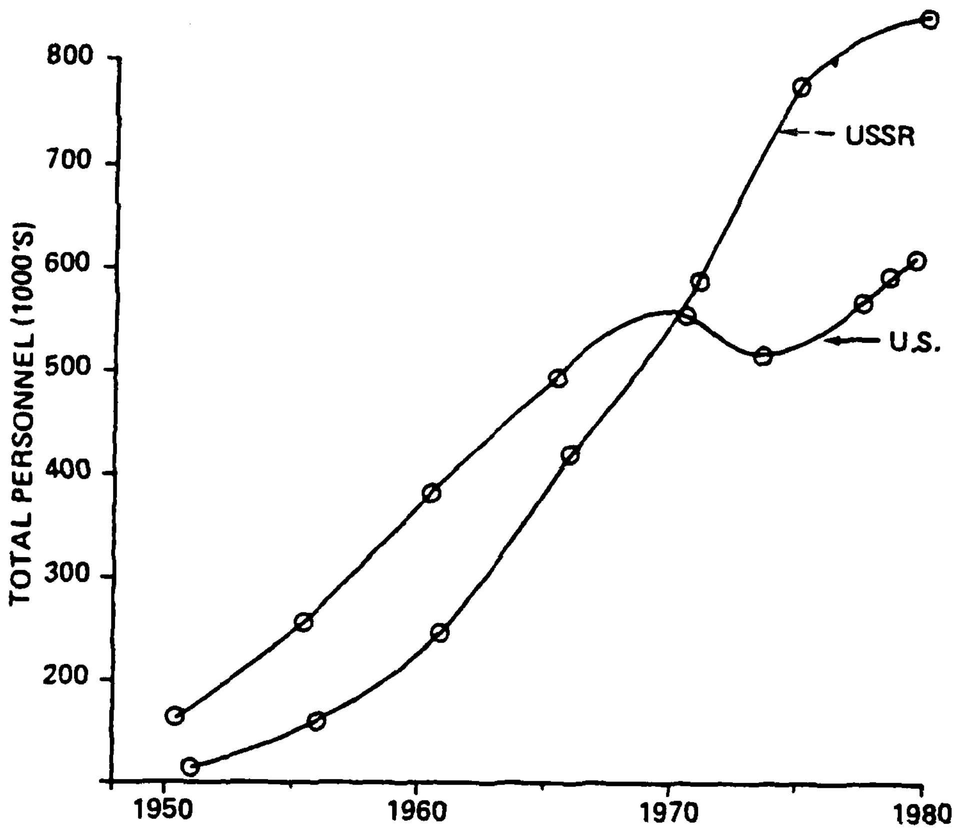
COMPBELL'S CONVERSION OF SOVIET EXPENDITURES FOR SCIENCE TO DOLLARS 1976

Expenditure Category	Ruble-Dollar Conversion Ratio (R/$)
Construction	0.7
Personnel Costs	0.16
Purchase of Equipment and Repairs	0.33
Overhead, Travel, Training	0.5
Other Materials & Supplies	0.27

Source: R.W. Campbell, Reference Source on Soviet R&D Statistics 1950-1978, Bloomington, IN, Indiana Univ., 1978, p 22.

FIGURE 2-12

SCIENTISTS AND ENGINEERS EMPLOYED IN R&D
IN THE US AND THE USSR 1950–1979



NOTE: US Data is Average Strength During Year
USSR Data is Year End Strength.

Source: Nolting and Feshbach, Statistics on R&D Employment in USSR, Dept of Commerce, 1981, p 44, Table 34.

OTHER (UNIQUE) R&D COMPARISON METHODS

Several researchers have devoted a large amount of time to comparing the research programs of US and the USSR based on such things as numbers of papers published, nobel prizes, patents, or copyrights awarded, etc.[41] Kruze-Vaucienne and Logston[42] published a table (based upon a 1976 NSF report)[43] which indicated that while the USSR had more than twice the number of total R&D scientists (and approximately twice the number of R&D scientists per capita), USSR publications tended to cite US publications at least twice as often as they cite their own publications. Computer Horizons, Inc., developed an extensive report[44] (for the NSF) on International Science Indicators using Science Citation Indexes.

While the methodology and the data compiled by these type reports are extremely interesting (especially when comparing research programs in the Western World),[45] they all, admittedly, have two primary problems when dealing with US-USSR comparisons:

1. The USSR has had, and continues to maintain, extreme centralized control over the publication of scientific papers. (See Chapter 4)

2. The USSR did not subscribe to International patent and copyright conventions until 1972[46] during the initiation of the "era of detente."

TECHNOLOGICAL AND MILITARY BALANCE

Collins[47] and Amman[48] have published excellent books on the status of USSR weapons inventory (with sidelight projections on weapons technology) and on the status of Soviet industrial technology, respectively. The former places its emphasis upon Soviet weapon systems in being while the latter traces Soviet industrial technology in comparison to Western (US with a heavy emphasis on British) technology.

Both indicate a heavy Soviet emphasis upon research in the weapons industries and upon mass production of weapons systems but their data is compartmentalized in such a way that they are only peripherally applicable to this study.

NOTES FOR CHAPTER 2

[1]Soviet and US Defense Activities, 1971-80, CIA, (SR 81-10005), Jan 1981, p 10, (Pentagon Library UA 17.U5 1981) (R-6-13).

[2]This is apparently a multimillion unit data base. See footnote 16.

[3]William T. Lee, The Estimation of Soviet Defense Expenditures, 1955-1975, New York, Praeger Publishers, 1977, p 12. (RSIC US 770 L482 1977), (R-4-17) A critical review of Lee's book is contained in P. Hansen, "Estimating Soviet Defense Expenditure, Soviet Studies, Vol 30, July 1978, pp 403-410. (R-4-32). A description of the total Soviet budget structure will be presented later in this paper.

[4]Lee, op cit, p 133. Also see Paul Gregory, "Economic Growth, US Defense Expenditures and the Soviet Defense Budget: A Suggested Model," Soviet Studies, Vol 26 (1874), pp 72-80.

[5]Soviet and US Defense Activities, 1971-80, Wash, DC, CIA (SR 81-10005), Jan 1981, p 1 (Pentagon Library UA 17.U5 1981) (R-6-13).

[6]The data presented in figure 2-3 and column 1 of Table 2-2 appear to match closely. Similarly the data in Figure 2-4 and column 2 of Table 2-2 are similar except for the tail off post 1977 on figure 2-4.

[7]Vadim Medish, The Soviet Union, Englewood Cliffs NJ, Prentice Hall, 1981, pp 158-60. (Pentagon Library DK 17.M4)

[8]Economic Report to the President, House Document Nr 97-3, Wash, D.C. GPO, Jan 1981, Table B-37 (Pentagon Library HC 106.5 A34 1981).

[9]Also See Paul Gregory et al, Measuring Relative USA and USSR Defense Spending Using Translog Information Functions to Obtain True Indexes, Wash, DC, National Council for Soviet and Far East European Research, 15 March 1982 (Pentagon Library UA 17.G74) (R-6-19). Gregory proposed that real Soviet defense expenditures were a function of the size of the Soviet economy and the size of the US defense budget.

[10]See Lee, op cit, pp 22-30. Basic reference is Stanley H. Cohn Soviet Defense Estimates: A Survey, SSC-IN-75-6, Stanford, CA, SRI Strategic Studies Center, 7 Feb 1975.

[11]Lee, op cit, p 134.

[12]WEFA is Wharton Econometric Forecasting Associates, University of Pennsylvania.

[13]See Donald W. Green (SRI) and Christopher Higgins (WEFA), The SRI-WEFA Soviet Soviet Econometric Model Phase I Documentation, SSC TM 2970-1, Stanford CA, SRI, Mar 1975 (R-6-12). See also SSC-IN-74-44.

[14] A description of the use of SOVMOD II in relation to US and world econometric models is contained in A Survey of Long-Range Forecasting Models and Data Resources: A Method for their application at the Department of Defense, Wash DC, Command and Control Technical Center, DCA 8 Aug 1979, p 103 (DTIC ADA082857) (T-9-1).

[15] Berliner maintains: "there is no soviet bottom line; although gross output comes close as serving as the ultimate criterion." See The Soviet Economy to the Year 2000, paper 6, Joseph Berliner, "Planning and Management," Wash DC, National Council for Soviet and Eastern European Research, 9 Nov 1981, p 21 (Pentagon Library 336.25.S72V6) (R-6-20F).

[16] Donald W. Green, et al, "An Evaluation of the 10th Five Year Plan Using the SRI-WEFA Econometric Model of the Soviet Union" in Soviet Economy in a New Perspective, A compendium of papers submitted to the JEC, GPO, 14 Oct 1976 (GPO SN 052-070-0396) (C-2-9).

[17] "Estimating Soviet Defense Expenditure" Soviet Studies, Vol 300 (1978), p 403 (R-4-32).

[18] Statement of MG Larken, Dep Dir DIA to JEC, 8 July 1981 in Allocation of Resources in the Soviet Union and China - 1981, Hearings before Subcommittee on International Trade, Part 7, GPO, 1982 (GPO SN) C-2-10).

[19] Collins, US-Soviet Military Balance, op cit, p 81.

[20] See: Letter, Director of Net Assessment, Office of the SECDEF, 16 Sep 1975, reproduced in Allocations, JEC, 1975, p 169 (GPO Nr 052-070-02905-6) (C-2-3). See also Henry S. Brasher, "No More Cheap Stuff for the Soviets," Washington Star, Feb 18, 1976.

[21] Collins, US-Soviet Military Balance, op cit, p 83.

[22] This is yet another indication, however, that there is a subsidizing of military expenditures by the civilian economy.

[23] There is no international open market ruble exchange. The so-called "official rate" of exchange is established not by the international market mechanism reflecting parity of purchasing power but rather by unilateral declaration by the Soviet government. The current official dollar to ruble exchange rate is about 1.6 but there is a flourishing black market upon which one can get several times more than the official rate for one dollar in currency (or other Western currencies).

[24] Imogene Edwards, Margaret Hughes, and James Noren, "U.S. and U.S.S.R: Comparisons of GNP" in Soviet Economy in a Time of Change, Vol 1, Jt. Econ. Comm., Congress of the United States, Washington, Oct 10, 1979, p 378. See also Franklyn Holzman, "Are the Soviets Really Outspending the U.S. on Defense?," International Security, Spring 1980, p 88. Professor Holzmann argues that the index number for defense and space expenditures should also be of the order of 1.5. He also states

that one of the major reasons the CIA does not make a rigorous ruble comparison is that, while virtually all of the Soviet inventory of weapons falls within U.S. production technology, the Soviets do not have the technology required to produce many of the U.S. weapons.

[25]See: USSR: Measures of Economic Growth and Development, prepared by CIA for use of JEC, Wash, DC, 8 Dec 1982, p vi (GPO Nr. 052-070-05792-1) (C-2-12). According to the CIA there is considerable evidence that new, high-priced (but only slightly altered) products are deliberately substituted for equivalent lower-priced products. The official data then treates such changes as if there were no real price increases, thus incorporating hidden inflation.

[26]NSE is defined as the equivalent of US DOD and NASA budgets plus the cost of nuclear weapons development and procurement.

[27]Hansen, footnote 3, p 405.

[28]Lee, op cit, Chapter 3.

[29]Note that Lee made no attempt to separate military and space RDTE at this point in time.

[30]Lee's table reflected computations for 1955-1975. Only 1970-1975 are shown in Table 2-5.

[31]MOD equates to the Soviet Ministry of Defense. This term has been specifically used rather than "Military," "Defense," etc. The Soviet MOD also performs R&D on space equipment (i.e., that research and development peformed by NASA in the U.S.A).

[32]Estimated Soviet Defense Spending and Trends, SR78-10121, Wash, DC, CIA (National Foreign Assessment Center), Jun 1978 p 11 (Pentagon Library UA770.U584).

[33]Soviet and US Defense Activities 1971-1980: A Dollar Cost Comparison, Wash, DC, CIA, (National Foreign Assessment Center), Jan 1981, p 3 (SR81-10005, NTIS PB81-928101) (R-6-13).

[34]The latter estimate appears to be the most popular estimate. See Table 2-3.

[35]See note on Figure 2-7. This author has not yet been able to verify the original source of Bronson's data. However, the data appears close to the numbers cited in Soviet statistics for the "Science and Science Services Sector."

[36]Nancy Nimitz, The Structure of Soviet Outlays on R&D in 1960 and 1968, Santa Monica, CA, RAND (for DDRE), Jun 1974 (DTIC AD A004598). See especially Tables B-2 to B-4. (R-4-8)

[37]This factor alone may account for the wide discrepancy between Nimitz' estimates and those made by Lee and subsequent investigators.

[38] Y.I. Valauyev, et al, Unique Characteristics of the Financing of Science in the USSR (US Translation), Wash DC, USAF, 24 Mar 1977, p 89 (DTIC AD B022030) (R-4-37).

[39] R. W. Campbell, Reference Source on Soviet-R&D Statistics 1930-1978, Bloomington, IN, Indiana Univ (for NSF), 1978, p 22 (NTIS PB80-139377) (R-4-26).

[40] L. E. Nolting and M. Feshbach, Statistics on Research and Development Employment in the USSR, Wash, DC, Dept of Commerce, Series P-95, Nr 79, Jun 1981 (GPO SN 003-024-03143-4) (R-4-2).

[41] The National Science Board of the NSF has published documents entitled "Science Indicators Year XX," for 1972, 1974, 1978, and 1980." See bibliography.

[42] Ursula Kruse-Vaucienne and John Logsdon, Science and Technology in the Soviet Union: A Profile, Wash DC, George Washington University, 1979, p 6 (Pentagon Library Q127.R96K78) (R-4-38)

[43] Science Indicators 1976, Wash DC, NSF, 1977.

[44] International Science Indicators - Development of Indicators of International Science Activity Using the Science Citation Index, Cherry Hill, NY, Computer Horizons, Inc. (for NSF), Mar 1979 (NTIS PB293 033) (S-2-26).

[45] Science Indicators - 1972, p viii (S-2-27) states that "the few such indicators which are presented ... are subject to considerable uncertainty as to valid interpretation and significance."

[46] Kruze-Vaucienne, Science and Technology in the Soviet Union, p 74. As in all bureaucratic societies, it must be expected that a decade or more time lag shall be required to open up the information loop. If Yuri Androprov responds in kind to the recent DoD policy on restriction of technical papers at international symposia, one must expect USSR statistics upon which the NSF reports are based will dry up quickly.

[47] John M. Collins, US-Soviet Military Balance: Concepts and Capabilities 1960-1980, NY, McGraw Hill, 1980 (RSIC UA23C7121980) (R-6-8).

[48] R. Amann, et al, The Technological Level of Soviet Industry, New Haven, CN, Yale Univ Press, 1977 (UAH T26.R9T4) (R-4-48).

CHAPTER 3

A MANPOWER, BUDGET, STRUCTURE SYNERGISM (MBSS) MODEL FOR ASSESSING MILITARY-SPACE RESEARCH AND DEVELOPMENT

INTRODUCTION:

Chapter two pointed out the major limitations of monetary methods for comparing US-USSR research efforts. Major points which require reiteration are:

1) There is a variation of up to four to one in the estimates of Soviet Military Space expenditures.[1]

2) The DIA estimates that it would take (of the order of) 5000 man-years of effort to prepare a detailed ruble estimate of U.S. Defense expenditures.[2]

3) The Soviet pricing system is considerably different from that used in a free market economy and there are at least three different prices for certain items of equipment.[3]

4) Soviet price indexes[4] cannot be directly coupled to U.S. inflation/deflation factors.[5]

5) The Soviet ruble is a non-convertible currency.[6]

As an amplification of point number three, Figure 3-1 reflects Bernstam's Model for the pricing of Soviet military equipment. Due to the nature of the Soviet governmental structure (mostly by virtue of the vast extent of state ownership of facilities, raw materials, etc.), the equivalent cost to the Soviet Union for a piece of military hardware is probably only 30 percent of the equivalent US cost.[7] While this price

FIGURE 3-1

THE BERNSTAM MODEL FOR PRICING OF SOVIET MILITARY EQUIPMENT

- A Soviet Airplane Factory prices a fighter airplane to be sold to the Soviet State at 10 M $* broken down as follows:

Materials, Energy, R&D	5 M $
Labor (Including Management)	3 M $
Profit	2 M $

- BUT

  1. The Profit instantly vanishes since it is appropriated by the State.

  2. Of the 5 M $, all but approximately 1 M $ (the cost of labor for the mining of metal or coal, refining oil, and salaries paid to R&D scientists) originally belonged to the State.

- Therefore the True Cost of the fighter airplane to the USSR is 3 M $!

- In the U.S., the 10 M $ Cost for the same airplane would be a true cost. The expenditures are real and the profit is real.

- For this reason, if the same airplane costs out at 10 M $ in both countries, the USSR can produce 3.3 airplanes for every one airplane produced by the U.S.

- And the only real measurable cost to the Soviet State for the production of Armaments (or any other item) is Labor!

*Assumed to be the ruble equivalent.

Source: A. Beichman, "The Cost of Soviet Defense - Fact versus Fiction" Washington Times, 17 Mar 1983 pg 4C. (Professor Mikhail Bernstam is currently at Hoover Institute, Stanford University).

ratio differential would not be valid in the research area (since manpower accounts for a higher percentage of the total cost in research than it does in production), all overhead is part of the Soviet State and therefore scientific manpower should be a better indicator than scientific expenditures.

Bernstam's conclusion is in consonance with Korol who (in 1965) concluded: "...that the ruble evaluation of the Soviet R&D effort has very little meaning either as an absolute or relative measure...it is not ruble valuation but the professional manpower engaged in research and development that provides a meaningful unit of measurement in the study and assessment of the magnitude of the Soviet R&D effort."[8]

Furthermore, scientific manpower should be an excellent indicator of total research commitment since by far the largest element of expense in most research programs (most but not all), is directly relateable to manpower. Salaries of personnel, social programs dealing with those personnel (medical benefits, education, training, retirement benefits, etc.) and operating expenses relateable to personnel (offices, laboratory facilities, common user computational facilities, etc.) make up at least 70% of the total research expenses in most national research programs.

The US Government, however, tends to control its manpower allocation to governmental research programs only through monetary methods (i.e. annual Congressional Appropriations) and makes no dedicated assessment of the numbers of S&E's which are performing research in the military-space sector at any given point in time.

Even if the exact numbers of research personnel in each of the two military space sectors were readily available, however, differences in the organizational structures of US and USSR research organizations, differences in national science policies, and (to a certain extent) differences in national governmental policies must be considered. The synergistic effect of these nationalist differences are considered necessary in order to obtain an overall estimate of the total effective research manpower applied to any sector of one nation (which may then be compared against a similar number in the same sector in the second nation).

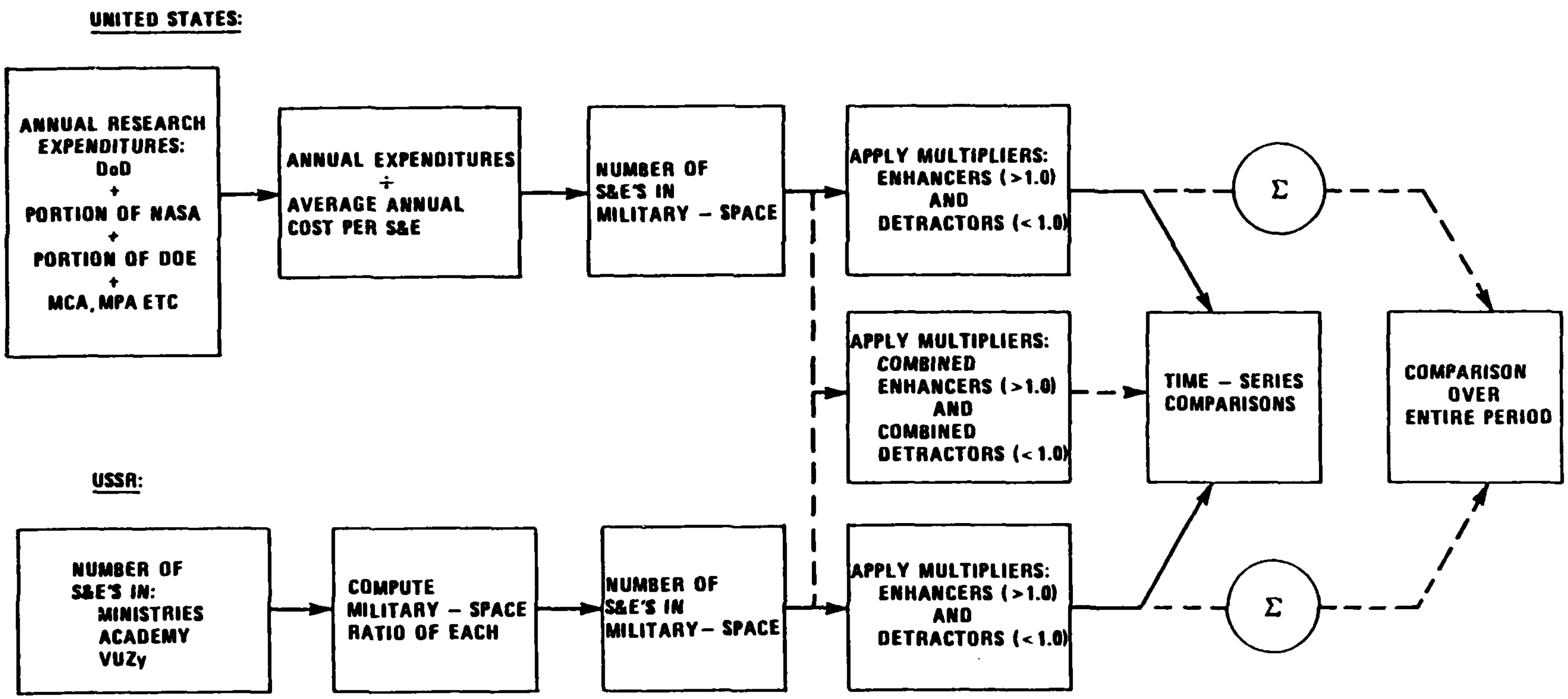
DESCRIPTION OF MODEL

Figure 3-2 presents a block diagram of a Manpower, Budget, Structure Synergism Model for comparison of US and USSR research efforts. Since Soviet research manpower numbers are available they are used as a direct input to the model. In the case of the US, however, an estimate of the numbers of researchers (funded by the Federal Government) must be made based upon budgetary data. Since the inputs to the models are not compared directly, the impact of varying rates of monetary inflation should be minimized. From the total numbers of S&E's in each nation, the number of S&E's applied to the military-space sector of each nation can then be estimated.

The concept of "Enhancers" and "Detractors" was introduced in order to adjust for nationalistic differences in research policies, manpower utilization philosophies, and research organizational structures. Both Enhancers and Detractors react in the form of multipliers, with an Enhancer being greater than 1.0 and a Detractor less than 1.0. For purposes of this research paper, a single qualitative attribute cannot simultaneously be an Enhancer for one nation and a detractor for the other nation (or vice versa). A particular qualitative attribute could,

FIGURE 3-2

MANPOWER, BUDGET, STRUCTURE, SYNERGISM (MBSS) MODEL



however, be an enhancer during one time frame and a detractor during a different time frame in the same nation.[9] After many trials and errors, the author settled upon the following four groupings[10] of Enhancer/Detractors:

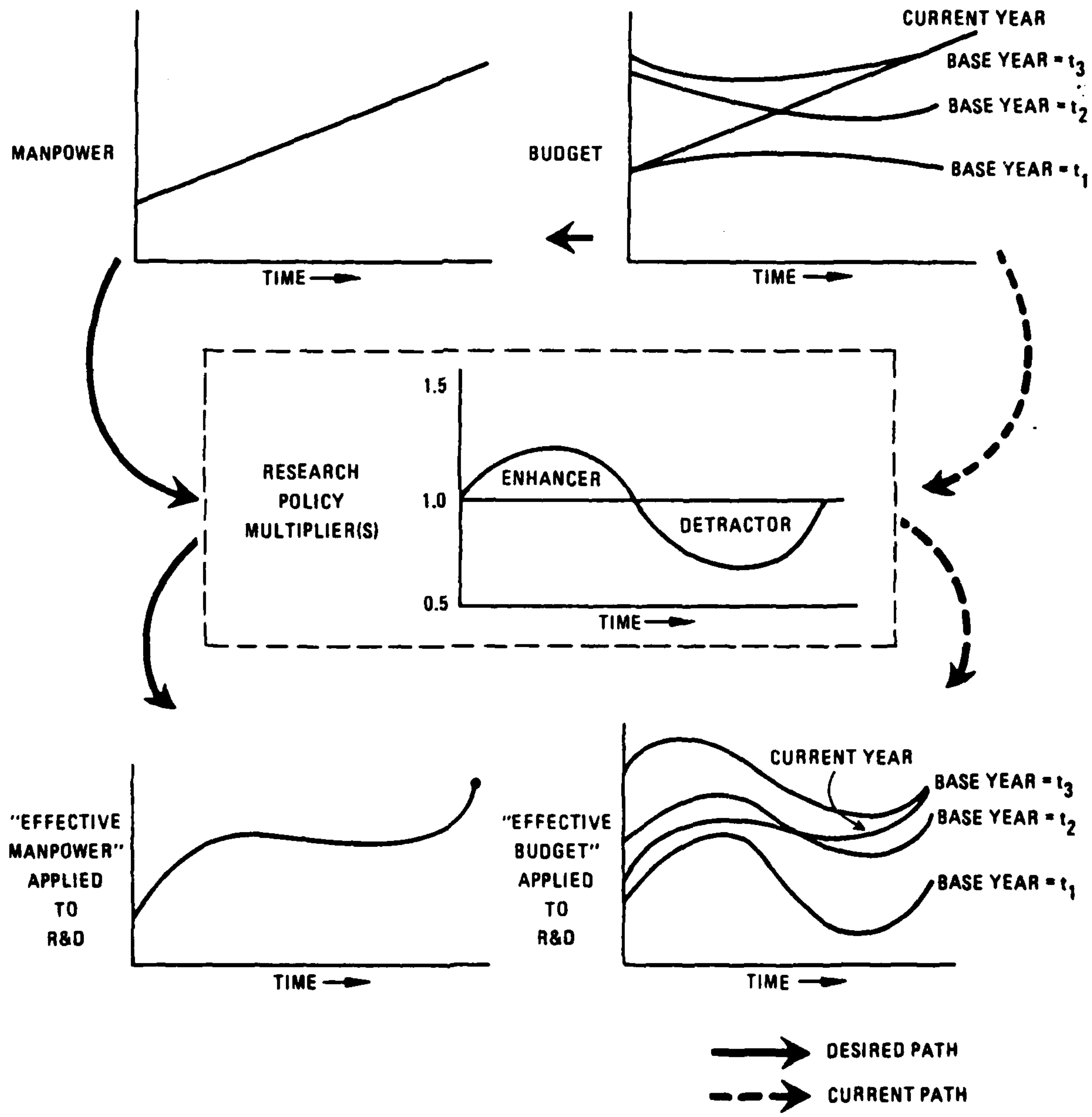
1. Control of Priorities
2. Control of Resources
3. Control of Adversary Conditions
4. Control of Production (Output).

Figure 3-3 provides a general indication of the impact of applying a constantly varying research multiplier (in this case a sine curve) to both a manpower and a budget profile. A sine curve was used only to provide a "worst case" condition. Typical Enhancer/Detractors over a ten year period would be quazi linear (with a positive or negative slope) or possibly "U" or "Bow" shaped. Of necessity, the budget profile must be identified as to current year (or base year FY XX) as shown in the graph on the upper right portion of the figure. The two graphs on the lower portion of Figure 3-3 reflect the data subsequent to the application of the sine curve multiplier. It is relatively obvious from the bottom right graph why synergism is generally not applied to budgetary comparisons. It is definitely preferable to convert budgetary data into direct S&E manpower and then apply research policy multipliers (as shown by the solid arrows). This also avoids the requirement for monetary conversions.

Research manpower data, as a bottom line, also offers a much better base for making time series comparisons than budgetary data since the vacillating effect of monetary inflation in the two countries under scrutiny tends not to be synchronous.[11] Furthermore, manpower commitments of a particular nation can easily be summed over a fairly

FIGURE 3-3

IMPACT OF VARYING RESEARCH POLICY



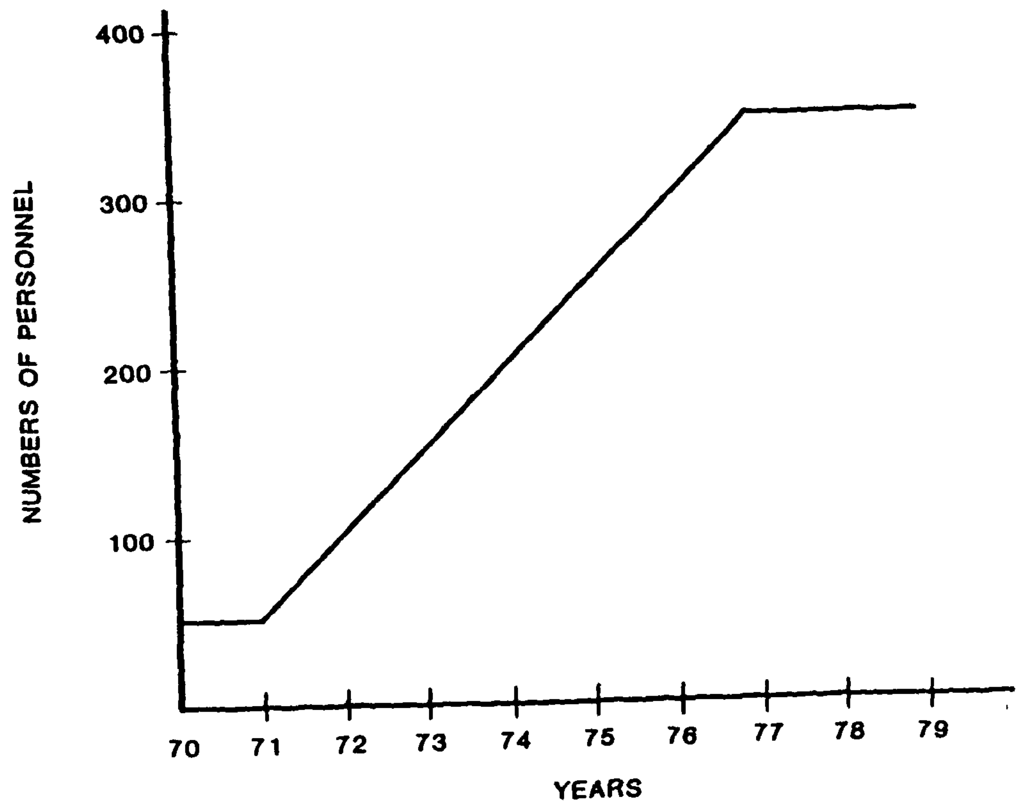
lengthy period of time (to provide total man-years of research efforts)[12] (see Figure 3-4), whereas summations of the expenditures of funds over a period of time are much less indicative of the particular nation's true impetus in R&D.[13] Comparison of total research manpower commitments over a period of time should therefore prove more indicative of the differences between national commitments to research in any given sector than those of other comparisons (especially monetary expenditures).

APPLICATION OF MODEL

The specific problem to be undertaken in this study is to examine and compare the relative research manpower applied by the US and the USSR for military-space applications during the 1970-1979 time frame for the reasons outlined in Chapter 1. The model itself, however, appears to be applicable for use in the examination of any particular sector of the two nations. It is obvious however, that the Enhancers and Detractors would vary greatly from sector to sector.

FIGURE 3-4

AN EXAMPLE OF THE SUMMATION OF MANPOWER OVER AN EXTENDED PERIOD OF TIME



AVERAGE STRENGTH DURING YEAR:	50	75	125	175	225	275	325	350	350
CUMULATIVE MANYEARS:	50	125	250	425	650	925	1250	1600	1950

NOTES FOR CHAPTER 3

[1]See Chapter 2, Figure 2-9.

[2]It is realized of course that the effort required to estimate only the Defense research portion would be considerably less.

[3]Separate prices are often established for collective farms, State enterprizes and foreign sales. See Chapter 2, footnotes 19 and 20.

[4]Or the price indexes in any other country's currency...

[5]That fact that this is being done is demonstrated in Table 2-2 Chapter 2.

[6]The Soviet ruble is not used outside of the Soviet Union, therefore it is non-floatable. See footnote 21, Chapter 2.

[7]A. Beichman, "The Cost of Soviet defense-Fact versus Fiction", Washington Times, 17 Mar 1983 p 4C.

[8]Alexander G. Korol, Soviet Research and Development, Cambridge, MA, MIT Press, 1965 p 227.

[9]Obviously, sudden radical changes in organizational structure or national policy could produce dramatic increases or decreases in the effective number of S&E personnel in a particular sector from one year to the next. The relocation of a unique laboratory could have a heavy impact upon the research effectiveness of a particular sector in one year followed by a return to normal effectiveness in the following year, etc.

[10]These four groupings appeared to the author to encompass all aspects of research. Most of the studies on research efficiency have tended to concentrate on the last Enhancer/Detractor, namely output. A common example for evaluation of a particular research organization is the number of technical documents or professional articles written. Kruze-Vaucienne reports the results of a 1976 NSF study of literature citations in which Soviet writers tended to cite US publications twice as often as US writers cited Soviet publications. (See: U. Kruze-Vaucienne et al, Science and Technology in the Soviet Union, George Washington Univ, Jun 1979 p 5.). The study failed to take into account however that few US scientists read the Russian language whereas most Soviet Scientists are required to read the English language.

[11]The General Accounting Office recently went on record to say that they are not really sure that "research" can be inflated or deflated using standard GNP Price deflators.

[12]In a synergistic model such as is proposed here, one must expect that a flat level (zero slope) of research manpower over a number of years would result in moderate annual increases in research output due to the introduction of more and more personal, desk-sized computers,

automated measuring instruments, more efficient laboratory equipment, etc. This does, however, presume annual capital expenditures for this equipment.

[13]Even in the U.S., where budget is the primary means of control, problems are encountered using escalation/deescalation factors to equate expenditures to a constant rate of purchasing power. Of the 27 Selected Acquisition Reports (SAR's) sent to the Congress in 1983, the Congressional Budget Office reported that 20 had used incorrect factors. In addition, budget expenditures give no indication of tooth-to-tail ratios (i.e., the ratio of S&E's to support personnel). R&D facility expenditures (non MILCON type) also tend to have "bumps" and "saddles" -- for example the large R&D plant expenditure by the USAF in 1977 (nearly one half billion dollars) (see Chapter 5), was primarily for a single test facility.

CHAPTER 4

SOVIET RESEARCH MANPOWER LEVELS IN THE MILITARY-SPACE SECTOR 1970-1979

INTRODUCTION:

In order to fully comprehend the meaning of a time-series stream of Soviet research manpower numbers, the reader must understand that the Soviet system is entirely different than the US system. During the course of the research for this study, the author has been astounded by the fact that there are far more dissimilarities between the systems than there are similarities. Nearly everyone is familiar with Winston Churchill's statement that Russia[1] is (or was)..."a riddle wrapped in a mystery inside an enigma."[2] Even today, foreign visitors, including those of the Warsaw Pact nations, are allowed access to only a small percentage (probably less than three percent) of the land mass (and populace) of the USSR and then only along specific access routes, and on prearranged schedules at prearranged locations, facilities, etc.[3]

The USSR is a total welfare state. It provides cheap housing[4] for its citizens (though considerably less spacious than that expected by Western standards), guaranteed employment[5], free education at all levels[6], free medical care[7], subsidized day care for preschool children (including infants)[8], cheap transportation[9] (to employment), and adequate pensions for the old and disabled. In addition the Soviet State provides to the Soviet citizen other advantages which are not really considered "welfare" in the Western world namely an extensive

Civil Defense System, an extensive national mobilization (and reconstitution) program, and a massive air defense of the heavily populated areas (especially Moscow).[10] In exchange for these welfare priviledges, the average Soviet citizen foregoes most of those things which the US citizen considers their basic "freedoms."[11] Checking accounts and "financed-purchases" are non-existent in the USSR.[12] The singular major personal advantage to the Soviet system (from a Westerner's point of view) seems to be the complete absence of organized crime.[13]

Since the USSR is a welfare state, with a centrally planned economy (versus a market economy in the US), control of priorities, control of resources, control of adversary conditions, and control of total national production is much easier than in the US. The major characteristics of the two systems are reflected in Figure 4-1. "Hero Projects" include such things as the Bratsk Hydroelectric Dam in Siberia (completed in the 1960's), the Kama River Truck Plant (completed in the the 1970's), and the 2000-mile BAM (Baykal-Amur-Mainline) railroad scheduled for completion in 1983.[14] The Soviet State allows itself the liberty to "buy versus build" major production facilities. For example, the Fiat Plant at Togliattigrad was purchased from Italy for 430 million dollars (1975) and the Kurst Iron and Steel Mill was purchased from West Germany for one billion dollars.[15]

The Soviet State controls the national economy by means of the "Five Year Plan." These plans have been in existence since the late 1920's (See Table 4-1) and differ markedly from the Five Year Defense Plan (FYDP) used by the US Department of Defense.[16] Soviet planning is a two way street, but final decisions as to their technical content are

FIGURE 4-1

MAJOR CHARACTERISTICS OF THE USSR CENTRALLY PLANNED ECONOMY AND THE US MARKET ECONOMY

ATTRIBUTE	USSR CENTRALLY PLANNED ECONOMY	US MARKET ECONOMY
Control of Priorities	o Five Year Plan (FYP) o "Hero Projects" o Rigid Control on Consumer Products Sector.	Competitive Except in Government Sector.
Control of Resources	o Logistics Annexes to FYP o State Control of Education and Workforce Tasking o State Control of Funds and Capital Assets o State Control on Foreign Imports. o State Information Control o Stability Funding o Guaranteed "Right to work"	Competitive Except for Government Control of Critical Materials, Selected Processes, Selected Information, etc.
Control of Adversary Conditions	o Virtually None (Internal) o Substantial Personal Bonuses for Managers and Workers of Organizations which fuffill FYP Targets	o Labor Unions o Lobbyist Groups o Industry vs Quality of Life Controversies o Consumer Financing (Availability of Product o Competition with Foreign Producers.
Control of Production	o Yearly Plan "Targets" o Monthly Cycles in Consumer Sector o State Price Control (Land and Capital Assets generally excluded) o State Subsidization in many Market Sectors o Different Quality Control Standards for: - Military-Space - Foreign Export	o Basically Competitive (Profit Motive) o Prices Directly Tied to Cost of Production Including Land, Capital Assets, etc. o Consumer Sector Generally Held in Highest Esteem.

TABLE 4-1

SOVIET NATIONAL PERSPECTIVE PLANS
(Dual Publication of Civilian and Military Plans)

Plans	Years Encompassed	Remarks
1st Five-Year Plan	1928-1932	
2nd Five-Year Plan	1933-1937	
3rd Five-Year Plan	1938-1942	Not completed due to WWII.
4th Five-Year Plan	1946-1950	
5th Five-Year Plan	1951-1955	
6th Five-Year Plan	1956-1960	Dropped in 3rd year.
Seven-Year Plan	1959-1965	
Twenty-Year Plan	1961-1980	Dropped after Kruschev left.
8th Five-Year Plan	1966-1970	
9th Five-Year Plan	1971-1975	
10th Five-Year Plan	1976-1980	
11th Five-Year Plan	1981-1985	

NOTE: Beginning with the first FYP, Military Industry was assigned to Group A (Top Priority). During the second FYP, output of Defense Industry increased 286% (See K. Krylov, "Soviet Military-Economic Complex," Military Review, Nov. 1971, p 90).

Source: Multiple compiled by author.

made at the top. Each of the FYP's contain a listing of approximately 200 S&T Objectives to be accomplished during the five-year period. Figure 4-2 provides a listing of some of the specific objectives of the Tenth FYP.[17] Subsidiary annual plans are prepared by each sector of the Soviet economy, by the various Ministries, and by each Soviet manufacturing facility, research organization, etc.

Unlike the US, the USSR has no competitive industrial sector. Figure 4-3 reflects a comparison between the operation of a typical industrial sector in the USSR versus the typical operation of the US industrial sector.[18] The first thing to note in the case of the USSR is that the State is the largest consumer of industrial goods, whereas, (in general) in the US, private individuals and businesses are the largest consumers.[19]

SOVIET R&D ORGANIZATIONAL STRUCTURE

The overall structure of Soviet S&T performer organizations is presented in Appendix B. A simplified view of this vast array of Soviet S&T organizations is reflected in Figure 4-4. The three major "organizational heads" of Soviet R&D are the Academy of Sciences (AN), the Ministries for the Branches of the Soviet Economy (usually referred to as "Branch"), and the Ministry of Education (usually referred to as the VUZy).

Figure 4-5 presents Dobrov's model of the mechanism of Soviet National Science Policy. At the very heart of the system (Block 3) appears "Regulation at the highest level of Soviet Management." This is a further indication that Soviet S&T management is centralized to the maximum extent possible, mainly within the confines of the CPSU.

The Soviet scientific establishment is the largest national

Figure 4-2

Examples of the 200 S-T Programs of the Tenth FYP (1976-1980)

(Excludes Military - Space)

- Development of equipment for transport - lifting, loading - unloading and warehouse operations

- Mechanization and Automation of Production

  Goal: 60% increase in productivity; 54% increase in production

- Mechanization of the Timber Industry

- Double the smelting of cast iron

- Increase Ammonia production (from 10% of all Soviet requirements to 80%)

- Series Production of 800 megawatt Heat Turbines

- Series Production of billion watt reactors

- Produce:
  Freight vehicles with a capacity up to 120 tons
  Diesel Locomotives: up to 8,000 HP
  Electric Locomotives: up to 10,000 HP
  Excavators with scoop capacity of up to 100 cubic meters
  20,000 new types of machines, equipment, etc.
  (8th FYP 8,400, 9th FYP 16,500)

- Increase electrical power output by five times
  - (Nuclear thereby conserving 30 million tons of conventional fuel)
  - Reduce expenditure of fossil fuel to 328 gram per KW hour (from 340 in 1975)

- Mass produce synthetic resins and plastics for use in construction

- Produce up to 1.5 million tons of synthetic fibers for the consumer market

- Develop powder metallurgy techniques

- Increase automation of technological processes by three times

Note: The original order of precedence has been maintained.

Source: M. Vilenskiy, Technical Progress in the Tenth Five Year Plan, (English Translation), Nov 1976 p. 10 (R-4-20).

FIGURE 4-3

COMPARISON OF US AUTOMOBILE COMPANY MARKET INTERFACES WITH THOSE OF THE SOVIET AUTOMOTIVE INDUSTRY

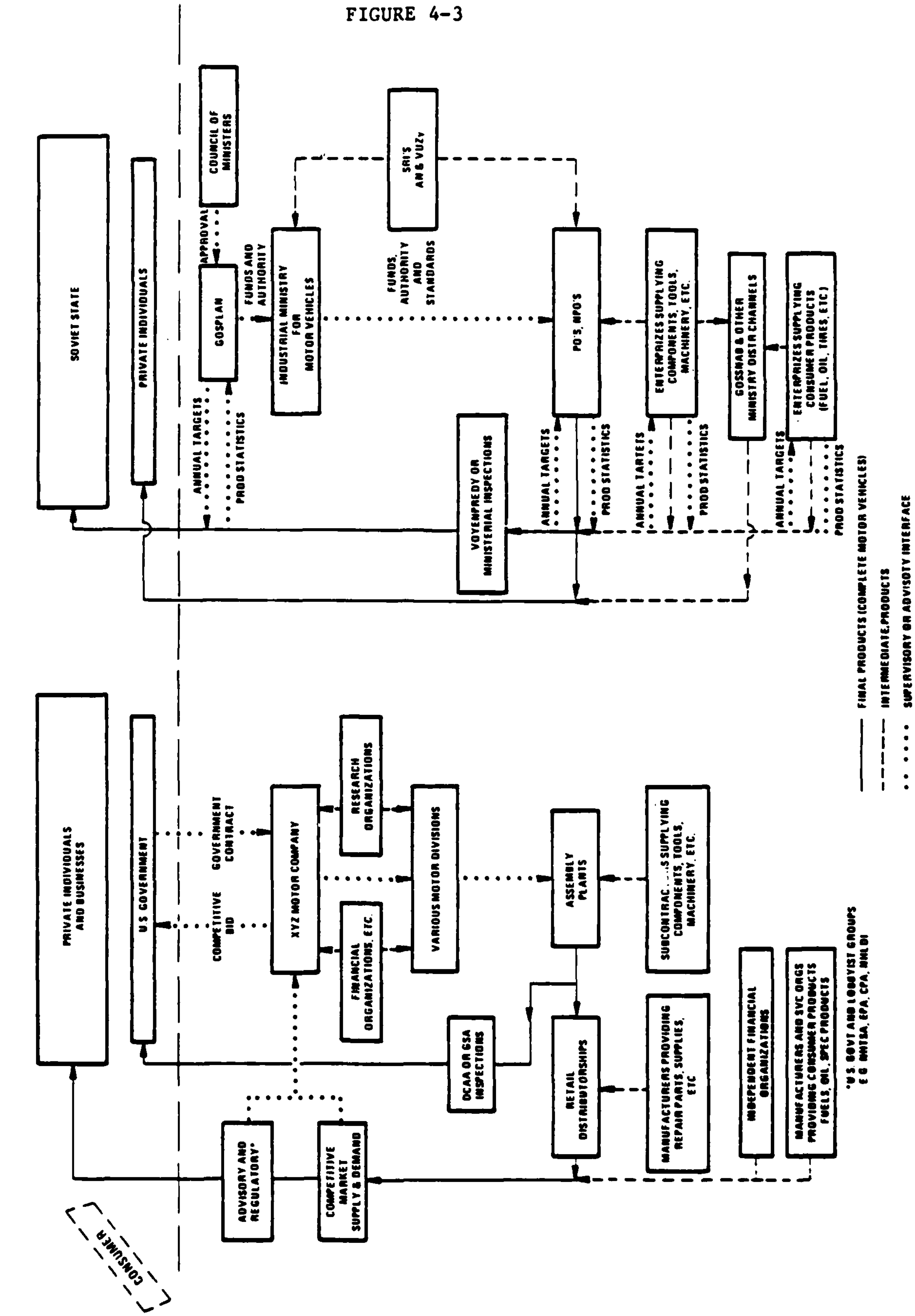


FIGURE 4-4

SOVIET ORGANIZATION FOR R&D
(Simplified)

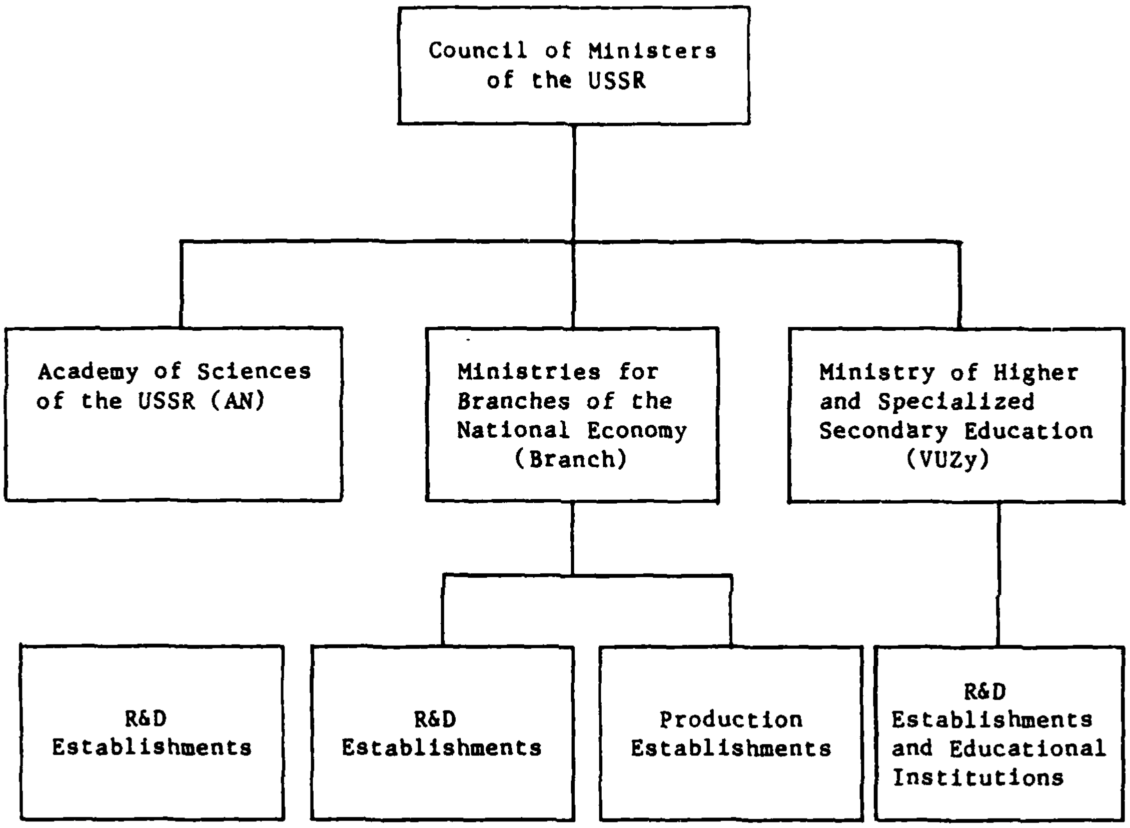
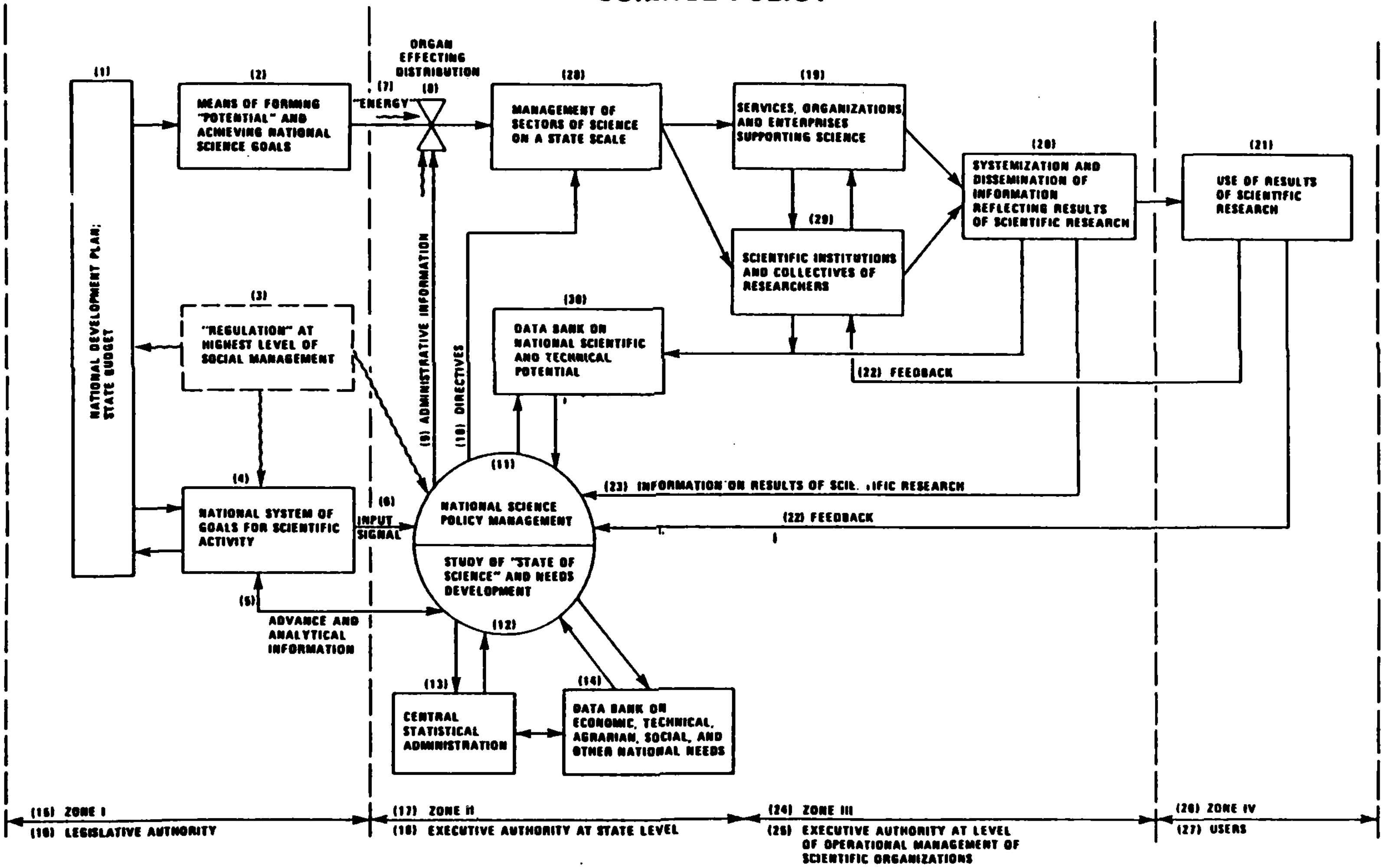


FIGURE 4-5

MODEL OF THE MECHANISM OF NATIONAL SCIENCE POLICY



Source: G. M. Dobrov, Science Management, USSR 1971, 26 Nov 1974.

scientific organization in the world, having nearly one-fourth of the world's scientific work force operating within an infrastructure of more than 5000 scientific institutions.[20] The major Ministries associated with military-space R&D and production are as shown on Table 4-2.[21] The interconnection between military requirements (i.e., from the MOD) and the Industrial Ministries is probably via the Military Industrial Commission (VPK) as shown on Figure 4-6.[22]

TOTAL SOVIET R&D MANPOWER

The Soviet TsSU (Central Statistical Administration) publishes annual data on Scientific Workers at the national level[23] as shown in Table 4-3.[24] Due to differences in the basic definitions of scientific workers in the two nations, plus the fact that the US manpower numbers contain both full-time and part-time employees, a conversion must be made in order to compare the Soviet numbers against US National Science Foundation (NSF)[25] and Bureau of Labor (BLS) manpower statistics. Feshbach[26] cites three primary computational methods which have been used over the years: Davies-Berry (1968), Bronson (1973), and Campbell (1976 and 1979). Feshbach revised the previous computations and presented the data reflected on Table 4-4 for comparison against US NSF and BLS manpower data. The major differences in Feshbach's calculation is in the removal of scientific manpower involved in Social Sciences and Humanities.[27] Appendix C provides a worksheet[28] for Feshbach's computation of Soviet Direct R&D Personnel, a completed worksheet for 1970, and a set of notes which explain his rationale for partitioning of research manpower. It is to be noted that the completed worksheet for 1970 agrees with the 1970 data on Table 4-3 and on Figure 2-12 (Chapter 2). Annual increments of S&E graduates continued to grow throughout the

TABLE 4-2

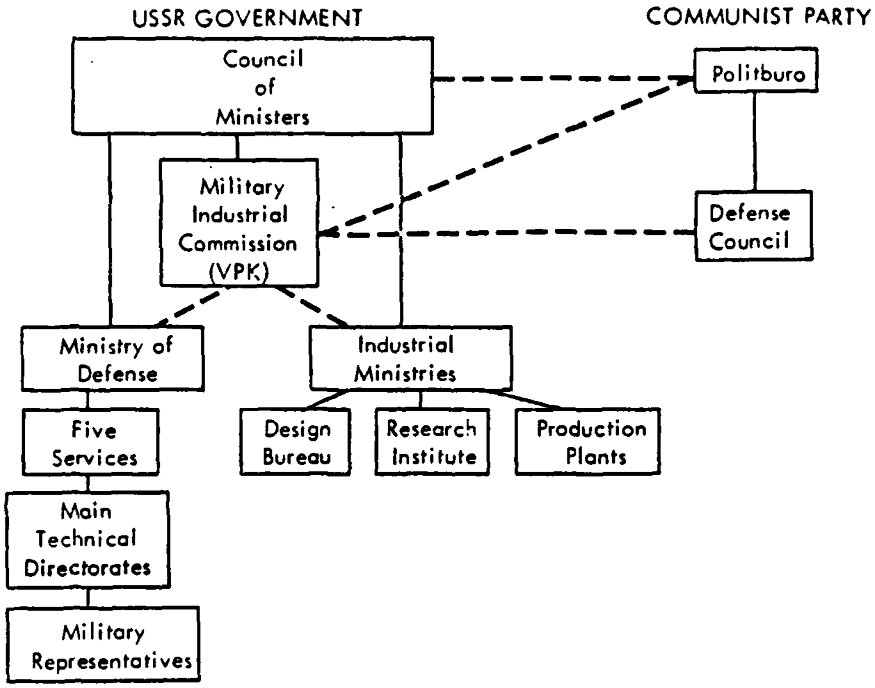
MAJOR MINISTRIES INVOLVED IN
MILITARY-SPACE RESEARCH AND PRODUCTION

MINISTRY	PRODUCT
General Machine Building	Rockets and Space Hardware
Machine Building	Munitions
Shipbuilding Industry	Ships, Landing Craft, etc.
Aviation Industry	Aircraft anad Helicopters
Defense Industry	Conventional Armaments
Radio Industry	Radios
Communication Equip Industry	Commnications
Medium Machine Building	Nuclear Devices
Electronic Industry	Radars
Chemical Industry	Rocket Fuel, Chemical Warfare Items

Source: Scott and Scott, The Armed Forces of the USSR, Boulder, Co., Westview Press, 1979, p. 295 (R-10-16), modified by author.

FIGURE 4-6

INTERRELATIONSHIPS - MILITARY USER AND INDUSTRIAL MINISTRIES



------- Direct Lines of Subordination

- - - - Interaction and coordination

Source: O'Brien, "Generation of Weapon Requirements in the Soviet Ground Forces", Army RDA, Jan-Feb 80, p 20.

TABLE 4-3

SCIENTIFIC WORKERS BY PLACE OF WORK 1970-1979
(In Thousands)

	Branch Scientific Institutions & Enterprizes	Academy of Sciences	VUZy	Total Number of Scientific Workers
1970	493.0	85.9	348.8	927.7
1971	545.8	90.4	366.7	1002.9
1972	582.6	94.6	378.8	1056.0
1973	617.1	97.0	394.4	1108.5
1974	658.5	100.4	410.8	1169.7
1975	690.1	105.5	427.8	1223.4
1976	704.3	107.7	441.5	1253.5
1977	708.7	111.7	459.2*	1279.6
1978	722.2	114.2	477.6*	1314.0
1979	726.0	117.6*	496.7*	1340.3
Man-years	6448.3	1025.0	4202.3	11,675.6
% Change 1970-79	47.3	36.9	42.4	

*Estimate

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Series P-65, Nr. 76, Wash DC, Dept of Commerce, Jun 81, Table 14, p. 19 (From the original Soviet published data.)

TABLE 4-4

FESHBACH'S COMPUTATION OF S&E'S EMPLOYED IN R&D IN THE USSR 1970-1979
(In Thousands)

Year	Adjusted Scientific Workers Less Specialists in the Social Sciences and Humanities	Adjusted Scientific Workers Less Specialists in the Humanities Alone
1970	590.8	661.9
1971	638.9	716.1
1972	672.7	754.0
1973	706.1	791.5
1974	745.1	835.2
1975	779.3	873.5
1976	798.5	895.0
1977	815.1	913.6
1978	837.0	938.2
1979	853.8	957.0

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Series P-95, Nr. 76, Wash DC, Dept of Commerce, Jun 81, Table 34, p. 44.

period as reflected in Figure 4-7. While the annual increment of total graduates is larger for the US, the USSR produced more than double the amount of graduates in the combined science and engineering fields.

ALLOCATION OF SOVIET R&D MANPOWER TO THE MILITARY-SPACE SECTOR

The author chose to use Nolting and Feshbach's data[29] as a starting point for calculation of the S&E manpower applied to the Soviet Military-Space efforts. The results are presented in Figure 4-8.

The mechanics of the allocation process for 1970, 1975, and 1979 are located in Appendix D. The suballocation of S&E manpower located in the Branch Ministries and Industrial Enterprises is based upon a wide range of sources which have resolved to a range of 48 to 64%.[30] The suballocation of 25% of the Academy of Sciences S&E to the military space effort may seem high but one must remember the close ties between the GOSPLAN, the GKNT and the AN.[31] The suballocation of VUZy S&E manpower follows the same rationale as that for the AN except that an upper bound is utilized. This is based upon the fact that VUZy supports the R&D manpower allocation dictated by the FYP (see Figure 4-9)[32] and receives contract research funds primarily through the Ministrial System.

The numbers of full-time graduate students were deleted since Feshbach computed these only to compare with NSF data (i.e., they are excluded from the Soviet definition of "scientific workers").

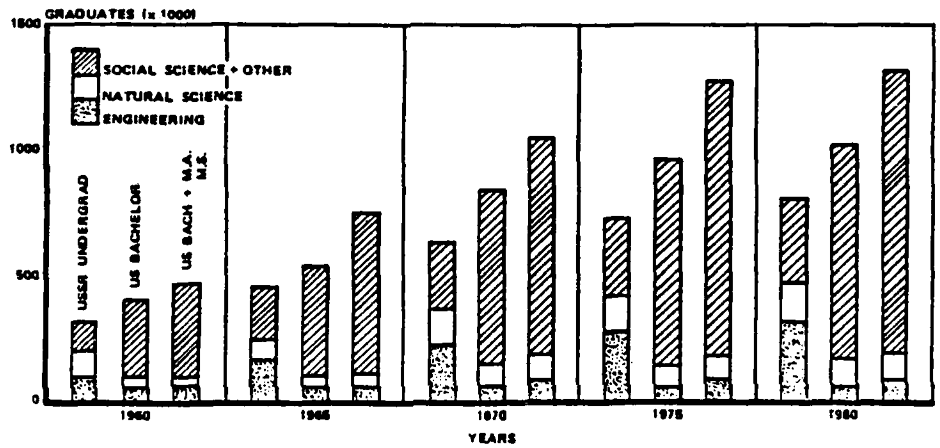
Feshbach's downward adjustment for "titleholders"[33] was also deleted since it is expected that a comparable percentage of "titleholders" will show up within the US S&E manpower calculation.

The number of "Voyenpredy"[34] assigned to research organizations were added to Feshbach's calculation since (the bulk of) these personnel

FIGURE 4-7

US/USSR NATURAL SCIENCE, ENGINEERING, SOCIAL SCIENCE GRADUATES -

1960, 1965, 1970, 1975, 1980*



* Natural sciences are medical, biological, physics, and mathematics.

**1980 USSR - Estimate based on 1978/79 statistics

Source: M. Papirtis et. al., Soviet Professional, Scientific and Technical Manpower, FTD USAF (for DIA), 22 Sep 81, p 3.

FIGURE 4-8

S&E'S EMPLOYED IN THE SOVIET MILITARY - SPACE SECTOR 1970 - 1979

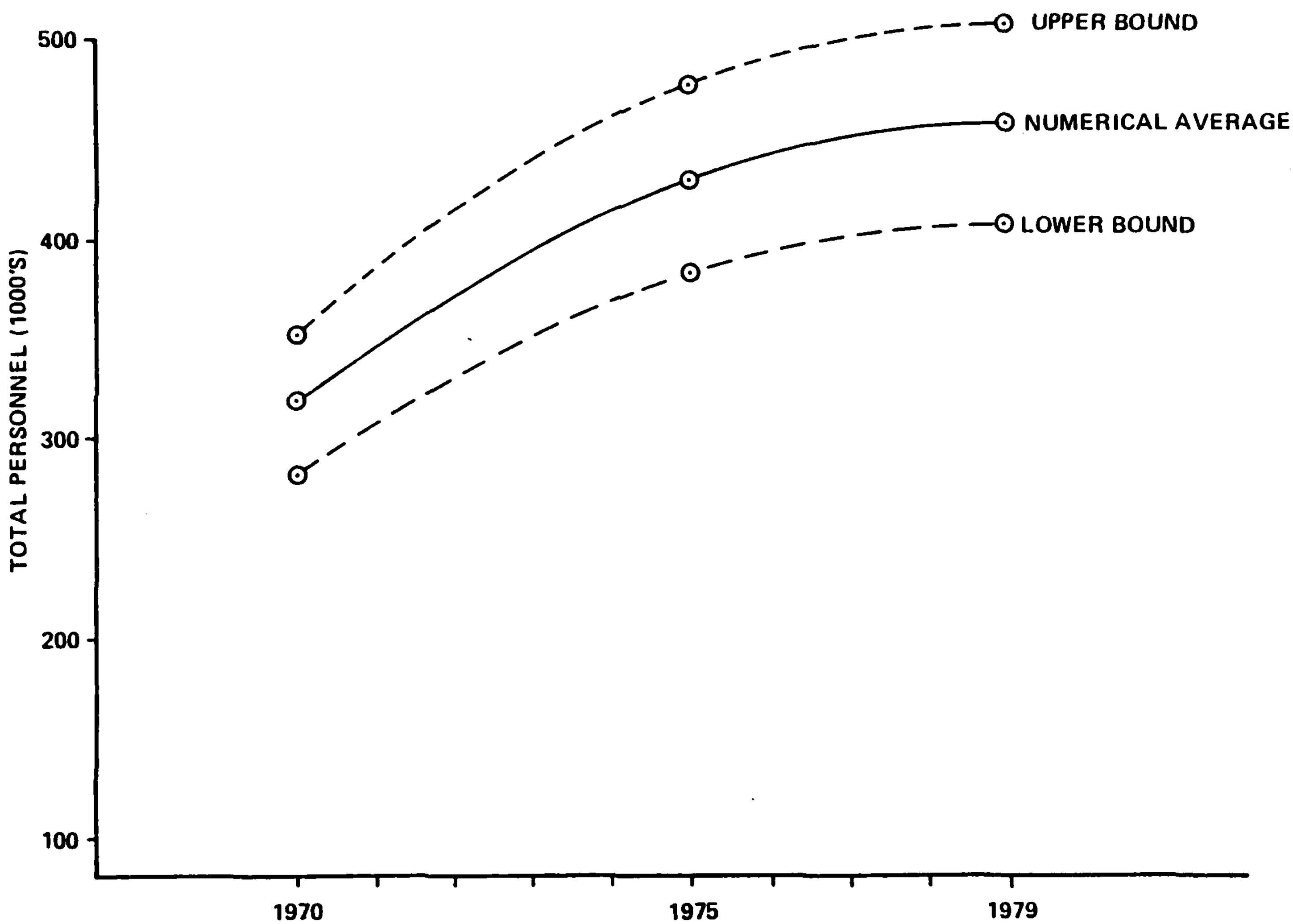
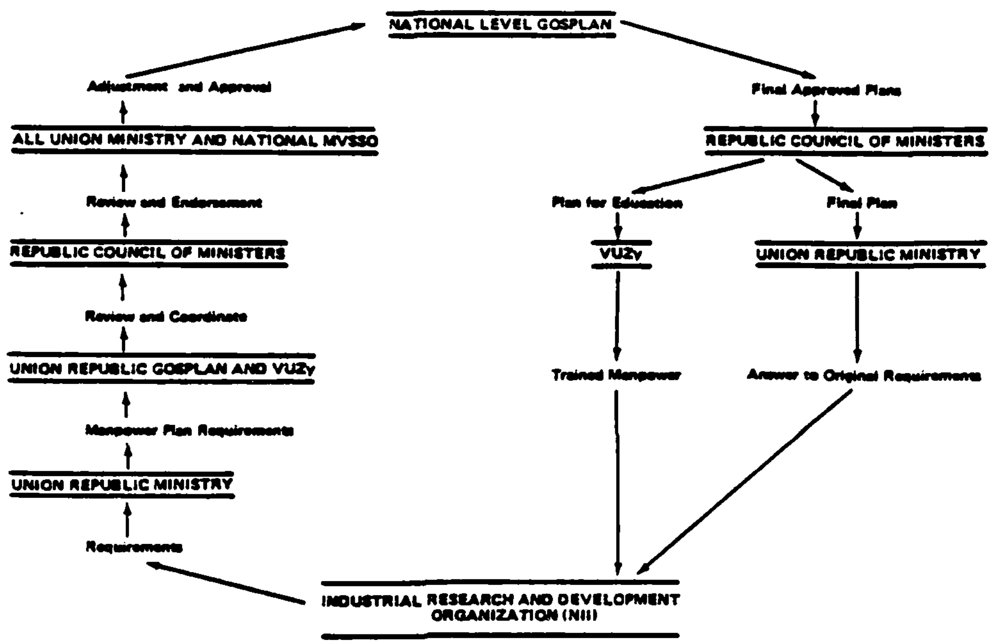


FIGURE 4-9

MANPOWER PLANNING CYCLE



Source: M. Papirtis et. al., Soviet Professional, Scientific and Technical Manpower, FTD USAF (for DIA), 22 Sep 81, p 10.

would show up in the US S&E manpower calculation (if the US military had such a program).

The total numbers reflected on Figure 4-8 are bounded rather than finite (even though the TsSU provides precise numbers in a wide variety of detail), mainly because of the lack of information (at least in the unclassified sources) relating to the size and numbers of the research institutes assigned to the major Industrial Ministries responsible for Weapon and Space Hardware Research Activities.[35]

UNIQUE ENHANCERS AND DETRACTORS OF SOVIET MILITARY-SPACE RESEARCH SECTOR

Referring back to Figure 4-1, the four attributes which were chosen for comparison were:

Control of Priorities

Control of Resources

Control of Adversary Conditions

Control of Production

Only the first three are of direct interest in comparative R&D analyses.

Control of Priorities

Beginning with the First FYP (1928-1932), Military Industry was assigned to Group A (top priority)[36] and this priority continues today. Centralized Planning (especially with heavy representation by the military in the CPSU, the Council of Ministers, and the various Industrial Ministries[37]) tends to insure that military research and development, continues to receive considerable priority over the consumer sector. Priority is extended to funding, technical manpower, critical materials, and critical (or unique) test facilities, laboratory facilities, etc. Medvedev cites the 1951 Soviet decree which stratified

Soviet Research priorities as reflected in Figure 4-10. For comparison purposes, a set of salary ranges are also provided on Figure 4-10. In order for the Soviet military space sector to conduct detailed planning (and thus maintain priority for this Sector) the author will later argue that portions of the scientific manpower deleted by Nolting and Feshbach must be added back in.

A second facet of control of priorities (which is often found elsewhere in other analyses) is the basic weapons system design philosophy pursued by the Soviets.

Soviet weapons design philosophy concentrates (by edict) upon simplicity, ruggedness, and low cost[38] ahead of advanced technology. An additional unique feature is that the Soviets tend to design military equipment toward maximum efficiency/cost effectiveness goals. As an example, the T-72 Tank design achieved a low silhouette primarily by limiting the maximum height of tank drivers to 5 ft. 6 inches.[39] LTG Aaron (Deputy Director of the DIA) testified to the JEC that the Cardinal Rules for Soviet Design and Development (of weapons systems) are:[40]

Off-the-shelf hardware

Proven technologies

New subsystems only as exceptions

Simple operation and repair

Reduce risk and development time

Innovations

In that same testimony LTG Aaron made the following illustrating anecdote:

> I remember one that they showed me (a gadget) in connection with a radar that had a friction wheel with a string, you turn the

FIGURE 4-10

STRATIFICATION OF SOVIET RESEARCH PRIORITIES AND CORRESPONDING WAGE RATES (1972)

CATEGORY I Research Institute (RI)

o Top priority for imported equipment, test equipment, new buildings, filling of staff vacancies, etc.	All military and classified scientific work; all Academy of Sciences research organizations.
o Enhanced personnel salaries.	

Category II RI

o Second priority for imported equipment, etc. (As above)	Institutes of Republic Academy of Sciences; Institutes of Academy of Medical Sciences, etc.
o Medium personnel salaries.	

Category III RI

o Lowest priority for imported equipment, etc. (As above)	All others.
o Lowest personnel salaries.	

EXAMPLE MONTHLY PERSONNEL SALARIES

Junior Scientific Worker (with Academic Degree)	
In Category I - RI	200 Rubles
Senior Scientific Worker (with Candidate of Sciences Degree)	
In Category I - RI	300
In Category II - RI	240
In Category III - RI	190
Senior Scientific Worker (with Doctor of Science)	
In Category I - RI	400

Source: Stratification: Zhores Medvedev, Soviet Science, New York, Norton & Co., 1978, pg. 69. (RSIC Q127.R9); Salary Data: U. Kruze-Vaucienne et al, Soviet Science and Technology, Washington, D.C., George Washington Univ., 1977 Table VI-2.

> little crank and the string would turn the friction wheel, and it would turn another gadget. I often thought if we gave that problem to industry, we would end up with a $200 servomechanism to turn that same wheel.[41]

There are numerous similar examples in the literature which indicate that priority is given to proven weapons technology over innovative (and revolutionary) technology. For example, Alexander[42] cites the case of where a detailed comparison was made between a Soviet aircraft engine and a US aircraft engine of about the same vintage and having comparable performance. The Soviet engine had only about 10% of the total number of parts as the US engine and was designed for simplicity and concern for cost. Engine idle was a simple throttle stop (therefore, idling RPM varied with ambient conditions), whereas the US engine had a fixed RPM requirement which necessitated sensors, servomechanisms, etc., all of which added to the complexity and cost. The raw materials cost per pound for the US engine was 2.14 times greater than that of the Soviet engine. Yet, the Soviet engine was (apparently) unusually reliable, requiring only about one-twelfth the maintenance hours per flight hour as the US engine. The estimated total production cost of the Soviet engine was one-third that of the US and life cycle estimates indicated a Soviet advantage of over 50%.

In a statement to the House Armed Services Committee (HASC), February 1977, Battista stated:

> People scoff and laugh at the Foxbat. It has vacuum tube technology in it. That vacuum tube technology and propulsion has carried that aircraft to 110,000 feet in 4 minutes 11.7 seconds, and all the fancy solid state componentry that we've got today can't put us in that envelope. So there is something to be said about old reliable, proven components.[43]

Alexander[44] has made an interesting (and enlightening) comparison of the Soviet T62 Tank and the US M60A1 Tank. The T-62 is less complex in almost every subsystem than its American counterpart. It has a manual transmission and a manual, lever-type steering system whereas the M60A1 has an automatic transmission and power steering. The same 12-cylinder diesel engine or 6-cylinder derivative has been used on almost all Soviet tanks since 1939, and it continues to power the T-62, (which will form the bulk of the tank force well into the 1980's.) The T-62 lacks a rangefinder and possesses only a fraction of the vision devices found in the American tank. The T-62, however, costs perhaps one-third to one-half less than the M60A1 to produce. The only subsystem changed between the T-62 and its predecessoı (the T-55) was the main gun. For decades, all Soviet tank guns had been previously used in towed artillery or ship-board applications until the adoption of the innovative smooth-bore, high-velocity gun on the T-62. This gun is an interesting counter-example to the general Soviet tendency to avoid technological risk. The Soviets began the use of smooth-bore tank gun techiques at least 20 years before any other country. Interestingly, the gun's very high muzzle velocity permitted considerable simplifications in the fire control system. The Soviet tank designers thus accepted technological risk in one subsystem to gain a reduction in complexity and cost elsewhere.

Control of Resources:

That the Soviet State is in firm control of the funds available for research and development is virtually unquestioned. Similarly, the use of buildings (laboratories), test equipment, etc. are controlled by the State since all are State owned. The Director of a Research Organization, in addition to funds, is allocated new construction, materials, etc. in the Annual Plan. Because supplies are allocated in detail, resources are not fungible; a simple ruble budget is not adequate to guarantee the availability of Soviet resources that have not been planned and allocated in advance. Research personnel are similarly allocated. It is difficult for Western observers to understand that the Soviet State is the sole educator and sole employer of professional scientific personnel. According to most sources, scientific personnel working on military-space programs are the "most pampered members of Soviet Society." In addition to extra pay by virtue of belonging to Category I Research Organizations (See Figure 4-10), they also receive special privileges in terms of housing, access to special State stores (for purchase of import goods), special vacation privileges, etc. By the same token, however, they are considerably more restricted in their freedom of fields of scientific inquiry, in their publication rights, etc.

The Soviet State also has complete control of the information base upon which Soviet scientists work.[45] Kruze-Vaucienne[46] provides an excellent description of the operation of the VINITI (the Soviet All-Union Institute of Scientific and Technical Information) which has been described as the largest single producer of scientific and technical abstracts in the world. Some of the more interesting points about the VINITI system include:

1. It receives (annually) 35,000 periodicals in 66 languages from 131 countries.

2. 23,000 state technical libraries are included in the system, employing up to 150,000 employees.

3. It receives all project reports, conference proceedings, computer programs, engineering design documents etc., generated within

the USSR.

4. It acts as the central registry point for all R&D projects, dissertations, etc.

5. All State organizations (but not individuals) have access to the system.[47]

6. Approximately 200 academicians are on selective disemination of abstract translations.

7. VINITI has exchange agreements with the US National Technical Informational Service (NTIS) and with the USAF.

The Soviets tend to heavily criticize the Western information systems for corporate concealment of R&D breakthroughs, duplication of information processing, and failure to establish centralized national information systems. (The reader is referred back to Chapter 1, especially Figure 1-1 and footnote number 15 of Chapter 1.)

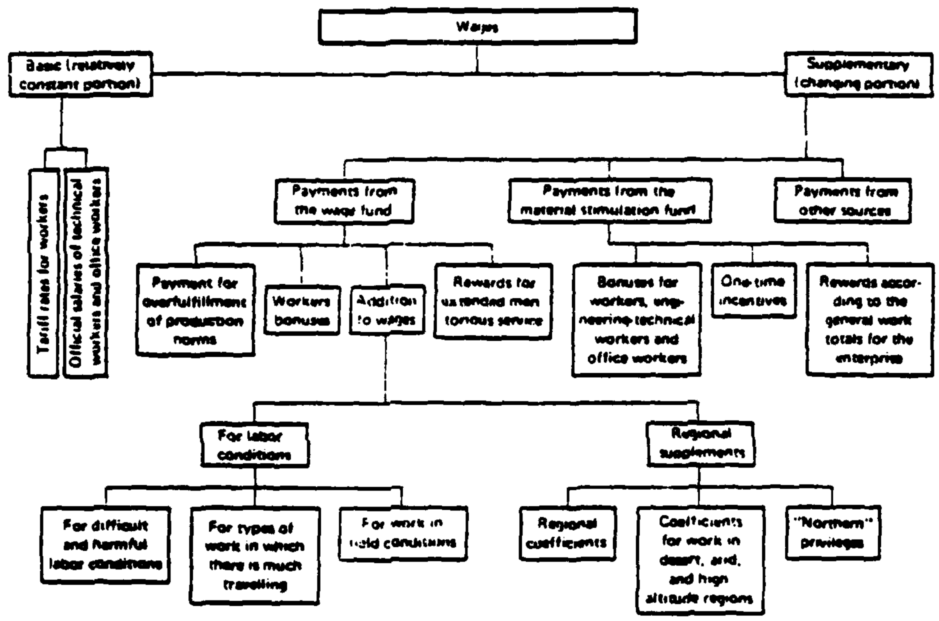
Control of Adversary Conditions:

There is virtually no adversary environment in the USSR such as that which exists in the US (e.g., labor unions, lobbyist groups, open Congressional debate, etc).

On the other hand the USSR has developed a very complex personnel wage incentive system. Krylov[48] depicts the wage incentive system as reflected in Figure 4-11. While Krylov's chart is primarily aimed at the Soviet system as a whole, it provides a flavor of the overall system. Zaleski[49] explains the wage and material incentive system available to Soviet scientific workers in a somewhat different manner. According to Zaleski, the funding incentives are determined by the return that R&D efforts yield to the consumer and the economy. There are three incentive funds available to Research Organizations:

FIGURE 4-11

SOVIET WAGE AND WAGE INCENTIVE SYSTEM



Source: Constantine Krylov, The Soviet Economy, Lexington, MA, Lexington Books, 1979, p 150. (Pentagon Library HC 336.25.K 79)

1. Fund for Material Incentives -- for bonuses to workers according to the annual results achieved by their institutes and for individual achievements.

2. Fund for Social and Cultural Measures and Housing -- for construction and repair of housing, for financing of cultural organizations and services, and for improvement of services furnished to workers.

3. Fund for Development of the Research Organization -- for additional investments for equipment, instruments, and materials relevant to research, and for programs encouraging technical achievements and improving the quality of research.

The three funds are, ultimately, under the control of the Director of the Research organization. Credits not used during one year may be carried over to the following year.

The Fund for Material Incentives and the Fund for Social and Cultural Measures and Housing are supplied from the following sources:

1. Profits generated by lower costs due to the introduction of new technology.

2. Profits anticipated from sales of new products, calculated as an annual economic effect.

3. Costs of prototypes of special equipment and of systems based on world-wide advanced technology, and whose economic effects cannot be determined at the national level.

4. Up to 20% of the wage funds for workers who participate directly in projects concerning environmental protection and technical safety, the economic effect of which cannot be directly estimated.

5. Profits resulting from the sale of equipment.

6. Ministrial reserves funds.

7. Rewards received from centralized funds for the development of new technology.

8. Remuneration for delivery of technical documentation.

Eighty percent of the funds thus obtained remains at the disposal of the research institute while 20% are transferred to central funds for bonuses within the Ministries. Sixty percent of the funds (i.e., of the 80%) are normally deposited into the Material Incentive Fund and 40% into the Fund for Social and Cultural Measures and Housing; however, Directors of research organizations may make equal distributions under certain conditions.

The Fund for the Development of the Research Organization is supplied from a combination of five sources:

1. 1.5% of the annual economic effect (on a national scale) guaranteed by the research organization; this sum cannot exceed 6% of the estimated cost of the work and is authorized only if the estimated cost in turn does not exceed 50% of the value of the economic effect projected by the research organization.

2. 75% of the profits obtained by the research institutes.

3. Returns from sales of licenses at home and abroad and proceeds from the sale of unused equipment.

4. Depreciation charges for complete renewal of fixed funds.

5. Profits obtained from sales of products of the Organization.

The payment of rewards to workers in research organizations who have taken direct part in the work are in proportion to the (estimated) economic effects of their innovative work. These premiums are to be paid regardless of other incentive systems in force. There are two categories of these premiums:

1. For the development and introduction of new techniques.

2. For results from Scientific and Production Activities.

Premium payments made for the first category are determined by fulfillment of work schedules outlined in the scientific-technical plan of the Organization. These premiums are paid after all the work is completed. The total amount of the premium is fixed by the Director of the Organization with the agreement of the Trade Union Committee.

Premiums contained in the Fund for Results from Scientific and Production Activities are paid, according to differentiated criteria, to senior staff member, engineers, technicians, and other employees as follows:

1. The staff members of an institute are paid this premium when the total cycle of work has been completed, i.e., from research to production; other workers receive bonuses after completion of specific projects.

2. Senior staff members are paid for realization of the major indicators (as determined by the superior state agency) for the organization as a whole -- R&D, transfer of technical documentation, design and testing of prototypes, etc.

3. Premiums for engineers, technicians, and other employees are set by the Director of the Organization. Provisions are made for suspension of payments for numerous reasons, e.g., professional errors, bad conduct, absenteeism, errors in accounting, unjustified over-estimating in proposals on price setting, etc.

While this description of the material incentives system has been

AD-A160 866 A MANPOWER BUDGET STRUCTURE SYNERGISM (MBSS) MODEL FOR THE COMPARISON OF..(U) SOUTHEASTERN INST OF TECH HUNTSVILLE AL R D BROWN AUG 83 SBI-AD-E950 748 2/3

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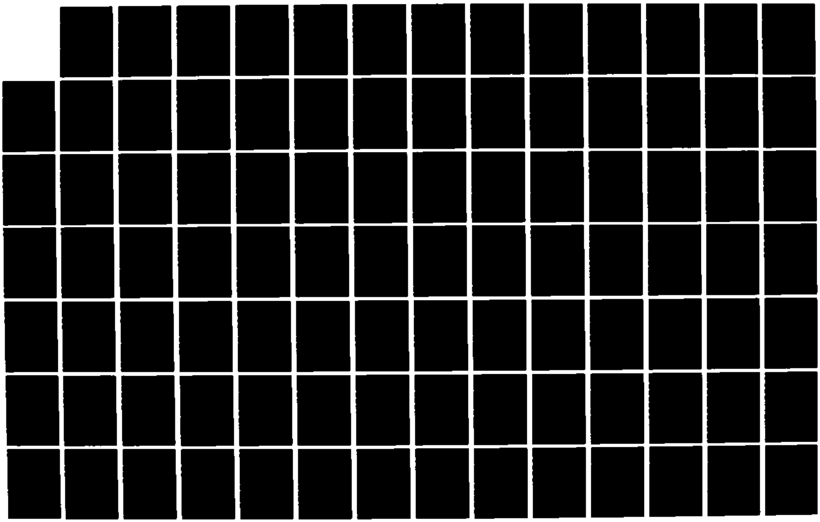
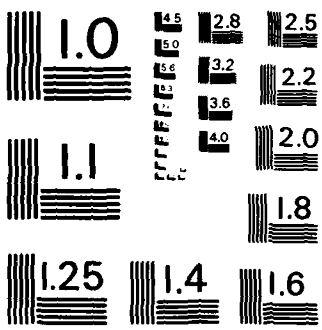



1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

somewhat detailed,[50] it was considered necessary in order to explain the magnitude of control which the Director of a Research Organization has over his employees (and in turn the control which the state has over the Director of the Research Organization). On the other hand, this complex system obviously requires a detailed interface between Research managers, scientists, economists and the like, which in turn has a detractive effect upon Soviet Military-space research.[51]

NOTES FOR CHAPTER 4

[1]The author will repeatedly use the terms "the Soviet State" and the "USSR" interchangeably. "Russia," however, is considered to have ceased to exist in 1917 when the Union of Soviet Socialist Republics came into existence.

[2]According to Websters Unabridged Dictionary (3d Ed), an enigma is "an intentionally obscure statement (e.g., riddle or complex metaphor) that depends for full comprehension on the alertness and ingenuity of the hearer or reader" or "a person that exhibits an incomprehensible mixture of opposed qualities." In the abridged editions, however, an enigma is more or less synonomous with both a riddle and a mystery.

[3]The Soviet penchant for secrecy is deeply ingrained historically and does not appear to be declining. See: Scott, William F. "The Myth of Free Travel in the USSR," Air Force Magazine, March 1983, pp 66-73.

[4]In the mid-1970's, a family of three paid 22 to 44 rubles per month for State housing. The average combined salary (husband and wife) at that was 220 rubles.

[5]This was established by article 40 of the State constitution adopted in 1936. For a complete translation of the 1936 (current today) constitution: see Medish, Vadim, The Soviet Union, Engelwood Cliffs, NJ, Prentice Hall, 1981, pp 333-356.

[6]From the early to mid-1970's, seven million students graduated from the Soviet secondary schools of which approximately one million were selected (by competitive examination) to go on to advanced schools (technical and university level) (Kaiser, Russia, NY, Pocket Books, 1976 p 135). University students receive a stipend during their studies and are assigned to their first job by the State (H. Smith, The Russians, NY, Ballantine Books, 1976, p 253.

[7]In 1977, the number of physicians per 1,000 people in the USSR was 3.5 versus 1.8 in the U.S. (World Military Expenditures and Arms Transfers, 1969-1978, Wash, DC, US Arms Control and Disarmanent Agency, 1980, p. 108). Approximately 70% of the physicians are women (Smith, as above, p 174). There is also a specialized medical channel for the priviliged class (which is known as the "4th Department" at the Ministry of Health).

[8]According to State policy, children should enter nursery schools when they are three months old.

[9]In the mid-1970's, subway fares were 5 Kopecks (Smith, as above p. 90). Private cars are now becoming available to Soviet consumers (for cash), but filling stations and repair facilities are both State owned and few and far between.

[10]For description of Civil Defense and Mobilization Structures see Scott and Scott, pp 241-43.

[11]Military Officers and S&E personnel enjoy special "perks" and considerably more freedom than the average Soviet citizen as will become clear later in this chapter.

[12]The USSR first allowed individual savings accounts (in the State Bank) in 1972. It was reported that by 1974, 80 billion rubles were located in these accounts (Kaiser, as above p 48). Soviet doctrine dictates that when "true communism" is achieved, the requirement for money should entirely disappear (R.G. Kaiser, Russia: the People and the Power, Pocket Books, 1976, p 57).

[13]The Soviet news media, however, often complains of small groups of teenagers (generally referred to as "hooligans") causing vandalism, etc. The media also complains of the "black market," but this is probably more akin to free-lance bartering of used consumer goods and free-lance sale of Western goods smuggled into the USSR by those few individuals who are allowed to travel outside the USSR.

[14]For a listing of other "Hero Projects" and further descriptions of the Soviet methods of providing the necessary labor force, see Soviet Economy in a Time of Change, JEC, Oct 1979, p 5, 164-176. Teenagers fresh out of secondary schools and not going on further are "solicited" to participate heavily in these projects.

[15]See R.G. Kaiser, Russia: The People and the Power, NY, Pocket Books, 1976, p 509-10.

[16]The DoD FYDP changes (often drastically) with each annual edition. The Soviet FYP is prepared in advance of the encompassed time frame by GOSPLAN, approved by the CPSU, and rigidly adhered to throughout the five-year period (even though the targets which were set may not be achieved, or even achievable). The two notable exceptions to this policy were the 3d and 6th FYP's (See Table 4-1).

[17]M. Vilenksky, Technical Progress in the Tenth Five-Year Plan, Translation from Russian), FTD AFSC, Jun 1978 (R-4-20). Vilenksky was not able to relate military-space S&T objectives since they are highly classified.

[18]The Automotive Sector was chosen because the Soviets are relatively free with exchange of information in this sector. This Sector does not include Tank, Armored Personnel Carrier (and similar vehicles) as does the U.S. sector. It must be noted, however, that there is virtually no "consumer pull" (for new products) as there is in the comparable U.S. sector.

[19]This statement is, in general, true although in certain highly specialized areas (e.g., atomic devices) the U.S. Government may be the major (or even the sole) user of the manufactured product.

[20]H. P. Ely, "Impact of the Technology Base on Soviet Weapon Development," Army RDA, May-Jun 1982, p 12. Ely based his statement upon a total number of "scientific workers" in 1977 of 1.3 million which is different than the 800,000 plus reflected on Figure 2-12, Chapter 2,

but his statement is still probably valid. The total number of scientific workers reported by Soviet statistics including both full and part time workers and graduate students approaches the number Ely used. Kruze-Vaucienne reported 5323 Research Institutes in 1976 of which 3620 were within the Ministrial system.

[21]All nine of the ministries listed on Table 4-2 are grouped within the 17-ministry grouping referred to in Soviet statistics as the Machine Building and Metalworking (MBMW) sector of the Soviet economy. See Lee, Estimation of Soviet Defense Expenditures 1955-1975, p 34.

[22]The exact relationship between the Defense Industry Department of the Central Committee of the CPSU, the GKNT, and the VPK is not exactly known but it is theorized that the VPK is involved in the prioritization process which is then reflected in the FYP by the GOSPLAN organization.

[23]The Soviets routinely publish manpower data for Scientific Workers (in general personnel with degrees) and for the Science and Science Services sector (which includes all personnel working for scientific institutions).

[24]This data appears in a number of English language sources including Feshbach, Statistics..., 1981 Campbell, Reference Source... 1978 etc., and is assumed to be valid data and not deliberate "disinformation."

[25]The NSF (as a part of its mission) routinely solicits, collects, and evaluates S&E manpower data from most research organizations (both public and private). They analyze the data from many aspects such as source of funding, demographic structure, geographical location, etc. They publish approximately 20 reports annually for the general information of the public.

[26]A description of each of the methods is contained in Appendix E to Nolting and Feshbach, Statistics on R&D Employment in the USSR, Wash DC Department of Commerce, June 1981.

[27]It is not clear that all of the "economists" should be excluded from the total count of Soviet S&E's. Most U.S. research organizations included in advanced or engineering development employ professional cost analysts who develop life cycle costs for weapons systems which are then used to defend the programs to the U.S. Congress. Under the method chosen in this paper to estimate the U.S. S&E manpower levels, these cost analysts are included. Contracting, accounting, legal, PIO, etc., have (whenever possible), however, been excluded since they have virtually no Soviet counterpart.

[28]The worksheet was devised by the author for purposes of simplicity and clarity. Nolting and Feshbach's description is difficult to follow even after detailed examination of their tables and text.

[29]That is the data listed on column 1 of Table 4-4. This is considered a conservative estimate due to the reduction of economists.

[30] Nimitz, in her 1968 calculation (Table B-3, p 94), estimated 39% of the total Soviet Diploma Level Manpower was dedicated to military hardware alone. This excluded military R&D manpower in the mixed defense-nondefense sectors of the MBMW (such as automotive, shipbuilding, machinery, etc.) and non-MBMW sectors such as construction, facility design, chemical, and power sectors. (Soviet Civil Defense R&D is also excluded.) Estimates of the proportion of military related to consumer related R&D in 1970 was as high as 70% (See: Area Handbook for the Soviet Union, DA PAM 550-95, Wash DC, GPO, 1971, p 601). Further, the growth in production facilities producing primarily military products versus those of primarily consumer products indicates a similar pattern in R&D manpower (i.e., greater than 50% for military related). (See statement bv LTG Aaron, Deputy Director, DIA, to JEC, Allocations, 1978.) The projected growth for machinery output of Defense Ministries during the 11th FYP according to testimony by LTG Williams, Director, DIA, to the JEC, Apr, 1982, (to be published, Allocations 1982, Table 18) was 43.3% versus 34.8% for the total civil ministries. This indicates a relative ratio of 1 to 1.25 ratio in comparable S&E manpower allocation.

[31] A number of social science research institutes are concerned with military strategy especially in the political-military-economic areas. Priority is given to basic technology which has possible military application (Scott and Scott, Armed Forces of the USSR, p 295). The great emphasis placed upon political-ideological indoctrination (which pre-supposes continued research in this area) can be obtained by scanning the Soviet Military Thought Series published by the USAF (now up to 15 volumes).

[32] The GOSPLAN influences the training and distribution of graduates of the VUZy. GOSPLAN establishes admission requirements, and quotas (which allow the schools to admit only a precise number of students per year in each speciality). In effect, the student has been requisitioned to work in a Research Institute of a particular Ministry prior to initiating his/her education.

[33] Feshbach defined "titleholders" as "the number of scientific workers that have advanced degrees and titles but are not actually employed in R&D," (Nolting and Feshbach, Statistics, p 39). He stated that the TsSU estimated the number of these personnel between 0.5 and 1.0 percent of the total scientific workers hence Feshbach used a .74% deduction for all years.

[34] Duties of the "Voyenpredy" (who are military officers assigned by the MOD to Soviet Research Institutes and Production Facilities), include calculation of costs, conducting tests, controlling manufacturing processes, and accepting equipment for the MOD. (See Scott and Scott, The Armed Forces of the USSR, Boulder, CO, Westview Press, 1979, p 297, P 10-16.) It is of interest to note that these officers are generally of equal stature as the head of the facility to which they are assigned, have no material interest in the fulfillment of the facility's portion of the annual or FYP targets, and are liable for court martial if they get caught accepting defective goods. (This is one of the major reasons that the quality of the equipment and materials

provided to the military is much higher than that provided to the consumer sector.) The total number of "Voyenpredy" was estimated based upon the numbers and sizes of the Soviet Research Institutions and upon the fact that officers can spend an entire career in this field and rise as high as Three Star General (US equivalent). (Also, see Heuer, AF Mag, Mar 81 on role of Sov S&T Officers.)

[35]For comparative purposes, Nimitz estimated the Soviet aircraft and missile industry alone (in 1968) employed 97,400 S&E's (Nimitz, p 98). If a rule of thumb estimate that 25% of the US DoD, DoE, NASA R&D effort is expended in the aerospace industry (and a comparable amount was expended in the USSR), then a "ball park" figure of 400,000 S&E's falls above the range of the current estimate (i.e., the estimate is on the conservative side). According to Leitenberg, Malcom Currie (of the OUSDRE) made the following statement before a Congressional Committee: "Ninety percent of the qualified Scientists and Engineers -- by qualified I mean those with graduate degrees comparable to our own -- are devoted to their space and military effort." (M. Leitenberg, USSR Military Expenditures, Footnote 17, p 20.) Dr. Currie later revised that estimate to "between 60 and 70 Percent" (same reference).

[36]Konstantine Krylov, "Soviet Military-Economic Complex," Military Review, Vol 51, Nov 1971, pp 89-97.

[37]By contrast the Executive Branch of the US Government has had firm control over the US military since the 1860's.

[38]Statement of Anthony R. Battista to HASC, Feb 1977 in: Hearings on Military Posture and HR 5068, DoD Auth for Appropriation for FY 78, HASC 95th Congress, 1st Session, Part III, Book 1, Wash, DC, GPO.

[39]By contrast the XM-1 Tank has been human engineered to accommodate nearly every height soldier available to the Army.

[40]Allocation of Resources in the Soviet Union and China - 1978, (Part 4 Soviet Union), Hearings Before the Subcommittee on Priorities and Economy in Government, JEC, 95th Congress, Wash, DC, GPO 1978, p 206. (C-2-8). Note that "innovations" appears last in the listing.

[41]Ibid, p 176.

[42]A.J. Alexander, The Process of Soviet Weapons Design, Rand Paper P-6137, Santa Monica, CA, Rand Corp., March, 1978, pp 7-8 (R-4-62.)

[43]Statement of Anthony R. Battista to HASC, Feb 1977, in Hearings on Military Posture and HR 5068, DoD Auth for Appropriation for FY 78, HASC 95th Congress, 1st Session, Part III, Book 1, Wash, DC, GPO, p 13.

[44]A.J. Alexander, The Process of Soviet Weapons Design, Santa Monica CA, Rand, March 1978, pp 7-10.

[45]More and more US research organizations are beginning to realize that information is a "resource" and that it must be treated as such.

[46]Ursula Kruze-Vaucienne and J. Logsdon, Science and Technology in the Soviet Union, Wash, DC, George Washington University, Jun 1979 (Pentagon Library Q127.R96K78), Chapter VIII.

[47]It is obvious that access to military-space research information is made available only to organizations which are actively included in this type research. It probably operates on a classification and need-to-know system similar to that which is used in the US.

[48]Konstantine Krylov, The Soviet Economy, Lexington, MA, Lexington Books, 1979, p 150. (Pentagon Library HC336.25.K79.)

[49]Eugene Zaleski, "Planning and Financing of Research and Development in the USSR" in Kruze-Vaucienne and Thomas, Soviet Science and Technology, Wash, DC, George Washington Univ, 1977, pp 282-86. (Pentagon Library Q127.R96.571, R-4-42)

[50]The impact of assessing this complex array of incentives may be the total explanation for growth of the economic branch of science in the USSR from 10th to 3rd from 1960 to 1968. (See Varshavskii, Scientific-Technical Revolution and change in Structure of Scientific Personnel in the USSR, Wright Patterson AFB OH, USAF (Translation of Soviet Document), 29 Jan 1975, (NTIS, R-4-52). On the other hand, the combined effect of cost/performance effectiveness and establishing the impact cost effectiveness (to allocate incentive pay) may explain the effect, in which case it may require a reevaluation of Feshbach's reduction of "Social Scientists" which includes "Economists".

[51]Further information on the detractive effect of this incentive system to the Soviet R&D community may be found in: Nolting, The 1968 Reform..., pp 6-7 and in Berliner, The Innovative Decision..., pp 493-500.

Chapter 5

US RESEARCH MANPOWER LEVELS IN THE MILITARY-SPACE SECTOR 1970-1979

INTRODUCTION:

As was noted on Figure 4-1 (Chapter 4), the major differences between the centrally planned economy of the USSR and the US market economy (in regard to R&D) are in control of priorities, control of resources and governmental influence over adversary conditions. The first two are basically competitive in the US system (except in the governmental sector). The existence of adversary conditions in the US which tends to regulate (or leave open for debate) the dedication of resources to the US military space sector are unique to the US system. Due to the existence of a market economy in the US (i.e., prices of everything from materials to manpower are allowed to "float" with supply and demand), detailed centralized national planning and control are not possible.[1]

The wide array of private scientific organizations, labor unions, consumer protection groups, lobbyist organizations, private news media organizations, etc., existent in the US are virtually absent in the USSR. In addition, open debate on national issues, in particular the allocation between national defense expenditures and "Quality of Life"[2] expenditures (i.e., guns versus butter) does not take place in the USSR.

US R&D ORGANIZATIONAL AND BUDGET STRUCTURE

The major differences between the US and USSR R&D structure include:

1. The relative absence of an "Academy of Sciences" system in the US (See Figure 4-4).

2. The absence (in the US) of a cabinet level Department of Education which controls the training and initial assignment of scientific personnel.

While the US does have a "National Academy of Sciences", it is listed as a "quasi-official" agency of the US Government[3] and administers only about 50 million dollars of funds annually. This does not (in any way) compare with the Soviet Academy of Sciences (AN)[4] which administers as high as 10% of the Soviet "Science" Budget (i.e., approximately one billion rubles - See Appendix A) and controls some 250 Research Institutes with a staff of up to 160,000 scientific workers.[5]

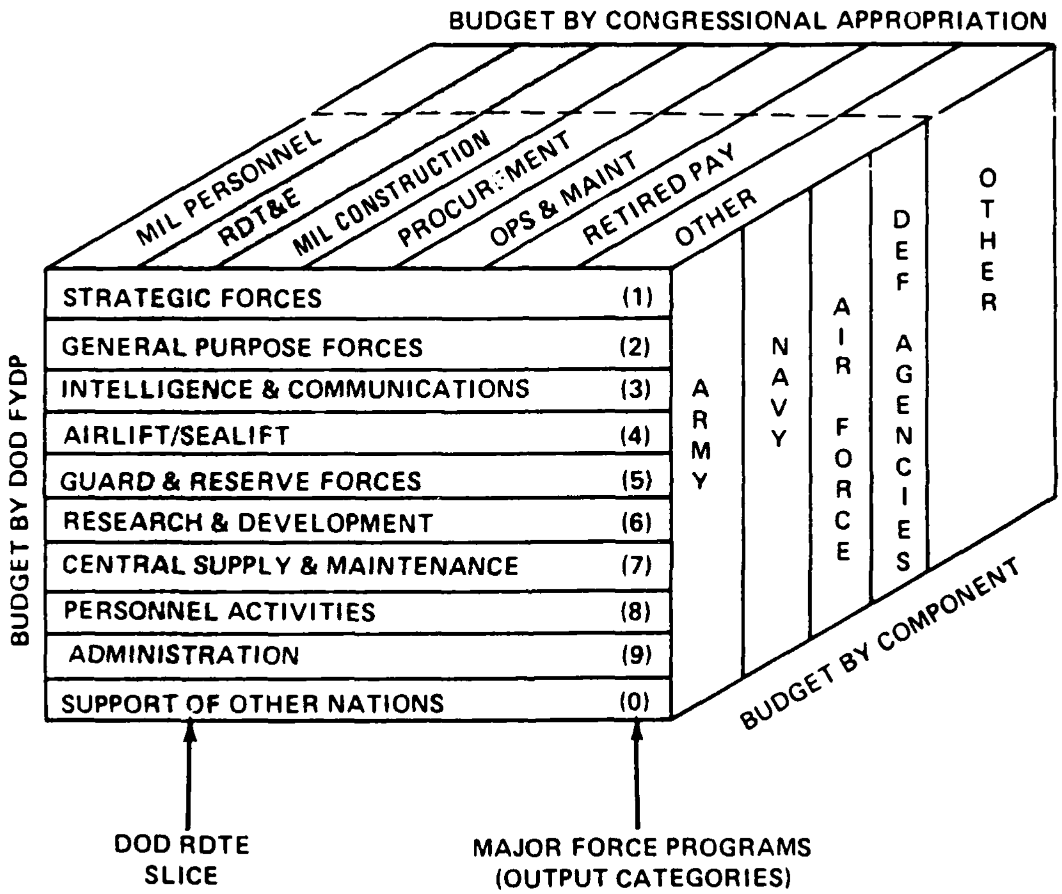
The US market mechanism for supply of S&E personnel, coupled with the state-supported and private college/university systems, do not readily lend themselves to centralized control of scientific manpower.[6]

The U.S. Government Laboratory structure is reasonably comparable with that of the USSR except in magnitude. The bulk of US research and development is conducted by non-government industrial firms (whereas in the USSR nearly all research is conducted by governmental organizations).

Figure 5-1 reflects the relationship of the Department of Defense Five Year Defense Plan (FYDP) to the major US Congressional appropriations process. To the casual observer, the slice under "RDTE" (which crosses the ten categories of DoD programs) should reflect the

FIGURE 5–1

DOD FYDP INTERFACE WITH CONGRESSIONAL APPROPRIATION



total DoD RDTE programs. Unfortunately, this is not true. Figure 5-2 reflects the difference between "apparent" and real DoD RDTE expenditures.[7] The DoD RDTE budget (the slice highlighted on Figure 5-1) does not include R&D expenditures for:

1. R&D for tactical and strategic nuclear weapons, which appears in the Department of Energy RDTE Budget.

2. Construction of major RDTE facilities, which appears in the Military Construction (MILCON) Budget.

3. Military personnel involved in R&D activities, which appears in the Military Personnel Budget.

4. Launch facility R&D in support of military communications satellites and Space Shuttle activities, which appear in the NASA Budget.[8]

The Congressional desire for monetary control of US Defense expenditures has resulted in a series of DoD source documents as reflected in Figure 5-3. A similar (but not identical) set of documents is available for the other programs involved in the US military-space sector. Most (if not all) are available to the general public.[9] Each of the individual line items reflected on the R-1 Computer Printout generally consists of the funds for research and development of a new (or modified) piece of equipment (or new technology area) for the DoD. The structure of the annual report by the SECDEF and the USDRE[10] has varied over the years. The 1982 structure is reflected on Figure 5-3. The Congress has imposed special reporting requirements upon DoD when conducting R&D on high cost programs.[11]

FIGURE 5-2

VIRTUAL VS REAL DOD R&D EXPENDITURES

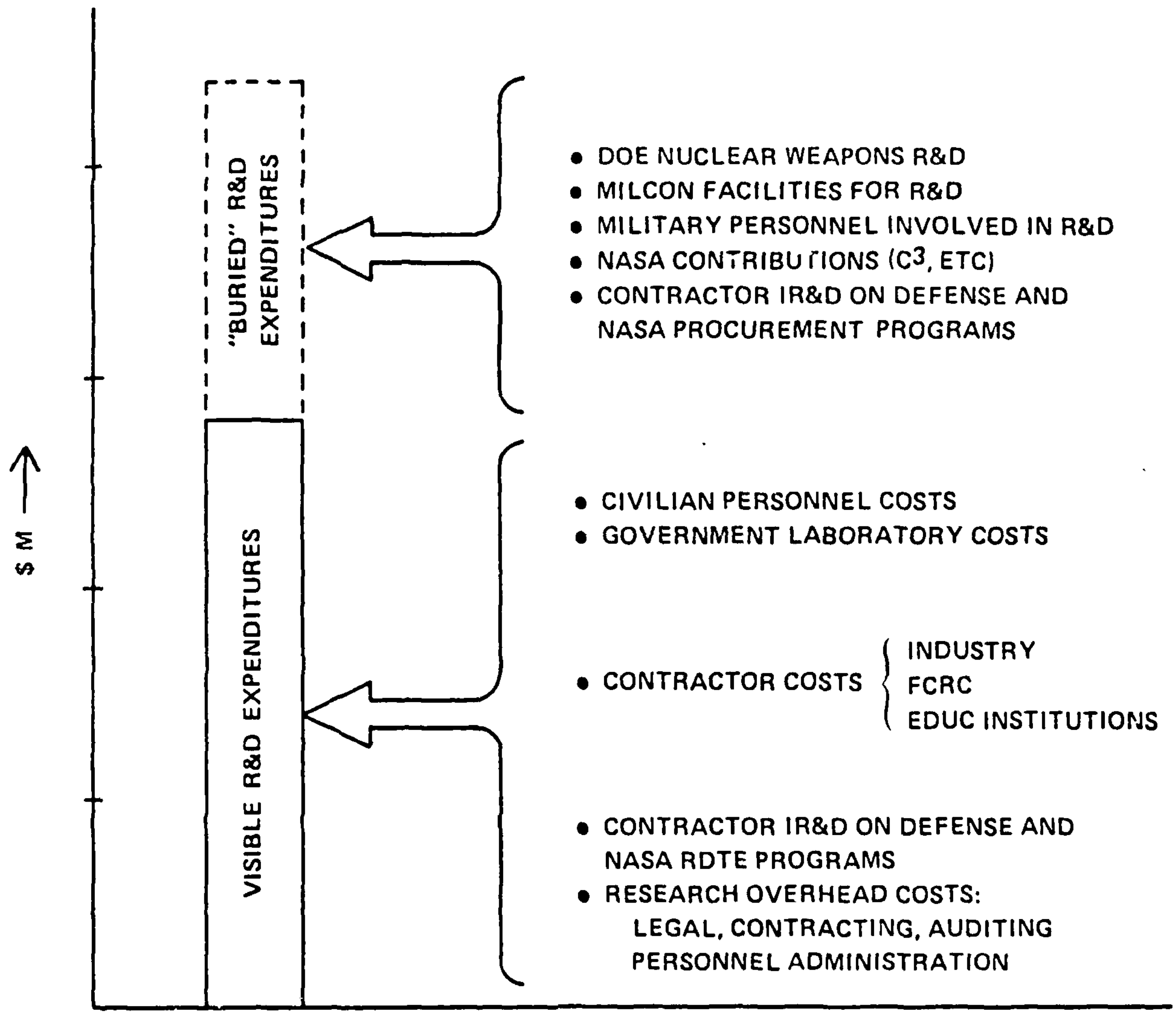


Figure 5-3

SOURCES OF DATA ON US DOD RDTE PROGRAMS

Document	Characterized by
Posture Statements by Weapons System Program Managers to Various Congressional Committees	Voluminous Technical and Programatic Data
"RDTE Programs" (R-1 Computer Printout)	850 Individual Line Items in FY 82
"FY XX DOD Program for RDA"* (Presentation to Congress by USDRE)	Science and Technology (S&T) Basic Research Exploratory Development Advanced Technology Development Strategic Warfare Tactical Warfare Defense wide C^3 I * Defense wide Mission Support
"FY XX DOD Annual Report"* (Presentation to Congress by the SECDEF)	Same as Above
OMB Special Reports	No Uniform Format

* These are annual statements provided to the Congress.

** C^3 I = Command, Control and Communications plus (Defense) Intelligence efforts.

ESTIMATE OF US R&D MANPOWER IN THE MILITARY-SPACE SECTOR

Feshbach provided an estimate of the total US - USSR S&E manpower which was previously presented in Figure 2-12. The National Science Foundation (NSF) and the Bureau of Labor Statistics (BLS), Department of Commerce solicit manpower input data from governmental and industrial sources from which a series of reports (annual, semi-annual and monthly) are published. Unfortunately, neither the NSF nor the BLS are in a "demand" position[12] in relation to manpower data.

The Defense Manpower Commission in 1976 stated:

> Costs of contractor manpower per person and by grade cannot be determined since these data are not fully maintained by the Government. These costs, however, are not particularly important since contractors bid and are hired on a "total job" basis. Contractors, less constrained by prescribed organization and management procedures are challenged by the competitive process to bring efficiencies to each job that drive down the cost of operations. Since contractors will not be used unless their costs to the Government are lower than a comparable Federal operation, they offer the Government a chance to save money, provided the quality and reliability of their work is satisfactory. Further, as new Civil Service retirement and insurance costs have added to the already high costs of Federal manpower, contractors are more likely to bid lower than the Government on a total-job costs basis.[13]

The author made formal inquiries to the Congress regarding the above statement and received replies which (essentially) substantiate the fact that no US governmental agency has an interest[14] in tracking the cost of S&E manpower purchased by the government. Inquiries to the Defense Technical Information Center (DTIC) were similarly non-responsive.[15] The investigator was therefore forced into making an estimate of the number of S&E personnel at contractor facilities funded by military-space programs. Appendix E reflects the method used to make that estimate. In general, two approaches were utilized:

1. Determination of the ratio of direct scientific labor to total cost and

2. Suballocation of available S&E manpower supported by Federal Funding in the major industrial sectors (and then to the military space sector) based upon total R&D expenditures and Federal expenditures in each sector.

The results of that estimate are reflected on Figure 5-4. It is to be noted that the total R&D personnel in the military-space sector probably reached a low point in the 1974-1976 time frame. It is also to be noted that the second method approaches the upper bound determined in the first method. Data from the second method was used as the most likely estimate.

UNIQUE ENHANCERS AND DETRACTORS OF US MILITARY - SPACE RESEARCH SECTOR

The analysis of the US military - space research sector shall follow that applied to the similar Soviet sector namely:[16]

Control of Priorities

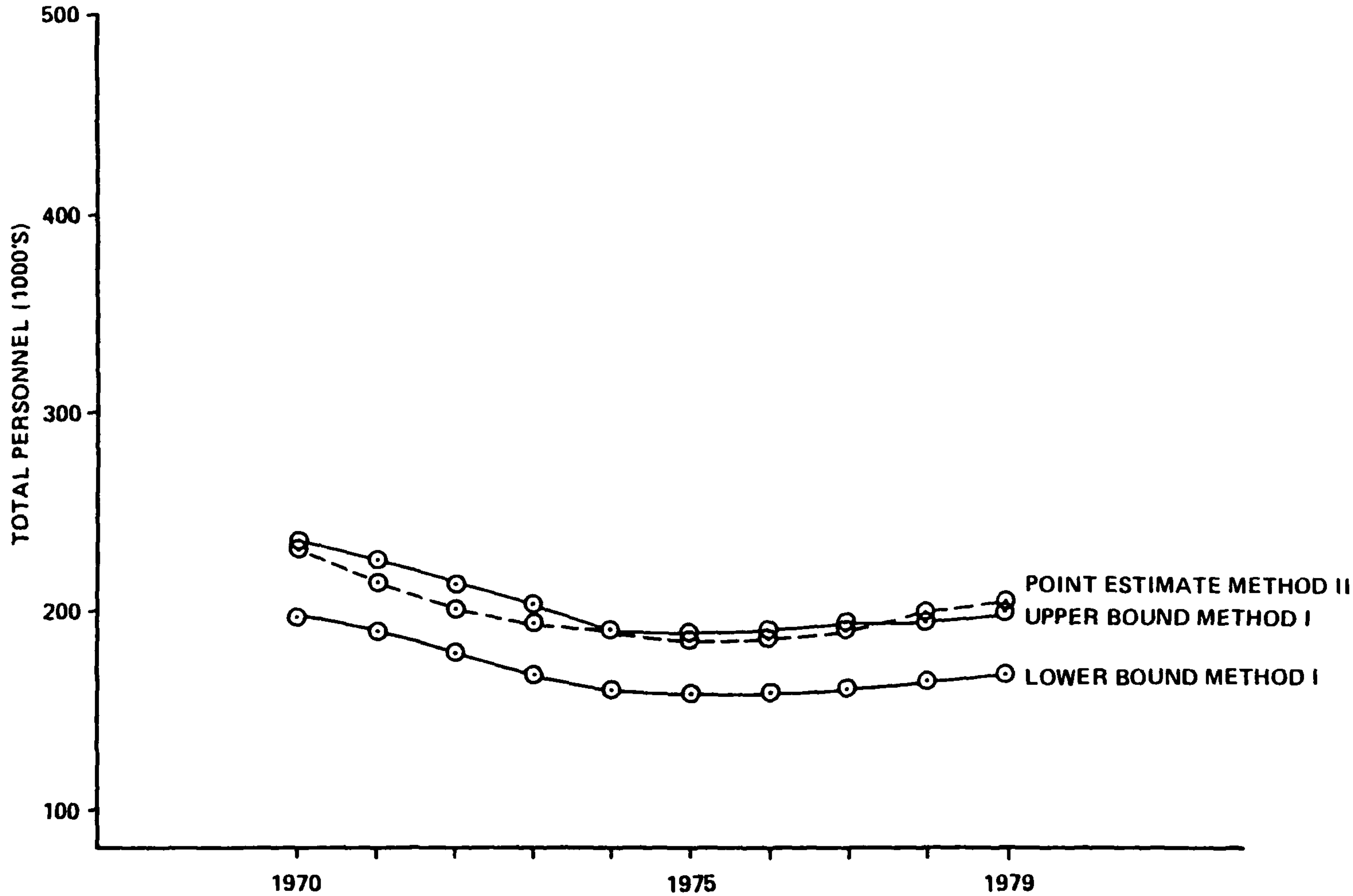
Control of Resources

Control of Adversary Conditions

Control of Production

A hotly debated issue each year in the US is the size and apportionment of the federal Budget for the current fiscal year (CFY) and the budget fiscal year (BFY), the latter being CFY plus 1. The debate starts in earnest each year in January when the President submits his budget to Congress for the fiscal year due to begin 1 October of that year.[17] Numerous committees and subcommittees of the Congress examine in detail the budget proposed by the President. Of paramount

FIGURE 5–4
S&E'S EMPLOYED IN THE US. MILITARY - SPACE SECTOR 1970 - 1979



importance to these various committees is the relative magnitude between "national defense and space" expenditures and "Quality of Life" expenditures. In the research arena, this places programs to develop a new missile or space system in direct competition with cancer research (etc ad infinitum). Numerous Federal Officials are called before Congressional Committees (most of which are open to the public) to testify as to the merits of their proposed expenditures. Often the fate of a particular R&D program (in the forthcoming fiscal year) will hang upon the support of a few key members of the various congressional committees/subcommittees. There has been much controversy in the past few years about the wisdom of the Congress' desire to micromanage various DoD, NASA and DoE programs. As N. Augustine stated:

> I doubt that any company would survive if its Board of Directors got involved into operating matters to the extent that the Army's "Board of Directors" does. The Congress, as with any Board of Directors, plays a very crucial role; but that role is not in day-to-day operations.
>
> Just as a company may have a large number of stockholders, those stockholders can't become involved in carrying out individual tasks within a company.
>
> If the stockholders, through the Board of Directors, are not satisfied with the manner in which those policies and goals are executed, they replace the management with individuals that they believe will perform in a manner which is satisfactory. Now, I realize that Congress understandably and properly gets very frustrated with what has unfortunately been a rather poor record in terms of cost control on the part of military development programs. I suspect that the attitude in Congress is that until the defense industry and the DOD do a better job of managing their activities they are going to help do it for us. It is hard to criticize this feeling ... but as a solution, it ... (is) ... simple, elegant, and wrong.[18]

Augustine went on to say (in response to a question about what changes would improve the R&D management process):

> ... Probably the most important ... is the matter of increasing program stability. An incredible amount of talent, time and

dollars is spent in industry, as it is in government, simply trying to keep programs alive that have already been approved. For example, each year within the Congress there takes place a minimum of 18 notes at a level potentially addressing individual R&D line items. It takes just over 8 years on the average to complete an engineering development program. If you multiply 8 times 18 you obtain the number of individual opportunities for a program to get into funding trouble in the Congress alone. This doesn't include internal reviews within the services, or the office of the Secretary of Defense, or the OMB, or the White House, or ...[19]

Augustine's comment also surfaces the issue of management internal to the US federal research organization. The key research positions (i.e. those positions which are responsible for the formulation of research programs and the subsequent defense of these programs before the Congress) tend to be filled with "political appointees"[20] which in turn tend to have a high turn-over rate. As an example, during the decade of the 70's the position of Secretary of Defense had five incumbents, the Deputy Secretary of Defense five incumbents and the Under Secretary of Defense Research and Engineering four incuments.[21] Approximately the same turnover rate applies to key NASA and DOE research positions. This turn-over rate further enhances the instability in US governmental research programs, particularly upon those in the military-space sector. As key personnel come and go, research programs are turned on and off which heavily impacts the contractor community. There is also the issue of the qualifications of personnel appointed to key federal R&D positions. In 1976, the Defense Manpower Commission (in its report to the President) stated:

Together with the need to sharpen our understanding of civilian control and the role of civilian appointees in the Department of Defense, there is an equal concern for the preparation of people for the positions to which they are called. Since the Department was established in 1947, individual civilians have remained in Defense positions for discouragingly brief periods. Probably in our society, and at the compensation levels that will be acceptable to the Congress, we cannot expect a dramatic improvement in the tenure of appointees. Nevertheless, much more could be done to prepare those appointed.

Where the justification for a civilian position is sound, then the incumbent has an enormous responsibility by any comparison elsewhere in business, law or education. Furthermore, the requirements for performance, often exacting, relate only imperfectly to the previous experiences of the appointee, regardless of what that person might have done. The demands of these Defense offices are unique. Even insofar as they are similar to roles elsewhere, such similarity often can be misleading because of altered legal constraints, Government requirements on accountability, and a unique set of priorities. Familiarity with these different conditions and some anticipation of the impact of these upon the decision process and upon operating methods could improve considerably the initial contributions of appointees.[22]

It has been estimated that the turnover in engineering staffs (California, 1982) has escalated to approximately 25% per year, causing heavily increased personnel training costs and lower aggregate learning/productivity.[23] Table 5-1 presents an overview of occupational mobility of US S&E's during the 1972 to 1978 time frame. While only 22% changed their occupations, 70% of the US S&E's changed jobs.[24] DARCOM, the major development agency of the US Army reported in excess of 20% annual S&E losses in 1976 and as high as 35% in grade GS-12 in 1980.[25]

Table 5-2 provides a comparison of the relative mobility between US scientists employed by the National Academy of Sciences and Soviet scientists employed by their Academy of Sciences (AN). While the AN sample size is small (relative to the total population), the data on Table 5-2 does tend to indicate that Soviet Scientists are nearly twice as likely as US Scientists to spend their entire career in a single institution.

Table 5-1.

OCCUPATIONAL MOBILITY: 1972 S&E's EMPLOYED IN 1978

1972 Occupation	1978 Occupation: Engineers	Computer Specialists	Mathematical Scientists	Physical Scientists	Other Scientists	Administration/ Management	Non Science/ Engineering
Engineers	77.1	1.1	0.1	0.7	.4	15.1	5.5
Computer Specialists	7.2	64.9	1.1	0.5	.9	19.7	5.7
Mathematical Scientists	7.8	6.8	58.4	1.3	2.7	12.5	10.5
Physical Scientists	5.2	1.2	0.3	70.8	4.8	11.3	6.4

Source: Science and Engineering Personnel: A National Overview, NSF 80-316, Wash., D.C., National Science Foundation Jun. 1980 Table B-38.

Table 5-2.

Number of Institutions in Which NAS and AN Scientists Were Employed Throughout Their Career.

Number of Employment Institutions	NAS Scientists (1970) N=470	AN Scientists (1970) N=261
1 Type	15.5	31.0
2 Types	33.8	34.5
3 Types	32.1	23.4
4 Types	13.6	9.2
5 Types	4.9	0.0

Source: L Lubrane and J Berg, "Academy Scientists in the USA and USSR: Background Characteristics, Institutional and Regional Mobility" in Thomas and Kruze-Vaucienne, Soviet Science and Technology, Wash., D.C., George Washington Univ., (for NSF), 1977, p 136. (Pentagon Library Q127 R96 S71, R-4-42)

CONTROL OF RESOURCES

The US research management community (starting with the President and Congress on down to the individual laboratory or small business) tends to have a firm control only over fiscal (monetary) resources. Manpower resources are entirely flexible. Upper limit manpower levels may be established (especially in the Federal Civil Service) but the actual "face versus space" is negotiable between management and individual scientists or engineers. The National Research Council (of the National Academy of Sciences) recommended in 1975 that the Secretary of Labor established a National Center for Manpower Study which would have broad interdepartmental responsibilities for the study of Manpower.[26] Apparently this recommendation was not adopted. In 1976 the Congress passed the National Science and Technology Policy, Organization and Priorities Act.[27] In that Act the Congress (supposedly):

1) Set a national policy of a "sound and healthy" technological structure.

2) Established the position of Director of the Office of Science and Technology Policy (OSTP), who also serves as Science Advisor to the President.

3) Outlined organizational elements for Federal Planning in science and technology, and

4) Declared that scientists, engineers, and technicians are an invaluable national resource to be as fully utilized as possible.

The Act directed OSTP (as one of its tasks) "to encourage the development and maintenance of an adequate scientific and technical manpower data base and to use it to assess the Federal impact on these human resources."[28]

Information (as a resource) is not totally controllable in the US due to strict enforcement of patent conventions, copyrights, proprietary data clauses, etc. Individuals (and companies) are allowed complete freedom of publication within the restrictions imposed by the various National Security Acts. While the US system of open publication (i.e. freedom of publication) is extremely desireable for exchange of information in the basic sciences, it appears dwarfed by the massive information facilities of the VINITI.[29]

CONTROL OF ADVERSARY CONDITIONS

The US military-space research community is strictly policed by an adversary environment, especially the Congress, the news media, lobbyist groups, etc. Labor Unions probably have a minimal impact upon the military-space R&D sector. Even an adversary environment exists between the various government competitors for their share of the Federal budget (e.g. DOD or NASA versus HEW) as noted earlier in this Chapter.

The Congress imposed a limitation upon DOD research in the early 1970's via the "Mansfield Ammendment" which required DOD basic research programs to show clear "military relevance".[30]

In 1975, the Congress imposed a requirement upon DoD to file Selected Acquisition Reports (SAR's) on all "major" military systems with expected multiyear outlays of more than 75 million dollars for RDTE (or more than 300 million dollars for procurement).[31] The Congress also imposed a two million dollar limitation upon Service Secretaries to reprogram funds within the DoD Appropriations without prior approval of four congressional Committees.[32] These and other actions created a definite adversary environment between DoD and the Congress.

Post-audit of DOD and NASA development contracts (and the threat of negative findings) also tends to act as an adversary condition. The Defense Contract Audit Agency (DCAA) has the responsibility for the audit of development contracts managed by DOD.[33]

There are significant segments of the US economy which refuse to compete for military research and development efforts.[34] (This could not happen in the USSR.) As an example, when Chrysler tried (in 1977) to "surge" tank production to replace the tanks shipped to Israel during the Arab-Israeli War, they found that one sole-source supplier of steel castings "preferred to do civilian business"[35] which in turn precluded increased production.

NOTES FOR CHAPTER 5

[1]The one available exception to this is in the control for nuclear weapons, specifically fissionable material.

[2]"Quality of Life" expenditures include such things as medical research, alternate energy source research etc., in addition to those expenditures which deal with economics and social problems. See: The Quality of Life Concept: A Potential New Tool for Decisionmakers, Wash. D.C., Booze-Allen Public Administration Services (for the EPA), March 1973 (NTIS PB 225-089).

[3]See The Government Organizational Manual, published annually by GPO.

[4]The usual abbreviations for the Soviet Academy of Sciences is AN (for AN Nauk-Association for Sciences).

[5]See Kruze-Vaucience and Logsdon, Science and Technology in the Soviet Union, Wash. D.C., George Washington University, June 1979, Chapter III. (Pentagon Library Q1217. R96 K78).

[6]In fact, freedom of academic endeavor is considered to be one of the basic rights of a US citizen.

[7]Investigators often complain about the "buried" R&D expenditures over and above that listed in the official Soviet Defense Budget, but only a few mention that a significant portion of the total US National Defense Expenditures are immediately visible. Many of the defense-related expenditures come under the purview of different Congressional Committees than those which review the traditional DoD Budget.

[8]Portions of these activities are funded by DoD RDTE Programs but in the context of a combined military-space comparison they must be prorated back in order to make a comparison with the Soviet Programs.

[9]The same is not true with the Soviet Budget. It takes, however, a considerable amount of reading to keep up with the US documents. There are various companies and associations which prepare annual analyses of the total impact of proposed and approved programs (e.g., American Academy for the Advancement of Sciences (AAAS), Brookings Institute, etc). The US news media often make generalized projections but they have a poor average on predicting the Congressional decisions regarding the major programs under consideration.

[10]"OUSDRE" is the Office of Under Secretary of Defense for Research and Engineering. This organization was formerly known as ODDR&E (Office of the Director, Defense Research and Engineering) the former position being abolished at the recommendation of the Blue Ribbon Defense Panel in 1970. The incumbent (i.e., the USDRE) plays a key role in formulating and defending research programs for DoD.

[11]The Congress imposed the requirement upon DoD to prepare a Selected Acquisition Report (SAR) for the development (or acquisition) of high cost items. In 1982 the Nunn Amendment required DoD to relate all costs to an FY 81 Baseline.

[12]Unlike that of the Soviet Statistical Administration (TsSU).

[13]Defense Manpower: The Keystone of National Security, Report to the President and the Congress, Washington, D.C., Defense Manpower Commission, Apr. 1976 p 148, Pentagon Library UA 17.5.U5 A34 1976.

[14]The exact statement received from the Congressional Research Service Library of Congress, 15 June 83 (Courtesy of Senator Heflin's Office) was:

> "According to a spokesman in the DoD Office of the Deputy Secretary of Defense for Research and Engineering and a spokesman at the NSF, data on the numbers of scientists and engineers who conducted research and development (R&D) under the DoD obligations from 1970 through 1982 are not available. Currently, these agencies do not collect this type of information."

[15]DTIC possesses an automated system for collection of professional man-years of effort versus funds expanded. The data base is, however, apparently destroyed after three years which made available information of little value to this dissertation.

[16]Once again, control of production has been omitted for this analysis. see Chapter 4.

[17]Prior to 1976, the US fiscal year was from 1 July to 30 June. In 1976 (the FY 77 budget) the fiscal year was changed to 1 October to 30 September. The three month transition period 1 Jul - 30 September - 1976 shows up on many documents as the "197T" budget. The reason for the change was supposedly to allow the Congress more time to make intelligent decisions regarding the appropriation of funds during the budget fiscal year.

[18]"Interview with Former ASA (R&D) Norman Augustine, RDA, Jan.-Feb. 1980 pg. 13.

[19]Ibid, pg. 9.

[20]This is not necessarily a derogatory term. The total number of political appointees as of August 1980 was 1556. A listing of these positions is published every four years (at election time) by the House Committee on Post Office and Civil Service in a book entitled "Policy and Supporting Positions. See "Political Appointments Climb" Federal Times, 4 Mar 1983 pg. 1, 16.

[21]David C. Acker, "The Maturing of the DOD Acquisition Process", Defense Systems Management Review, Summer 1980, pg. 62.

[22]Defense Manpower: The Keystone of National Security, Report to the president and the Congress, Washington, DC, Defense Manpower Commission, April 1976, pg. 436. (Pentagon Library UA 17.5.U5A334 1976)

[23]Wayne Allen, "Causes of Weapons Cost Growth: Three Perspectives", Resource Management Journal, Summer 1982, pg. 6.

[24]Science and Engineering Personnel: A National Overview, NSF 80-316, Washington, D.C., National Science Foundation, June 1980. Table B-38.

[25]The DARCOM Manpower Baseline Requirement - FY 80, Washington, D.C., HQ DARCOM (U.S. Army), Feb. 1981 pg. 69. (A-4-17)

[26]Knowledge and Policy in Manpower: A Study of the Manpower R&D Program in the Dept. of Labor, Washington, DC, National Research Council (of the NAS), Nov. 1975, p 40, (NTIS PB 249 698; NASA N 76-78274) (S-1-2).

[27]Public Law 94-282, 11 May 1976.

[28]Science and Engineering Manpower Forecasting: Its Use in Policymaking, PSAD 79-75, Washington, D.C., General Accounting Office, 27 June 1979, pg. 9. (p-4-1).

[29]See Chapter 4.

[30]W.H. Shapley et al, Research and Development-AAAS Report VI, Washington, DC, American Association for the Advancement of Science, 1981, p 98. (C-1-20).

[31]The Congress and DoD had a running battle in the late 1970's over this Legislation, because the Pentagon failed to designate several multi-billion dollar development programs as "major". Examples included MX missile and base construction (28 billion), TRIDENT missile (27 billion) and Light Armored Vehicles (1.5 billion). See: "Hill Goes After Pentagon Cost Overruns" Washington Post, 7 Aug 1982, p D8.

[32]The four Committees are the Senate Armed Services Committee (SASC), House Armed Services Committee (HASC), Senate Appropriations Committee (SAC), House Appropriations Committee (HAC).

[33]Surprisingly, the General Accounting Office (GAO) has been barred from access to audit information on Defense contracts since the late 1960's. See Mollenhoff, C., "Auditing Defense Contracts: Questionable Integrity" Washington Times, 8 Dec. 1982, p. 11.

[34]This was particularly true in the University Sector in the early 1970's.

[35]Leighton, R.M., "Defense Industry: Uncompetitive, Ill-Prepared" (Review of book by Jacques S. Gansler), Army Magazine, April 1981, p 81. (D-9-1).

Chapter 6

COMPARISON OF US AND SOVIET RESEARCH MANPOWER IN THE MILITARY-SPACE SECTOR 1970-1979

INTRODUCTION:

Estimates of the total numbers of R&D manpower in the Soviet and US Military-Space Sectors have been developed in Chapters 4 and 5 respectively. The raw estimates are presented on Table 6-1 and Figure 6-1. The data indicates that the USSR began the decade by applying 36 percent more scientific manpower assets to the military-space program than the US and ended it by applying 110 to 140 percent more. The data indicates that US research manpower hit a low in about 1975 whereas Soviet manpower has continued to increase throughout the decade. Advancements in the basic sciences cannot be guaranteed by augmenting scientific manyears of effort, but it is probably true that the allocation of additional manpower to a priority project in the applied sciences can assure success even if at a high cost and low efficiency. Korol[1] noted that Soviet efforts were especially outstanding in those fields of applied sciences where the output was directly proportional to scientific manpower input. Similarly, the results of PROJECT HINDSIGHT[2] (a high level U.S. Committee which studied the impact of research on weapons systems placed into production from 1942 to 1965) reported that recognition of technical needs (by the Services) (and thus dedication of scientific manpower to critical technologies) was the key to effective utilization of science and technology (in the military sector).

Table 6-1

Author's Estimates of Research Personnel
Employed by The US and USSR Military-Space Sector

	U.S		USSR	
Year	Range (1)	Point Estimate (2)	Range (3)	Average (4)
1970	200-235	233	286-356	321
1971	190-225	214		
1972	180-215	201		
1973	170-205	197		
1974	160-190	189		
1975	160-190	188	384-481	433
1976	160-190	188		
1977	165-195	194		
1978	165-195	200		
1979	170-200	205	409-511	460

Source: Columns 1 and 2: Table E-21 and Figure E2; Columns 3 and 4 Figure 4-7.

The major U.S. and Soviet military-space Enhancer/Detractor qualities identified in this study are reflected on Figure 6-2, each of which will be discussed and quantified separately.

In general, investigators must be very careful not to confuse overall evaluations of Soviet Science with evaluations on any given sector of Soviet Science. An attribute which may be considered a detractor to overall Soviet science may actually be an enhancer to one of the subordinate fields of Soviet Research. A typical example (applicable to this paper) is that many investigators consider the priority afforded to the Soviet military-space sector is an overall detractor to Soviet Science.[3] Only those Enhancers/Detractors which would affect a military-space research comparison by five percent or more in one or more years during the 1970's have been included. The use of the Manpower Budget Structure Synergism (MBSS) Model and the results of the comparisons are reflected in the final portions of this Chapter.

QUANTIFICATION OF MAJOR ENHANCERS/DETRACTORS

CONTROL OF PRIORITIES

The Soviet system for detailed planning of research efforts is to be admired.[4] As N. Augustine (former Assistant Secretary of Army for R&D) has stated:

> ...speaking from a professional perspective, I would enjoy managing the Soviet Army's R&D budget. It would be a very easy job. In the U.S., tough decisions have to be made day-in and day-out on programs that can't be started. However, in the Soviet Union, they simply start programs...[5]

It is unfortunate that the DoD Five Year Development Plan (FYDP) (and similar NASA and DOE plans) do not possess the same stability as the Soviet Five Year Plan (FYP). The U.S. congressional penchant for

FIGURE 6-2

MAJOR ENHANCERS/DETRACTORS
APPLICABLE TO US AND SOVIET MILITARY-SPACE EFFORTS

ATTRIBUTE	USSR	US
Control of Priorities	+ Detailed Centralized Planning (Enhancer) +	
Control of Resources		- Numerous Program Redirections (Detractor) - - High S&E Personnel Turnover Rate (Detractor) - + Access to Scientific computers, Copying Facilities, etc. (Enhancer) +
Control of Adversary Conditions	- Detailed Personnel Incentives (Detractor) -	

decisions based upon "Pork Barrel" criteria[6] virtually negates the effectiveness of the DOD FYDP as a five year planning tool.[7] The Soviet FYP (and the accompanying Annual S&T Plan) outlines for the Director of a Soviet research organization not only his technical goals but the level (number) of scientific personnel which he can expect to have available, an itemization of new facilities to be constructed, funding and priority for purchase (or allocation) of materials, test equipment, etc., and the amount of flexibility allowed in the pursuit of technical goals. The Organization for Economic Cooperation and Development (OECD), citing Soviet sources states that Soviet planners have reduced the difficulties in planning and forecasting R&D by setting aside a certain amount of time and funds (approximately ten to 15 percent) for "unforeseen projects."[8] Since Soviet weapons design philosophy is so conventional (i.e. low risk), that amount of time and funds is probably adequate.[9]

The overall manpower contribution (i.e. enhanced multiplier effect) of detailed Soviet planning to the Soviet military-space effort is assessed by this author to be approximately ten percent.[10]

A portion of this (4%) compensates for the deletion of scientific manpower in the economic fields during the original computation of Soviet Research personnel in Appendix D. Due to the concentration which Soviet designers place upon cost effectiveness in their designs, this author feels that the scientific manpower required to perform this function must be added back into the total numbers of scientific manpower for Soviet military space. The author's opinion on this point is further reinforced by the existence of a "Department of the Chief Economist" at the Deputy Director Level of Research Institutes in the

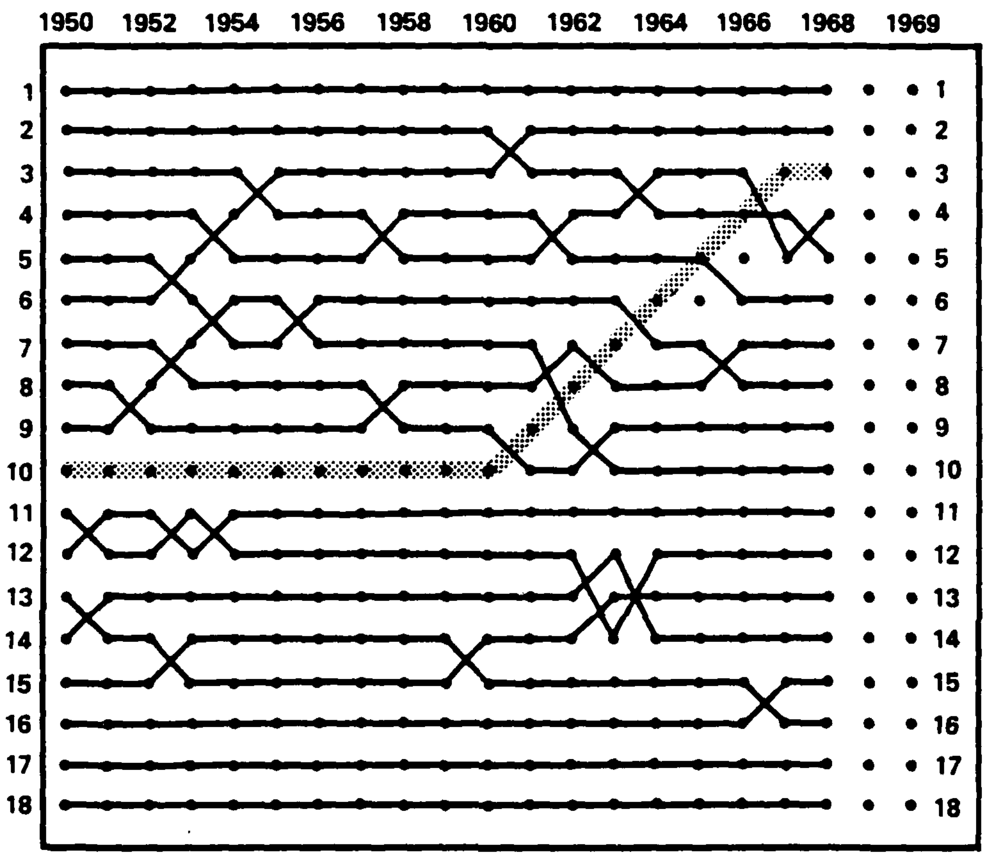
Industrial Ministries (See Figure B-2, Appendix B). The equivalent (U.S.) personnel have been included in the U.S. manpower calculation in the form of staff systems analysts and industrial contractor personnel who concentrate upon design-to-cost, life cycle cost, and similar aspects of the various US research programs. (These personnel appear both in Government Extramural and in Industrial Contractor personnel under direct U.S. scientific manpower.)

An additional four percent has been added to Soviet scientific manpower (once again primarily professional economists) to perform the detailed "up front planning which is eventually reflected in the Soviet Five Year Plan and the annual S&T Plans. The latter percentage was based upon the fact that the number of Doctors of Sciences in "Economics and Planning" was at 5.8% of the total Doctoral-level Scientists in 1965[11] and the fact that the economics field was the fastest growing field in the USSR in the late 1960's (See Figure 6-3). Nolting and Feshbach reduced the number of Soviet Scientific workers by approximately 201,000 (See Appendix C, Figure C-3) in 1970. This author must argue that within the military-space sector, a quantity of approximately 30,000 professional economists, cost analysts and the like must be considered to be performing the functions required by the unique Soviet priority control systems.

In summation, the combined effect of top governmental priority afforded to this sector; the manpower augmentation provided to conduct detailed planning and enforce design control; and the availability of research flexibility results in this particular Enhancer being the largest in magnitude assessed during this research. The combined effect was estimated to be at (or above) ten percent and relatively stable (ie.

FIGURE 6-3

SCIENTIFIC PERSONNEL MIGRATION PATTERNS
(INITIALLY ORDERED BY TOTAL NUMBERS OF PERSONNEL WORKING IN FIELD)



Branches of science (1950):

1- technical
2- medical
3- philological
4- chemical
5- agricultural
6- physicomathematical
7- pedagogical
8- biological
9- historical
10- economic
11- art criticism
12- geological and mineralogical
13- philosophical
14- geographical
15- veterinary
16- juridical
17- architectural
18- pharmaceutical

Source: K.M. Varshavskii, Scientific - Technical Revolution and Change in Structure of Scientific Personnal in the USSR, Translation of Soviet Document, Wright Patterson AFB OH, FTD USAF 29 Jun 75, p 56. (R-4-52).

non-fluctuating) during the decade of the 1970's.

CONTROL OF RESOURCES

The extent of control of resources available to Directors of Soviet research organizations has been covered in the preceding section. In the US military-space sector, however, two major U.S. Detractors and one major Enhancer have been identified:

Detractor - Numerous Program Redirections

Detractor - High turnover rate in Scientific Personnel

Enhancer - Access to Scientific Computers and Copying Facilities.

The large number of start-stop actions in military-space research programs are mainly at the initiation of Congress, although occasionally at the initiation of OSD or the Armed Services.[12] Augustine stated the situation succinctly:

> A great amount of talent, time and dollars is spent in industry as well as government simply trying to keep programs alive that have been previously approved... We pay a great price for this lack of stability. Robert Townsend described the behavior as the tendency to go around pulling up flowers to see if the roots are healthy. If we could achieve better stability... we could obtain a great deal more for our R&D dollars.[13]

A 1982 GAO report expressed the belief that instability has resulted in additional (hardware) unit costs in the neighborhood of ten to 30 percent.[14] The U.S. news media and private authors also have an impact upon program redirections by virtue of their influence on Congress. The permanent loss to the US Military-space sector (in terms of wasted scientific efforts, unusable engineering drawings, repeated justification of previously approved programs and the like) is estimated at three to five percent of the total research program. The mid decade (1975) had the highest number of start-stop actions.

The depth and power of the "political appointee" system upon the U.S. military-space sector must not be underrated. While this system is a necessary part of U.S. policy for civilian control over the military (which the US adopted in the 1860's),[15] it (unfortunately) significantly contributes both to military-space program instability and to increased scientific personnel turnover rates. While (in a loose sense) all key Soviet R&D managers are "political appointees" (since they are appointed by the Soviet State), their long tenure and close affiliation with the Soviet military tend to enhance both program stability and the retention of priority for the Soviet military-space sector.

It is estimated that Directors of U.S. Research Organizations spend up to 20% of their time performing personnel-related activities, much of which is related to personnel turnover.[16] The Soviet counterpart can generally count on having a low turnover rate in both scientific and support personnel and therefore can more fully concentrate his efforts on accomplishment of technical objectives. In turn, the additional benefits provided to Soviet Scientists working in the military-space sector tend to be adequate to maintain the low turnover rate.[17]

The excessive time-requirements placed upon U.S. research managers for personnel-related activity stems primarily from high turn over rates at all tenure levels of S&E personnel. It is estimated that if there is a 25% annual turnover rate (See Chapter 5) and if it takes 30 working days for a new incumbent to become fully competent in a new position (a very optimistic estimate), then there is an annual loss of approximately three percent in direct US S&E effort. Coupled with the loss of managerial time in personnel selection, extraordinary supervision etc., it is estimated that this detractor constituted three to five percent of the available S&E effort, progressing from three percent in 1970 to five percent in 1979.

The single U.S. enhancer of Scientific manpower identified by this investigator was the immediate availability of scientific computers (from hand-held to mainframe), copying machines, and automatic memory typewriters. During the decade of the 1970's availability of these devices steadily increased to the extent that by 1979 most S&E's (in both government and industry) had access to all three types of devices. Many Soviet Sources from the mid 1970's complain about the lack of labor saving devices and make references such as "the office slide rule or abacus", "copying of figures and graphs on tracing paper" and the like.[18] According to Western observers in Moscow, as late as 1981 the availability of photocopying machines (standard office copies ala' Xerox) was virtually non-existent.[19] The total estimated contribution of these devices to the U.S. (mostly in terms of time saved) ranges from one percent at the beginning of the decade to five percent at the end of the decade.

CONTROL OF ADVERSARY CONDITIONS

The detracting effect of the U.S. lack of control of adversary conditions is assumed to have been included in the "Program Redirection" (or "Instability") Detractor. The USSR has (virtually) no internal adversary environment such as that which exists in the US in the form of Labor Unions, Lobbyist Groups, open Congressional debate, etc. In Chapter 4 however, the Soviet system of wage and material incentives was introduced. In order for this complex system to operate, it requires an extraordinary (and time consuming) interface between R&D managers, scientists, economists, and auditors in order to compute such things as "profits generated by lower costs", "costs of systems based on world-wide advanced technology", and similar indicators upon which to base personnel bonuses as well as provide certification of scientific workers. The detractive effect of this complex, burdensome system is estimated to be three to five percent of the total Soviet Research program and is considered to be uniform (approximately four percent) throughout the decade.

OTHER POTENTIAL ENHANCERS/DETRACTORS

There are many other potential enhancers/detractors which have been used by other investigators to compare US-Soviet Research and Development Activities. Table 6-2 Lists the major characteristics of Soviet science (ala Kruze-Vaucienne)[20] with the authors assessment as to the potential enhancer/detractor effort for comparison of US-Soviet military-space research activities. Those not identified in Figure 6-1 have been assessed to not have reached five percent at any time during the decade of the 1970's. The issue of secrecy in Soviet science was not raised by Kruze-Vaucienne. While there are more stringent limitations placed upon open publication in the Soviet science sector than in the US Science sector, the level of secrecy maintained in the two military-space sectors is probably on a par (except possibly for NASA).[21]

USE OF THE MANPOWER BUDGET STRUCTURE SYNERGISM MODEL

Using the annual US and Soviet Manpower data for the military-space sector as reflected in Table 6-1, Enhancer and Detractor Factors (those identified and quantified in the last Section) were applied.[22] Tables 6-3, 6-4, and Figure 6-4 present the time-series manpower levels after

TABLE 6-2

CHARACTERISTICS OF SOVIET SCIENCE

ATTRIBUTE (1)	POTENTIAL AS MILITARY-SPACE ENHANCER/DETRACTOR (2)
Science enjoys high national prestige.	Military-Space Enhancer
As a class, Soviet scientists enjoy social perquisites greater than their Western counterparts.	Military-Space Enhancer
Science is recognized to be a key component military competitiveness by Soviet military leaders.	Military-Space Enhancer
Science is incorporated into Marxist-Leninist ideology as a major contributor to the development of the socialist economy and society.	Not Applicable to Military-Space
As part of a centralized economy, science is state-directed and supported. The scientific establishment is, however, internally fragmented and compartmentalized.	Military-Space tends to be less fragmented.
Scientific programs are developed through an iterative process between a variety of scientific committees, councils, and central government organs and institutions.	Military-Space Control by VPK
The mobility of Military-Space scientists is relatively low, both in terms of Enhancer educational field and work place.	Military-Space Enhancer
The Soviet Union devotes a large and expanding portion of its resources to what is now the largest national scientific organization in the world. The returns of this substantial investment, however, appear to be comparatively less than the return from proportional investments in the West in terms of quality, efficiency, and quantity of finished products. There are unmistakable pressures within the Soviet leadership to improve effectiveness and application of science, and the poor links between science, technology and the economy are acknowledged.	Not Applicable to Military-Space

(Continued Next Page)

TABLE 6-2 (continued)

Non-military science is performed in three often competing sets of organizations: the Academy network, the industrial ministry system, and the university system.	Not Applicable to Military-Space
Basic research is primarily conducted within the Academy network: applied research is mainly the responsibility of the ministry system.	Not Applicable to Military-Space
Soviet higher educational institutions generally carry out less research than their U.S. counterparts.	See Appendix D
Science at universities in the U.S.S.R. seems generally more applied in orientation than at U.S. universities.	Military-Space Enhancer
The Soviet economy, in which science plays an integral part, is centrally planned and hierarchical; science essentially responds to government directives rather than to market forces.	Military-Space Enhancer
Soviet bureaucracy is as pervasive as it is rigid. Soviet scientists in general seem to accept the type of bureaucratic behavior characteristic of centrally-planned economy.	Not Applicable
Soviet science is controlled not only by the government but also by direct oversight of the Party and the KGB. The Party maintains representation in laboratories and research institutes; the KGB controls travel by Soviet scientists,	See Chapter 4 and Appendix B
See Chapter 4 monitors visiting foreign scientists, and censors scientific publications.	See Chapter 4

Source: Column 1: Ursula Kruze-Vaucienne and John Logsdon, Science and Technology in the Soviet Union, Washington University (for NSF) June 1979, p 4. (Pentagon Library Q 127. R96 K78)
Column 2: Authors Assessment.

application of the Enhancer/Detractor Multipliers and the cumulative manpower total for the decade. It is to be noted that the maximum range of the combined US multiplier was only 3% whereas the Soviet combined multiplier remained constant throughout the period (at 1.06). While one may argue over the authors estimates of the magnitude of individual enhancers or detractors, there can be little doubt that differences in the two systems exist (some of which are to the advantage of the Soviet Military-Space Sector and some to the advantage of the US Military-Space Sector) and that a synergism exists between the enhancers and detractors in each nation.

The rate of growth of Soviet Military-Space research manpower was much greater in the 1970-75 time frame (42%) than in the 75-79 time frame (6%).[23] The US data, on the other hand, indicates a low in 1975 with gradual growth up through 1979. The 1979 level, however, was 11% lower than the 1970 level. At first glance one would tend to explain the drop from 1970 to 1975 by S&E salary increases and lower-than inflation increases in the Federal Military-Space Budgets. One must remember, however, that the total US S&E assets also dropped during this period (See Figure 2-12). It is more likely that the Military-Space Sector was still feeling the aftermath of the Vietnam War during this period. Subsequent to 1975 (with additional funding) research manpower in the Sector began to slowly increase. It is to be noted that the cumulative total for the Soviet Military-Space effort is approximately 4.3 million manyears of effort during the decade versus 1.9 million for the US (a factor of 2.3 to one). It was mentioned earlier that a large amount of scientific manpower in a given sector does not guarantee success in basic research but it probably guarantees at least "fair"

TABLE 6-3

SYNERGISTIC ESTIMATE OF US RESEARCH MANPOWER IN THE MILITARY-SPACE SECTOR

Fiscal Year	Raw Manpower Level (1000's)	Enhancer and Detractors D1*	D2*	E1*	Combined Factor	Manpower Level For Comparisons (1000's)
1970	233	0.97	0.97	1.01	0.95	221
1971	214	0.97	0.97	1.01	0.95	203
1972	201	0.97	0.97	1.02	0.96	193
1973	197	0.96	0.96	1.02	0.94	185
1974	189	0.95	0.96	1.03	0.94	178
1975	188	0.95	0.96	1.03	0.94	177
1976	188	0.96	0.96	1.04	0.96	181
1977	194	0.97	0.96	1.04	0.97	188
1978	200	0.97	0.95	1.05	0.97	194
1979	205	0.97	0.95	1.05	0.97	199
TOTAL	-	N/A	N/A	N/A	N/A	1919

*Qualification of Enhancer/Detractors:

D1 = Detractor for "Program Re-Directions"

D2 = Detractor for "S&E Turnover"

E1 = Enhancer for "Computation and Automation"

Sources: Raw Manpower Level Table 6-1; Enhancers and Detractors: See Text.

TABLE 6-4

SYNERGISTIC ESTIMATE OF USSR RESEARCH MANPOWER IN THE MILITARY-SPACE SECTOR

Fiscal Year	Raw Manpower Level (1000's)	Enhancer and Detractors E1*	D1*	Combined Factor	Manpower Level For Comparisons (1000's)
1970	304	1.10	0.96	1.06	322
1971	330	1.10	0.96	1.06	350
1972	356	1.10	0.96	1.06	377
1973	382	1.10	0.96	1.06	405
1974	408	1.10	0.96	1.06	432
1975	433	1.10	0.96	1.06	459
1976	440	1.10	0.96	1.06	466
1977	447	1.10	0.96	1.06	474
1978	454	1.10	0.96	1.06	481
1979	460	1.10	0.96	1.06	487
TOTAL	-	N/A	N/A	N/A	4253

*Qualification of Enhancer/Detractors:

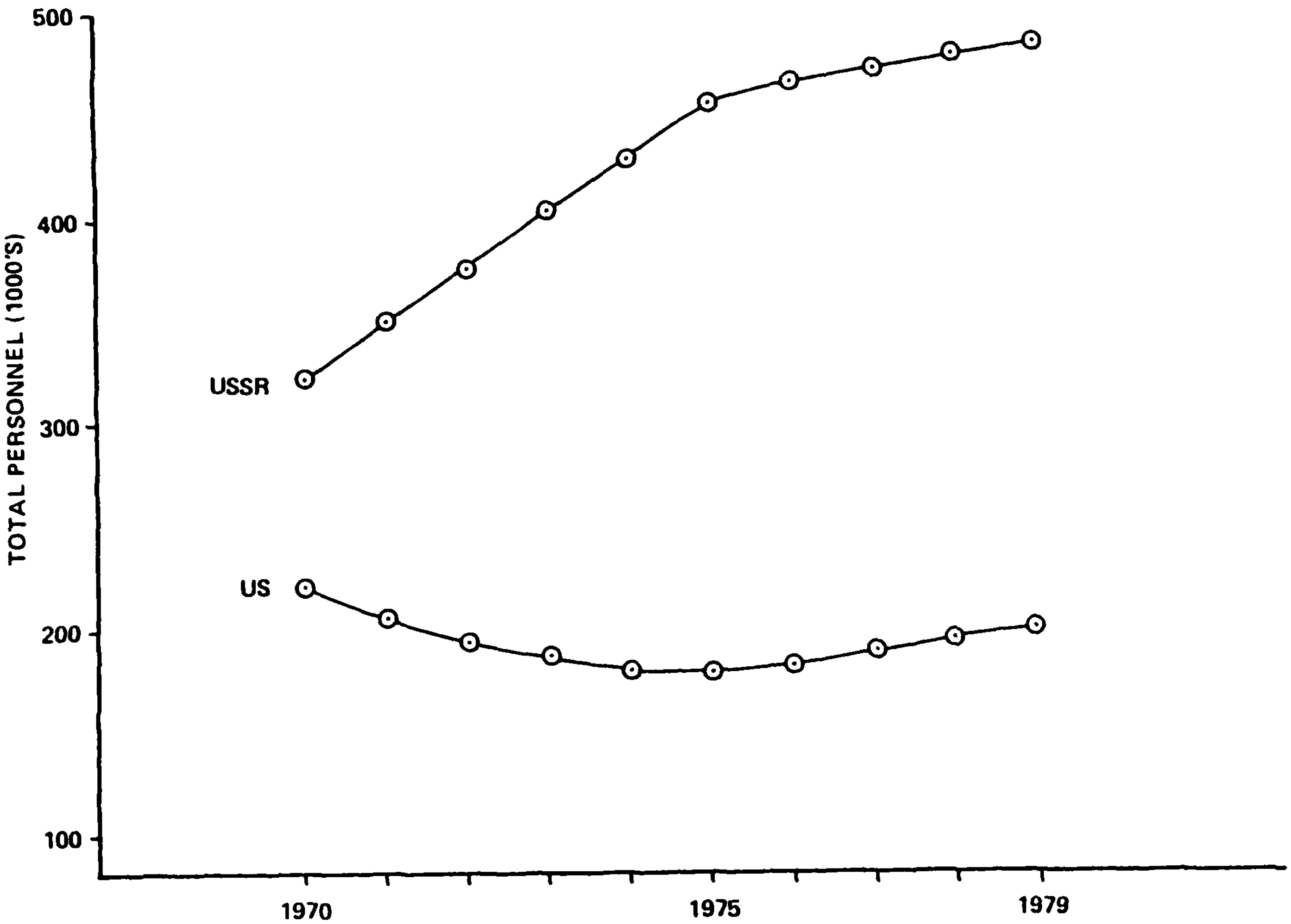
E1 = Enhancer for Priority Control

D1 = Detractor for Excessive Personnel Incentives

Sources: Raw Manpower Level Average from Table 6-1; Enhancers and Detractors: See Text.

FIGURE 6–4

S&E'S EMPLOYED IN THE US AND SOVIET MILITARY – SPACE SECTOR 1970 – 1979
(AFTER ENHANCER/DETRACTOR MULTIPLIERS HAVE BEEN APPLIED)



success in the applied research fields. This, in general, has been borne out by the number of new (high performance) production models of various equipment the Soviets introduced during the 1970's[24] ranging from new tanks, aircraft, and strategic missiles[25] to new space-related hardware.

SUMMARY:

The quantity and structure of research manpower, coupled with an assessment of the synergism of constantly varying nationalistic research organizational structures and policies, has the capability of providing a significantly better method for the comparative assessment of military-space research programs than the previous methods employed. Consider for example, the extreme expenditures ranges reflected on Figure 2-9 Chapter 2. A factor of nearly four exists between the lower and the upper most ruble estimate of the 1975 Soviet military space expenditures. Coupling this wide range with a very difficult (if not impossible) ruble-to-dollar conversion, the problem becomes unmanageable except "at a very high level of aggregation."[26] The method presented in this research paper however, lends itself to lower levels of disaggregation and thus to more finite comparisons.

In addition, the methodology presented in this research paper offers the prospect of an introspective examination of the US military-space program with the ultimate aim of improving our own national research system.

NOTES FOR CHAPTER 6

[1]Alexander G. Korol, Soviet Research and Development, Cambridge MA, MIT Press, 1965. p 233.

[2]See C.W. Chalmers and R.S. Isenson, "Project Hindsight", Science, 23 June 1967, pp 1571-1577.

[3]See for example: U. Kruze-Vaucienne and J. Logsdon, Science and Technology in the Soviet Union, Washington, D.C.. George Washington University, Jun 79, p 4.

[4]This admiration stems from the fact that the Soviets make up their minds to conduct research in a particular field and stick to that decision.

[5]"Interview with Former ASA (R&D) Norman Augustine", Army RDA Magazine, Jan-Feb 80, p 10.

[6]The term "Pork Barrel" generally refers to succuming to the interests of the geographical area (i.e. state) represented by the various legislators rather than making decisions (casting votes) based upon an objective view of the needs of the entire nation.

[7]Senator Denton (R-Alabama) recently stated that more time was spent on the Senate Floor debating "where" the MX should be built than "whether or not it should be built."

[8]E. Zaleski et al, Science Policy in the USSR, Paris, Organization for Economic Cooperation and Development, 1969, p 91.

[9]A further example of conservatism in Soviet weapons design is reflected by the fact that the same 12 cylinder diesel engines (or its 6 cylinder equivalent) has been used on almost all Soviet tanks since 1939. This engine-series powers the Soviet T62 Tank which probably will form the bulk of the Soviet tank force well into the 1980's. See A.J. Alexander, The Process of Soviet Weapons Design, Santa Monica, CA, RAND Corp., March 1978; p 9. (Air Univ. Library M-30352-16-U) (R-4-62)

[10]Authors estimate.

[11]E. Zaleski et al, Science Policy in the USSR, Paris, Organization for Economic Cooperation and Development, 1969. Table 8, pp 148-9.

[12]The Army Attack Helicopter is one example of a Service initiated start-stop sequence. It was terminated in 1975 when 90 to 95% completed. See "Interview with former ASA (R&D) Norm Augustine," Army RDA Magazine, Jan-Feb 1980, p 15.

[13]"Interview with Former ASA (R&D) Norman Augustine", Army RDA Magazine, Jan-Feb 80, pp 9-10. (D-6-7)

[14]Comproller General Letter to SECDEF Weinberger, Wash DC, 24 Jun 1982, Inclosure 1 p 5 (B-202082) (C-6-2)

[15]"Lincoln as CinC", Army Magazine, Sep 79, p 38.

[16]Some private sector managers spend 10-25% of their time administering merit pay alone. See "Federal Merit Pay: Important Concerns Need Attention", Comproller General Report Nr FPCD-81-9, Washington, D.C., GAO, 3 March 1981 p ii. (GAO B-165959, Acc Nr 114595), P-4-9. Also see F.J. West, "Secretaries of Defense: Why Most have failed", Naval War College Review, Mar-Apr 1981; pp 86-92. West presents the following allocation of the Secretary of Defense's time (taken from a 1975 log) versus similar data for Chief Executive Officers in industry prepared by Harvard Business Review:

SECDEF		US CEO's	
Congress	14%	Directors	7%
Cabinet Peers	21	Peers	16
Military	16		
Own Staff	32	Subordinates	48
Press	6	Clients	20
Self	11	Other	8

[17]Those individuals who desire additional academic and publishing freedom not afforded by the Soviet military-space sector tend to migrate to other R&D sectors after their initial post-training assignment (usually three years).

[18]G.M. Dobrov,, Upravlinnya Naukoyu, (Science Management) Moscow 1971 (Edited Translation USAF) pp 381-82. (DTIC AD A 004-346) (R-4-21)

[19]See M Rosenwasser, "Russians Limit Use of Copying Machines" (Byline AP, Moscow), Reprinted Huntsville Times, 28 Sep 1981 p C8. According to Rosenwasser, Soviet workers claim they have to get permission from their supervisor, that persons supervisor, and a representative of the security department in order to copy papers on their jobs. The actual reproduction is accomplished by a fourth individual.

[20]See Ursula Kruze-Vaucienne and John Logsdon, Science and Technology in the Soviet Union, Washington, D.C., George Washington University (from NSF), Jun 79, Chapter 1.

[21]Several disturbing instances have occurred recently, however, whereby classified Department of Defense documents have been deliberately leaked to the US News media. See for Example: G. F. Wilson, "Air Force Eyeing More Missiles?" Washington Post News Service (reprinted in Huntsville Times, Huntsville AL, 2 July 1983, p A1) whereby a Secret level document was supposedly provided to a news reporter by persons unknown. This type of leak is unknown in the USSR since the newspapers etc are State owned.

[22] Enhancers are those with a value greater than 1.0 and detractors are those with a value of less than 1.0.

[23] This generally is consistent with the information (on total Soviet S&E's) presented on Figure 2-12. Through a demographic analysis of the USSR, Feshbach has concluded that the total Soviet Labor Force hit a high in 1975 and will decline to a low point in 1985. See Murray Feshbach, "Population and Labor Force" (Paper 11 of 12), The Soviet Economy to the Year 2000, Washington, D.C., National Council for Soviet and East European Research, 25 Nov 1981, Figure 1, p 19. Based upon the Soviet priority for science, the labor squeeze will probably not affect new entrants into the military-space research sector as much as it will into other sectors of the Soviet economy.

[24] This is further reinforced by the fact that the Soviets placed into production 12 new ICBM/SLBM models during the 1960's and 70's and conducted nearly twice the number of space launches. See C.A. Robinson, "Technology is Key to Strategies Advances, Aviation Week, 14 March 83, p 24, "Score Card for the Space Race, USN&WR 27 April 1981, p 32. and A.J. Alexander, The Process of Soviet Weapons Designs, Santa Monica, CA, RAND Corp., March 1978, p 5. (R-4-62)

[25] See Omaha-World-Herald, 27 Jun 1982 for a quick comparison of actual and projected introduction of new weapons systems:

	US	USSR
Bombers:	B-52 (1955)	Bear (1955)
	FB-111 (1969)	Bison (1955)
		Backfire (1976)
	B1B (1985?)	Black Jack (1985?)
ICBM's	TITAN II (1963)	SS 11 (1966)
	MINUTEMAN (1965)	SS 13 (1969)
	MINUTEMAN (1970)	SS 18 (1974)
		SS 17 (1975)
		SS 19 (1975)
		(4 New ICBM's under development)
SLBM's	POSEIDON (1971)	Yankee (1968)
		Delta (1971)
		Delta II (1976)
		Delta III (1978)
	TRIDENT (1982)	Typhoon (1981)

[26] Note the similarity between this statement and the CIA quotes in Chapter 2.

Chapter 7

SUMMARY AND RECOMMENDATIONS FOR FUTURE STUDIES

SUMMARY:

This research paper has presented a new and unique method for comparing U.S. and Soviet military-space research efforts. It has presented methods for:

1. The allocation of the total nationalistic research programs to the military-space research sector in terms of direct S&E manpower.

2. The adjustments required to compensate for nationalistic differences in research policy and organizational structure.

3. The time-series comparison of S&E research manpower for the military-space activities of the two countries for the years 1970 to 1979.

4. The comparison of cumulative S&E research manpower devoted to each of the military-space sectors during the decade of the 1970's.

The techniques developed in this research paper offer the following distinct advantages:

1) The techniques do not rely upon ruble expenditures published in the official Soviet Budget.

2) The techniques do not require conversions of rubles to dollars or vice versa (a significant improvement over current practices).

3) The techniques do not require the application of either constant dollar theory to U.S. budgetary data nor constant Gross Value of Output

theory to Soviet econometric data, (both of which have considerable limitations).

4) The techniques negate the impact of different and constantly varying annual rates of inflation in the two countries.

The results of this research therefore provide decisionmakers with a U.S. - Soviet comparison of military-space research efforts in terms which laymen (especially non-Sovietologists) can understand, and could result in a significant enhancement in the state-of-the-art of US-USSR comparative technology in general.

No attempt was made to equate military-space research manpower back to expenditures either in rubles or dollars nor to a single comparison in either of the monetary currencies. For those who desire simplistic "bottom line" ratios, it is a simple calculation to take the scientific manpower level of the U.S. military-space research sector for a particular year (Table 6-3) and compare it against the USSR military-space research manpower for the same year (Table 6-4). For example, in 1979, the USSR maintained a level of military-space research manpower of approximately 2.4 times that of the U.S. (487 divided by 199). In spite of the fact that conservatism has been utilized throughout this research paper, the results reflect an even larger gap between the US and the Soviet committments in the military-space research sector than have been reflected by traditional budgetary comparisons.

The relative ratios of scientific manpower commitments to the military-space sector must be considered to be an indication of the nationalistic desire to excell in that field. The Soviet Union has made a major commitment to the military-space sector in the decade of the 1970's and (should they develop a major technological breakthrough) possesses the resources with which to rapidly exploit a breakthrough into an operational weapons system leaving the rest of the world hostage to their superiority.

RECOMMENDATIONS FOR FUTURE STUDIES:

Major recommendations for future studies/research efforts may be classified in two categories, namely 1) research aimed at expanding the scope of this dissertation and 2) research aimed at obtaining a better insight into the allocation of U.S. resources to the military-space sector (especially that of the Department of Defense).

Recommendations aimed at expanding the scope of this dissertation include:

1. Examination of research efforts applied to other major sectors of the two nationalistic systems (e.g. Energy, Transportation, Communications etc.).

2. Examination of the remaining product and service sectors (in addition to the above) and preparation of a total research manpower model for both nations.

3. Utilize classified data on the Soviet military-space research sector to "fine tune" the data developed in this research paper.

4. Expand the methodology to include other nationalistic systems (e.g. those of the Western European Nations).

Recommendations for research aimed at improving the insight into the allocation of U.S. resources to the military space sector include:

1. Perform a cost benefit analysis relative to improvement of the DTIC system to facilitate collection (and retention) of professional manpower versus cost information, including segregation of the data by

DoD categories of research (see Figure 5-3). Study the impact of implementation of similar data collection systems in NASA and DoE.

2. Conduct a cost benefit (Rate of Return) analysis of the tradeoffs between increasing "up front planning" versus decreasing "after the fact auditing" of U.S. Defense and Space Programs.

APPENDIX A

SOVIET ORGANIZATIONAL, BUDGET AND PLANNING INFORMATION
RELATING TO MILITARY-SPACE ACTIVITIES

INTRODUCTION:

Figure A-1 reflects the general overall structure of the Soviet governing bodies. The Communist Party (CPSU) is the only elite organization that cuts across all other elites. The approximately 16 million members of the Communist Party (6% of the total population) constitute the majority of the Soviet scientific, economic, artistic, and military decisionmakers. The military which comprises about 1.5 percent of the Soviet population, occupies more than eight percent of the seats on the Central Committee of the CPSU.[1] In addition 83% of the Politburo in 1976 had Technical Backgrounds.[2]

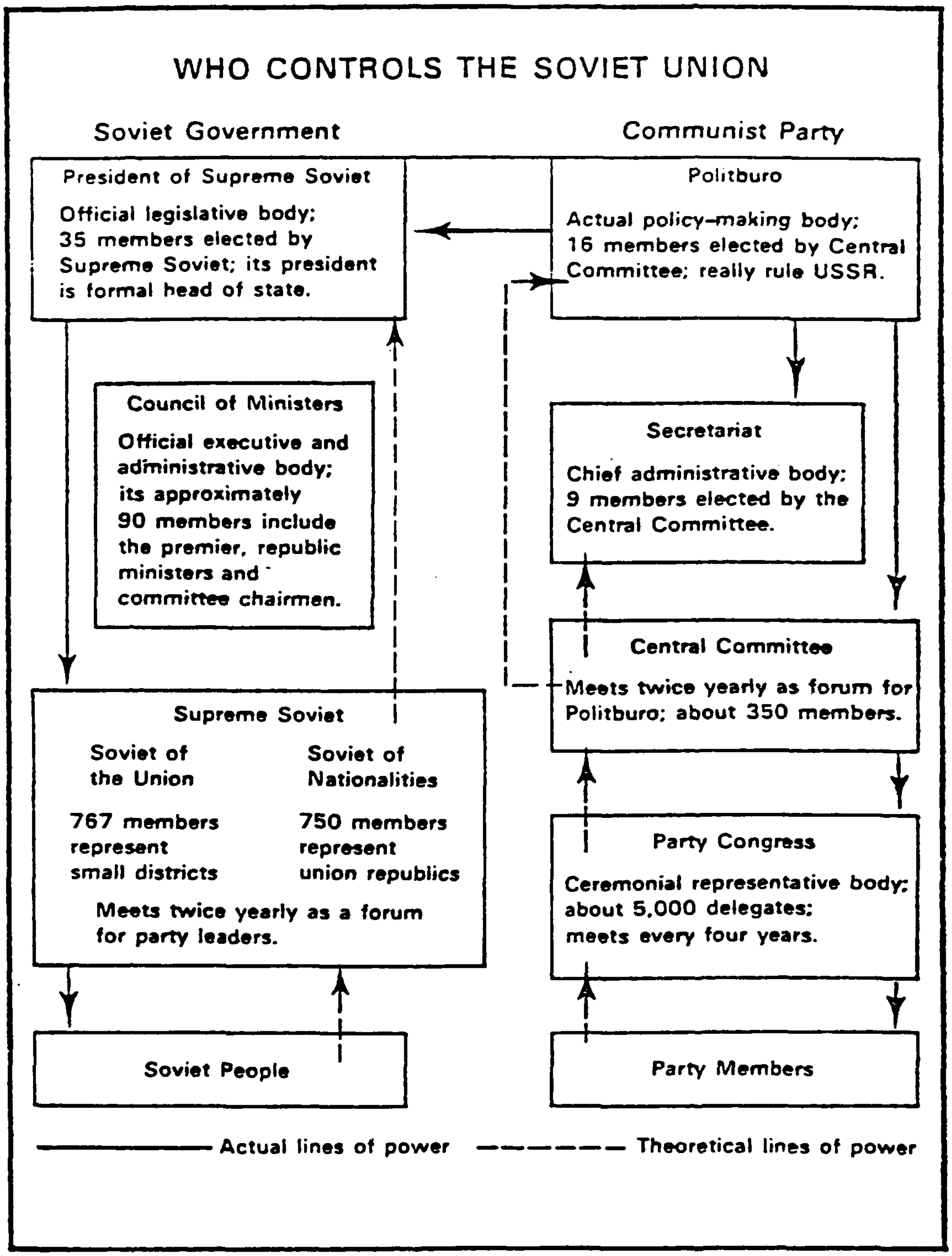
Table A-1 presents a snapshot of the official (i.e. Published) State Budget for the USSR for the period 1970-1975. It is to be noted that the "official" position is that Soviet defense expenditures remained constant (or actually declined) during the period. All other evidence, however, points to the contrary.[3]

SOVIET NATIONAL RESEARCH DIRECTION[4]

<u>The Council of Ministers of the USSR</u>

The Council of Ministers is the most powerful organ of Soviet state administration and the final authority on the organization and responsibilities of Soviet ministries. (See Figure A-2) It is charged with making the Soviet polity and economy work.

FIGURE A-1



Source: Hendrix G. D., "Soviet Education and the Military" Military Review, Dec., 1978, p 24.

TABLE A-I
Soviet State Budget 1970-75
(Billions of Current Rubles)

GROUP		1970	1971	1972	1973	1974	1975
I	FNE						
	Industry/Construction	30.5					
	Agriculture and Procmt	12.4					
	Trade	6.3					
	Transportation	2.8					
	Communications	0.3					
	Communal Economy	6.5					
	FNE Residual	15.8					
	TOTAL	74.6	80.4	84.9	91.3	99.7	110.6
II	Sociocultural Meas (SCM)						
	Education	18.2					
	Science	6.5	7.0	7.3	7.5	7.9	8.0
	Health	9.2					
	Physical Culture	0.1					
	Social Security	12.7					
	Social Insurance	7.3					
	Aid to Mothers	0.4					
	SS for Kolkhoz*	1.4					
	TOTAL	55.9	59.4	63.5	67.3	71.3	76.8
III	Defense	17.9	17.9	17.9	17.9	17.7	17.4
IV	Administration	1.7	2.0	2.2	2.5	2.7	2.9
V	Pmt - State Loans	.1					
VI	Budget Residual	4.4	4.5	4.7	5.0	6.1	7.0
Total Reported Expenditures		154.6	164.2	173.2	184.0	197.4	214.7

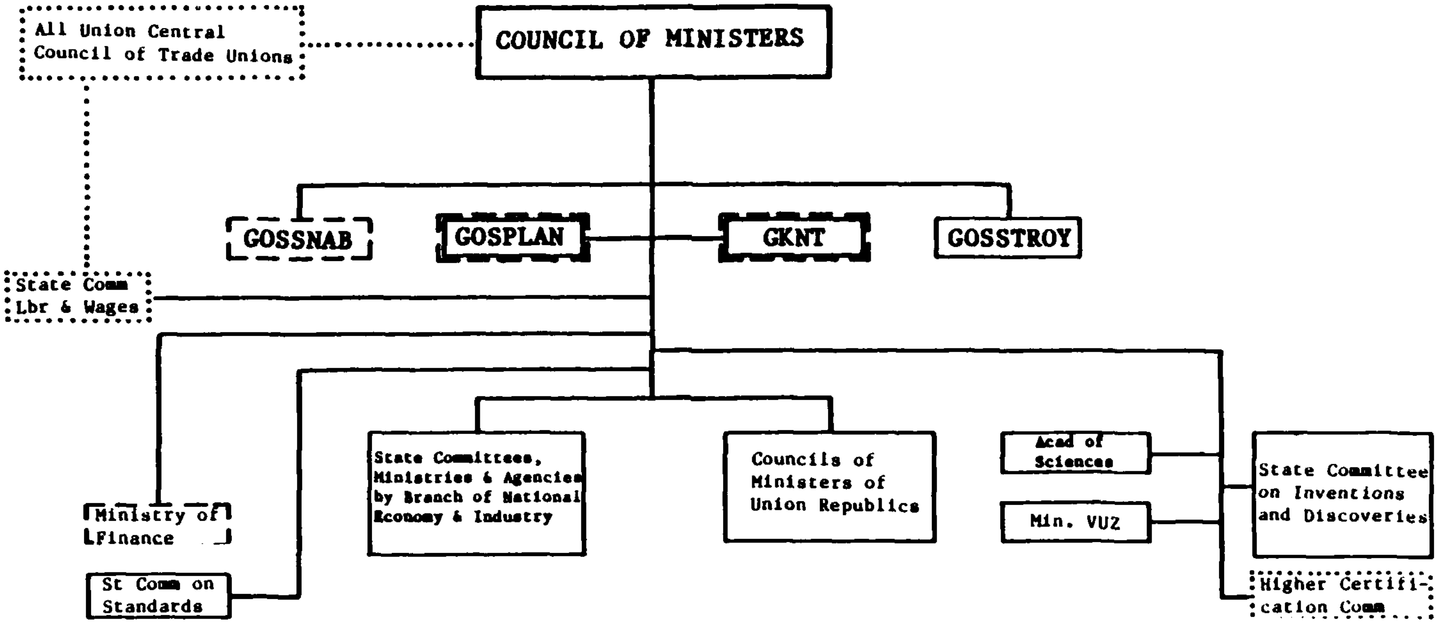
*Collective Farms (as opposed to state farms).

Source: William T. Lee, The Estimation of Soviet Defense Expenditures 1955-1975, NY, Praeger Publishers, 1977 pp 308-10 (from Soviet Sources).

FIGURE A-2

SOVIET ORGANIZATIONS RESPONSIBLE FOR

FORMATION, IMPLEMENTATION AND SUPPORT OF SCIENCE POLICY



——— RESPONSIBLE FOR FORMATION AND IMPLEMENTATION OF SCIENCE POLICY

– – – – PARTICIPATE IN DETERMINATION OF RESOURCES

——— INFLUENCE FORMATION OF SCIENCE POLICY

.... INFLUENCE EMPLOYEE SALARIES AND WORK CONDITIONS

Source: USSR Short Answers to US Questions Relating to USSR R&D Planning and Management, Washington, D.C., Joint Soviet American Working Group on Collaboration in Science Policy 20, Feb 79, p 9.

Composed of nearly 100 members, the Council includes the heads of the most important government agencies, and ex officio, the chairmen of the Councils of Ministers of the constituent union republics.[5] With the exception of the latter group, each member of the Council is responsible for administering specific sectors of the nation's economic, political, military, or socio-cultural life. Their administrative domain may include, for example, a branch of industry; a national level or interrepublic service, such as the running of the railroads; a functional area, such as planning or finance; or management of one of the various agencies.

Chairmen of State Committees sit on the USSR Council of Ministers and are afforded the same status as ministries. State committees deal primarily with matters that cut across the jurisdictions of conventional departments. The State Committees, which influence the development of science and technology most significantly[6] include:

1. The State Planning Committee (Gosplan)
2. The State Committee for Science and Technology (GKNT)
3. The State Committee for Material and Technical Supply (Gossnab)
4. The State Committee for Construction Affairs (Gosstroy)
5. The State Committee for Inventions and Discoveries (Goskomizobreteniya)
6. The State Committee for Standards (Gosstandart)
7. The State Bank (Gosbank)
8. The Central Statistical Administration (TsSU)

In addition, the Military Industrial Commission (VPK) exercises considerable influence over Research and Development regarding Soviet military space programs.

Due to the unwieldy size of the Council of Ministers, cohesion and coordination are provided by a Presidium, a kind of inner cabinet. The Presidium includes the chairman, two first deputy chairmen, and 9 to 10 deputy chairmen. The Chairman of the USSR Council of Ministers is designated "Premier" and is the effective, operational leader of the Soviet government. Among the deputy chairmen are the heads of four of the State Committees which interface most importantly with S&T policy (the GKNT, Gosplan, Gossnab, and Gosstroy).

The Council of Ministers, as the principal policy-making organ of the government, has general responsibility for organizing and administering all scientific, technical, and production activities in the Soviet economy. All state facilities ultimately report to the Council. Overseeing the critical planning function is a major occupation of the Council. The plans of all subordinate organs and facilities are derived from the national plan, which is inspired, prepared under the guidance of, and approved by the Council of Ministers. In the sphere of R&D planning and management, the scope and breadth of the Council's ultimate authority are illustrated by the following Soviet enumeration of pertinent Council responsibilities:[7]

1. General administration of R&D
2. Resolution of all questions concerning the organization and administration of R&D
3. Development of measures to improve the management of R&D
4. Examination and approval of the "main directions" of R&D
5. Establishment of procedures for developing R&D plans and for introducing research results into the national economy
6. Development of the plan for S&T progress

7. Organization of S&T information

8. Finance of R&D

9. Resolution of questions on wages and working conditions of scientists and engineers

10. Training of scientific and engineering personnel

11. Resolution of questions about copyright, patents, and laws on invention and discovery.

The State Planning Committee (Gosplan)

Gosplan has overall responsibility for the formulation of economic plans which guide the activities of subordinate organizations in the pursuit of the objectives laid down by the central Soviet leadership. Functioning essentially as the "nerve center" of the Soviet economy, Gosplan possesses considerable power over establishments in every field. As a union-republic agency, Gosplan's authority extends to activities throughout the economy. Gosplan maintains departments for at least 30 different branches of the economy and also has departments concerned with general policy matters. The major functions of Gosplan relating to S&T include:[8]

1. Collaboration with the GKNT in consideration of large interbranch (interministerial) S&T projects.

2. Planning the introduction of new technology.

3. Consideration of the overall volume of capital investment for S&T.

4. Collaboration with the Ministry of Finance and the GKNT to determine the levels of funding for S&T projects.

5. Collaboration with Gossnab on planning material and technical supplies for R&D institutions.

6. Participation in developing plans for training scientific manpower.

7. Collaboration with the State-Committee on labor and Social Problems and with the All-Union Council of Trade Unions on wages and working conditions for scientific personnel.

The Gosplan is also one of the two primary sources of aggregate statistical data released to Soviet citizens and Western observers (the other being the Central Statistical Directorate (TsSU).[9]

The St.te Committee for Science and Technology (GKNT)

Within the Soviet governmental structure, the State Committee for Science and Technology occupies a pivotal role. It acts as a "special balancing mechanism" for the USSR Council of Ministers, providing cohesion and coordination among the state committees and central departments. The GKNT is the agency that bears primary responsibility for ensuring the formulation and conduct of a unified S&T policy.

The GKNT itself consists of approximately 70 members, one-third of whom are members of the USSR Academy of Sciences and other academies. Some Government ministers and prominent industrial leaders also sit on the GKNT. The State Committee, as such, meets only once or twice a year to consider the main directions for the development of science and technology as well as to approve the list of priority R&D problems to be included in the Five Year Plan.

The executive body of the GKNT is the Collegium, which meets weekly and examines all problems that come before the GKNT. Though the Collegium acts as an advisory body, its decisions become decrees and its orders are followed by all departments of the State Committee.

In addition to various functional divisions charged with handling international liaison, information dissemination, science organization, and other tasks, departments have been established to monitor S&T developments in particular branches of industry, such as chemicals and machine building. Also functioning under the GKNT is an elaborate network of advisory bodies which assist in the analysis of institutional and policy problems of science and technology. Integral to this special consultative machinery are more than 60 scientific councils on major interbranch S&T problems. Some 5,500 persons participate in the work of these councils.

The GKNT thus is the principal state agency concerned with overall S&T policy and performance. While possessing limited direct authority over the actual conduct of research, development, and innovation, the GKNT exercises important guidance and liaison functions for other ministries and agencies in R&D planning, coordination, and performance. With respect to R&D planning and interagency coordination, the GKNT:[10]

1. Prepares S&T forecasts and approves procedures for developing such forecasts

2. Draws up proposals for the main directions of R&D

3. Drafts a list of major S&T problems to be solved during the next Five Year Plan (See Chapter 4 for some examples)

4. Cooperates with Gosplan, Gosstroy, and the Academy of Sciences in developing proposals for the Five Year Plans for S&T

5. Cooperates with Gosplan and the Academy of Sciences in proposals for introducing R&D results into the economy.

The GKNT also has a significant role in supporting and monitoring ongoing R&D. The GKNT develops indicators to measure S&T progress and exercises control over development of the R&D resource base. It may decree the establishment or closing of institutions, and it approves overall requirements for machinery and equipment in the draft enterprise plans. Together with Gosplan and Gossnab, it participates in supplying equipment to priority projects. With Gossnab it plans the financing of materials, technical supplies and the distribution of materials and equipment. In collaboration with the State Committee for Labor and Social Problems, the GKNT develops proposals regarding the payment of scientists. Operationally, the committee has the authority to review important research conducted at institutes, and it may issue binding directions to cease R&D work which is redundant or of no value.

The State Committee for Material and Technical Supply (Gossnab)

In the Soviet Union the allocation of commodities is centrally planned in accordance with the output targets specified by Gosplan. Provision of critical (short supply) materials, machines, etc., is planned by Gosplan itself while supply of the remainder is planned by all-union or union-republic agencies. Inputs for industrial R&D are included in the overall material and technical supply system, and special provisions have been made for acquisition of requirements for the Academy of Science and university facilities.

Organizations requiring supplies submit their requests to Gossnab. The transfer of items, however, takes place only when Gossnab issues orders for their delivery. In general, Gossnab's Authority is used to resolve conflicting demands on supply and to balance the material needs of producers and consumers.[11]

Military Industrial Commission (VPK)

The Military Industrial Commission acts in a coordinating role between the users of military/space hardware (primarily the Ministry of Defense), the producers of that hardware (the Industrial Ministries), and the Communist Party (probably to establish and maintain priorities).[12] In 1975, the VPK consisted of the following individuals:[13]

Secretary, Communist Party

Deputy Chairman, Council of Ministers

Minister of Defense

Minister of Defense Industries

Minister of Aviation Industry

Minister of General Machine Building

Minister of Medium Machine Building

Minister of Radio Industry

Minister of Electronics Industry

Minister of Instrument Making

Chairman, USSR Gosplan

SOVIET INDUSTRIAL STRUCTURE

Soviet industry is organized on a branch-of-industry concept, each "branch" being defined by its products (e.g., Aviation, oil chemical, etc.). Each "branch" is managed by an industrial ministry of the Council of Ministers. Currently there are about 50 union-level industrial ministries in the USSR Council of Ministers. (See Complete Listing in Table A-2.) The research institutes and design organizations subordinate to the industrial ministries at the union and union-republic levels constitute what probably are the most important Soviet resources

TABLE A-2

Correlation of USSR Ministries with the State Budget Structure

<u>Group I, Financing the National Economy (FNE)</u>

1. Ministry of the Aviation Industry
2. Ministry of the Automobile Industry
3. Ministry of the Gas Industry
4. Ministry of Machine Building
5. Ministry of Machine Building for the Light, Food, and Household Equipment Industries.
6. Ministry of the Medical Industry
7. Ministry of the Oil Industry
8. Ministry of the Defense Industry
9. Ministry of the Radio Industry
10. Ministry of Medium Machine Building
11. Ministry of the Machine and Hand Tools Industry
12. Ministry of Communal, Building and Roadbuilding Machinery
13. Ministry of the Shipbuilding Industry
14. Ministry of Tractor and Agricultural Machinery Construction
15. Ministry of Transport Construction
16. Ministry of Heavy, Power and Transport Machine Building
17. Ministry of Chemical and Oil Equipment Production
18. Ministry of the Chemical Industry
19. Ministry of Cellulose and Paper Industry
20. Ministry of the Electronics Industry
21. Ministry of the Electrical Engineering Industry
22. Ministry of Geology
23. Ministry of Light Industry
24. Ministry of the Timber and Wood-Processing Industry
25. Ministry of Installation and Special Construction Projects
26. Ministry of the Meat and Milk Industry
27. Ministry of the Oil-Processing and Petrochemical Industry
28. Ministry of the Food Industry
29. Ministry of Industrial Construction
30. Ministry of the Building Materials Industry
31. Ministry of Fisheries
32. Ministry of Agricultural Construction
33. Ministry of Construction
34. Ministry for the Construction of Heavy Industry Enterprises
35. Ministry of the Coal Industry
36. Ministry of Non-Ferrous Metallurgy
37. Ministry of Ferrous Metallurgy
38. Ministry of Power and Electrification
39. Ministry of General Machine Building
40. Ministry of State Purchases
41. Ministry of Melioration and Water Economy
42. Ministry of Agriculture
43. Ministry of Foreign Trade
44. Ministry of Instrument Making, Automatic Devices and Control Systems

Group I, Financing the National Economy (FNE) - Continued

45. Ministry of Trade
46. Ministry of Civil Aviation
47. Ministry of the Merchant Marine
48. Ministry of Railroad Communications
49. Ministry of Postal Services and Telecommunications

Group II, Sociocultural (SCM)

1. Ministry of Higher and Special Secondary Education
2. Ministry of Health
3. Ministry of Culture
4. Ministry of Education

Group III, Defense

1. Ministry of Defense

Group IV, Administration

1. Ministry of Foreign Affairs
2. Ministry of Finance

Group V, State Loans

Group VI, Budget Residual

1. Ministry of State Security
2. Ministry of Internal Affairs

Source: W.T. Lee, The Estimation of Soviet Defense Expenditures, 1955 - 1975, New York, Praeger Publishers, 1977, pp 304-05.

for applied R&D. The ministerial "branch" system includes over half of all scientific manpower in the Soviet Union and spends at least 80% of the "Science Budget". (See Appendix B)

The basic units of Soviet industry traditionally have been and, to a large extent, still are research institutes, design bureaus, and production enterprises. However, after many years of experimentation with different management forms, the USSR Council of Ministers decreed (in 1973) that the industrial ministries would switch to a management structure in which the basic units would be either production associations (PO) or science-production associations (NPO), the latter of which would consist of group of both production enterprises and R&D institutions. Both POs and NPOs may report directly to the central ministry or be subordinate to other industrial associations. At present, most industrial ministries have made or are making the transition to the new system.[14]

An industrial ministry has broad responsibilities in planning and managing R&D in its specialty area. The ministry is responsible for evaluating the economic and technological level of production and of product output. It determines the best ways of utilizing R&D results and of raising the level of development of the branch on the basis of S&T achievements both at home and abroad. Ministerial authorities not only plan and oversee the solution of the most important branch S&T problems but they also participate -- sometimes as the lead agency -- in the solution of comprehensive interbranch problems. Responsibilities include those of "line" planning and administration of branch facilities and programs, along with interaction between the ministry and state organs on functional issues, such as standards and invention policies.

The internal organization of a typical industrial ministry contains a collegium which consists of the minister and his deputies. A scientific-technical council of ministry, composed of leading scientists and engineers, deliberates "branch" technology policy and monitors the technical performance of subordinate scientific and production facilities. A "technical administration" subdivision of the Scientific-Technical Council is specifically charged with overseeing the development and implementation of technology policy within the ministry and with the formulation of the technical chapters of the ministry plan.

SOVIET R&D PLANS

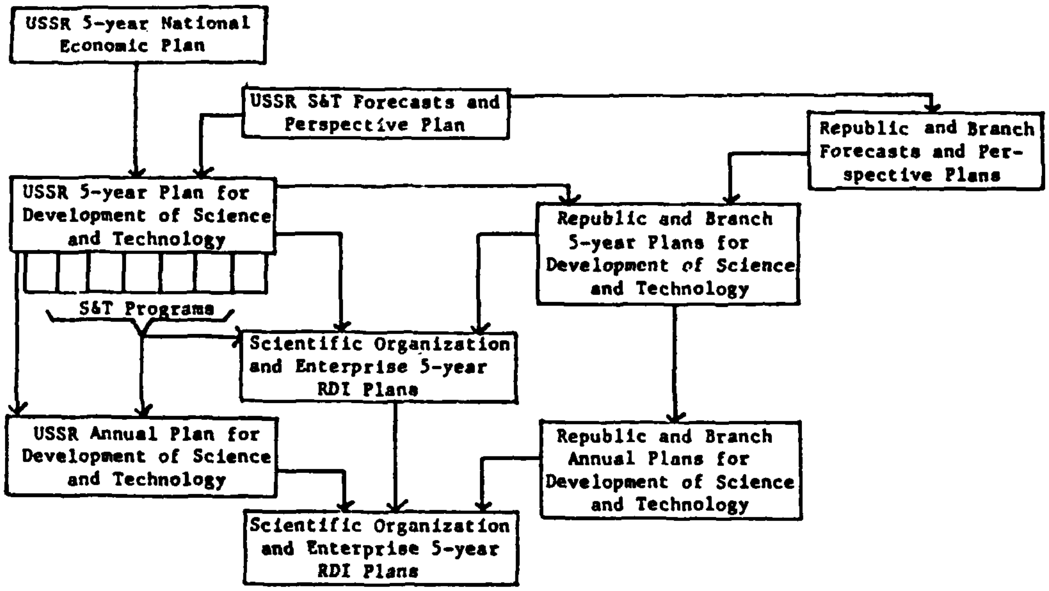
Soviet R&D plans tend to be segregated temporally. Each of the responsible planning levels formulate plans which correspond to three time frames: (1) long-term plans; (2) five-year plans; and (3) annual plans.

Long-term plans (designated as the "Perspective Plans") are largely forcasts of alternative trends in science and technology and of the development of specific new products and processes over a period of the next ten to 20 years. These plans and forecasts serve primarily as guidelines to orient economic strategy and science policy and tend not to be binding.

The five-year and annual plans, however, incorporate "targets" which have been specified (in the long-term and five-year plans) and they are more detailed. In recent years, the Five-Year Plan has become more important than the annual plan, since Soviet authorities have placed increased emphasis on careful and comprehensive formulation of goals over longer periods in order to concentrate resources more effectively on priority projects and to provide greater direction and control over the nation's R&D effort. The connection between the various kinds of R&D plans, segregated by administrative hierarchy, by functions or program, and by duration of operation, is illustrated in Figure A-3.

FIGURE A-3

STRUCTURE OF SOVIET RESEARCH, DEVELOPMENT, AND INNOVATION PLANS AND FORECASTS



Source: Louvan E. Nolting, The Planning of Research, Development, and Innovation in the U.S.S.R. (Foreign Economic Report Nr. 14) Washington, D.C., Dept. of Commerce 1978, p. 23. (R-4-41), Reproduced in S-2-2 (1980) NSF p. 7.

NOTES FOR APPENDIX A

[1] S.F. Kime, "How the Soviet Union is ruled", Air Force Magazine, March 1980, pg. 56, and E.L. Warner, The Military in Contemporary Soviet Politics: An Institutional Analysis, New York, Praeger Publishers 1977, pg. 281. (RSIC UA 770 W 281) (R-10-17).

[2] U. Kruze-Vaucienne and J. Logsdon, Science and Technology in the Soviet Union, Washington, D.C., George Washington University (for NSF), June 1979, Table II-2. (Pentagon Library Q 127.R96 K78) (R-4-38)

[3] While the size of the Soviet Armed Forces has remained relatively constant (or possibly even dropped) during the period, the quantities of new weapons systems introduced into the field have continued to increase.

[4] This section is patterned after the corresponding sections in Science Policy: USA/USSR, Vol II Science Policy in the Soviet Union, Washington, D.C., National Science Foundation, 1980. (GPO S/N 038-000-00457-3)

[5] Ministries in the Soviet Union are basically of three types:

a. All-Union Ministries: Established for sectors of national importance and priority with no clear republic orientation. Examples are the defense and aviation industries. These ministries, which are highly centralized in Moscow, directly administer activities and facilities under their jurisdiction, regardless of their geographical location.

b. Union-Republic Ministries: Established for sectors where there is significant intrarepublic activity. Union-republic ministries may administer a few activities directly, but they ordinarily operate through counterpart ministries bearing the same name in each of the republics. Legally, union-republic ministries are responsible both to the Republic Councils of Ministers and legislative organs as well as to their parent ministry in Moscow. Some union-republic ministries (such as Agriculture, Culture, Education, Health, etc.) have counterpart ministries in all Republics; whereas others (such as Coal Industry, Ferrous Metallurgy, etc.) have counterpart ministries in only selected Republics.

c. Republic Ministries: Generally concerned with services, such as automotive transport or local industry. Republic ministries are not represented in the USSR Council of Ministers, but operate under the immediate supervision of the Republic councils of ministers and legislative organs.

[6]Other minor agencies of the Council whose activities influence science and technology include: The State Committee for Utilization of Atomic Energy; The Main Administration of Microbiological Industry; The Committee for Lenin and State Prizes in Science and Technology; The State Committee for Inventions and Discoveries, etc.

[7]See Science Policy in the USSR, op cit, pg. 31. This information was provided by Soviet representatives to a Joint US-USSR Working Group in 1976.

[8]"USSR Short Answers" pg. 8.

[9]The Gosplan tends to be equally interested in the ex ante and ex post data whereas the TsSU is primarily interested in the latter. Since targets for R&D are difficult to identify ex ante, much of the applied R&D is excluded from the Gosplan. On the other hand, since the TsSU tries to count everything ex post, it is probably the best source of data on the Science and Science Services Sector. See W.T. Lee, The Estimation of Soviet Defense Expenditures 1955-1975, NY, Praeger, 1977 pg. 38.

[10]See Science Policy in the USSR, op cit, pg. 40, which cites a 1977 Soviet Source.

[11]See E. Zaleski et al, Science Policy in the USSR, Paris, OECD, 1969 pgs. 83-88.

[12]For a short description of the interface between the military users and design and production facilites see P.A. O'Brien, "Generation of Weapon Requirements in the Soviet Ground Forces," Army RDA Magazine, Jan-Feb 1980, pgs. 20-21.

[13]See W.T. Lee, The Estimation of Soviet Defense Expenditures, 1955-1975, NY, Praeger 1977, pg. 35.

[14]For years Soviet R&D and production activities had been organizationally separate from each other. Even within the same ministry, research and development establishments and production units came under different channels of planning, management, finance, and supply. This pattern of organization tended to create strong departmental barriers against the effective linking of research with production. A major purpose of the management restructuring at the ministries was to break down these obstacles.

APPENDIX B

SOVIET S&T PERFORMER ORGANIZATIONS

INTRODUCTION:

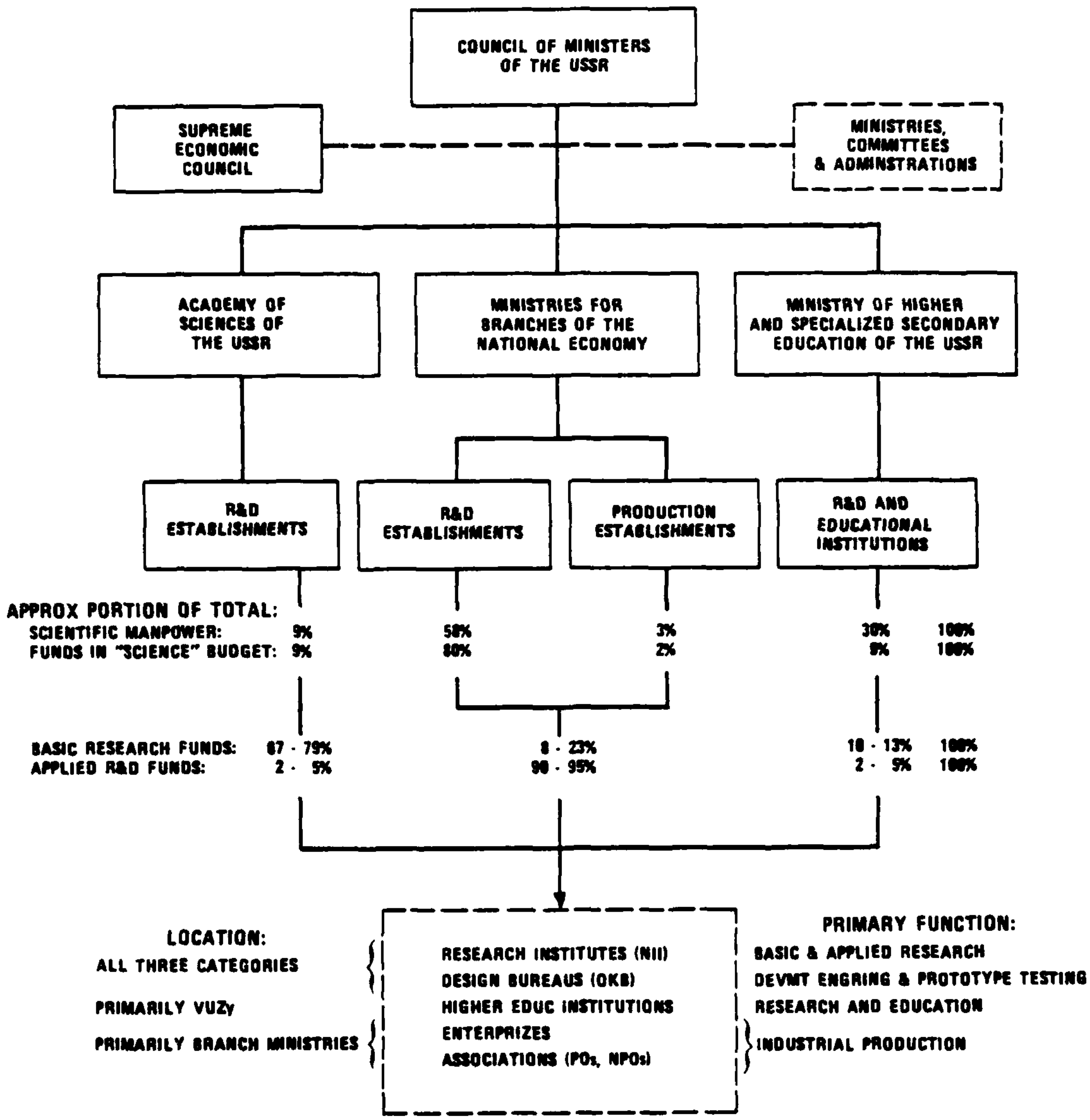
The Soviet S&T establishment consists of a vast array of organizations which conduct research and development. Figure B-1 provides an overall view of the organizational structure of Soviet S&T. In general, five basic organizational types are used: Research Institutes (NII), Design Bureaus (OKB), Higher Educational Institutions (VUZy), Enterprises, and Associations with primary functions as shown on Figure B-1. Soviet S&T organizations have, however, been undergoing institutional evolution for a number of years and thus some of the types are no longer pure. (See Appendix A) For example, some "Research Institutes" do only design or prototype work and little or no research; whereas others concentrate almost entirely on experimental testing or assisting industrial plants (i.e., a more proper function of a "design bureau").

Organizational dissociation of functional performers is increasingly giving way to new, more integrated structures, like the "associations." The whole organizational edifice, particularly at the lower levels, is in motion and this fact should be taken into account when examining various organizational structures.

Figure B-1 also presents an approximate allocation of manpower and funds between the various organizational elements. The reference to percentages of the "Science" budget should not, however, be

FIGURE B-1

SOVIET ORGANIZATION FOR R&D



Source: Percentages: Science Policy In The Soviet Union, Washington, D.C., National Science Foundation, Jun 1980, p. 46.

misinterpreted to mean that the Science budget is the only source of R&D funds.

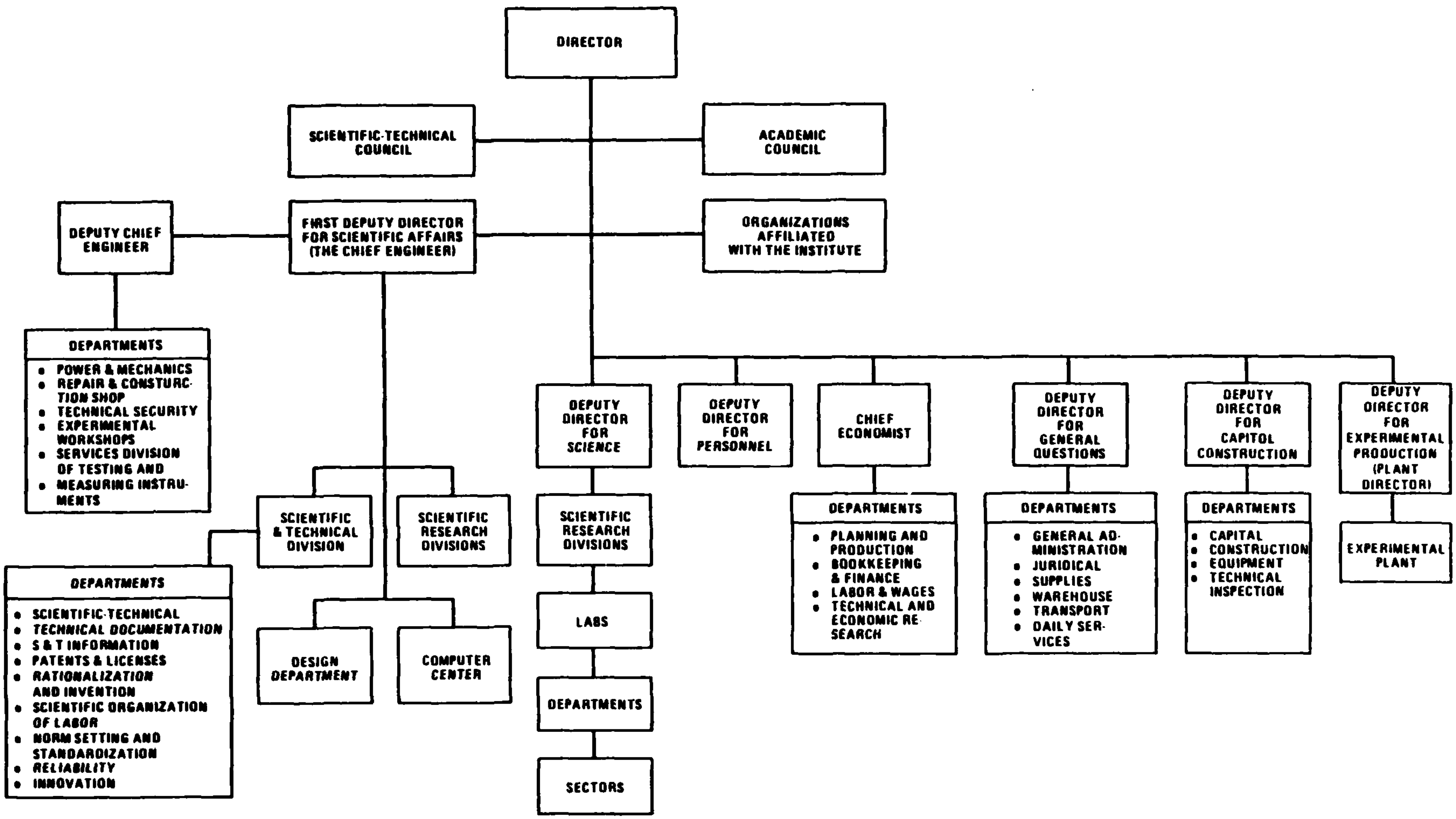
SCIENTIFIC RESEARCH INSTITUTES

Basic and applied scientific research and certain design tasks are accomplished at institutes under the Academies of Sciences, the Ministry of Higher Education, (MinVUZ), and the branch ministries. While some institutes are quite small with no more than 40 to 50 persons, others are major research organizations with several hundreds of scientists and engineers. Institutes vary widely in the presence or absence of design, and testing facilities. Some research institutes are "broad-profile," engaging in all stages of R&D, whereas others are "specialized," (i.e. limited to applied research, to development, or to the testing of prototypes). Some act as "Lead" institutes, determining technical policies and research assignments for a group of subordinate institutes, while others operate independently or subordinately.

Figure B-2 provides the organizational structure of a research institute attached to an industrial branch ministry. In general, the structural format of an Academy institute is less complex than that of a branch institute. The Academy system as a whole is, in fact, less bureaucratically organized and operated than the R&D subsystem of the ministries. There was a major emphasis in the 1960's and again in the 1970's to shift a number of the Research Institutes from the Academy of Sciences to the Branch Ministries.[1] The number of Scientific Research Institutes is continually growing, however, and numbered over 2800 in 1975.

FIGURE B-2

ORGANIZATIONAL STRUCTURE OF A RESEARCH INSTITUTE OF AN INDUSTRIAL MINISTRY



SOURCE: D. M. GVISHIANI ET AL, EDS., OSNOVNYYE PRINTSIPY I OBSHCHIYE PROBLEM UPRAVLENIYA NAUKOY (BASIC PRINCIPLES AND GENERAL PROBLEMS IN THE MANAGEMENT OF SCIENCE) (MOSCOW, 1973), P. 226.

DESIGN BUREAUS

Design and development engineering tasks are carried out by design bureaus or institutes. The design bureaus range in size from small groups within production enterprises to large independent organizations of several hundred design engineers and technologists (known as experimental plants). While some design facilities limit their work to designing new products and machines, others also build and test prototypes. Still other Design Bureaus are primarily engaged in process designing, designing of machinery and installations, development of processes for the manufacture of new products or production line modernization. They are variously titled design-technological bureaus, project-design and technological bureaus, or scientific research project-technological institutes (dependent upon the functions they perform). In addition, there are so-called "project institutes" that specialize in the designing and planning of new plants or renovation of old enterprises. Although scientific research is conducted at design bureaus, it is of secondary importance to work on product and process development and the building of prototypes. Some design bureaus, however, do extensive industrial research and are often indistinguishable from research institutes.[2]

HIGHER EDUCATIONAL INSTITUTIONS

Most educational institutions conduct research of some kind. These include (1) comprehensive universities, such as Moscow State University, where a broad curriculum of natural sciences and humanities is offered; (2) higher level schools such as the Bauman Moscow Higher Technical School and the polytechnic institutes, where a variety of engineering courses may be pursued; and (3) a large number of specialized single-curriculum institutes such as the Leningrad Institute for Aviation Instrument Construction and the Mendeleyev Moscow Chemical Technical Institute. The institutes concentrate on applied research, most of which is funded through contracts with industry. University research generally is conducted within departmental structures by an individual professor; but in some universities special scientific research institutes have been formed. A VUZ scientific research institute may be subordinate to a related faculty of the VUZ or to the VUZ as a whole. Research laboratories may be similarly subordinated. VUZ labs may be branch laboratories or problem laboratories. The former conduct research on an industrial organization's needs for new materials, processes, and equipment, whereas problem laboratories are created for the execution of major scientific, engineering, and experimental design projects. In VUZy under the USSR Ministry of Higher and Specialized Secondary Education at the end of 1971 there were 55 scientific research institutes, 419 problem laboratories, and 528 branch laboratories.[3]

INDUSTRIAL ENTERPRISES

An enterprise is a legally independent entity concerned almost exclusively with production. It has its own technical, production, and financial plan containing production, organizational, and technical chapters and targets. It has its own assets, including working capital. When on an independent balance sheet, it has an account in the State Bank. The term enterprise (predprijative) is a generic term that covers a number of forms of production organizations. One is the plant (zavod), which is an industrial enterprise with mechanized means of production. The terms "factory" (fabrika), "combine" (kombinat), and "firm" (firma) are specialized kinds of plants.[4]

A relatively recent innovation in the Soviet Industrial Sector is the "independent enterprise" which operates under a principle of economic management known as "khozraschet," (which is generally translated as self-supporting for economic accountability). In the broadest sense, this operating principle implies that the organization is to operate (and to be evaluated) on the sole basis of economic criteria. It is expected to cover current operating expenses by revenue from the sale of its output, and to finance internally (or by credit) a significant part of its capital investment. To reinforce this economic orientation, success indicators for the organization (which in turn determine the size of personnel bonuses) are economic in nature, including profitability, sales, and measures of productivity. Concomitant with the economic orientation, the directors of establishments operating under the "khozraschet" principle are accorded greater authority to make decisions at the operational level. With a restriction on the number of official targets which can be specified by middle- and upper-level management, as well as a policy of unofficial interference, the focus of decision-making responsibility has shifted downward in Soviet industry, without challenging the ultimate supremacy of the central leadership.

In general, "factory science" has not been a prominent feature of Soviet industry. Historically, the organizational approach has emphasized the separation of industrial research from production as well as the centralization of R&D assets in institutes designed to serve the needs of the branch as a whole rather than those of individual enterprises. Consequently, most enterprises lack adequate in-house R&D facilities. The enterprise-level R&D system of factory laboratories, design offices, experimental shops, and other scientific subdivisions are not classified under the "Science and Science Services Sector" category of economic and social organizations, and their activity is not included in the national plan section for financing research and design work.[5] In many instances, however, the enterprise R&D system does play a vital role in the application of new technology, in the creation of new products and processes, in the improvement of product quality or production efficiency, and in the maintenance of quality control or technological control of operations.

ASSOCIATIONS

Production associations (POs) and science-production associations (NPOs) are two entities which are gradually replacing the independent enterprises as the basic units of the Soviet industrial organization. Eventually, almost all of Soviet industry will be converted to the associational form of management. By the fall of 1976 there were more than 3000 PO's in industry. Although they had assimilated less than ten percent of all enterprises, production associations at that time already accounted for nearly 40 percent of the total industrial output. At the same time, NPOs--a more selective form of the new organization--numbered less than 120. Generally there are not more than three to four NPOs per Ministry.

The associations were created by the Soviet leadership to accelerate technological progress and to reduce the lead times in the implementation of new technology. Therefore, both the PO and NPO organizations may include institutes and design bureaus. In the production association, scientific organizations are usually only of local significance and confine their primary research-development-innovation activity to the production needs of the association. In the NPO's, on the other hand, these units are responsible for general purpose or branch-wide R&D, including development of innovations for the branch as a whole. The "lead" organization also differs between the PO and the NPO. While this role belongs to an industrial enterprise in the production association, it is generally performed by a powerful research institute in the NPO.

The NPO fulfills the functions of a branch scientific-technical center. Its chief task is to create and apply new technology within the shortest possible time. It is not predominantly a producing organization but rather is intended primarily to carry out R&D on new products and processes. Ideally, when a new product has been brought successfully through its first production runs by an NPO, the mass production of the article is taken up by the production associations. In line with their concern for the entire research-to-production cycle, several NPOs have developed special start-up plants and installation units which assist other production facilities in introducing and debugging new technology.

Some NPOs specialize in the creation of new products, some develop production technology and control systems, and still others concentrate on the development and assimilation of new technological processes. Among the most important tasks of NPOs are reported to be the installation and adjustment of new technology, the conduct of patent/license work, the maintenance of S&T information services, the forecasting of new product demand, and the development of estimates of labor and materials requirements.

NOTES FOR APPENDIX B

[1]L. Nolting and M. Feshbach, Statistics on Research and Development Employment in the USSR, Wash, DC, Dept of Commerce, Series P-95 Nr 76, Jun 1981, Table 1.

[2]Zaleski et al, Science Policy in the USSR, Paris, OECD, 1969, pp 406-408, 541-546. (R-4-1)

[3]Science Policy: USA/USSR, VOL II: Science Policy in the Soviet Union, Wash., DC, National Science Foundation, 1980, p 70.

[4]The term factory (fabrika) is used primarily for plants in light industry and for plants engaged in the initial processing of raw materials. When several technologically related production activities are combined, the resulting enterprise is called a combine (kombinat). A combine may consist of a lead plant with several subordinate ones, or it may be a single plant. Such enterprises have existed in metallurgy, chemicals, textiles, food, and some other branches of industry for many years. The firm (firma) is an early type of production association in which the management of the lead plant serves as the management of a firm consisting of several plants. When a firm is organized no new management structure is set up. Usually the enterprises that make up the firm are located in a single geographical area around a major city. Firms are most often found in the light and food industries.

[5]See Definition of Science and Science Services, in: L. Nolting and M. Feshbach, Statistics on Research and Development Employment in the USSR, Wash., DC, Dept. of Commerce, Series P-95 Nr. 76, June 1981, Appendix B.

APPENDIX C

FESHBACH'S COMPUTATION OF TOTAL SOVIET R&D PERSONNEL

Nolting and Feshbach[1] set out to calculate the numbers of Soviet Scientific personnel which would correspond to U.S. statistics compiled by the National Science Foundation (NSF) and the Bureau of Labor Statistics (BLS) of the Department of Commerce. The Soviet definition of "Scientific Workers" is reflected in Figure C-1. Reporting of Soviet manpower data is dictated (i.e made mandatory) by the TsSU.[2] Since Feshbach's calculation is somewhat hard to follow, Figure C-2 provides a simplified outline of the method used to obtain the final Soviet numbers. Tables C-1 through C-4 provide the bulk of the data (summarized from the original Soviet data) which Feshbach used in his time-series calculations. The major adjustments to the raw Soviet data include the reduction of scientists from the "Social Sciences and Humanities" category and the addition of Graduate Students. Figure C-3 provides the actual number of Soviet Scientists calculated by Feshbach for 1970.

FIGURE C-1

SOVIET DEFINITION OF "SCIENTIFIC WORKER"

Includes:

All personnel with Advanced Degrees and Scientific Titles regardless of current place or type of work (Includes Social Sciences and Humanities)

Members of the Soviet Academy of Sciences Organization

Personnel with or without advanced degrees (or titles) who perform "scientific" research work in scientific institutions or are engaged in research at VUZy

Specialists without advanced degrees who perform "scientific work" in industrial enterprizes and project organizations

Persons holding management positions in scientific research

All persons who are engaged full time in carrying out research projects that are components of the science plans of specialized ministries or state plans.

Excludes:

Technicians and Laboratory Assistants without higher education

Individual Inventors

Graduate Students

Research Trainees

Meterological and Geological Personnel

Source: Nolting and Feshbach, Statistics on Research and Development Employment in the USSR, Washington, D.C., Dept. of Commerce, Series P 95, Nr 79, Jun 1981, p 17.

FIGURE C-2

Feshbach's Rationale for Computation of Soviet Direct R&D Personnel

Computation Year is ________

Starting Point:

Reported Number of Scientific Workers ________ (Table C-1*) = A

Step 1: Modify for Inclusion of Social Sciences and Humanities Research Workers. Reduce total by the number of Scientific Workers in Social Sciences and Humanities.

________ (Table C-2*) = B

Subtotal A minus B ________ = C

Step 2: Modify for VUZ non-R&D & Part-Time Workers

VUZ Part-Time ________ (Table C-3*) = D

D x 0.642 ________ = E1
(FTE) D x 0.642** x 0.25 ________ = E2

Subtotal A minus E1 plus E2 ________ = F

Step 3: Modify for "Title Holders Not Actually Involved in R&D."

F x 0.0075 ________ = G

Subtotal F minus G ________ = H

Step 4: Modify for Graduate Students

Convert Full-Time Graduate Students to FTE
I = Full-Time Graduate Students ________ (Table C-4) = (I)
I x .773** x .25 ________ = (J)
K = Part-Time Graduate Student ________ = (K)
K x .773 x .42 x .25 ________ = (L)

Subtotal H plus J plus L ________ = M

*Soviet Sources
**See Table 32 Feshbach

TABLE C-1

Scientific Workers: 1970 to 1979*

Year	Number
1970	927,709
1971	1,002,930
1972	1,056,017
1973	(1,108,500)
1974	(1,160,700)
1975	1,223,428
1976	(1,253,500)
1977	(1,279,600)
1978	(1,314,000)
1979	(1,340,300)

* At end of year. Figures in parentheses are rounded to the nearest hundred.

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Table 14, from original Soviet Sources.

TABLE C-2

Distribution of Scientific Workers, by Branch of Science: 1968 to 1974

	1970	1971	1972	1973*	1974*
Total Scientific Workers	927,709	1,002,930	1,056,017	1,108,500	1,169,700
Physics/ Math	95,272	(NA)	106,137	111,000	116,900
Chemistry	45,815	(NA)	49,814	51,900	53,700
Biology	37,342	(NA)	41,840	43,500	45,500
Geology/ Mineralogy	20,342	(NA)	22,401	23,400	24,500
Technical Services	409,470	(NA)	484,968	514,700	548,000
Agriculture/ Veterinary Sciences	35,446	(NA)	38,701	39,800	41,700
Medicine/ Pharma- ceutics	49,957	(NA)	55,122	56,600	59,000
Social Sciences & Humanities	200,812	(NA)	219,117	226,500	234,800
Archi- tecture	2,590	(NA)	2,997	3,100	3,300
Other Sciences (Military or military Related)	30,663	(NA)	34,920	38,000	39,500

* Rounded to nearest hundred.

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Wash DC, Dept of Commerce Table 28, from Soviet Sources.

TABLE C-3

VUZ Scientific Workers Engaged Full Time and Part Time in R&D: 1969 to 1976 (At End of Year)

Year	Total (1)	Full Time (2)	Part Time (Research & Teaching Personnel) (3)
1969	327,200	40,300	286,900
1970	348,872	45,617	303,255
1971	366,703	53,580	313,123
1972	378,800	(NA)	(NA)
1973	394,400	(NA)	(NA)
1974	410,818	70,496	340,32[illegible]
1975	427,800	(NA)	(NA)
1976	441,500	79,200	362,300

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Table 24, from Soviet Sources.

TABLE C-4

DISTRIBUTION OF GRADUATE STUDENTS (ASPIRANTY), BY FULL AND PART TIME STUDY AND BY PLACE OF STUDY: 1969 TO 1978

Year	Full-time Students	Part-time Students	Total	Students in higher educational institutions	Students in other scientific institutions
1969......	55,603	43,929	99,532	57,010	42,522
1970......	55,024	44,403	99,427	56,909	42,518
1971......	53,839	45,469	99,308	56,997	42,311
1972......	52,501	46,444	98,945	57,252	41,693
1973......	49,702	49,158	98,860	57,640	41,220
1974......	45,357	51,582	96,939	56,570	40,369
1975......	41,857	53,818	95,675	55,706	39,969
1976......	39,794	55,863	95,657	55,937	39,720
1977......	39,626	57,042	96,668	57,417	39,251
1978......	38,747	57,272	96,019	57,413	38,606

Source: Nolting and Feshbach, Statistics on R&D Employment in the USSR, Washington D.C., Dept. of Commerce Jun 1981, Table 26, (from Soviet Sources).

FIGURE C-3

Feshbach's Rationale for Computation of Soviet Direct R&D Personnel

Computation Year is 1970

Starting Point:

Reported Number of Scientific Workers	927,709 (Table C-1*)	= A

Step 1: Modify for Inclusion of Social Sciences and Humanities Research Workers. Reduce total by the number of Scientific Workers in Social Sciences and Humanities.

	200,812 (Table C-2*)	= B
Subtotal A minus B	726,897	= C

Step 2: Modify for VUZ non-R&D & Part-Time Workers

VUZ Part-Time	303,255 (Table C-3*)	= D
D x 0.642	194,690	= E1
(FTE) D x 0.642** x 0.25	48,673	= E2
Subtotal A minus E1 plus E2	580,800	= F

Step 3: Modify for "Title Holders Not Actually Involved in R&D."

F x 0.0075	4,357	= G
Subtotal F minus G	576,523	= H

Step 4: Modify for Graduate Students

Convert Full-Time Graduate Students to FTE		
I = Full-Time Graduate Students	55,024 (Table C-4)	= (I)
I x .773** x .25	10,633	= (J)
K = Part-Time Graduate Students	44,403	= (K)
K x .773 x .42 x .25	3,604	= (L)
Subtotal H plus J plus L	590,760	= M

*Soviet Sources
**See Table 32 Feshbach

NOTES FOR APPENDIX C

[1] L. E. Nolting and M. Feshbach, Statistics on Research and Development Employment in the USSR, Washington, DC, Department of Commerce, June 1981. Feshbach has also written a series of monographs dealing with Soviet manpower which appear in a wide variety of books and journals.

[2] The NSF and the BLS on the other hand depend upon reports submitted voluntarily by U.S. industrial firms, universities and government agencies. Their numbers are then biased upwards to include the total population.

APPENDIX D

AUTHORS CALCULATION OF SOVIET S&E MANPOWER
EMPLOYED IN THE MILITARY SPACE SECTOR

The starting point was the number of Scientific Workers reported by Valuyev[1] and utilized by Nolting and Feshbach.[2] In consonance with Nolting and Feshbach, Social Science and Humanities Scientific Workers were excluded[3] and then an adjustment made for Part Time workers. (The NSF and BLS data utilizes only Full Time Equivalents - FTE).

Computation of the total number of S&T qualified officers in the Soviet Armed Forces[4] is reflected in Figure D-1. (Figure D-1 also presents an overview of the structure of the Soviet Military establishment... which is considerably different from that of the U.S. Military establishment). The total number of Soviet Military Officers listed on Figure D-1 (267,400) is ultra-conservative. As an example, other estimates place this number as high as 960,000.[5] which would (in turn) increase the number of S&T qualified officers. A select number of the Soviet S&T officers act as MOD representatives at industrial facilities and Research Institutes that have substantial R&D (or production) contracts for the military. These officers are designated as "Voyenpredy".[6] The duties of the Voyenpredy include the conducting of tests, acceptance of equipment for the MOD calculation (or verification) of costs and inspection of production processes. Voyenpredy officers can be court-martialled for the acceptance of inferior goods for delivery to the MOD[7]. This in itself tends to

FIGURE D-1
COMPUTATION OF S&T QUALIFIED OFFICERS
IN SOVIET ARMED FORCES

	Troop Strength 1982[1]	% Officers[6] /Number	% Officers Tech Qualified[3]	Nr of Qualified S&T Officers[9]
Strategic Rocket Forces	385,000	8%/30,800	80%	24,600
Soviet Ground Forces	1,825,000	4%/91,250	25%	22,800
PVO - Strany	550,000	8%/44,000	60%	26,400
Soviet Air Forces	490,000	8%/39,200	50%	19,600
Soviet Navy	443,000	5%/22,150	25%	5,500
HQ and Support Troops	800,000	5%/40,000	25%	10,000
HQ MOD[5]				
Troops of Civil Defense	(70-100K)[2]			
Troops of TYL				
Const & Billeting Troops	(100-400K)[4]			
Special Troops				
Engr, Chem, Signal				
Road Building				
Railroad Building				
Automotive				
SUBTOTAL	4,500,000[7]	267,400[8]		108,900
Border Troops (KGB) Internal Troops (MVD)	400,000		N/A	N/A
TOTAL	4,900,000			
Annual Conscription Rate	2,000,000			

NOTES:

1 Organization of the Soviet Armed Forces, Air Force Mag, Mar 1982 pg. 50
2 Scott and Scott, The Armed Forces of the USSR, pg. 243-4.
3 J. Hover, "The Rule of the Soviet S&T Officer, Air Force Mag Mar 81 pg 61.
4 Scott and Scott, ibid pg. 24.
5 Including Inspectorate & Armaments
6 C. Shelton, The Soviet System for Commissionary Officers, Air Force Mag Mar 81, pg. 51.
7 Includes Approximately 70,000 Military Policitical Admin Officers
8 Probably Considerably Low. Other estimates include: 675,000 (S. Abbot "The Soviet Army", Soldiers Oct 1970 pg. 26); 720-960K (Shelton as above pg. 57) (and 15-20% plus Graduates of 50K/Year (Scott & Scott As Above pg 335).
9 Authors estimate.

maintain a much higher quality standard for military-related items (and research) as opposed to those for other sectors of the economy. Many authors have noted that three sets of standards exist for identical production goods (in their order of quality): the military, foreign sales, and domestic consumption.[8] Other observers have stated that Soviet consumers carefully examine date-stamps on consumer products.[9] Products which have been produced late in the month (on particularly late in the year) tend to remain unsold since Soviet consumers automatically consider them to be inferior products.[10]

Some "voyenpredy" apparently spend their entire career in this field. In larger plants and RI's, the Commander of the military team is a field grade officer equal in experience (and in rank) to the plant manager or research director.[11] The total number of "voyenpredy" officers was assumed to be approximately 4% of the total available S&T officers.

Estimates of the fraction of total Soviet R&D devoted to the military (alone) range from 40 to 80 percent.[12] According to JEC testimony, the Gross Value of Output[13] of the Defense portion of the Soviet Machinery Sector varied from 57.9 to 59.1 percent in 1972 and 1975 respectively.[14] Nolting and Feshbach (from Soviet Sources) allocated between 60.3 (1970) and 61.7 (1977) percent of total Soviet Industry to the Machine Building and Metal Working (MBMW) Sector.[15] Nimitz[16] (from a U.S. analog approach to the subdivision of Soviet Industry) calculated that (in 1968) 74.8% of all Diploma level Manpower was devoted to the MBMW Sector. Treml[17] on the other hand, from a re-aggregation of a 110 Sector to 56 Sector to 18 Sector analysis of the Soviet Economy, estimated a total employment in MBMW of 13,173 thousand employees (in 1972) which at a U.S. Analog of 4.2% (very low for the Soviet Sector)[18] would result in approximately 554,000 FTE S&E's in the MBMW Sector. The combination of the foregoing, plus repeated references to the priority assignment of scientific manpower to the military-space sector, lead this investigator to settle upon a range of 48-64% allocation of the Scientific workers in the Branch Ministies and Industrial enterprizes to the Soviet Military Space Sector.

Tables D-1 through D-3 present the calculations for 1970, 1975 and 1979 respectively and Table D-4 presents a summary.

For purposes of a cross check on the estimates made in Tables D-1 to D-4, the author made a point estimate using Input-Output Tables prepared by Treml[19] and others. Figure D-2 presents a summary of the 1972 average annual employment for only the MBMW Sector. Using a summation of only the Electro-Technical, Precision Instruments, Chemical[20], Transportation, Automotive[21], Bearings, and Radio sectors (the major components of the Soviet Military-Space Industry) a total employment of approximately 7.5 million is obtained. Using a factor of 4.2% per 100 as a ratio of S&E personnel to non-S&E personnel (which is low even by U.S. standards[22]) an estimated total of 315,000 S&E's would be employed in Soviet Military-Space Activities. This number lies roughly on the upper boundary of the estimate presented in Figure 4-7.

The estimate therefore, (i.e. the upper bound) remains on the conservative side considering that shipbuilding (and its associated R&D) is apparently hidden by aggregation in Section 16 (Transportation and Communications).[23]

TABLE D-1

S&E Manpower Employed in the Sov Mil-Space Sector - 1970
(Structured to Match Feshbachs Calculations)

Sov Org/Sector		Sov Input Data [1] (Thousands)	Less Soc Sc & Humanities [4]	Subtotal R&D only	FTE Adjust-ment	Subtotal R&D only	% Range Attribut-able to Mil-Space	Nr S&E in Mil Space Low/High
Branch Ministries		419.1	47.0	370.3	N/A	370.3		
Ind Enterprizes		73.9	8.3	65.3	N/A	65.3		
Subtotal		(493.0) [11]	(55.3)			(435.6)	48-64 [12]	209/279
Acad of Sciences		85.9	20.7	67.3	N/A	67.3	Lo 25	17/17
VUZy:	FT	45.6	16.3	29.3	N/A	29.3		
	PT	303.2	108.5	194.7	-146.0 [5]	48.7		
	Total	(348.8)	(124.8)	224.0		78.0	Hi 50	39/39
Subtotal		927.7 [2]	200.8	726.9	-146.0	580.9		
Grad Students [3]	FT	55	11.9	43.1	10.7 [6]	10.7		
	PT	44	9.6	34.4	3.6 [6]	3.6		
Subtotal					595.2			
Feshbachs Adjustment [7]					-4.5			
Feshbachs Adjusted Total					590.7 [8]			
Military "Voyenpredy"					16.0 [9]		100	16/16 [13]
Other Mil Scientists					5.0 [10]		100	5/5
Total								286/356

(Table D-1 continued on next page)

TABLE D-1 (continued)

NOTES:

1. Feshbach Table 17.
2. Reported Scientific Workers Ts SU; Nar Khoz etc. cited in Feshbach Table 14; Also agrees with Valuyev R-4-37, 1976 p 7.
3. Grad Students excluded from Scientific Workers by Definitions; Feshbach adds is to compare with NSF Data (Table 26).
4. 35.8% for VUZy; 24.1% for Acad (See Table 82 Feshbach); Branch computes at 11.2% to match with Feshbach.
5. Computed as [PT x 0.25] - PT; Reduces all by PT then adds back FTE.
6. FT Grad Students computed at 25%; PT 42% of 25%.
7. Feshbach *adjusts downward by 0.0075 for Titleholders not* involved in R & D.
8. Feshbach's Final Number to compare with NSF Data, See Table 34.
9. Taken as 4% of Officer Corps of 400,000, Armed Forces of 4 Million.
10. Primarily attached to HQ Staffs etc for R & D Managment.
11. Nimitz (R-4-8) calculated 504,000 for all Sov Industry (1968); 74.8% of which (377,000) was in MBMW.
12. MBMW=80% of Total Sc Workers in Sov Industry (Nimitz Table B4); Mil-Space receives 60-80% of Sc Talent in MBMW.
13. 13,280 Military may have been included in 927.7; see table is Feshbach, but if is considered doubtful.

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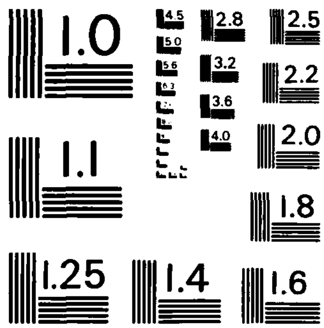

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TABLE D-2

S&E Manpower Employed in the Sov Mil-Space Sector - 1975

Sov Org/Sector	Sov Input Data [1] (Thousands)	Less Soc Sc & Humanities [3]	Subtotal R&D only	FTN Adjust-ment	Subtotal R&D only	% Range Attribut-able to Mil-Space	Nr S&E in Mil Space Low/High
Branch Ministries							
Ind Enterprizes							
Subtotal	690.1	85.6	604.5	N/A	604.5	48-64 [7]	290/387
Acad of Sciences	105.5	25.4	80.1	N/A	80.1	Lo 25	20/20
VUZy: FT	76.6 [4]	27.4	49.2	N/A	49.2		
PT	351.2 [4]	125.7	225.5	-169.1 [5]	56.4		
Total	(427.8)	(153.1)	(274.7)		(105.6)	Hi 50	53/53
Subtotal	1223.4 [2]	264.1	959.3		790.2 [6]		
Military "Voyenpredy"					16.0	100	16/16 [8]
Other Mil Scientists					5.0	100	5/5
Total							384/481

NOTES:

1. Feshbach Table 17
2. Agrees with TsSU data cited in Table 14 Feshbach; Also agrees with Valuyer, R-4-37, 1976 p 9
3. Table 32 Feshbach, 12.4% Branch, 24.1% Acad, 35.8% VUZy
4. Interpolated from 1976 Data - See Table 24 Feshbach - 17.9% FT, 82.1% PT
5. Computed as [PT x 0.25] - PT; Reduces all PT then adds back FTE
6. Compares with 779.3 Table 34 Feshbach; Grad Students omitted, No Title holder deduction
7. MBMW =80% of Total Sc Workers in Sov Industry (Nimitz Table B4); Mil-Space receives 60-80% of Sc Talent in MBMW.
8. See 1970 Computation

TABLE D-3

S&E Manpower Employed in the Sov Mil-Space Sector - 1979

Sov Org/Sector	Sov Input Data [1] (Thousands)	Less Soc Sc & Humanites [3]	Subtotal R&D only	FTN Adjust-ment	Subtotal R&D only	% Range Attribut-able to Mil-Space	Nr S&E in Mil Space Low/High
Branch Ministries							
Ind Enterprizes							
Subtotal	726.0	90.0	636.0	N/A	636.0	48-64 [7]	305/407
Acad of Sciences	117.6	28.3	89.3	N/A	89.3	Lo 25	22/22
VUZy: FT	88.9 [4]	31.8	57.1	N/A	57.1		
PT	407.8 [4]	146.0	261.8	-196.4 [5]	65.4		
Total	(496.7)	(177.8)	(318.9)		(122.5)	Hi 50	61/61
Subtotal	1340.3 [2]	296.1	1044.2		847.8 [6]		
Military "Voyenpredy"					16.0		16/16 [8]
Other Mil Scientists					5.0		5/5
Total							409/511

NOTES:
1. Feshbach Table 17
2. Agrees with TsSU data cited in Table 14 Feshbach;
3. Table 32 Feshbach, 12.4% Branch, 24.1% Acad, 35.8% VUZy
4. Interpolated from 1976 Data - See Table 24 Feshbach - 17.9% FT, 82.1% PT
5. Computed as [PT x 0.25] - PT; Reduces all by PT then adds back FTE
6. Compares with 853.8 Table 34 Feshbach; Grad Students omitted, No Title holder deduction
7. MBMW =80% of Total Sc Workers in Sov Industry (Nimitz Table B4); Mil-Space receives 60-80% of Sc Talent in MBMW.
8. See 1970 Computation

TABLE D-4
S & E Employed in Soviet Military Space Research
(In Thousands)

Year	Scientific Workers in Total Economy*	Scientific Workers in Military-Space (Average)	Average % Col 1/Col 2
1970	590.8	321	54.3
1971	638.9		
1972	672.7		
1973	706.1		
1974	745.1		
1975	779.3	433	55.6
1976	798.5		
1977	815.1		
1978	837.0		
1979	853.8	460	53.8

* Adjusted by Feshbach to parallel NSF Data.

FIGURE D-2

AVERAGE ANNUAL EMPLOYMENT IN MBMW SECTOR - 1972

SECTOR 6 OF 18 SECTOR TABLE

56 Sector Table	110 Sector Table	Description*	Employment (Thousands of Work Years)
8	14	Electric Power	597.6
9	15	Energy & Power	176.3
10	16,17	Electrotechnical M & E, Cable Prod	834.3
11	20,21,22	Metalwork M & E	210.1
12	23	Tools & Dies	127.8
13	24	Precision Instruments	765.0
14	25,26,27	Mining, Metallurgical M & E	249.6
15	28,29	Pumps & Chemical M & E	228.1
16	30-34,36	Specialized M & E	341.5
17	35	Construction M & E	114.9
18	37,38	Transportation M & E	442.0
19	39	Automobiles	772.1
20	40	Agricultural M & E	752.8
21	41	Bearings	133.2
22	18-19,42-43	Radio & Other MB	4318.9
23	44	Sanitary Engineering Products	135.9
24	45	Other Metalwares	626.3
25	46	Metal Structures	160.8
26	47	Repair of M & E	2206.8
27	48	Abrasives	28.6
		TOTAL	13,172.6**

*M & E - Machinery and Equipment
**The 1972 Final Demand for Labor was 86,626.4

NOTE: Nimitz estimated 11,275 for MBMW IN 1968 (Table B-4) based upon Treml's 1966 I-O Tables. A factor of 4.2% was then used as an estimate of Diploma Level Manpower in Industrial R&D (U.S. analog).

Sources: D. Gallik, V Treml et al "The 1972 Input-Output Table and the Changing Structure of the Soviet Economy" in Soviet Economy in a Time of Change, Vol I, JEC 96th Congress, 10 Oct 1979, pp. 423-471 and V. Treml, Price Indexes for Soviet Input-Output Tables for 1959-1975, Washington, D.C., SRI International (for CIA), Jun 1978 p 2.

NOTES FOR APPENDIX D

[1]Y.I. Valuyev et al, The Unique Characteristics of the Financing of Science in the USSR (Moscow 24 Mar 1977), Summarized by SRI International for NSF Arlington, VA, Feb 1978, p 7. (NTIS PB 81-249807)

[2]L. Nolting and M. Feshbach, Statistics on Research and Development Employment in the USSR, Washington, DC, Dept. of Commerce, Series P-95, Nr 79, Jun 1981, Chapter 4. See also Appendix C.

[3]As will be seen in Chapter 6, a portion of these will be added back in.

[4]Although the base data for Figure D-1 is for 1982, the total size of the Soviet Armed Forces has remained relatively constant during the 1970's and early 1980's.

[5]C. Shelton, "The Soviet System for Commissioning Officers", Air Force Magazine, March 1981, p 57.

[6]U. Kruze-Vaucienne and J. Thomas, Soviet Science and Technology, Washington, D.C., George Washington University (for NSF) 1977 p 205.

[7]J.E. Hever, "The Role of the Soviet S&T Officer," Air Force Magazine, Mar 1981, p 64.

[8]See H. Smith, The Russians, NY, Ballantine Books, Jan 1977, pp 312-15.

[9]Apparently consumer products (e.g. Kitchen appliances) must have a date of final assembly permanently stamped on the product. (This is an interesting innovation in itself...)

[10]See C.A. Krylov, The Soviet Economy, Lexington, MA, Lexington Books, 1976 pg. 94, for a graph of the impact of production "spurts" in Soviet industry. Krylov's conclusion (based upon data from a 1966 Soviet Economic Journal Article) is that 70% of the total monthly production typically occurs in the last ten days of the production month. Also see Smith, op cit p 317.

[11]U Kruze-Vaucienne and J. Thomas, op cit, p 206.

[12]E.A. Molander et al, What About the Russians and Nuclear War?, NY, Pocket Books 1983 p 79.

[13]The Gross Value of Output (GVO) comes the closest to the Soviet equivalent of a bottom line. See Berliner, "Planning and Management" pg. 21 in: The Soviet Economy to the year 2000, Washington, D.C., National Council for Soviet and Eastern European Research 1982 (Pentagon Library 336.25.S72 V6).

NOTES FOR APPENDIX D (continued)

14"Allocation of Resources in the Soviet Union and China - 1979", Hearings before the Subcommittee on Priorities and Energy in Govt. JEC, PART 5, 96th Congress, Washington, D.C. GPO 1980 p 97.

15Nolting and Feshbach, op cit Table 22.

16N. Nimitz, The Structure of Soviet Outlays on R&D in 1960 and 1968, Santa Monica, CA, RAND, Jun 74 Table B3.

17D. Gallik, V. Treml et al, "The 1972 Input - Output Table and the Changing Structure of the Soviet Economy" in Soviet Economy in a Time of change. Vol. I, JEC, 96th Congress, Washington, D.C, GPO, 10 Oct 1979 pp 40-471 and V. Treml, Price Indexes for Soviet 18 Sector Input-Output Tables for 1959-1975, Arlington, VA, SRI International (for CIA) Jun 1978 p 2. (DTIC AD A059 169)

18In high technology areas such as the military-space sector, the U.S. analog is closer to seven percent (See Table E-17, Appendix E).

19See D. Gallik, V. Treml et al "The 1972 Input-Output Table and the Changing Structure of the Soviet Economy" in: Soviet Economy in a Time of Change Vol I, JEC, 96th Congress, 10 Oct 1979 pp 423-471; and V. Treml, Price Indexes for Soviet Input-Output Tables for 1959-1975, Washington, D.C., SRI International (for CIA), Jun 1978 p 2.

20Unlike the U.S. Chemical Industry, the Soviet Chemical Industry is a major defense-related industry. It provides military explosives, rocket fuels, and chemical warfare material in addition to semi-finished goods for Soviet Defense Industrial production. See statement by LTG J. A. Williams, Director DIA, to JEC, 29 Jun 1982 p 17 (C-2-11) (To be published).

21Once again the Soviet Automotive sector is a major Soviet Defense Industry whereas in the U.S., Defense-Space purchases in this sector are relatively minor (by comparison).

22The U.S. Aerospace Space Industry averaged 80 S&E's per 1000 Employees from 1972 to 1978 (See Table E-17).

23See D. Gallik, V. Trend et al, op cit 426-27.

APPENDIX E

CALCULATION OF THE NUMBERS OF S&E PERSONNEL IN THE US MILITARY SPACE SECTOR

Table E-1 presents trends in the percentages of Federal and Non-Federal Research and Development (R&D) outlays and an estimate of Total National R&D expenditures for fiscal years 1970 through 1979. Total Defense - Space R&D expenditures were then derived as reflected on Table E-2. Note that the combined defense - space percentage dropped 13 percent during the decade. Table E-3 reflects the distribution of Federal expenditures provided by Defense (including AEC/DOE) and Space. The data on Tables E-2 and E-3 are similar (although not exactly identical)[1] in that they show slight dips in total expenditures in 1971 and 1974.

The Defense - space R&D expenditures derived on Tables E-2 and E-3 contain both intramural (i.e. consumed by the government) and extramural (consumed by outside performer) expenses. A breakdown of intramural and extramural expenses (by research category) for DoD, NASA and DOE for FY 77 is reflected in Table E-4. (Data on the DOE was included on Table E-3 only to note the striking difference between the intramural-extramural balance between the DOE and the other two agencies. The DOE has relatively few in-house laboratories by comparison to the other agencies.) In order to determine the relative number of S&E's employed with extramural funds, it was initially assumed that the ratio of intra versus extramural funds held relatively constant during the time frame involved (i.e. 28% and 73%).[2]

The Department of Defense over the years has used several different sub breakdowns of the R&D categories as depicted in Table E-5. The current DoD categories are listed as the point of departure. This dissertation, however, will remain with the National Science Foundation categories of Basic Research, Applied Research and Development.

Table E-6 represents average salary ranges in industry during the decade of concern.[3] In order to compute a range of probable S&E employed by means of the availability of extramural funds, the reverse procedure from the computation of an Independent Government Cost Estimate (IGCE) was utilized. As noted on Table E-7, dependent upon the upper and lower bounds of the overhead rates[4] (70% to 130%) and G&A (18.5% to 30%),[5] Ratios of Direct Labor to Total Cost (RDLTC) may vary from one to 2.4 to one to 3.6 (or obversely, the amount of funds available for payment of direct salaries could vary from 41.4% down to 27.9%. Another way of expressing this data, in terms of cost to the government per S&E purchased on contract is reflected in Table E-8. Cost Analysts prefer to describe costs by means of Cost Estimating Relationships (CER's) based upon accumulated data, for example:[6]

$$\text{Cost of research (1MY)} = 1.38\ e^{0.5537^{*}}\ (\text{Year} - 1900)$$

Therefore:

COR (1970) = \$ 66,552

COR (1979) = \$109,543.

Obviously, use of the above CER would result in higher estimated cost to the government than the ratios used on Table E-8.

Table E-9 reflects the total number of Full Time Equivalent (FTE) Scientists and Engineers employed in research and development in the

U.S. during 1970 to 1979 as estimated by the National Science Foundation. Table E-10 provides suballocation of the Federal S&E's to the Defense - space sector based upon funding allocations to the sector. Table E-11 then provides an initial estimate of Total S&E's in the U.S. Defense Space Sector for 1970, 1975 and 1979. The investigator realized at this point that it was being proposed that the military space sector was consuming from 37 to 51% of the total U.S. R&D scientific manpower assets available in 1970 and from 26 to 36% of the 1979 assets. Referring back to Table E-1 these were on the high side but within the range of funding percentages for the Defense Space Sector versus all other Sectors.

It was then realized however, that the NASA RDTE Budget probably contains a much higher percentage of other Direct Costs (e.g. hardware) than does the DoD RDTE budget. According to AAAS[7] all of the NASA budget is classified by OMB and NSF as R&D except for about 23 million dollars for scientific and technical information activities (i.e. NASA has no procurement budget.) Manned Space Flight Activities expendible boosters, and the Shuttle production would (under DoD standards) normally be found in Procurement. Therefore the NASA budget was recalculated at an "Other Direct Cost" ratio of 50% as reflected in Table E-12. In addition, the contractor S&E average salary base was raised by ten percent throughout the decade.[8]

The result of the recomputation is reflected on Table E-13[9] and Figure E-1. The estimate now ranged from 33 to 42% of the available S&E's in 1970 and from 24 to 31 percent in 1979, both of which sounded more reasonable.

At this point in the analysis the investigator obtained some summary level information for FY 80 to FY 82 from the Defense Technical Information Center (DTIC). This data reflected that the Department of Defense estimated that they were utilizing not more than 35,000 contractor S&E personnel in FY 81 (whereas my 1979 estimate was 86-129,000). When comparing the total reported funds however, it was discovered that the DTIC system is only summarizing 50-60% of the total Defense RDTE budget. It was also determined that the statistical portion of the system is very flawed (i.e. it accepts whatever information it is given and has no method for verification).[10]

In order to validate (or invalidate) the estimate provided in Figure E-1, the investigator undertook an examination of funding and manpower availability data from other National Science Foundation data.[11] Table E-14 and E-15 reflect the methodology for the calculation of R&D manpower supporting the military-space sector. The data has been rearranged by leading federally funded sectors (Table E-14) and then manpower allocated in the same ratios as funds to (first) the federally funded efforts and then (second) to the military - space sector. The identical method was used for 1971 through 1979, the results of which are reflected on Table E-16. If anything, the numbers on Table E-15 are probably biased downwards because of the relatively high number of S&E's per thousand employees in the aerospace industry (See Table E-17).

A similar method was used for calculation of the S&E manpower in support of the military-space sector at universities and at Federally Funded Contract Research Centers (FFCRC's) (See Tables E-18 to E-20.) Table E-21 provides a summary of the Total estimated R&D personnel employed in the U.S. military-space sector for 1970 to 1979.

TABLE E-1

TRENDS IN DEFENSE, SPACE AND ALL OTHER R&D
OUTLAYS BY SOURCE, 1970 - 1979
(PERCENTS AND BILLIONS OF CURRENT DOLLARS)

Pecentages*

Fiscal Year	Federal					Total National R&D Expenditures
	Total	Defense related	Space related	Civilian related	Non-Federal	
1970	57	33	10	14	43	26.1
1971	56	32	9	15	44	26.6
1972	55	32	8	15	45	28.4
1973	53	31	7	15	47	30.6
1974	51	28	7	16	49	32.8
1975	51	27	7	17	49	35.2
1976	51	26	8	17	49	38.9
1977	50	25	7	18	50	42.9
1978	50	24	7	19	50	48.0
1979	49	23	7	19	51	54.2

* All percentages rounded to nearest full percent

Source: National Patterns of Science and Technology Resources 1981, NSF 81-311, Washington, D.C., National Science Foundation Tables 6 and 13 (S-2-21).

TABLE E-2

DEFENSE-SPACE R&D OUTLAYS

FY	Combined Defense-Space (Percent) (1)	National R&D Expenditures (Billions of Current $) (2)	Defense-Space R&D Expenditures (Billions of Current $) (3)
1970	43	26.1	11.2
1971	41	26.6	10.9
1972	40	28.4	11.4
1973	38	30.6	11.6
1974	35	32.8	11.5
1975	34	35.2	12.0
1976	34	38.9	13.2
1977	32	42.9	13.7
1978	31	48.0	14.9
1979	30	54.2	16.3

Sources: Columns 1 and 2, NSF 78-313, (See Table E-1).
Percentages rounded to nearest full percent.
Column 3 = Col. 1 x Col. 2.

TABLE E-3

FEDERAL R&D EXPENDITURES FOR DEFENSE AND SPACE
(DOLLARS IN BILLIONS)

	Defense*	(AEC/DOE)	Space**	(MSF)	(Shuttle)	TOTAL
1970	7.981	(.629)	3.510	(1.679)	(.013)	11.491
1971	8.110	(.609)	2.893	(.910)	(.063)	11.003
1972	8.902	(.594)	2.714	(.582)	(.064)	11.616
1973	9.002	(.608)	2.601	(.071)	(.202)	11.603
1974	9.016	(.607)	2.478		(.515)	11.494
1975	9.679	(.678)	2.511		(.794)	12.190
1976&7T	10.430	(.801)	2.863		(1.203)	13.293
1977	11.864	(.924)	3.066		(1.409)	14.930
1978	12.786***	(.987)	3.141		(1.346)	15.927***
1979	13.833***	(1.023)	3.383		(1.436)	17.216***

*Including Defense-related Atomic Energy Activities
**Including Manned Space Flight and Shuttle As Shown
***Estimates

Source: An Analysis of Federal R&D Funding by Function, FY 1969 - 1979, (NSF 78-320) Washington, D.C., National Science Foundation, Dec. 1978, Appendix C. p 34.

TABLE E-4

R&D OBLIGATIONS - FY 77
(BILLIONS OF CURRENT DOLLARS)*

	Intra Mural	Extra Mural	Percentage Research vs Developmt	TOTAL
DEPARTMENT OF DEFENSE				
Research:	.8	1.2	18%	2.0
Basic	(.1)	(.2)		(.3)
Applied	(.7)	(1.0)		(1.7)
Development	2.3	6.6	82%	8.9
DoD RDTE	3.1	7.8	100%	10.9
(Intra vs Extramural)	(28%)	(72%)		
NASA				
Research:	.6	.6	22%	1.2
Basic	(.2)	(.2)		(.4)
Applied	(.4)	(.4)		(.8)
Development	.4	2.1	78%	2.5
NASA RDTE	1.0	2.7	100%	3.7
(Intra vs Extramural)	(27%)	(73%)		
DEPARTMENT OF ENERGY				
Research:	.03	.9	26%	.9
Basic		(.4)		(.4)
Applied	(.03)	(.5)		(.5)
Development	.1	2.5	74%	2.6
DoE RDTE	.1	3.4		3.5
(Intra vs Extramural)	(3%)	(97%)		

*Rounded to nearest .1 Billion

Source: Federal Funds for Research and Development Fiscal Years 1977, 1978, and 1979, Vol. XXVII Detailed Statistical Tables Appendix C, NSF 78-312, Washington, D.C., National Science Foundation, 1978, Tables C-7, C-10, C-29, C-48, C-67, (C-1-29).

TABLE E-5

R&D BY DoD BUDGET CATEGORY

	Current Categories	1966[1]	1979[2]	1982[3]
		Percentage of Funds Allocated		
6.1	Basic Research	5		3.5
6.2	Exploratory Research	12	20.5	11.0
6.3A	Non Systems Advanced Development			
6.3B	Systems Advanced Development	16		17.3
6.4	Engineering Development	30	64.5	38.4
6.5	Management and Support	22	15	10.0
---	Operational Systems Development	15		19.9

1966 Performers[1]

Industry	66%
DoD Labs	24%
Colleges & Non-Profit	9.5
Foreign	.5
	100.0

1979 Performers[2]

Industry	67.1%
DoD Labs	27.1
Colleges	3.3
Non-Profits	2.1
	100.0

1982 6.1 Performers[3]

Industry	18%
Government Labs	35%
Universities	47%

Sources:

[1]Sanders, R, ed, Defense Research and Development, Washington, D.C., Industrial College of the Armed Forces, 1968, pp 18-20.

[2]"Defense 80", Armed Forces Information Se:vice Pamphlet, 1 Jun 80, p 15.

[3]Suttle, J.R., (USDRE, R&AT), "Basic Research", Defense 82, Jun 82, p 24.

TABLE E-6

AVERAGE SALARIES
SCIENCE AND ENGINEERING IN INDUSTRY

YEAR	S&E's (Thousand's of $)
1970	14.5
1971	15.5
1972	16.5
1973	17.5
1974	19.3
1975	20.5
1976	23.0
1977	25.0
1978	27.2
1979	29.0

Source: Table B-7 and Chart 8, NSF 80-316; Table B26, NSF 79-322.

TABLE E-7

ESTIMATE OF INDUSTRIAL RESEARCH PERSONNEL
FUNDED BY GOVERNMENT SECTOR

Assumption: Research Personnal Proportional to Research Cost

Low Estimate***		High Estimate	
Direct Scientific Labor	41.4	Direct Scientific Labor	27.9
Labor Overhead (70%) (Including Clerical)		Labor Overhead (130%) (Including Clerical)	
Other Direct Charges (ODC)*:		ODC*	
Travel		Travel	
Matls		Matls	
Computer Spt		Computer Spt	
Test Equipment, etc.			
Subtotal	10%	Subtotal	10%
G&A (18.5%)**		G&A (30%)**	
Fee (9%)		Fee (9%)	
TOTAL	=100	TOTAL	=100
RDLTC:****	1:2.4		1:3.6

*Excludes Government Furnished Equipment (FGE), which is included in intramural expenditures

**Includes Contractor IR&D on R&D Contracts but NOT from Production Contracts

***FCRC's & Universities may be equivalent to low estimate

****Ratio of Direct Scientific Labor to Total Cost

TABLE E-8

COST TO GOVERNMENT OF S&E MANPOWER
PURCHASED ON CONTRACT

	Average S&E Salary (1)	Low RDLTC (1:2.4) (2)	High RDLTC (1:3.6) (3)	Average (4)
1970	$14,500	$34,800	$ 52,200	$43,500
1971	15,500	37,200	55,800	46,500
1972	16,500	39,600	59,400	49,500
1973	17,500	42,000	63,000	52,500
1974	19,300	46,320	69,480	57,900
1975	20,500	49,200	73,800	61,500
1976	23,000	55,200	82,800	69,000
1977	25,000	60,000	90,000	75,000
1978	27,200	65,280	97,920	81,600
1979	29,000	69,600	104,400	87,000

Source:
Column 1: Table E-6;
Columns 2 & 3: Column 1 times Ratio in ( );
Column 4: Numerical Average of Columns 2 & 3.

TABLE E-9

Full Time Equivalent (FTE) Scientists and Engineers:[1] Employed in Research and Development in the US, 1970-1979 (In Thousands)

Fiscal Year	Federal[2] Government	(Military[2] in DoD)	Industry[3,4]	Other[5]	Total[6]
1970	69.5	14.0	377.4	102.8	549.7
1971	68.5	12.0	363.4	100.9	532.8
1972	65.2	10.7	353.3	100.0	518.5
1973	62.3	8.1	357.4	97.8	517.5
1974	65.0	7.0	359.5	100.9	525.4
1975	64.5	7.7	362.6	107.7	534.8
1976	65.3	7.4	372.4	112.2	549.9
1977	64.5	7.2	390.1	116.5	571.1
1978	65.0	7.4	410.0	120.0	595.0
1979	65.5	7.2	421.0	123.5	610.0

NOTES:

[1]Number of full time employees plus the FTE of part time employees. Excludes scientists and engineers employed in State and local government agencies. Totals may be understated by about 5 percent because of incomplete data on summer employment at universities and colleges.

[2]Includes both civilian and military service personnel and managers of R&D. Military R&D scientists and engineers in the Department of Defense were estimated at the levels shown in the next column.

[3]Includes professional R&D personnel employed at FFCRC's administered by organizations in the sector.

[4]Excludes social scientists.

[5]Includes S&E's employed by universities, colleges, university-associated FFCRC's and other non profit institutions. Graduate students receiving stipends and engaged in R&D have been reduced to full time equivalency.

[6]The data for FY 1972 - 1979 are identical to the data utilized by Feshback Table 34 and presented on Figure 2-12.

Sources:			
	1970, 1971	NSF 73-303	Table B-10
	1972 to 1979	NSF 78-313	Table B-10

TABLE E-10

Allocation of Federal S&E to Military Space

Year	Total Federal Percentage of R&D Outlay (1)	Def - Space Portion of Fed Outlay (2)	Def - Space Share of Federal (%) (3)	Total Federal S&E's (4)	Def - Space S&E's (5)
1970	57	43	75.4	69.5	52.4
1971	56	41	73.2	68.5	50.1
1972	55	40	72.7	65.2	47.4
1973	53	38	71.7	62.3	44.7
1974	51	35	68.6	65.0	44.6
1975	52	35	67.3	64.5	43.4
1976	51	34	66.6	65.3	43.5
1977	50	33	66.0	64.5	42.6
1978	50	33	66.0	65.0	42.9
1979	50	33	66.0	65.5	43.2

Source: Columns 1 and 2: Table E-1
Columns 4: Table E-9
Columns 3 and 5: Computed by author

TABLE E-11

COMPUTATION OF TOTAL S&E'S IN US DEFENSE-SPACE SECTOR

	1970	1975	1979
Federal R&D Expenditures for Defense & Space (Table E-2) (Billions of Current Dollars)	11.1	12.3	17.0
Federal R&D Expenditures for Defense & & Space Extramural (Table E-3) (Billions of Current Dollars)	8.0	8.9	12.2
Average S&E Salary (Thousands of Dollars)	14.5	20.5	29.0
Number of Industrial S&E's (Thousands)			
from Low RDLTC* (2.4)	229.9**	180.9	175.3
from High RDLTC* (3.6)	153.3	120.6	116.9
Number of Fed S&E's (Thousands) (Table E-8)	52.4	43.4	43.2
Range of Total S&E's in Defense and Space (Thousands)	206-282	164-224	160-219

* RDLTC = Ratio of Direct Scientific Labor to Total Cost

** 8 B $ - (14,500 x 2.4) = 229,885 = 229.9K

TABLE E-12

ESTIMATE OF INDUSTRIAL RESEARCH PERSONNEL
FUNDED BY GOVERNMENT SECTOR

NASA ACTIVITIES ONLY

Direct Labor	20.5
Labor Overhead	(130%)
Subtotal	
Other Direct Charges*	50%
G&A**	30%
Fee	9%
TOTAL	≈ 100
RDLTC***	1:4.9

* Includes special materials, special tooling, etc. Excludes GFE.

** Includes Contractor IR&D on R&D Contracts but NOT for Production Contracts

*** Ratio of Direct Scientific Labor to Total Cost

TABLE E-13

RECOMPUTATION OF TOTAL S&E'S IN US DEFENSE-SPACE SECTOR

	1970	1975	1979
Federal R&D Expenditures for Defense & Space (Table E-3) (Billions of Current Dollars)	11.5	12.2	17.2
Federal R&D Expenditures for Defense Extramural (Table E-4) (Billions of Current Dollars)	5.7	7.0	9.9
Federal R&D Expenditures for Space Extramural (Billions of Current Dollars)	2.5	1.8	2.5
Subtotal Extramural	8.2	8.8	12.4
Average S&E Salary (Thousands)	16.0	22.3	32.0
Number of Industrial S&E's in Defense (Thousands)			
from Low RDLTC* (2.4)	148.8**	130.8	128.9
from High RDLTC* (2.4)	99.0	87.2	85.9
Number of Industrial S&E's in Space from Special RDLTC rate (4.9)	31.9	16.5	15.9
Number of Fed S&E's (Thousands) (Table E-10)	52.4	43.3	43.2
TOTAL S&E's in Defense and Space (Thousands) Average	184-233	147-191	145-188

* RDLTC = Ratio of Direct Scientific Labor to Total Cost

** 5.7 B $ - (16,000 x 2.4) = 148,844 = 148.8 K

TABLE E-14

FUNDS AND PERSONNEL AVAILABLE FOR INDUSTRIAL R&D PERFORMANCE 1970

(Rearranged by Leading Federally Funded Areas)

Industry	Federal Funds (1)	Corporate Funds (2)	Total Funds (3)	FTE S&E's* (4)
Aircraft & Missiles	4,005	1,213	5,218	92.2
Electronic Components & Commo.	1,420	1,183	2,603	64.8
Other Electrical Equipment	791	825	1,616	35.8
Motor Vehicles & Equipment	314	1,278	1,592	25.5
Office Machines (Incl Computers)	262	1,469	1,731	42.3
Prof & Scientific Instruments	194	550	744	15.0
Chemicals	180	1,593	1,773	40.1
All Others	613	2,177	2,790	59.7
TOTAL	7,779	10,288	18,067	375.4

* Annual Average

Source: National Patterns of Science and Technology Resources, 1981, NSF 81-311, Washington, D.C., National Sciences Foundation, April 1981, Tables 38, (Col. 3), 39 (Col. 1), 40 and 49 (Col. 4). (S-2-21).

TABLE E-15
ESTIMATE OF S&E'S
FUNDED BY MILITARY-SPACE SECTOR 1970

Industry	% Federal of Total[1] (1)	FTE S&E's[2] (2)	Nr S&E's Funded by Fed Gov't[3] (3)	Estimated MIL-Sp%[4] (4)	Estimated S&E's MIL-Sp (5)
Aircraft & Missiles	77	92.2	71.5	100	71.5
Electronic Components & Commo.	55	64.8	35.6	90	32.0
Other Electrical Equipment	49	35.8	17.9	90	16.1
Motor Vehicles & Equipment	20	25.5	5.1	95	4.9
Office Machines Including Computers)	15	42.3	6.3	84	5.3
Prof & Scientific Equipment	26	15.0	3.9	84	3.3
Chemicals	10	40.1	4.0	---	
All Others	22	59.7	13.1	---	

Estimate of FTE Industrial S&E's Working in MIL-Space (1970) ... 133.1

NOTES:

1. From Columns 1 and 3 Table E-14
2. Annual Average; Column 4 Table E-14
3. Estimate: Column 1 times Column 2
4. Competitors for assets with Military Space and 1972 Percentage of TOTAL Fed R&D Budget include:

Department of Agriculture	0.1%	
Department of Commerce	0.4	
Department of Education	.9	
Department of Energy	8.1	(Includes some DoD Spt)
Department of Health & Hum Svcs	2.1	
Department of Interior	.7	
Department of Transportation	2.0	
Environmental Protection Agency	.7	
All Others	.9	
Military - Space	84.1	

Source: Footnote 4: National Patterns of Science and Technology Resources 1981, NSF 81-311, Washington, D.C., National Sciences Foundation, Apr 1981, Table 34.

TABLE E-16

ESTIMATE OF S&E'S
FUNDED BY MILITARY-SPACE SECTOR 1970 - 1979

YEAR	FTE Industrial S&E's Funded by Military-Space
1970	133.1
1971	118.2
1972	108.7
1973	108.6
1974	101.0
1975	99.2
1976	97.2
1977	103.3
1978	107.4
1979	109.8

TABLE E-17

FTE R&D S&E'S PER 1000 EMPLOYEES BY INDUSTRY

(In Leading Federally Funded Sectors)

Industry	1970	1975	1978
Aircraft & Missiles	73	72	87
Electronic Components & Commo.	46	44-49	46-51
Other Electrical Equipment	41	40	40
Motor Vehicles & Equipment	20	22	24
Office Machines (Incl. Computers)	28	36	38
Professional Scientific Equipment*	29	38	44
Chemicals	39	41	42

* Data is for Office Computing & Accounting Machines

Source: National Patterns of Science and Technology Resources, 1981, NSF 81-311, Washington, D.C., National Sciences Foundations, Apr 1981, Table 50.

TABLE E-18

FTE R&D S&E'S EMPLOYED IN COLLEGES AND UNIVERSITIES
1969, 1972, THRU 1980

YEAR	Number of R&D FTE's
1969	50,400
1970	(49,900)*
1971	(49,400)*
1972	48,900
1973	46,900
1974	48,000
1975	51,600
1976	52,900
1977	54,400
1978	55,919
1979	(56,518)*
1980	57,116

* Authors estimate

Source: NSF 81-31, Table 65 (S-2-21)

TABLE E-19
ALLOCATION OF FTE UNIVERSITY/COLLEGE
R&D SCIENTISTS AND ENGINEERS MILITARY-SPACE

YEAR	Number of R&D FTE S&E Pers (1)	% of Funding Support by Federal Govt. (2)	Estimated Nr of FTE R&D S&E Supported by Fed Government (3)	Defense-Space Share of Federal Share (4)	Estimated R&D S&E Supported by Military-Space (Thousands) (5)
1970	49,900	70.6	35.2	75.4	26.5
1971	49,400	(71.8)*	35 5	73.2	26.0
1972	48,900	68.3	33.4	72.7	24.3
1973	46,900	68.8	32.3	71.7	23.2
1974	48,000	67.2	32.3	68.6	22.2
1975	51,600	67.1	34.6	67.3	23.3
1976	52,900	67.4	35.7	66.6	23.8
1977	54,400	67.2	36.6	66.0	24.2
1978	55,919	66.3	37.1	66.0	24.5
1979	56,518	66.2	37.4	66.0	24.7

* Authors Estimate

Sources: Column 1: Table E-18
Column 2: NSF 81-311 Table 51 (Source of Funds Section)
Column 3: Column 1 times Column 2
Column 4: Table E-10
Column 5: Column 3 times Column 4

Table E-20

ALLOCATION OF FTE FFCRC S&E'S
TO MILITARY-SPACE

YEAR	"Other" Category[1] (1)	FTE R&D S&E's Employed by Univ. etc. (2)	Nr of S&E Emply by FFCRDC & (3)	% Share to Military Space Sector (4)	Nr of FFCRC S&E Pers funded by Mil-Space (5)
1970	102.8	49.9	52.9	40%	21.1
1971	100.9	49.4	51.5		20.6
1972	100.0	48.9	51.1		20.4
1973	97.8	46.9	51.3		20.5
1974	100.9	48.0	52.9		21.1
1975	107.7	51.6	56.1		22.4
1976	112.2	52.9	59.3		23.7
1977	116.5	54.4	62.1		24.5
1978	120.0	55.9	64.1		25.7
1979	123.5	56.5	67.0		26.8

Notes: [1]Includes S&E's employed by universities, colleges, university-associated FFCRDC's and other non-profit institutions. Graduate students receiving stipends and engaged in R&D have been reduced to full time equivalency (FTE).

Sources: Column 1: Table E-9
Column 2: Table E-19
Column 3: Column 1 minus Column 3
Column 4: See NSF 79-322 Table B-14 and Text.
Column 5: Column 3 times Column 4

TABLE E-21

ESTIMATED TOTAL R&D PERSONNEL
EMPLOYED IN MILITARY-SPACE SECTOR

YEAR	Employed by Fed. Govt. (1)	Employed by Industry (2)	Employed by Universities & Colleges (3)	Employed by FFCRC & Non-Profits (4)	TOTAL
1970	52.4	133.1	26.5	21.2	233.2
1971	50.1	118.2	26.0	20.6	214.9
1972	47.4	108.7	24.3	20.4	200.8
1973	44.7	108.6	23.2	20.5	197.0
1974	44.6	101.0	22.2	21.2	189.0
1975	43.4	99.2	23.3	22.4	188.3
1976	43.5	97.2	23.8	23.7	188.2
1977	42.6	103.3	24.2	24.5	194.6
1978	42.2	107.4	24.5	25.7	200.0
1979	43.2	109.8	24.7	26.8	204.5

NOTES FOR APPENDIX E

[1]Minor differences are always encountered when dealing with funds at the national level. One author may be utilizing appropriated funds, another obligated funds and a third expended funds, all of which may differ in any particular year (and especially in relatively recent years). In addition, in this case, the percentages reflected on Table E-1 have been rounded to the nearest full percent.

[2]This assumption was made because the only available detailed statistical tables containing a breakout of extramural funds was for FY 77.

[3]This is a national average of all S&E's in the country including those in basic research, applied research, and development.

[4]Overhead was assumed to include all management (except research supervision), marketing, administrative and operations expenses.

[5]It is realized that overhead rates and G&A vary from contractor to contractor and have gradually trended upwards during the 1970's (due mostly to increased paperwork created by additional governmental contract clauses), but the author merely wanted to obtain initial bounds on the problem.

[6]This particular CER was furnished to the author by an MDAC Cost Analyst circa 1975.

[7]Willis H Shapley et al, Research and Development in the Federal Budget: FY 78, Washington, DC, Am Association for Advancement of Science, 1977.

[8]The NSF (in 1978) reported the average cost per R&D S&E in the top 400 companies as follows:

1972	$57,200	1975	$70,360
1973	61,300	1976	73,300
1974	66,900		

Reference is NSF 78-314 Table B-31. There has recently been much speculation about enhanced salaries' in the military-space sector during the late 1970's. The author chose to increase by 10% across the decade.

[9]It is interesting to note that Gen Marsh estimated 150,000 S&E's in Defense funded contractor activities. See Defense, January 1982, page 28.

[10]It is probable that research funds spent by "Project Offices" are not reported (or only a small portion are collected). Since the system has no built in cross check (i.e. a system to query missing funding or manpower entries) and does not roll up user funds unless specifically requested (not available via terminal), erroneous entries tend not to be detected.

[11]The NSF publishes a wide variety of reports annually dealing with research funding and manpower. No readily available source nor index apparently exists for this highly valuable system of reports.

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