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COMPARISON OF US AND USSR ATOMIC ENERGY PROGRAMS

JULY 1962

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SUMMARY

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COMPARISON OF US AND USSR ATOMIC ENERGY PROGRAMS

At the present time the United States has an over-all superiority relative to the Soviet Union in the field of nuclear energy. The US lead is manifested in such areas as: amounts of fissionable material produced, gross numbers of weapons manufactured, reactor and production technology, numbers of research reactors in operation, and resources devoted to peaceful uses. However, the USSR has apparently made technological advances at rates at least equal to those achieved by the US in several areas which are of prime significance to the Soviet national defense posture. As a result of the military orientation of the USSR's nuclear program, by 1961 the Soviet Union had surpassed the United States in at least one area, that of very high-yield thermonuclear weapons [redacted]. The USSR had also by 1961 essentially achieved parity with the US in yield-to-weight ratios of thermonuclear weapons [redacted] It should be noted that the results of the US DOMINIC and NOUGAT test series have not yet been fully evaluated.

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Organization and Philosophy

In 1939 the US government initiated investigations into the energy known to exist in the nucleus of matter, particularly uranium. Shortly thereafter the USSR also recognized the feasibility of obtaining energy from the fission of uranium and in August 1940 began their investigations.

The US program expanded rapidly under dual civilian and military control during the war years. In 1946 the program was placed under primary civilian control with the establishment of the Atomic Energy Commission. On the other hand, the Soviet program was at a standstill from the time of the German invasion of the USSR in 1941 until late 1943. It was only when the US successfully detonated the world's first nuclear weapons in 1945 that the Soviet program showed signs of real impetus and progress.

Both the US and USSR programs in the early years were primarily militarily oriented and closely controlled by government organizations, although the Atomic Energy Act of 1946 recognized that the national program should include private research and industry, international cooperation, and the use of atomic energy for peaceful purposes. These aspects were further broadened by the AE Act of 1954. The Soviet Union took similar steps to handle the non-military aspect with the creation of the Chief Directorate for the Utilization of Atomic Energy in 1956 although on a much more restricted basis.

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The programs of the two countries are essentially similar in a broad sense, with both pursuing dual approaches in military and non-military applications. The degree of control exercised by each country appears largely related to the nature of government in each country. Within these limitations and considering the magnitude of parts of their respective programs there are many areas of similarity in their scope. It is evident that if the Soviets consider a particular area of prime significance to their military or national defense posture, they have the capability of so directing their research as to usually achieve technological advances at least equal to that which has taken place in the US.

Uranium Ore and Feed Materials Production (See Annex A - Table II)

The US and the USSR have each procured about the same amount of uranium ore through mid-1962. In addition, both countries, through mid-1962, had obtained something over 50 percent of their supply from foreign sources. The Soviet Union will continue along this path through 1966, whereas the US expects to obtain upwards of 75 percent of its supply from domestic sources during the next four years. The Soviets have not discovered large sedimentary ore deposits similar to the Ambrosia Lake deposit in New Mexico. This lack, in combination with low average ore grade (0.12 percent uranium versus 0.25 percent uranium for the average of US ores) and with comparatively low efficiencies in ore concentration processes, has resulted in relatively higher mining and ore concentration costs than in the US.

Inasmuch as Soviet cumulative production of fissionable materials is substantially less than that of the US, our National Estimates for some years have indicated an unusually large excess reserve of Soviet uranium over current needs. We have no satisfactory explanation for this apparent excess procurement.

Uranium-235 (See Annex A - Table II)

Both the US and USSR, early in their respective programs, investigated the various means of separating isotopes of uranium such as gaseous diffusion, electro-magnetic, ultra-centrifuge and thermal diffusion. Although both countries built production scale electro-magnetic facilities, they ultimately chose the gaseous diffusion method for expansion of their U-235 program.

Initially the USSR suffered considerable set-backs in the operation and performance of their gaseous diffusion process. Although they have made improvements, their estimated current efficiency is significantly lower than current US accomplishments.

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The Soviets are continuing to expand their gaseous diffusion program and their annual production is expected to double during the next 5 years. On the other hand, the US production has been cut back and no plans are contemplated for expansion at this time.

The values below indicate that the US cumulative production of U-235 is substantially larger than that of the USSR.

Plutonium and Other Materials (See Annex A - Table II)

The USSR did not produce plutonium until almost 4 years after the US. Construction of additional reactors and separation facilities have continued in both programs. The values below indicate that the US cumulative production of plutonium equivalent is considerably larger than that estimated for the USSR. Intelligence information does not permit the separate identification of the several reactor products (i.e., plutonium, tritium, U-233, polonium, etc.) actually manufactured. Thus, the total reactor-products production is expressed in terms of equivalent amounts of plutonium and is termed plutonium equivalent. On the basis of our analysis of Soviet weapons tests and stockpile assumptions, it would appear that there is a growing imbalance between Soviet plutonium and U-235 production. However, we have no evidence of major expansion of plutonium production facilities at the present time. US plutonium production is also leveling off.

TABLE

Fissionable Materials Production, Mid-year 1962
(Cumulative, in kilograms, rounded)

	US		USSR (Estimated)	
Material	Total Production	Allocated for Weapons Use	Total Production	Available for Weapons Use
U-235	*	*	[redacted]	
Pu Equivalent	*	*		

*To be furnished separately by the AEC.

[redacted]

The Soviets have tested very high yield weapons (25 and 58 MT) and will almost certainly stockpile limited quantities of their much-talked-of 100-MT weapon. The largest US stockpile weapon has a yield [redacted] DOE b(3) Assuming a suitable nose cone has been developed, the Soviets could deliver a 25 MT device in their [redacted] ICBMs. Only a few of these missiles are believed to be available. The present US vehicles are equipped with warheads [redacted] DOE b3

Since 1945 the US has detonated [redacted] nuclear devices yielding a total of [redacted] megatons. Beginning with the first Soviet nuclear test in 1949, the US Atomic Energy Detection System (USAEDS) has detected [redacted] Soviet nuclear detonations with a total yield of [redacted] megatons. [redacted]

In their testing program the Soviets have demonstrated a willingness or a necessity to test live nuclear warheads in a greater number and variety of operational weapons systems than has the US. In some areas Soviet weapons development has proceeded at a relatively faster pace than that of the US. Soviet warheads are believed to have been delivered by surface-to-air missiles, MRBMs and sub-launched 350-nautical mile ballistic missiles, and possibly shorter range missiles.

Comparative breakdowns in nuclear weapons allocations for 1962-1964 are listed in Annex A, Table III. It should be noted that the results of the US DOMINIC and NOUGAT test series have not yet been fully evaluated.

We believe that the Soviet system for control of nuclear weapons is generally similar to that in the US. Control over the weapons stored at Soviet operational sites is under the Ministry of Defense; control over the weapons at the national sites is exercised by the Ministry of Medium Machine Building.

[redacted]

[redacted]

The Soviets have located near their western periphery operational nuclear weapon storage sites in addition to a national stockpile site. These sites are in excellent position to service Soviet forces in the Satellites but their location would impose a transportation delay.

Research and Testing Reactors (See Annex A - Table I)

Currently the US is operating about four times as many research, test, and teaching reactors as the USSR. Because of the classified nature of the Soviet effort it is difficult to make a relative assessment of the two programs. It is probable that the open nature of the US research program has permitted extensive use of US data by the Soviets and thereby decreased their need for a comparable number of research reactors. The Soviets appear to have the number and variety of reactors necessary to perform the basic research required for various applied programs but have not developed as many types of reactors or carried out as broad a research program.

Nuclear Power Stations (See Annex A - Table I)

The initial programs in the development of nuclear power stations in the two countries appear to have been markedly different.

The US sought to develop a strong technological basis which would permit development of minimum cost nuclear power. This has resulted in the construction of a variety of low and intermediate power prototypes from which private industry selected the most promising concepts for development into full-scale plants. In addition, a substantial effort is being made by the US to develop military power reactors for use in remote locations and for major military installations. As of the present time the US has 19 operable plants having a total electrical generating capacity of about 410 megawatts.

The USSR attempted to go directly to full-sized power reactors in order to obtain the operational experience and data necessary to determine which type was most beneficial for future development. Moreover, the Soviets tried to use their nuclear power development for propaganda purposes. They apparently also overestimated their technological capabilities, and as a result, at least on the basis of their original planned program, their nuclear power effort has been unsuccessful. Instead of having the planned 2,000 to 2,500 megawatts of nuclear power by 1960, they have achieved only 255 megawatts from four reactors as of mid-1962. The Soviets claim that this slippage is due to a reconsideration of the economic factors involved. As of the present time, the US has three central station power reactors in operation having a total electrical generating capacity of about 400 megawatts. During the next few months ten additional reactors will begin operation, increasing this total capacity to about 900 megawatts. In addition to the above, 14 experimental power reactors and reactor experiments have been operated and 8 are under construction.

Nuclear Propulsion Systems for Naval and Marine Vessels (See Annex A - Table I)

Surface Ships

By the end of 1962 the US will be generating ten times more shaft horsepower in nuclear-powered surface ships than the USSR. The US has in operation an aircraft carrier, "Enterprise," a guided-missile cruiser, "Long Beach," and a destroyer frigate, "Bainbridge." These three ships, together with the merchant ship "NS Savannah," develop a total of 442,000 shaft horsepower. The USSR has one nuclear-powered icebreaker which develops 44,000 shaft horsepower. The US has authorized the construction of a second destroyer. The Soviets have considered utilization of atomic power for construction of a large tanker, but latest information indicates that such plans have been postponed or canceled. We do not believe that the Soviets have developed any nuclear-powered military surface ships.

Nuclear-Powered Submarines

Seven US shipyards have constructed the 26 nuclear submarines which are now in operation. A total of 61 nuclear submarines have been authorized, which include 29 Polaris-missile submarines. Starting construction about 4 years after the US laid the first keel, the two shipyards of the USSR have produced up to 20 nuclear submarines, most of which are operational at this time. The 1963 production of the US program is planned to be about 10 submarines per year, whereas the 1963 USSR rate is estimated at 8 to 10 submarines per year. Although the available data are not conclusive, the reliability and performance of US nuclear submarine propulsion systems are believed to be superior to the Soviet system.

The missile nuclear submarines now operational in the Soviet fleet contain either three ballistic-type or six cruise-type missiles. This is compared to sixteen ballistic missiles on each of the US Polaris-type submarines. The Soviet missiles are short-ranged and have a warhead with a yield approaching three megatons, whereas the US Polaris missiles are medium range and have a warhead [redacted] The USSR is developing a submerge-launch ballistic missile submarine system, with medium or intermediate range missiles.

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[redacted]

[redacted]

Aircraft Nuclear Propulsion

Developmental work on materials for high-temperature, high-performance reactors was actively pursued in both the US and USSR during the late 1950's. Although information obtained during this period indicated the existence of a Soviet aircraft nuclear propulsion program, the lack of firm intelligence during 1960-62 precludes a valid comparison with the US effort which was terminated in 1961. We have estimated that the USSR has had the capability to fly a nuclear test bed during the past two years, and with the proper priorities could have an aircraft nuclear power plant in early 1963-64. This might permit a first militarily useful nuclear-powered aircraft to become available in 1966. However, the lack of evidence of the program, the decreasing frequency of Soviet statements on progress, and the apparent general level of their reactor technology indicate that the Soviet aircraft nuclear propulsion effort may have encountered serious obstacles.

Nuclear Ramjet Propulsion

Demonstration of a ramjet reactor system for use in a supersonic low altitude missile (SLAM) is the present goal of the US PLUTO program. No similar Soviet program has been identified.

Space Propulsion

The US, through the Rover Program, is oriented toward a flight demonstration of a nuclear rocket in the 1966-67 period. On the other hand there is no firm information which confirms or denies the existence of a nuclear-powered rocket program in the USSR.

Electrical propulsion systems for space vehicles are being developed in both countries with emphasis on the ion-type propulsion system. The USSR is reportedly working toward development of a 75-kilowatt ion engine for flight testing in 1964. The US expects to flight test in 1966 SNAP-8, a nuclear reactor and electrical conversion system that will be used to provide 30-60 kilowatts of electrical power for an ion propulsion engine. It may be possible to test the ion propulsion engine with the initial flight test of SNAP-8. The US is developing a space power generating system designated SNAP-50 that will provide 300-1,000 kilowatts of electrical power for an ion propulsion engine. SNAP-50 is scheduled for flight testing in 1969.

System for Nuclear Auxiliary Power (SNAP)

The US has an extensive program for the development and application of auxiliary nuclear power for space vehicles and other uses. Although we do not know the magnitude of the Soviet program, there are indications that they are placing a greater proportion of their effort on the development of a thermionic reactor-type nuclear power system.

Peaceful Uses Programs, Other Than Power Production

Basic Philosophy

The US policy toward peaceful uses stresses the application of nuclear energy for the benefit and progress of mankind. This policy has been implemented with large domestic and foreign programs.

Prior to 1960, the USSR policy toward peaceful uses appeared to have a goal of obtaining propaganda value rather than real value. Since that time the Soviets have given a higher priority to their peaceful uses programs and it is expected that their policy will be more positive in actually implementing such programs. However, their attitude toward foreign programs appears to be associated with political policies and gains which will aid their own internal programs.

Nuclear Physics

The US clearly leads in the number of experimental machines, their quality, and in the experimental results obtained. The 2-3 year lead which the US has in theoretical aspects of high energy physics will continue to increase unless the quality of Soviet research is improved markedly.

Medical and Biological Research

In the biomedical area the Soviet and US programs are not strictly comparable, since the Soviet atomic energy organization does not directly sponsor biomedical research. The Soviet Ministry of Health, through its Academy of Medical Sciences, plans and controls biological research. The total support of atomic energy research in the medical and biological fields is less than that in the US and the fraction of effort devoted to health and safety problems is also less.

Controlled Thermonuclear Reactions

The USSR program in this field is comparable in scope and depth to the CTR program in the US. It is larger than the US program from the standpoint of personnel staffing, having about 50 percent more scientists and engineers. However, both programs are essentially equivalent in results obtained thus far, although each country is employing somewhat different methods of approach.

Use of Nuclear Explosions for Non-Military Use (PLOWSHARE)

Using conventional explosives, the Soviets have accumulated considerable experience and data on massive explosions. Although this data would be applicable to a Plowshare type effort, the Soviet Union is not known to have a program for investigation of the peaceful uses of nuclear explosions. The United States, on the other hand, has openly worked on such a program since early 1957 and has conducted several tests using both chemical and nuclear explosives. The US is actively investigating the possibility of using nuclear explosives in excavation, mining, improvement of water and oil resources, and for unique scientific experiments in chemistry and nuclear physics.

International Cooperation

The US has a much larger program than the USSR for providing assistance to other countries in the nuclear energy field. The US has concluded 38 bilateral agreements for cooperation in the peaceful uses of nuclear energy and has supplied 52 reactors to other countries which are currently in operation or under construction. The USSR has concluded only 14 agreements with Bloc and selected underdeveloped countries and has supplied to them only 15 reactors, which are currently in operation or under construction. Soviet assistance in the nuclear energy field to the underdeveloped countries seems to have been provided to further the Soviet program for achieving the political and economic dependency of these underdeveloped nations.

The US is supporting the IAEA to a much greater extent than the USSR, both economically and materially. The US assessment for the regular budget is almost three times that of the USSR, and the US has offered 5070 kilograms of fissionable material while the USSR has offered 50 kilograms. The Soviet participation in the IAEA appears to be devoted to ensuring that any political, propaganda, or scientific activities of the IAEA do not conflict with Soviet interests.

The USSR is not known to be providing assistance to the other members of the Warsaw Pact comparable to that provided by the US to its NATO partners.

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ANNEX A

NUMERICAL COMPARISON OF THE US AND USSR ATOMIC ENERGY PROGRAMS

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ANNEX A

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TABLE I
NUCLEAR REACTOR PROGRAM

Research and Testing Reactors

	US	USSR
Number in Operation	83	19
Under Construction	15	3

Nuclear Power Plants

	US (Cumulative)		USSR (Cumulative)	
End-Calendar Year	Plants	Capacity (MWe)	Plants	Capacity (MWe)
Central Station				
1962	11	923.6	2	310
1964	14	1041.9	2	310
Experimental Power				
1962	11	38.45	2	55
1964	18	60.35	2	55
Military Power				
1962	7	8.0	1	2
1964	8	9.0	1	2
Dual Purpose				
1962	--	--	1 a/	200
1964	1	-- b/	1 a/	200

Nuclear Propulsion Systems

Surface Vessels	US	USSR
End 1962, number	3	1
Shaft Horsepower	420,000	44,000

	US Mid-1962	US Mid-1965	USSR Mid-1962	USSR Mid-1965
Attack Submarines	16	31	5	13-15
Missile Submarines	10	37	15	27-30
Total	26	68	20	40-45

a/ One plant, 2 reactors, 100 MWe each.
b/ Designed to permit installation of additional equipment to produce by-product electric power.

[redacted]

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TABLE II
NUCLEAR MATERIALS PRODUCTION

Uranium Ore Production (Tons, U_3O_8)

		US	USSR
1946-62	Domestic	96,803	103,600
	Foreign	125,357	116,500
	Total	222,160	220,150
1963-66	Projected Domestic	69,800	51,800
	Projected Foreign	24,500	59,570
	Total	94,300	111,370

Cumulative Uranium-235 Production (Kilograms, 93%)

	US	USSR
Mid-1961	*	[redacted]
Mid-1962	*	
Mid-1963	*	
Mid-1964	*	

Cumulative Uranium-235 Available for Weapons (Kilograms, 93%)

	US	USSR
Mid-1961	*	[redacted]
Mid-1962	*	
Mid-1963	*	
Mid-1964	*	

Cumulative Plutonium Equivalent Production (Kilograms)

	US	USSR
Mid-1961	*	[redacted]
Mid-1962	*	
Mid-1963	*	
Mid-1964	*	

Cumulative Heavy Water Production (Metric Tons)

	US	USSR
Mid-1961	[redacted]	[redacted]
Mid-1962		
Mid-1963		
Mid-1964		

*To be furnished separately by the AEC

[redacted]

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TABLE III - A

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1962, ALTERNATIVE "A"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
			LONG-RANGE ATTACK FORCES		
STRATEGIC DETERRENT FORCES					
a. Strategic Bombs [redacted]	*	*	a. Long Range Aviation (90 KT - 8 MT)**	1,200	3,800
b. Strategic Warheads [redacted]	*	*	b. Rocket Forces (0.5 - 8 MT)	1,100	2,200
[redacted]TAL:	(*)	(*)		(2,300)	(6,000)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	2,000	70
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	600	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW [redacted]	*	*	(5 - 200 KT)	750	30
GRAND TOTALS: (Rounded)	*	*		5,650	6,100

*To be furnished separately by the AEC

**Stockpile could include a few very high-yield bombs (25-100 MT).

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TABLE III - B

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1962, ALTERNATIVE "B"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
STRATEGIC DETERRENT FORCES			LONG-RANGE ATTACK FORCES		
a. Strategic Bombs [redacted]	*	*	a. Long Range Aviation (90 KT-8 MT)**	800	2,200
b. Strategic Warheads [redacted]	*	*	b. Rocket Force (0.5-8MT)	900	1,800
SUBTOTAL:	(*)	(*)		(1,700)	(4,000)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	3,000	130
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	600	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW	*	*	(5 - 200 KT)	750	30
GRAND TOTALS (Rounded)	*	*		6,050	4,200

*To be furnished separately by the AEC
**Stockpile could include a few very high-yield bombs (25-100 MT).

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TABLE III - C

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1963, ALTERNATIVE "A"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
STRATEGIC DETERRENT FORCES			LONG-RANGE ATTACK FORCES		
a. Strategic Bombs [redacted]	*	*	a. Long-Range Aviation (90 KT - 8 MT)**	1,200	5,800
b. Strategic Warheads [redacted]	*	*	b. Rocket Force (0.5 - 8 MT)	1,600	4,200
SUB TOTAL:	(*)	(*)		(2,800)	(10,000)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	2,500	100
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	1,500	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW [redacted]	*	*	(5 - 200 KT)	1,000	100
GRAND TOTALS (Rounded)	*	*		7,800	10,200

*To be furnished separately by the AEC

**It is possible that this stockpile will include a few 100-MT bombs.

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[redacted]

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TABLE III - D

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1963, ALTERNATIVE "B"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
			LONG-RANGE ATTACK FORCES		
STRATEGIC DETERRENT FORCES					
a. Strategic Bombs [redacted]	*	*	a. Long-Range Aviation (90 KT - 8 MT)**	800	3,000
b. Strategic Warheads [redacted]	*	*	b. Rocket Force (0.5 - 8 MT)	1,350	4,300
SUB TOTAL:	(*)	(*)		(2,150)	(7,300)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	4,000	150
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	1,500	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW [redacted]	*	*	(5 - 200 KT)	1,000	100
GRAND TOTALS (Rounded)	*	*		8,650	7,50[illegible]

*To be furnished separately by the AEC
**It is possible that this stockpile will include a few 100-MT bombs.

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TABLE III - E

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1964, ALTERNATIVE "A"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
STRATEGIC DETERRENT FORCES			LONG-RANGE ATTACK FORCES		
a. Strategic Bombs [redacted]	*	*	a. Long-Range Aviation (90 KT - 8 MT)**	1,200	5,800
b. Strategic Warheads [redacted]	*	*	b. Rocket Force (0.5 - 8 MT)	1,850	7,400
SUB TOTAL:	(*)	(*)		(3,050)	(13,200)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	3,500	100
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	2,000	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW [redacted]	*	*	(5 - 200 KT)	1,250	100
GRAND TOTALS (Rounded)	*	*		9,800	13,400

*To be furnished separately by the AEC
**Stockpile could include a few 100-MT weapons.

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TABLE III - F

NUCLEAR WEAPONS STOCKPILE ALLOCATION, MID-1964, ALTERNATIVE "B"

US	No. Weapons	Total Yield (MT)	USSR	No. Weapons	Total Yield (MT)
STRATEGIC DETERRENT FORCES			LONG-RANGE ATTACK FORCES		
a. Strategic Bombs [redacted]	*	*	a. Long Range Aviation (90 KT - 8 MT)**	800	3,100
b. Strategic Warheads [redacted]	*	*	b. Rocket Force (0.5 - 8 MT)	1,700	7,000
[redacted] TOTAL:	(*)	(*)		(2,500)	(10,100)
GENERAL PURPOSE FORCES			THEATER FIELD FORCES		
Tactical Forces [redacted]	*	*	(5 - 200 KT)	4,500	160
AIR DEFENSE			AIR DEFENSE		
[redacted]	*	*	(3 KT)	2,000	Negligible
NAVAL OPERATIONS			NAVAL OPERATIONS		
Naval Defense & Naval ASW [redacted]	*	*	(5 - 200 KT)	1,250	100
GRAND TOTALS (Rounded)	*	*		10,250	10,400

*To be furnished separately by the AEC
**Stockpile could include a few 100-MT weapons.

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TABLE IV

TOTAL MEGATONNAGE OF US AND USSR TESTS

Date	US No. Shots	US Yield (MT)*	USSR No. Shots	USSR Yield (MT)
1945	1	0.03	---------	---------
1946	[redacted]	[redacted]	---------	---------
1948	[redacted]	[redacted]	---------	---------
1949	[redacted]	[redacted]	1	[redacted]
1951	[redacted]	[redacted]	[redacted]	[redacted]
1952	[redacted]	[redacted]	[redacted]	[redacted]
1953	[redacted]	[redacted]	[redacted]	[redacted]
1954	[redacted]	[redacted]	[redacted]	[redacted]
1955	[redacted]	[redacted]	[redacted]	[redacted]
1956	[redacted]	[redacted]	[redacted]	[redacted]
1957	[redacted]	[redacted]	[redacted]	[redacted]
1958	[redacted]	[redacted]	[redacted]	[redacted]
1961	[redacted]	[redacted]	[redacted]	[redacted]
1962	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL	[redacted]	[redacted]	[redacted]	[redacted]

*As of 19 July 1962

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ANNEX B

UNITED STATES ATOMIC ENERGY PROGRAM

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I. Organization of the United States Atomic Energy Program

Initial governmental investigation leading to the US atomic energy program began with the Presidential Advisory Committee on Uranium in 1939, which, in mid-1940, came under the jurisdiction of the newly established National Defense Research Committee. In June 1941, the President established the Office of Scientific Research and Development and the Committee on Uranium became the OSRD Section on Uranium. During this period the military members of the Sections were dropped to a liaison function. From 1939 through 1942 much of the basic planning for construction of isotope separation, heavy water and plutonium production facilities was initiated, and the program acquired a wartime urgency of developing an atomic bomb to assist the war effort. In 1941, the size of the construction program was recognized and the Army Corps of Engineers was brought into the program primarily as constructor and operator. The nuclear program then continued under a dual civilian and military control until the Fall of 1942, when the Manhattan Engineer District took control and the newly established Military Policy Committee of the War Department assumed general responsibility. With the war over, the single purposeness of the effort declined, the controversy over domestic legislation control arose, and negotiations for international control dragged on interminably. The Atomic Energy Act of 1946 established the Atomic Energy Commission to succeed the Manhattan Engineer District of the Army's Corps of Engineers as the Federal agency responsible for the national atomic energy program. Formal transfer was carried out December 31, 1946.

The Atomic Energy Commission inherited from the Manhattan Engineer District a vast complex of Government-owned laboratories, manufacturing plants, and community facilities. The Manhattan District did not operate these facilities with its own personnel. Through contractual arrangements, it drew upon the recognized resources of academic and industrial organizations for management and operation. One of the first major decisions of the newly created Commission was to continue with the contract method of program execution established by its predecessor. The Commission has adhered to this early decision and it is an integral part of the Government policy to give impetus to private participation in atomic energy work.

The Commission's charter was amended by the Atomic Energy Act of 1954 which broadened the objectives of the national atomic energy program and relaxed some of the restrictions of the original Act, particularly with respect to private participation and international cooperation in the development and use of the peaceful atom. The new Act

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contains the following declaration of policy:

"a. the development, use, and control of atomic energy shall be directed so as to make the maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security; and

"b. the development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in free enterprise."

To implement this policy the Act provides for:

"a. a program of conducting, assisting, and fostering research and development in order to encourage maximum scientific and industrial progress;

"b. a program for the dissemination of unclassified scientific and technical information and for the control, dissemination, and declassification of Restricted Data, subject to appropriate safeguards, so as to encourage scientific and industrial progress;

"c. a program for Government control of the possession, use, and production of atomic energy and special nuclear material so directed as to make the maximum contribution to the common defense and security and the national welfare;

"d. a program to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public;

"e. a program of international cooperation to promote the common defense and security and to make available to cooperating nations the benefits of peaceful applications of atomic energy as widely as expanding technology and considerations of the common defense and security will permit; and

"f. a program of administration which will be consistent with the foregoing policies and programs, with international arrangements, and with agreements for cooperation, which will enable the Congress to be currently informed so as to take further legislative action as may be appropriate."

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In formulating its programs, the Commission seeks to avoid competition with the private industrial and research sector of the nation's economy. It is further the policy of the agency to create opportunities for private initiative by withdrawing from or reducing its own effort in areas where private organizations demonstrate both the capacity and the desire to undertake activities on their own account.

Under the Atomic Energy Act of 1954, the Commission is assigned principal responsibility for regulating private participation in the development and use of atomic energy for peaceful purposes. In exercising its regulatory powers, the agency seeks to reduce control to the minimum degree consistent with the security of the nation and the health and safety of the public and the atomic worker.

Military requirements for nuclear weapons are fulfilled by the AEC consulting with the Department of Defense, through the statutory Military Liaison Committee, on all atomic energy matters relating to the development, manufacture, use, and storage of nuclear weapons, the allocation of special nuclear material for military research, and the control of information relating to the manufacture or utilization of nuclear weapons. Weapons development at the laboratories has been conducted to meet specific DOD weapons systems requirements for better reliability, greater safety, greater versatility, and increased effectiveness per pound of warhead weight. The production of nuclear weapons by the AEC according to DOD requirements is conducted under Presidential consent and direction, which is obtained by the AEC at least once each year.

The Commission's international activities are two-fold: a) Mutual Defense Agreements under which the exchange of classified information relating to nuclear weapons with other nations and NATO; and b) technical cooperation with other nations and with international agencies to increase the world-wide utilization of atomic energy for peaceful purposes. Both activities are conducted through the Department of State, in conjunction with the Department of Defense where appropriate, in support of overall U.S. foreign policies and programs.

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II. Nuclear Reactor Program

A. Research and Testing Reactors

As of the end of June 1962 there were 83 test, research, and teaching reactors operable in the United States; another 15 were being built, and 14 more were in the planning stage. Very different sizes of reactors are included in this category; for example, the Advanced Test Reactor planned for completion in 1965 will have a capacity of 250 thermal megawatts, while a teaching reactor located at a university may have negligible capacity.

The number and versatility of the US research and testing reactor program permit considerable capability to obtain basic physics data, to perform irradiation testing, and to advance the technology applicable to all types of reactors - civilian, military and space. About a dozen reactor types are represented.

In summary:

Test, Research, and Teaching Reactors

	Operable	Being Built	Planned
General Irradiation Test	4	1	
Special test	9	1	
Research	33	9	3
Teaching	37	4	11
	83	15	14

General irradiation and test reactors are tank-type, light water-moderated and coated reactors used for materials and components testing. Thermal capacity of reactors in this category range from 40 MWt to 250 MWt. Included in this category are the Engineering Test Reactor and the Advanced Test Reactor.

Special test reactors are used to investigate a variety of problems related to the fundamental mechanics and the effects of extremely rapid power surges. The Special Power Excursion Reactor Test (SPERT) series consists of four reactors. One is open tank, two are pressurized water, and the fourth is a pool type. They are used to perform experiments on various core types, to conduct transient tests with various coolant flows

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and moderator-coolant combinations, and to study the instabilities resulting from hydro-dynamic effects. The Kinetic Experiment on Water Boilers (KEWB), is a homogeneous reactor designed to provide data on the dynamics of simple homogeneous reactors. The Transient Reactor Test (TREAT), a graphite-type reactor, is used to conduct studies in fast reactor safety.

Research reactors are those reactors used primarily as a research tool for basic or applied research regardless of operating power. The nation's oldest operating reactor, the Oak Ridge Graphite Reactor, which began operating in 1943, falls in this category. The capacity of the research reactor varies greatly. The High Flux Isotope Reactor, a pool, flux trap reactor being built primarily for the production of research quantities of transuranium radioisotopes, is to come into operation in 1964, and will have a capacity of 100 MWt. On the other hand, the Livermore Water Boiler, a homogeneous reactor which began operating in 1953, has a capacity of only 500 thermal watts.

Teaching reactors are operated primarily for the purpose of training in the operation and utilization of reactors and for instruction in reactor theory and performance. In this area certain manufacturers have adapted general standard designations for the reactors which they produce.

B. Nuclear Power Stations

Our civilian nuclear power objectives - which are under review - have included the following: to achieve economically competitive power in high cost areas of the United States (defined as areas where fossil fuel costs are 35 ¢ per million BTU's or higher) by 1968; to improve reactor technology so as to extend the benefits of nuclear power to wider areas; to maintain United States world leadership in civilian nuclear power technology and to assist friendly foreign nations to achieve economic nuclear power; and to develop breeder-type reactors to make full use of the energy latent in both uranium and thorium.

To achieve these goals the United States by the end of 1962 will have twelve reactor experiments and experimental reactors in operation to determine the feasibility and develop the technology for various reactor systems: water-cooled, organic-cooled, liquid-metal-cooled, gas-cooled, and advanced concepts. Some reactors in this effort have served their purpose and have been dismantled. Others are being used in further advanced developmental programs. The EBR-1 at Idaho, for example, which produced the first nuclear electric power in the United States on December 21, 1951, is being modified to operate with its fourth core, which will be used in the investigation of plutonium fuels.

United States participation with Canada in the development of heavy water reactor technology and with Euratom in joint programs of research and development and nuclear power should be considered significant adjuncts to our domestic nuclear power program. These efforts are discussed in more detail under International Cooperation.

The technology for the water reactors has advanced to the point where it is believed that large-scale units of these types are near achieving the objective for high cost areas. In general the US has or is working on the following basic power reactor types: Pressurized water, boiling water, boiling water-nuclear superheat, sodium graphite thermal, fast breeder, organic-cooled, pressure-tube-heavy water, and the gas-cooled.

At the end of 1962 there will be in operation 11 central station prototype plants with a total capacity of 923.6 net electrical megawatts. However, there have been two principal factors which have caused delay. These are the selection of economically attractive plant locations which are also suitable from safety aspects, and the reluctance of industry to undertake privately financed projects.

The Government has offered incentives to encourage privately and publicly owned utilities to construct nuclear power plants. Types of assistance offered to privately financed utilities include: waiver for five years of use charges for fuel and heavy water, and support of specified research and development. For cooperatively or municipally owned plants, the Government will provide (and own) the reactor portion of the nuclear power plant and sell the steam to the utility. Pending authorization legislation would permit in addition to waivers and support of research and development, design assistance for first-of-a-kind, large commercial size nuclear power plants.

For the purposes of this paper military power plants are also considered. Military power reactors are being developed for use in remote locations and for major military installations requiring substantial blocks of power independent of conventional fuel supply. At the end of 1962, seven military power plants will be in operation. Two of these plants are at locations outside the continental United States.

Certain advanced reactor concepts are being explored. These include the molten salt, the pebble bed, beryllium oxide moderated and gas-cooled, high-temperature gas-cooled, and plutonium fuel concepts. In addition research and development is being carried forward on a thermionic conversion system to generate electricity from a nuclear fission heat source.

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NUCLEAR POWER STATIONS

Year	Plants (Year - end Cumulative)	Capacity 1/ (net EMW) (Year - end Cumulative)
Central Station Prototypes		
1962	11	923.6
1963	13	1,001.9
1964	14	1,131.9
1965	16	1,494.9
1966	17	1,849.9
Reactor Experiments and Experimental Reactors		
1962	11	38.4
1963	13	38.4
1964	18	60.3
1965	19	60.3
Military Power Plants and Reactor Experiment		
1962	7	8.0
1963	7	8.0
1964	8	9.0
1965	9	19.0
Dual Purpose Reactors		
1964 2/	1	- - 2/

1/ Beginning in 1962, 111 EMW equivalent from conventional superheat are included. Beginning 1964, 50 EMW equivalent dissipated by a heat sink at Shippingport are included.

2/ The new plutonium production reactor at Hanford is scheduled for completion in 1964, and is designed to permit, by installation of additional equipment, the production of by-product electric power.

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C. **Nuclear Propulsion Systems for Naval and Marine Vessels Surface Ships.** [redacted]

Surface Ships

The Navy has 4 surface ships authorized. An aircraft carrier, and a guided missile cruiser are in operation, a destroyer (frigate) is about to undergo sea trial, and a second destroyer frigate has been authorized. A tabular summary of the surface ships follows:

Name and type	Number of Reactors	Total Shaft Horsepower	Status
Guided missile cruiser *Long Beach*	2	[redacted]	Commissioned 1961
Aircraft carrier *Enterprise*	8		Commissioned 1961
Destroyer (frigate) *Bainbridge*	2		Near sea trials
Destroyer (frigate)	2		Construction to start in 1962

The NS *Savannah* is a joint AEC-Maritime Administration project directed toward the development of economically competitive nuclear merchant ships. The ship is engaged in demonstration runs out of Yorktown, Virginia. A series of minor construction delays and a decision to extend the prescribed testing period to assure a relatively trouble-free start-up period caused a delay in placing the ship in operation. The *Savannah* is driven by a pressurized water reactor rated at 69 MWt for normal operation, and which can provide a maximum continuous shaft horsepower of 22,000 to a single screw. Fuel is UO_2 with average enrichment of 4.4 percent. Other characteristics are: length - 595'6"; displacement - 24,416 short tons; cargo capacity 11,200 short tons; passengers - 60; officers and crew - 110; and normal operating speed of 21 knots.

Nuclear powered submarines. At June 30, 1962, the Navy had 61 nuclear powered submarines authorized of which 26 were in operation. Included are 29 Polaris missile submarines of which 9 are in operation. Each Polaris submarine currently carries 16 missiles with a range of 1200 nmi; and a pay load [redacted] The 1963 appropriations will increase the total authorized nuclear submarines to 75, of which 35 will be Polaris-type submarines.

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The following propulsion systems for submarines have been developed.

Reactor System	Designation	Shaft Horsepower	Submarines Operating	Submarines Planned a/
S2W	Submarine thermal reactor	[redacted]	2	-
S3W	Submarine fleet reactor		3	-
S4W	Submarine fleet reactor		2	-
S5W	Attack Submarine reactor		17 b/	35 c/
S1C/S2C	Small submarine reactor		1	-
S3G/S4G	Submarine advanced reactor		1	-
			26	35

a/ Includes under construction.
b/ Nine are for Polaris submarines.
c/ Twenty are for Polaris submarines.
d/ Total shaft horsepower for a two-reactor system.

Land prototypes. Land-based prototypes were used in development of certain of the naval reactor propulsions systems. There are now five land-based prototypes in operation and a sixth is under construction. The one under construction is to be completed in 1964, and will be used to develop the natural circulation reactor, a concept which offers quieter operation, greater inherent safety, and simpler maintenance. The other land prototypes are being used primarily for core improvement work.

Core improvement. Present core improvement effort for submarines is directed at extending the life of the cores [redacted] effort for the large surface ships is to develop cores of about five times the energy of the present cores in the aircraft carrier.

DoE b(3)

Chronological development. The following are selected dates in the Navy reactor program.

1953 - Startup of S1W facility at NRTS; prototype for Nautilus.
1954 - Nautilus commissioned.
1955 - Startup of S1G land prototype for sodium reactor propulsion system for the Seawolf.
1957 - Seawolf commissioned.
1957 - Sodium land-based prototype dismantled.
1960 - Seawolf recommissioned with pressurized water system.
1961 - Nuclear powered cruiser Long Beach commissioned.
1961 - Nuclear powered aircraft Enterprise commissioned.

(End CONFIDENTIAL)

D. Nuclear Propulsion for Aircraft, Missile and Space

(Begin UNCLASSIFIED)

1. Aircraft Nuclear Propulsion (ANP)

The program for Aircraft Nuclear Propulsion - a joint AEC-Air Force effort - was terminated by Presidential decision in March 1961. At the time of termination work was being carried forward on several substantial technical problem areas such as shielding against component and personnel damage by radiation, thermodynamics of liquid coolants, development of high temperature materials, and radiobiology. There were two approaches under development. In the direct cycle approach heat was to be transferred within the reactor core to air which had passed through the turbojet engine compressor. In the indirect cycle approach heat from the reactor core was to be transferred by a liquid metal coolant to air in the radiator.

The development work on high temperature, high performance reactors for the ANP program has been redirected toward the objectives of the Advanced Space Power Systems, described below. (End UNCLASSIFIED)

2. Missile Propulsion.

(Begin CONFIDENTIAL, [redacted]

The current program of Project PLUTO, the effort for nuclear ramjet propulsion, is directed toward demonstrating the feasibility of a reactor system suitable for a strategic missile capable of flying to any point on earth at a speed of Mach-3 and at an altitude of about 1,000 feet. In successful tests in the fall of 1961, an experimental propulsion test reactor achieved a power level of 170 megawatts for 95 seconds with a maximum core temperature of 2,750°F. Present plans call for the test of a full-size flight-type core at about 600 megawatts in the summer of 1963, and performance at 2,500°F. The reactor will also tolerate 8 G's in all directions. A further propulsion system ground test program for Project PLUTO is being developed. Chance-Vought under contract to the Air Force is currently conducting vehicle studies involving wind tunnel tests, air thermodynamics, and other work to support a ground test program.

Studies have been undertaken on nuclear ramjet engines for sea-based missile applications, with particular emphasis on compatability with a vehicle which is capable of being launched from existing Polaris submarines.

3. Space Propulsion.

The near-term objective for Project ROVER, the effort to develop nuclear rocket propulsion for space missions, is to demonstrate a nuclear propulsion engine utilizing a reactor of approximately 1,120 megawatts for flight demonstration in 1967. Three reactor tests, completed in 1960, demonstrated the feasibility of niobium-carbide clad UC_2 - graphite, rod-type fuel elements. Tests of a series of reactors more closely approximating the rocket engine reactor began in late 1961 and are to be completed in the spring of 1963. Design objectives are: a power level of 1,200 megawatts, 56,000 pounds of thrust from liquid hydrogen propellant, and propellant temperature of 4,000°F. Concurrently development is taking place of a nuclear rocket engine. Flight tests of a nuclear rocket engine are planned for the first part of 1967 as a third stage of an Advanced Saturn vehicle.

For ion propulsion the SNAP 8 reactor project is being developed with NASA, and will power one or two 30 electric kilowatt turboelectric units. The system will be used in orbital tests of experimental electrical propulsion devices.

The objective of the effort on Advanced Space Power Systems is to develop large nuclear-electric space plants capable of providing electrical power in the megawatt range as the primary power source for ion propulsion, communications, television, and radar satellites. Ion propulsion for deep space missiles, and the requirements of advanced space vehicles and satellites, require relatively high power levels. A major part of the effort is SNAP-50, the designation for an advanced prototype reactor for use in a turboelectric system*. Objectives are: a power level of 300 to 1,000 electrical kilowatts, a specific weight of 10 pounds per electric kilowatt, and unattended operation in a space environment for a minimum period of 10,000 hours. The present schedule calls for flight testing by 1970. Test operation of a reactor experiment to demonstrate the technology required for SNAP-50 is scheduled for the spring of 1965. This SNAP-50 represents a more long range program than those of the other SNAP reactor projects, since the higher power levels require the development of an advanced reactor technology beyond that used in other reactor systems.

E. Nuclear Auxiliary Power Supplies

Satellite Power Sources

The objectives of the Systems for Nuclear Auxiliary Power (SNAP) Program is to develop small, light weight nuclear power sources for satellites, space craft, and other unattended equipment. Odd-numbered SNAP projects utilize heat from radioisotope decay. Even-numbered SNAP projects utilize heat from the operation of small reactors.

Already performing successfully in orbit are two SNAP-3 type units powering instruments for two TRANSIT-4 navigational satellites, and two SNAP isotope units for remote weather installations. Another SNAP isotope unit was in experimental operation to provide power for a navigational buoy.

The following table contains data applicable to the first-of-type SNAP isotope and reactor units.

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* The reactor system to be used in this effort uses the Li-Cb technology developed for the Indirect Cycle Aircraft Nuclear Propulsion program.

Table 1 - SNAP RADIOISOTOPE PROJECTS

Isotope Unit	SNAP-3	SNAP-7A	SNAP-7B	SNAP-7C	SNAP-7D	SNAP-7E	SNAP-9A	SNAP-11	SNAP-13
Operational environment	Space (TRANSIT-4)	Floating navigational buoy	Shore-based navigational light	Remote weather station (Antarctica)	Remote weather station (boat)	Deepsea acoustic beacon	Space (TRANSIT)	Space-lunar landing (SURVEYOR)	Space interplanetary probes
Capacity Electrical (to load)	2.7 watts	5 watts	30 watts	5 watts	30 watts	4 watts	20 watts	20 watts	12.5 watts
Operational lifetime	5 years	2 years	2 years	2 years	2 years	2 years	5 years	4 months	4 months
Type power conversion equipment	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermo-electric generator	Thermionic generator
Fuel nuclide	Pu-238	Sr-90	Sr-90	Sr-90	Sr-90	Sr-90	Pu-238	Cm-242	Cm-242
Schedule dates for first unit Placed in operation by using agency	June 1961	Dec. 1961	Oct. 1962	Dec. 1962	Aug. 1962	Aug. 1962	Late 1962	n.d. 2/	n.d. 2/

2/ Not determined

Table 2 - SNAP REACTOR PROJECTS

Reactor Project	SNAP-2	SNAP-4	SNAP-8	SNAP-10A
Operational environment	Space	Underwater	Space	Space
Capacity Electrical	3 KW	1,000-4,000 KW	30 KW	.5 KW
Operational lifetime	1 year	1 or more years	10,000 hours	1 year
Type power conversion equipment	Mercury Rankine combined rotating unit	Steam turboelectric generator	Mercury Rankine combined rotating unit	Thermoelectric converter
Schedule dates Delivery of system to using agency	-December 1964	n.d. 1/	May 1964	April 1963

1/ Not determined

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Satellite and Small Power Sources

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III. Nuclear Materials Production

[redacted]

A. Uranium Ore (U_3O_8) Production

Domestic Production and Foreign Procurement
Tons U_3O_8

FY	Domestic	Canada	Overseas	Total
1943-1962 (Actual)	96,803	62,364	62,993	222,160
*	*	*	*	
Projected:				
1963	17,000	6,900	4,200	28,100
1964	16,500	2,275	3,835	22,610
1965	15,000	1,540	2,805	19,345
1966	14,500	500	1,600	16,600
First ½ 1967	6,800	220	625	7,645
Total Projected	69,800	11,435	13,065	94,300

Estimated Ore Reserves, Domestic: 71,000,000 tons ore, containing 175,000 tons U_3O_8 at January 1, 1962

Canadian: 296,000,000 tons of ore, containing 355,000 tons of U_3O_8 as of January 1961 (latest official figures available)

Ore Concentration Techniques

A total of 24 privately owned uranium processing mills are in operation in the United States. Ore treatment processes include (a) alkaline leaching with uranium recovery by alkaline precipitation or by ion exchange, and (b) acid leaching with uranium recovery by ion exchange or by solvent extraction. Ion exchange practise is divided between resin-in-pulp and column contractors. The highly efficient processes of recovering uranium by ion exchange and solvent extraction was initiated in the US in 1955 and 1956, respectively. The processes in use are summarized as follows:

Process	Number of Mills
Alkaline Leach	
Alkaline precipitation	4
resin-in-pulp	1

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Process	Number of Mills
Acid Leach	
Column ion exchange	3
resin-in-pulp	7
Solvent extraction	9

Current Ore Stockpiles

There are no stockpiles of uranium concentrates. Normal working inventory at the mills at May 31, 1962 totaled 635,000 tons ore containing approximately 2,350 tons U_3O_8. AEC-held ore stocks which are committed to the mills for processing totaled about 370,000 tons of ore containing 1,950 tons U_3O_8.

Other Reserves

There are substantial tonnages of recoverable uranium 235 in the partially depleted gaseous diffusion plant tailings.

The US is no longer dependent on foreign sources of supply, although approximately 25,000 tons U_3O_8 remain to be delivered under earlier foreign contracts. US productive capacity and ore reserves are sufficient to meet anticipated civilian and military needs for uranium for the next ten years. Delivery rates could be increased, if necessary, but a high rate of production for an extended period would require extensive exploration and the discovery of new ore deposits. Additional foreign uranium also could be obtained.

B. Uranium-235

[redacted]

The importance of uranium-235 was recognized very early in the development of the US nuclear program. What was not known was whether the technical difficulties foreseen could be overcome, or which would be the most effective and quickest means of separating the isotope from natural uranium. Accordingly, it was decided to proceed along the several most promising lines of attack, and development began on the gaseous diffusion, electromagnetic, thermal diffusion and ultracentrifuge methods of isotope separation. Initially, gaseous diffusion, electromagnetic and thermal diffusion plants were constructed and operated at the first uranium-235 site at Oak Ridge, and all three isotope separation methods contributed to the production of uranium-235 for the first atomic bomb. The success of the gaseous diffusion plants eventually led to the shutdown of the other methods of separation.

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Although expanding over the ensuing years, Oak Ridge remained the sole US isotope separation plant until the Paducah and Portsmouth facilities went on stream in February 1953 and September 1954, respectively.

Cumulative U-235 equivalent top product production are:

CUMULATIVE U-235 PRODUCTION
(Kg. Equivalent Top Product)

	US*		USSR	
	Total	Allocated for Weapons Use	Total	Available for Weapons
Mid-1962	---	---	[redacted]	[redacted]
1963	---	---		
1964	---	---		

* Key transmitted separately

As the three gaseous diffusion plants feed or are supported by one another at varying levels of enrichment, individual rates of equivalent top product production are not meaningful and have not been presented. Quantities of Soviet U-235 production have been included for comparative purposes. [redacted]

[redacted]

Research and development on gas centrifuge technology for separating isotopes is being pursued by AEC at an annual level of $2 million.

The gas centrifuge, unlike the gaseous diffusion process, offers a technique for producing uranium 235 on a small scale and at a relatively low capital cost. A primary aim is to assess the likelihood that the gas centrifuge process might enable additional nations to achieve a nuclear weapons capability. Development work is also being carried out in West Germany, the Netherlands, and the United Kingdom. To minimize dissemination of current results, agreements for classification have been concluded with these countries. [redacted]

C. Plutonium [redacted]

Development and construction of the first research reactor (CP-1) which went critical on December 2, 1942, and design of the first production reactor at Hanford progressed simultaneously. The first Hanford reactor became critical in September 1944. The chemical separation

[redacted]

[redacted]

facilities at Hanford were ready to receive the first batch of irradiated slugs from the B pile in November 1944. Hanford remained the principal plutonium production site until January 1954 when Savannah River became operational. The first production reactors at Hanford were graphite-moderated, whereas the Savannah River reactors are heavy-water moderated.

Cumulative production of plutonium equivalent (includes tritium) are presented below:

CUMULATIVE PLUTONIUM EQUIVALENT PRODUCTION
(Kilograms)

	US *	USSR
Mid-1962	- -	
Mid-1963	- -	
Mid-1964		

* Key transmitted separately

D. Other Materials

1. The original heavy water separation was a combined electrolytic and catalytic process established at Trail, British Columbia in June 1943, with a rate of about 0.5 tons per month, followed by installation of a water distillation process at three Army Ordnance Works at Morgantown, Wabash River and Alabama Ordnance Works with estimated rates of 0.4, 1.2 and 0.8 tons per month. These remained the principal producers of heavy water until the first dual-temperature operation facility was built at Dana in August 1952 (design annual rate - 240 tons) followed by a dual-temperature installation at Savannah River in January 1953 (design annual rate - 240 tons). Eventually, US requirements for heavy water were more than met, and the Dana plant was placed on standby status in August 1957 and since February 1958 the Savannah River heavy water production has been curtailed considerably.

2. Lithium - Lithium production was initiated at Oak Ridge in September 1953 using a combination of the flat tray electrochemical method of separation (ELEX) and the column exchange electrochemical method (COLEX). The ELEX process was terminated in 1956 and the present lithium production is accomplished by the Colex process at Oak Ridge.

3. Tritium - Tritium has been produced at both Hanford and Savannah River using the excess radioactivity from the reactors. At the present time, Savannah River heavy water piles produce all the tritium required by the atomic energy program.

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IV. Nuclear Weapons Program

Chapter 9 of the Atomic Energy Act of 1954, entitled "Military Application of Atomic Energy," defines the Commission's authorities and responsibilities in the area of nuclear military application:

"Sec. 91. AUTHORITY.--
"a. The Commission is authorized to --
"(1) conduct experiments and do research and development work in the military application of atomic energy; and
"(2) engage in the production of atomic weapons, or atomic weapon parts, except that such activities shall be carried on only to the extent that the express consent and direction of the President of the United States has been obtained, which consent and direction shall be obtained at least once each year.
"b. The President from time to time may direct the Commission (1) to deliver such quantities of special nuclear material or atomic weapons to the Department of Defense for such use as he deems necessary in the interest of national defense, or (2) to authorize the Department of Defense to manufacture, produce, or acquire any atomic weapon or utilization facility for military purposes: Provided, however, That such authorization shall not extend to the production of special nuclear material other than that incidental to the operation of such utilization facilities."

A. Research and Development

1. Origin

The Los Alamos Scientific Laboratory (LASL), operated by the University of California, was formed in 1943 under the Manhattan District to solve the mass of technical problems involved in constructing a workable atomic bomb from the fissionable material being produced at Hanford and Oak Ridge, and to produce atomic weapons.

In the early days of the AEC, all atomic bomb production was performed by the Los Alamos Laboratory. However, the rapid expansion of the atomic weapons program resulted in transferring the actual work of mass production of atomic weapons to new plants designed for this purpose.

The physical limitation of the Los Alamos Scientific Laboratory both in equipment and manpower resulted in the formation in the Summer of 1952 of a separate project under the University of California Lawrence Radiation Laboratory, at Livermore, to do basic research and development work on thermonuclear devices; and in 1955, Lawrence

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Radiation Laboratory, at Livermore, was expanded to provide for weapon development through a point where the design can be released to production channels.

In order to relieve Los Alamos of production problems, the operation of the Sandia Laboratory was transferred on November 1, 1949, to the Sandia Corporation, formed specifically to take over this contract. Sandia Corporation develops, designs, and engineers for production the portions of nuclear weapons which are primarily related to the adapting of the nuclear assembly (initiators, fissionable material, HE, and detonators) for operational utilization by the Armed Forces. The Sandia Corporation has responsibility for the engineering, design, and development of "non-nuclear assemblies," which includes such things as ballistic cases, fuzes, power supplies, testing and handling equipment, and basic studies related to delivery systems in general. Surveillance of weapons in the stockpile and supervision of modification to these weapons; adaptation of new weapon models to various aircraft; adaptation of nuclear warheads to guided missiles; and testing and quality control of production items, are performed by Sandia.

In addition to these, other installations do some research and development, e.g., Mound Laboratory is doing research and development in such areas as high explosive detonators.

2. Current Status

During recent years the US weapons laboratories have been kept up to date with the latest equipment and facilities, e.g., computers, and the level of competence in technical and scientific manpower has been maintained and quantitatively increased. They are now in a position to pursue a very aggressive weapon development program. During the period of the moratorium, 1958 thru 1961, weapons development was limited to work which could be carried out in the laboratory, without testing, and as a result the enthusiasm, imagination, and vigor of the laboratories declined substantially. Thus upon sudden resumption of testing by the Soviets, the laboratories were hampered in the rapid formulation of a comprehensive and progressive test program.

3. Trends in Program Emphasis

Weapons produced from 1945 to 1954 were fission implosion and gun-assembly types.

Although the U.S. Nuclear weapons stockpile is constantly changing as new types of weapons are introduced, some weapons of the early fission implosion type are still in stockpile in varying sizes from 22" diameter to 60" in diameter. Fission implosion weapons have been constantly improved over the years through the development of hollow shells, boosting, etc., to provide more efficient utilization of fissionable material, increased invulnerability to enemy counteraction, and increased operational readiness. At the same time, emphasis has been placed on the development of very lightweight weapons.

Thermonuclear weapon development really got underway in the early 1950's and in 1954, the first thermonuclear weapons were produced for stockpile.

Up to the 1962 test series, the trend of weapons characteristics has been to smaller, lighter, plutonium bearing weapons, consisting of greater proportion of warheads (missile application), with much greater yields for comparable sizes. This in turn involves some new concepts in major components such as, initiation, gas boosting and firing. This also involves increased use of plutonium. In addition, there has been a pronounced design trend (in LRL designs) toward using much more [redacted]

B. Weapon Test Sites

The first nuclear detonation occurred at Trinity in New Mexico in 1945. Subsequent testing took place at the Eniwetok Proving Ground in 1946 and 1948. The RANGER series of 1951 initiated the Nevada Test Site. Up to 1958, except for the ARGUS detonations in the South Atlantic and the ORANGE and TEAK tests of Johnston Island, the Eniwetok test site has been primarily used for very high yield tests and the Nevada Test Site has been used for low yield tests. In 1962, the US established a nuclear weapons test site at Christmas Island which had previously been used by the United Kingdom for her tests. The US has also detonated several underwater tests, e.g., BIKINI BAKER, WIGWAM, and SWORDFISH, as well as conducted underground tests. A summary of US nuclear tests held up to date is attached. [redacted]

[redacted]

TABLE 2

U. S. NUCLEAR TEST SERIES

[redacted]

Name	Place	Number of Shots	Date	Largest Yield of Any Shot	Total Yield of Series
Trinity	New Mexico	1	1945	[redacted]	[redacted]
Crossroads	Eniwetok Proving Ground	2	1946		
Sandstone	Eniwetok Proving Ground	3	1948		
Ranger	Nevada Test Site	5	1951		
Greenhouse	Eniwetok Proving Ground	4	1951		
Buster-Jangle	Nevada Test Site	7	1951		
Tumbler-Snapper	Nevada Test Site	8	1952		
Ivy	Eniwetok Proving Ground	2	1952		
Upshot-Knothole	Nevada Test Site	11	1953		
Castle	Eniwetok Proving Ground	6	1954		
Teapot	Nevada Test Site	14	1955		
Wigwam (DOD)	Pacific	1	1955		
Redwing	Eniwetok Proving Ground	17	1956		
Plumbob	Nevada Test Site	24	1957		
Hardtack Phase I	Eniwetok Proving Ground	34	1958		
Argus (DOD)	South Atlantic	3	1958		
Hardtack Phase II	Nevada Test Site	19	1958		
Dominic	Christmas Island	26	1962		
Dominic	Johnston Island*	1	1962		
Nougat	Nevada *	57	1961-62		
			Grand Total		[redacted]

* Series incomplete as of 17 July 1962

[redacted]

[redacted]

[redacted]

C. Weapon Fabrication Sites

The production of atomic weapons is subject by law to approval by the President. Once each year and after coordination with the DOD, the AEC submits to the President a request for authority to produce certain numbers of weapons by certain types.

It is, of course, necessary that there be long-range coordination with the DOD to establish the facilities and resources for effecting the annual production authorized by the President.

There are eleven prime facilities used by the AEC for the production and assembly of weapons not counting the modification centers at stockpile sites, etc. The plants concerned are generally owned by the government and primarily built by the AEC, but are operated by civilian contractors.

The US weapon production flow chart is rather complex, with each installation generally but not necessarily uniquely carrying out one part of the production process. For example, enriched uranium and enriched lithium are produced at Oak Ridge and fabricated into shapes at either Oak Ridge or Rocky Flats. These components then flow to one of several fabrication or assembly installations.

D. Stockpile Facilities

Nuclear weapons storage policy and procedures have undergone several changes since the establishment of the Atomic Energy Commission.

Initially, all weapons produced were held under AEC custody in certain central storage locations.

On August 24, 1950, the President authorized initial dispersal of a small number of nuclear weapons to specified locations and the transfer of these to the DOD.

Beginning with an initial authorization on October 21, 1953, the President established certain allowable figures as to the number of weapons which might be transferred to the DOD. Thereafter, these were called for and transferred as requested by the DOD. The weapons available for transfer during the early years after this period were only the low yield fission design.

By early 1955, a small number of thermonuclear weapons were available and stored in national storage sites. The DOD believed that these, like the fission weapons, should be moved out where necessary to areas where they would be closer to using units and less vulnerable in case of enemy attack. In August 1955, the President approved the dispersal of higher yield weapons (specifying them to be the weapons of over 600 KT) but directed that all those dispersed including those within the United States, on ships at sea and on overseas bases remain in AEC custody. It was directed that this custody be maintained in such a manner as to insure "immediate readiness for use." AEC custody was initially accomplished by the presence at each base or on each ship concerned by a civilian AEC custodian with an assistant. On November 24, 1956, however, the President approved in writing the use of military personnel of the various bases and ships concerned as AEC custodians reporting to the AEC with regard to their custodial functions.

On January 3, 1959, the President approved the transfer of high yield weapons dispersed to the DOD and specified that all dispersed weapons be in the custody of the DOD. The AEC retains control of weapons at National Stockpile Sites.

Subsequent to World War II, a program was initiated to build a series of National Stockpile Sites (NSS's) to house the stockpile of nuclear weapons. Sometime later, this program was enlarged to include some Operational Storage Sites (OSS's) which were very similar to the National Stockpile Sites except that they were smaller and usually adjacent to a delivery force. These sites were funded by AEC and operated jointly by AEC and DOD.

In 1949, it was recognized that nuclear weapons would have to be placed near our delivery forces overseas. As a result, two Overseas Operational Storage Sites were constructed. Since that time, the program has expanded considerably and the President has authorized the storage of weapons in other countries.

E. Weapons in Stockpile

For comparative purposes, the US stockpile figures have been presented in Annex A, Table III, in the nearest equivalent tabulation to the stockpile allocation used in the "Intelligence Assumptions for Planning."

F. Trends in US Weapon Development

The results of the DOMINIC and NOUGAT Test Series have of course not yet been fully evaluated. Thus an up-to-date comparison of the US and USSR developments in nuclear weapons cannot be made. It should be noted, therefore, that US weapons development in terms of efficiencies, yield to weight ratios, etc., as discussed relative to the USSR weapons development on pages 10 and 11, Comparison of US and USSR Atomic Energy Programs, and Section V f of ANNEX C, Soviet Atomic Energy Program has been made on the basis of US Weapons testing through 1958 and Soviet testing through 1961.

G. Advance Nuclear Weapons Research

It is probable that the United States could, with continued unlimited testing, during the next 5-10 years approach the practical upper limits of performance in both thermonuclear and fission designs. In addition, progress could also be made in the development of a pure fusion weapon as well as other advanced concepts. [redacted]

V. Peaceful Uses Program Other Than Power Production

A. Basic Philosophy

The basic philosophy of the U. S. peaceful uses program is expressed in Section I of the Atomic Energy Act of 1954 (see Part I).

Since 1953 and especially since passage of the Atomic Energy Act of 1954 the United States has advanced steadily in the development of the various applications of the nuclear sciences and techniques for the benefit and progress of mankind. During this period the Atomic Energy Commission has taken a number of steps to encourage industrial participation in the Atomic Energy Program. For example, it has withdrawn from areas of service when industry showed a capability to provide the services on an economic and competitive basis; it has taken steps to make greater quantities of radioisotopes recovered from fission products available; and it has taken steps to insure that the growth of the nuclear program was carried out in a manner consistent with protecting the public health and safety.

Consistent with the Atomic Energy Act of 1954 the Commission has continually reviewed data within the definition of Restricted Data to determine that which could be declassified and published without the undue risk to the common defense and security, and has, through its technical information program, furnished technical materials of aid to the scientific and technological community.

International cooperation to advance the civilian uses of nuclear energy is an important segment of U. S. foreign policy. U. S. cooperation and assistance consistent with this policy has taken many forms. Authorization for the major cooperative activities in the "atoms for peace" program is provided in the Agreement for Cooperation now in effect with 38 nations, the International Atomic Energy Agency, the European Atomic Energy Community and the City of West Berlin. Some activities such as the shipment of radioisotopes have been administered on a less formal basis.

B. Research in High-Energy Physics

The U. S. after World War II initiated an intensive and broadly-based research effort in high energy physics, founded initially by the Navy and later by the atomic energy program. From the outset the U.S. has established and maintained a position of world leadership in this frontier area of basic science.

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Traditionally the strength of the U.S. effort has lain in experimental work. In recent years, the American effort in theoretical research has improved. This, coupled with a close cooperation between experimentalists and theorists to a much greater extent than in the Soviet Union, has given the U.S. a position of unquestioned leadership.

The U.S. program has dwelt mainly on the following: search for new particles (the bulk of the so-called "strange particles" has been discovered by Americans), search for new phenomena, determination of such particle properties as mass, structure, lifetime, spin, magnetic moment and mode of decay, the behavior of matter due to electric forces via electromagnetic interactions and studies of neutrino induced reactions at high and low energies. These studies, both experimental and theoretical, constitute a massive attack on the frontiers of high energy phenomena and it is likely that the present momentum of the U.S. program, if sustained, will keep the U.S. in the lead relative to Western Europe and the Soviet Bloc. Increasing concern is being felt in this country, however, about the cost of the U.S. program both in scientific manpower and physical resources and the balance of scientific effort between high energy physics and other areas of basic science such as nuclear or solid state physics.

High energy accelerators (defined as those with energies of more than 200 Mev) presently in operation include 7 electron and 8 proton accelerators. Two additional proton accelerators and one linear accelerator under construction are scheduled for completion in 1962, 1963, and 1967, respectively. The list of accelerators may be organized by function, type, and energies as shown below:

Type	Number	Range of Maximum Energy, Bev
Electron accelerators (8 total)		
Synchrotrons	5	0.3 - 6
Betatrons	1	0.3
Linear accelerators*	2	0.7 - (10-20)
Proton accelerators (10 total)		
Synchrotrons**	2	1.5 - 33
Synchrocyclotrons	5	0.24 - 0.74

* The Stanford University linear accelerator, under construction is expected to deliver particles with energies of from 10 to 20 Bev.

** Two under construction

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The newest and highest energy accelerator in the world, the Alternating Gradient Accelerator (AGS) at Brookhaven, successfully accelerated a beam of protons to more than 30 Bev in July 1960, thus exceeding design energies. Subsequently, beam energies in the range of 33 Bev have been obtained. Work to date with the AGS has been directed toward analyzing the yields of atomic particles (pi-mesons, K-mesons and Antiprotons) which are produced in secondary beams when the primary proton beam strikes target material. Results obtained with 30 Bev protons show that secondary beams are especially rich in K-mesons and antiprotons when the secondary beams are in the 10 to 15 Bev range.

The Stanford University linear accelerator, being constructed near Palo Alto, California, will give scientists an advanced tool for research in high-energy physics by providing a high-intensity, well-collimated beam of electrons.

C. Controlled Thermonuclear Reactions Research

Research on controlled fusion reactions is conducted by the AEC at a continuing annual cost of about $26 million. There are about 380 scientists directly working on the US controlled fusion program. Successive goals of this research effort are as follows: First, to heat and confine a plasma of ionized gas at particle energies sufficient to yield significant amounts of thermonuclear energy during confinement. For a plasma of deuterium-tritium, temperatures of the order of 60 million degrees Centigrade are required. Second, to study an ignited plasma to ascertain whether a pilot plant yielding net power can be produced. And Third, to assess the possibility of economical generation of fusion power.

During 1960 and 1961, considerable progress was made toward achievement of the first goal, using different experimental devices. Although ignition energy has not yet been achieved, several laboratories are producing plasmas with ion energies so high that it is reasonable to expect such achievements in the near future. Emphasis is therefore being placed on the second goal, and more specifically, upon attempts to increase plasma confinement times to practical periods. This effort can be expected to continue for 5 to 10 years and the outcome cannot be predicted. Ultimate achievement of the economical generation of fusion power, should it prove technically and economically feasible, is many years away.

Major work is carried on at four laboratories; the Lawrence Radiation Laboratory (LRL) at Berkely and Livermore, California;

the Los Alamos Scientific Laboratory (LASL), Los Alamos, New Mexico; the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee; and the Naval Research Laboratory (NRL), Washington, D. C. Specialized support is provided by several other laboratories. Five approaches are being followed: In the stellerator at Princeton, gas is heated in an endless tube provided with very strong externally applied, spiral magnetic fields; in the magnetic mirror devices at LRL and ORNL plasma or a beam of particles (ions or neutral atoms) are supplied from a neutral source, and trapped in mirrors or cusp magnetic field configurations; in self-confinement and fast-pulsed devices at LASL, NRL, and LRL, the plasma is heated either by inducing strong currents in the plasma or else by rapidly applying very strong external fields; in the Astron device at LRL, electrons having velocity approaching that of light are injected to form a rotating cylindrical layer. The magnetic field of this layer, together with external fields, is able to confine ions, and the fast electrons impart kinetic energy to the ions; in the rotating plasma devices at Los Alamos and LRL, ions and electrons are accelerated by electric fields applied to the plasma in such a way as to impart rotational motion.

D. <u>Plowshare</u>

Peaceful uses for nuclear explosives (PLOWSHARE) have been seriously considered in the United States since February 1957 and actual nuclear experiments in the field have been possible since the end of the moratorium on nuclear weapon testing in September 1961. Two major areas are under development:

1. engineering applications which include excavation, mining, and improvement of water and oil resources, which are based on data from past high explosive experiments and weapons effects tests; specific development was begun in 1962 with Project SEDAN on July 6, and will continue at the rate of about two experiments a year; and

2. scientific applications which include unique research in chemistry, physics, transuranium elements and other fields and which is based on data and techniques from past weapon tests; the first experiment of this type was Project Gnome on December 10, 1961, and future experiments will be conducted at the rate of about one each year.

Development of cheaper nuclear explosives with less radioactivity will also be pursued using technology from the weapons program which will be tested in scheduled Plowshare projects. Expenditures in fiscal year 1963 of about $10.0 million are expected to rise in the next five years to $30.0 million.

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E. International Cooperation

Since 1955 the United States has cooperated internationally in the peaceful uses of atomic energy under provisions of research and power agreements entered into with other countries. At present 38 bilateral agreements for cooperation in the civil uses of atomic energy are in effect with 36 countries and the City of West Berlin. Of these, 24 are for research, 14 for power. The United States also has bilateral Agreements for Cooperation with the International Atomic Energy Agency and the European Atomic Energy Community (EURATOM).

An important aspect of the US program of international cooperation has been the requirement of safeguards provisions in its bilateral agreements to assure that assistance furnished would not be diverted to military uses. Periodic inspections are made by US safeguards inspectors to assure that the terms of the safeguards provisions are being honored by our bilateral partners. The United States with the assistance of other friendly Member States of the International Atomic Energy Agency was able to secure adoption of a safeguards system administered by the IAEA.

US participation in the International Atomic Energy Agency has provided information, equipment, and financial assistance to the Agency program. From 1958 through 1962 the United States has provided $8.95 million for the IAEA assessed budget and $2.39 million to the voluntary budget. Included in US assistance have been $150,000 worth of U-235 offered cost-free for research, two mobile radioisotope laboratories, $600,000 for construction of a permanent Agency laboratory, $435,500 worth of equipment for Member States, 305 fellowships, and the services of 31 cost-free consultants and experts.

Cooperation between the US and EURATOM has been carried out under two programs, the US-EURATOM Joint Nuclear Power Program and the US-EURATOM Joint Research and Development Program. To date two power reactor projects have been accepted under the joint power program. Under the first round invitation issued in 1959 SENN (Societa Elletronucleare Nazionale) is building a 150-electrical-megawatt boiling water reactor in Italy at Punta Fiume, now near completion and expected to be in operation in 1963. On July 2, 1962, the US-EURATOM Joint Reactor Board announced acceptance of the proposal from SENA (Franco-Belgian Society for Nuclear Energy for Ardennes) to construct a 210-MWE pressurized water reactor near Givet, France, on the Franco-Belgian border, to be operable by December 31, 1965. One other project of comparable size will be included under the second round invitation.

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Since its initiation in December 1958, the US-EURATOM Joint Research and Development Program has authorized 91 proposals for work - 60 of them to be carried out in Europe, 31 in the United States and amounting to about $24 million. Forty-two European and 17 United States organizations are represented in this program which has as its objectives the improvement of the performance of types of reactors to be constructed under the joint nuclear power program and the lowering of fuel cycle costs.

A number of major technical exchange programs are beginning to pay dividends for the US domestic program as well as for our bilateral partners. One of the most extensive of these efforts is the cooperation between the United States and Canada on the development of heavy water reactor technology, to which the US is contributing $5 million in research projects in this country, in addition to the usual exchange of personnel.

Transfer of special nuclear materials bilaterally and through international organizations has already reached significant proportions and will be increasingly important within the next few years. An estimated $50 million worth of special nuclear materials will be required for the EURATOM program over the next ten years, an item of some importance to the US economy. Materials transfers to date are as follows:

MATERIAL SUPPLIED TO OTHER COUNTRIES
UNDER AGREEMENTS FOR COOPERATION

As of May 31, 1962

Total enriched uranium	34,183.6	kilograms
U-235	1,498.7	kilograms
Plutonium	4,889	grams
U-233	626	grams
Heavy water	419	tons
Normal uranium	19,083	kilograms
Depleted uranium	325	kilograms

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The US program of international cooperation has offered important assistance to other countries and international organizations by the distribution of libraries and the opening of US facilities to foreign visitors and trainees. Eighty-eight depository libraries have been distributed to 62 countries and five international organizations. Since 1950 a total of 2,135 persons from 63 foreign countries have attended formal training courses and received individual training assignments at AEC facilities. More than 6,000 foreign nationals have visited AEC field installations, and during the period from 1959 - 1960 approximately 2,000 AEC and contractor personnel traveled abroad on official business.

Under its program of reactor and equipment grants, the US has made commitments for a total of 26 research reactor grants to other countries, each grant not to exceed $350,000. To date, 17 of these grants have been paid with a total expenditure of $5,950,000.

A total of 30 countries have received grants of nuclear energy equipment, other than reactors, having a total value of $3,490,268. Included in these equipment grants are 39 completely equipped laboratories.

Table 3 shows the status and type of aid the US is providing to other countries.

Table 4 is an itemized account of US support to the IAEA.

TABLE 3

United States Atomic Energy Assistance to Other Countries

I. U.S. Built Research Reactors - Operating, TOTAL - 37

Country	Reactor Type (KW)	Location	Status
Sweden	Tank 30,000 KW (General irradiation test)	Studsvik	Operable in 1960
Japan	Tank 10,000 KW (General irradiation test)	Tokai-Mura	Operable in 1960
Japan	Research 50 KW	Tokai-Mura	Operable in 1957
Japan	Teaching, Negligible power	Osaka	Operable in 1961
Japan	Research, 100 KW	Yokosuka City	Operable in 1961
Netherlands	General irradiation test; 20,000 KW	Petten	Operable in 1961
Austria	Pool type, Research, 5,000 KW	Seibersdorf	Operable in 1960
Austria	Triga Mk. II, Teaching 100 KW	Vienna	Operable in 1962
Australia	UTR-10, Teaching 10 KW	Lucas Heights	Operable in 1961
Brazil	Pool type, Research 5,000 KW	Sao Paulo	Operable in 1960
Brazil	Triga Mk. I, Teaching 30 KW	Belo Horizonte	Operable in 1960
Canada	Pool type, Research 1,000 KW	Hamilton, Ontario	Operable in 1959
Congo	Triga Mk. I, Teaching 50 KW	Leopoldville	Operable in 1959

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Country	Reactor Type (KW)	Location	Status
Natl. China	Pool type, Research 1,000 KW	Hsinchu	Operable in 1961
Denmark	Tank type, Research 5,000	Riso	Operable in 1958
Denmark	Teaching, 0.5 KW	Riso	Operable in 1957
Germany	Pool type, Research 1,000 KW	Munich	Operable in 1957
Germany	Pool type, Research 5,000 KW	Geesthacht	Operable in 1958
Germany	Teaching, 50 KW	Frankfurt	Operable in 1958
Germany	Teaching, negligible power	Duisburg	Operable in 1958
Greece	Pool type, Research 1,000 KW	Athens	Operable in 1961
Israel	Pool type, Research 5,000 KW	Nebi Rubin	Operable in 1960
Italy	Tank type, Research 5,000 KW	Ispra	Operable in 1959
Italy	Triga Mk. II, 100 KW	Rome	Operable in 1960
Italy	Pool type, Research 1,000 KW	Saluggia	Operable in 1959
Italy	Teaching, negligible power	Palermo	Operable in 1960
Italy	Teaching, 50 KW	Milan	Operable in 1959
Portugal	Pool type, Research 1,000 KW	Sacavem	Operable in 1961
Spain	Pool type, Research 3,000 KW	Moncloa	Operable in 1958

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Country	Reactor Type (KW)	Location	Status
Switzerland	Pool type, Research 1,000 KW	Wuerenlingen	Operable in 1955
Switzerland	Teaching, negligible power	Basel	Operable in 1958
Switzerland	Teaching, negligible power	Geneva	Operable in 1958
Turkey	Pool type, Teaching 1,000 KW	Istanbul	Operable in 1962
Venezuela	Pool type, Research 3,000 KW	Caracus	Operable in 1960
Korea	Triga Mk. II, Research 100 KW	Seoul	Operable in 1962
West Berlin	Teaching, 50 KW	West Berlin	Operable in 1958
Finland	Triga Mk. II, 100 KW	Helsinki	Operable in 1962

U.S. Research Reactors Being Built - TOTAL - 10

Iran	Pool type, Research 5,000 KW	Tehran	Completion scheduled 1962
Italy	Pool type, Research 5,000 KW	Livorno	Completion scheduled 1962
Indonesia	Triga Mk. II, Research 100 KW	Bandung	Completion scheduled 1962
Japan	Triga Mk. II, Research 100 KW	Kawasaki City	Completion scheduled 1962
Japan	Tank type, Research, 1,000 KW	Kyoto	Completion scheduled 1965
Netherlands	Pool type, Research 100 KW	Delft	Completion scheduled 1962
Pakistan	Pool type, Research 5,000 KW	Rawalpindi	Completion scheduled 1963

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Country	Reactor Type (KW)	Location	Status
Philippines	Pool type, Research 1,000 KW	Quezon City	Completion scheduled 1962
Thailand	Pool type, Research 1,000 KW	Bangkok	Completion scheduled 1962
Vietnam	Triga Mk. II, Research 100 KW	Dalat	Completion scheduled 1962

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II. U. S. Built Power Reactors

Operable - TOTAL - 1

Country	Reactor Type (MW)	Location	Status
Germany	Boiling Water 15,000 MWE	Kahl-am-Main	Operable in 1960

Being Built - TOTAL - 4

Country	Reactor Type (MW)	Location	Status
Belgium	Pressurized water, 115 MWE	Mol	Completion scheduled 1962
Italy	Pressurized water, 165 MWE	Trina (SELNI)	Completion scheduled 1964
Italy	Boiling water, 150 MWE	Punta Fiume (SENN)	Completion scheduled 1963
Japan	Boiling water, 12 MWE	Tokai-Mura	Completion scheduled 1963

III. Cyclotrons

(No U.S. aid for this type of equipment)

IV. Electrostatic Generators

Country	Size	Location	Status
Mexico	3 MEV	National Autonomous University of Mexico, Mexico City	Grant made in FY 1962 Not yet delivered
Greece	.4 MEV	Democritus Nuclear Research Center, Athens	Grant made in FY 1960

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TABLE 4

SUPPORT TO THE IAEA BY THE UNITED STATES

Items			
1. Regular Budget	1958		$ 1,362,864
	1959		1,698,648
	1960		1,899,559
	1961		2,000,283
	1962		1,988,155
		Total	$ 8,949,509
2. Operational Budget	1958		$ 64,570
	1959		591,522
	1960		500,000
	1961		630,970 1/
	1962		603,201
			$ 2,390,263
3. Cost-free Materials for Research			$ 150,000 2/ worth U-235
4. Facilities:			
Permanent Laboratory			$ 600,000
2 Mobile Radioisotope Laboratories			118,700
5. Special Equipment Grants			433,500
6. Research Contracts Finances			
7. Fellowships Offered			305

1/ At April 30, 1961. Subject to increase up to $750,000 to match contributions from other members.

2/ $50,000 allocated to Finnish and Yugoslav research reactors and $50,000 offered for 1962.

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Items	
8. Cost-free Experts and Consultants	31 provided 3/
9. Small Power Reactor Assistance	IAEA participation in US projects
10. Library Items	About 38,000
11. Materials Available for Sale or Lease:	
Kilograms of U-235 Source Materials	5,070 If not available commercially

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3/ 28 from the US used by the IAEA at a cost of approximately $97,500.

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F. Medical and Biological Research

The AEC's medical, biological, and environmental research program consists of research in three broad categories: Scientific areas underlying the interaction of radiation with biological systems, which accounts for about sixty percent of the effort; Health and Safety in atomic energy programs and devices, which accounts for twenty-five percent; and beneficial applications of special nuclear and radioactive materials.

Approximately two-thirds of the program costs are incurred in support of work at Government-owned facilities, and the remaining work is accomplished under approximately six hundred research contracts with universities, colleges, and other institutions.

In order to study the interaction of radiation with biological systems, research is being carried on in the areas of molecular biology, genetics, somatic effects, internal emmitters, environmental sciences and radiological physics.

Health and Safety problems arising during the exploitation of nuclear materials and energy are studied through applied research in health physics, radiation instrumentation, prophydaxis and therapy, chemical toxicity, nuclear energy civil effects, and fallout.

Beneficial applications are developed through research which promotes utilization of special nuclear materials, and includes cancer research, utilizing radioisotopes and other unique radiation sources; medical and biological research; agricultural research for the improvement of economically important animals and crops; and research to determine the nutritional, microbiological, wholesomeness and health aspects of foods processed with relatively low doses of radiation.

G. Isotope Development

Research and development of technology required for extending and speeding up the application of radioisotopes in engineering, agriculture, medicine, and research is supported by AEC at an annual level of about $7 million. This work is aimed at supplementing technology now employed by more than 2,800 licensed medical institutions and physicians, 2,000 industrial concerns, and nearly 2,000 other licensed users.

Of special interest is the investigation of the radiation pasteurization of foods, looking initially to prolong the shelf life of fish and fruit products.

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H. East-West Exchange Program

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Exchanges in the peaceful applications of atomic energy are a part of the over-all U.S. exchange program and are developed by the AEC and coordinated with the Department of State. Exchange contacts with the Soviet Bloc have increased United States knowledge of the Soviet Bloc's capabilities and technical and scientific advances in the field of atomic energy. Soviet Bloc scientists have received considerable technical information of value to the Soviet nuclear program. [redacted]

I. Mutual Defense Cooperation

[redacted]

Agreements for Cooperation with other nations for mutual defense purposes may provide for the exchange of certain classified information concerning nuclear weapons and military reactors and for the transfer of the less sensitive non-nuclear parts of atomic weapons systems necessary to improve the training and operational readiness of Armed Forces. Under certain conditions, these agreements may also provide for the transfer of military reactors, non-nuclear parts of weapons, and nuclear material for military purposes. The United States presently has mutual defense purposes agreements under provisions of the Atomic Energy Act with NATO, Australia, Canada, France (two, one of which provides for transfer of nuclear materials for prototype submarine propulsion plant), Federal Republic of Germany, Greece, Italy, Netherlands, Turkey, and the United Kingdom. The United States-United Kingdom Agreement for Cooperation is considerably broader than other agreements, providing for the exchange of more detailed atomic weapon information and the sale of a submarine propulsion reactor. The Mutual Defense Purposes Agreement between the U.S. and Canada, while not so broad as that with the United Kingdom, is more extensive than those entered into with other countries or NATO. [redacted]

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ANNEX C

SOVIET ATOMIC ENERGY PROGRAM

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The Chief Directorate for the Utilization of Atomic Energy attached to the Council of Ministers was created in mid-1956 to take over the non-military applications of atomic energy, including developing cooperation between the USSR and other countries in the non-military uses of atomic energy, the introduction of atomic energy into industry, and the coordination of research in nuclear technology. Its first chairman was Ye. P. Slavskiy, now the Minister of Medium Machine Building. In 1960, under the chairmanship of V. S. Yemelyanov, the Chief Directorate was reorganized and elevated to ministerial level as the State Committee of the USSR Council of Ministers for the Utilization of Atomic Energy. As a result, it probably acquired more authority and a higher priority in carrying out its "peaceful uses" efforts. Recently, Yemelyanov was relieved of his position as chairman, apparently for reasons of health, and was succeeded by Petrosyants, who had been a Deputy Minister of Medium Machine Building.

There is very close cooperation and coordination between the Ministry of Medium Machine Building and the State Committee. The Ministry, in all likelihood, controls the availability of nuclear materials for peaceful purposes, and the State Committee acts as a buffer between the sensitive production ministry and the consumer industries, including representatives of all other countries.

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II. Nuclear Reactor Program (Non-production Types)

A. Research and Testing Reactors

Since 1955 the Soviets have constructed and placed into operation 18 research reactors of 11 different types within the USSR. The Soviet research reactor facilities are used both for the nuclear training of personnel as well as for extensive studies of neutron physics, materials testing and development, radiochemistry, isotope production, and new reactor concepts. This program is of fundamental importance in the areas of fissionable material production and weapons development. However, it is not known to what extent the program has aided the Soviets in achieving their technological goals.

The variety of research reactors indicates an excellent capability in this field. However, in recent years the Soviets have adopted the IRT type as their general-purpose research reactor.

The following comments can be made on certain types of reactors used to perform special functions:

(a) The VVR-S, a tank-type reactor, is used principally for general studies in neutron physics, such as cross-section measurement, and has been sent to many Soviet Bloc countries.

(b) The IRT swimming-pool-type reactor is low cost and very simple in construction. It is recommended by the Soviets for use in universities and research centers. This type is adaptable to radiation damage, shielding, and general irradiation-type studies.

(c) The VVR-M tank-type reactors are primarily being used for research on electronic equipment associated with a reactor program.

(d) The RPT graphite-moderated reactor is the Soviet version of the materials test reactor and is used primarily for inpile testing of new fuel element designs, coolants, and other major reactor components.

(e) The BR series of fast reactors at Obninsk is significant not only for the development of breeder-type reactors, but also for the development of compact reactors for future propulsion systems. The BR-5 reactor was the first reactor to use a plutonium oxide fuel.

(f) The IBR merry-go-round type pulsed reactor at Dubna, with its associated one-kilometer time-of-flight spectrometer, is a very impressive experimental instrument. It emits a pulse of 10^{18} to 10^{19} neutrons over a time interval of 100 microseconds. At present the full length of the spectrometer has not been used because of excessive scattering of the neutron beam.

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(g) The VVR-Ts is a tank-type specialized radiochemical research reactor.

(h) The SM-50, a 50-megawatt, intermediate flux trap type reactor has a central water cavity where a thermal neutron flux of 2.2 x 10^{15} neutrons/cm^2/sec is obtained.

(i) The OR-15, a 15-MWt organic cooled and moderated type test reactor was recently constructed to provide data on the physics, heat transfer, and coolant characteristics.

Despite considerable research, the Soviets also have not undertaken to construct any homogeneous reactors or liquid-metal-fueled reactors.

Soviet research reactors built or contracted for in other countries are carried under the section on International Cooperation.

Table 1

Soviet Test, Research, and Teaching Reactors

	Operable	Dismantled	Being Built
General Irradiation Test (1)	2	1	---
Special Test (2)	5	3	---
Research (3)	7	---	2
Teaching (4)	5	---	1
TOTAL	19	4	3

NOTE: No information is available as to the number of research reactors being planned.

(1) Includes the VVR-2 and RPT reactors.

(2) Includes the fast-reactor experiments, (BR series), the IBR pulsed reactor and OR-15 reactor.

(3) Includes the VVR-S, WR-Ts, and VVR-M series of reactors.

(4) IRT-type reactors.

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B. Nuclear Electric Power Station

In July 1954 the Soviets had put into service "the first atomic industrial type electric power station in the world" generating 5 MWe. Elated with this "first", the Soviets planned to lead the world in atomic power generation. In 1956 it was announced in the sixth Five-Year-Plan that five large power reactor installations were to be built and go into service by 1960, producing 2000 to 2500 MWe.

British success with nuclear power stations beginning with Calder Hall in late 1956 and American successes beginning with Shippingport in 1957 began to deprive the Soviets of leadership in the field. In September 1958 the Soviets put into service a 100-MWe generating plant utilizing heat from a plutonium production reactor at Tomsk in Central Siberia.

By 1960, technical difficulties, and the fact that the nuclear power would cost several times as much as thermal or hydroelectric power had, changed the Soviet attitude toward nuclear power. As of January 1961 the Soviet Union claimed only 105 MWe of nuclear power generation in operation, although the sixth Five-Year-Plan in 1956 had called for 2,000-2,500 MWe by 1960. The planned 420 MWe plant at Voronezh was reduced to 210 MWe capacity, and the planned 400 MWe plant at Beloyarsk reduced to 100 MWe. Voronezh and Beloyarsk nuclear power plants are both behind schedule and are due to start operation in 1962. Technical difficulties may further delay these installations, but it is quite probable that both reactors will go critical in 1962.

Besides the installations at Voronezh and Beloyarsk, a pressurized water reactor similar to the Voronezh reactor had been planned for a location near Leningrad, and an experimental program was to be carried out near Ul'yanovsk. Here it was planned to construct a prototype bulk boiling water reactor, a fast breeder, and a sodium graphite reactor, all of about 50-MWe capacity, and a 5-10 MWe homogeneous thorium breeder. Construction of the Leningrad reactor installation has been indefinitely postponed, and there is evidence that only the 50-MWe boiling water reactor has been built at Maldek in Ul'yanovsk Oblast. Apparently the fast breeder, sodium graphite, and homogeneous thorium experiments have been postponed.

The 150-MWe heavy water moderated, gas-cooled reactor, planned by the Soviet Union in 1956, was assigned to Czechoslovakia for joint development by both countries. This reactor is covered in the International Section of this appendix.

For the future, Soviet scientists have been considering the use of super-critical steam as the medium for carrying heat from reactor to turbine. A thermal efficiency of 40 percent could be realized by this use of super-critical steam as the coolant compared to the present 29 percent efficiency of the pressurized water system. Considering the fact that the Soviets have not yet built any large super-critical steam boilers for conventional fuels, it is not likely that a Soviet nuclear power station employing super-critical steam will be constructed within the decade.

Table 2

Soviet Nuclear Power Stations

Calendar Year	Startup Plants	Startup Capacity (MWe gross)	Calendar Year-end Plants	Calendar Year-end Capacity (MWe gross)
		Central Station Prototypes		
1962	2	310	2	310
1963	2	310	2	310
1964	-	---	2	310
		Experimental Power Reactors		
1962	2	55	2	55
1963	2	55	2	55
1964	2	55	2	55
		Military Power Plants and Experimental Reactors		
1962	1	2	1	2
1963	1	2	1	2
1964	1	2	1	2
		Dual Purpose Reactors		
1962	1*	200*	1*	200*
1963	1	200	1	200
1964	1	200	1	200

*one plant, 2 reactors, 100 MWe each. No Soviet claim on second 100 MWe. Six reactors previously planned.

C. Nuclear Propulsion Systems for Naval and Marine Vessels

Surface Ships. The Soviet development of nuclear propulsion for naval and marine vessels began shortly after the successful operation of the "first" atomic power station in June 1954. By early 1956 plans had been completed and the keel laid for the atomic icebreaker "Lenin". The "Lenin" was launched in December 1957, began its dockside trials in August 1959, and completed its sea trials in December of the same year. The "Lenin" propulsion plant consists of three pressurized water reactors (PWR) each rated at 90,000 KWt. One of the reactors is kept in a standby condition while the other two are used for ship operation, delivering a maximum of 44,000 shaft horsepower to the turboelectric drive system. The reactor fuel is 5-percent enriched uranium dioxide. Two of the reactors have zirconium-niobium alloy as the clad material and the other stainless steel. The coolant loop is designed to operate at high temperatures and pressures, conditions which tend to accelerate the corrosion rate within the system. This has led to frequent repairs and equipment replacement.

During the sea trials and its 1960 voyage, the "Lenin" encountered a considerable number of problems, both with the nuclear and conventional units of the propulsion system. After extensive modifications (some of which were undoubtedly based on information obtained during the Soviet visit to the "NS Savannah"), it was placed on expeditionary-type service and used in October and November 1961 to establish polar ice stations and position numerous automatic weather stations deep in the Arctic ice pack. The Soviets have considered utilization of atomic power for construction of a large tanker, but latest information indicates that such plans have been postponed or canceled.

Nuclear-Powered Submarines. The Soviet nuclear submarine program was developed concurrently with that of the "Lenin". The keel of the first nuclear submarine was laid at Severodvinsk in 1956, launching took place in mid-1958, and it was at sea in mid-1959. This submarine was later identified as a torpedo attack-type submarine ("N" class). Construction on the second class ("H" class) of nuclear submarines was begun shortly after the "N" class, and first began its sea trials in September 1959. The "H" class is armed with three ballistic missiles estimated to have a range of about 350 nm and capable of being fired from the submarine while in a surfaced condition. The third class of nuclear submarines ("E" class), armed with six cruise missiles having a range of 200 nm, is being constructed in the Far East at Komsomolsk-on-Amur. It is believed the delivery of the first submarine of this type was made in late 1960. All the classes of submarines are believed to be powered by a standardized reactor system built around a version of the "Lenin" reactor and which could deliver about 15,000 to 20,000 shaft horsepower depending on the modifications incorporated.

Improved Soviet nuclear submarines are believed under development. It is expected that some of these will be capable of firing from a submerged position ballistic missiles with a range perhaps as high as 2,000 nm.

Land Prototype. The crews of the "Lenin" and presumably those of the submarines have been trained at Obninsk nuclear power station. The 2-MWe mobile atomic power station based on a pressurized water system was probably the PWR prototype and is now being used for training purposes.

It is estimated that as of 1 July 1962 the USSR has up to 20 nuclear submarines, of which about 75 percent are missile firing, not all of which are operational. The USSR is expected to construct nuclear submarines at the rate of 69 in 1963.

Chronological Development. The following are related dates in the Soviet naval nuclear propulsion program:

1954 -- Design of nuclear submarine began

Mid-1956 -- Keel laid for the first nuclear submarine ("N" class)

Mid-1957 -- Inpile tests of PWR fuel element completed

Mid-1958 -- First nuclear submarine launched

End-1958 -- PWR prototype and training reactor operational

Mid-1959 -- Sea trials of first nuclear submarine

Sept. 1959 -- Sea trials of first nuclear ballistic-missile submarine ("H" class)

1961 -- Sea trials of first cruise-missile submarine ("E" class)

1962-63 -- Improved nuclear ballistic-missile submarine expected

D. Nuclear Propulsion for Aircraft, Missiles, and Space

[redacted]

If the Soviet ANP program was initiated in 1956, was supported continuously at a high level, and progressed with no major setbacks, the Soviets could possibly produce an aircraft nuclear power plant as early as 1963-64. This might permit a first militarily-useful nuclear-powered aircraft to become available in 1966. However, the lack of evidence of the continued existence of the program since 1960, the decreasing frequency of Soviet statements on progress, and the apparent general level of reactor technology indicates that the effort may have encountered serious obstacles.

Nuclear Ramjets. To date there is no specific evidence which indicates that the Soviets have a nuclear ramjet missile under development, although analysis of the Soviet literature and other information indicates an excellent conventional ramjet research program. If the Soviets have such a program, it is not expected that they will flight test a nuclear ramjet engine before 1966.

Nuclear Rockets. In April 1960 the Soviet rocket authority, L.I. Sedov, stated that the Soviet Union had both a theoretical and experimental research study on nuclear-propelled rockets in progress but as yet did not have an existing engine. In August of the same year Sedov made the statement that the Soviets did not have an atomic-powered rocket program and that they would wait until the Americans finished their atomic rocket motor. Then they would see if this problem could be solved without investing tremendous sums of money in such a project. There is no other information on the possible existence of such a program.

Electrical Propulsion Space Systems. It appears that the major Soviet effort toward the development of electric propulsion systems is directed toward an ion propulsion system. Much of the experimentation on ion propulsion is a by-product of CTR research, especially in the areas of ion sources, plasma-ion interactions, and diagnostics. Currently available information indicates that the USSR is planning for in-flight instrumentation to be completed in early 1962 for subsequent testing of an ion engine in space. As the range of measurement of the instruments has been reported to be 75-500 kilowatts, a nuclear reactor would be the most likely power source for the ion engine. Since ion-propulsion-type experiments have been conducted by Soviet fast reactor scientists, it is likely that a fast reactor will be the nuclear power source for the 75-kilowatt ion engine. Such a system could probably be flight tested by 1964, barring major difficulties in the developing of the power source.

E. Nuclear Auxiliary (Non-Propulsion) Power Supplies

Based on Soviet capabilities in reactor technology, the utilization of radioisotopes, and thermoelectric materials development, we estimate that they have the current capability to develop nuclear heat sources producing in the order of several hundreds of watts, which are suitable for use as auxiliary power supplies in aero-space vehicles. We have no evidence that the Soviets have utilized nuclear auxiliary power supplies in their space program. In addition to the ion-propulsion power supply, there is good evidence from the literature that a thermionic-type nuclear power supply is being actively developed. This will permit an increase in the expected lifetime of the space power system by eliminating the moving parts normally associated with turbo-electric power supplies.

III. Nuclear Materials Production

A. Uranium Ore Production

Table 3

Estimated Domestic Production and Foreign Procurement

Fiscal Year	Domestic Uranium Metal (Metric Tons)	Domestic U_3O_8 Short Tons	Satellites Uranium Metal (Metric Tons)	Satellites U_3O_8 Short Tons	Total Uranium Metal (Metric Tons)	Total U_3O_8 Short Tons
1946-1962	80,000	103,600	90,000	116,500	170,000	220,150
Projected-FY						
1963						
1964						
1965						
1966						
Total Projected						

The Soviets have, through the years, obtained about 50 percent of their uranium from the Satellites, the largest contributor being East Germany -- about 5400 metric tons of recoverable uranium in 1962. Czechoslovakia, Bulgaria, Rumania, Hungary, and Poland together supplied the USSR with about 4600 metric tons in 1962. The Satellites are expected to continue to supply the Soviets at a slightly expanding rate during the next 5 years.

It is estimated that in 1962 Soviet domestic recoverable uranium will be about 8900 metric tons. The Krivoy Rog district in the Ukraine is the leading uranium producer in the USSR with an annual output of about 3000 metric tons of recoverable uranium. The Fergana Valley in Central Asia is the second largest producer, followed by the Frunze-Lake Issyk-kul' district and the Pyatigorsk area in the northern Caucasus. Many other small widely scattered operations each produce 50 to 100 metric tons of recoverable uranium annually. As the Soviets have no large sedimentary deposits similar to the Ambrosia Lake deposit in New Mexico, this factor

[redacted]

in combination with a low average grade of all of their ores of 0.12 percent uranium has resulted in comparatively high mining and o[illegible] concentration costs.

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The Soviets have used many ore concentration techniques similar to those used in the US. However, their recovery of uranium from coals and from iron ore slags is a native development. The older Soviet concentration plants use a precipitation process, while the plants built since 1957 use the more efficient, more economical resin-in-pulp ion exchange technique. However, the Soviets have experienced difficulty in producing large quantities of high-quality resins and have been forced to rely on East German and Western sources to furnish an adequate supply. This is not a very satisfactory situation to the Soviets, and consequently they have become very interested in the solvent extraction process. [redacted]

The Soviet Bloc has estimated reserves of at least 300,000 tons of recoverable uranium. In addition, the USSR has over the years probably maintained uranium stockpiles of uranium concentrates or feed materials which would enable them to operate fissionable materials plants for 2 to 4 years in the event of a failure of their ore supply.

B. Uranium-235

In the late 1940's and early 1950's, Soviet scientists, with the aid of German scientists, conducted research on the various methods for separating uranium isotopes. Production-scale facilities were constructed utilizing electromagnetic, thermal, and gaseous diffusion processes. It is believed that the interest in the ultra-centrifuge method has continued, but we do not know that the Soviets are using this method on a production scale. The Soviets are using the gaseous diffusion method as their primary process for production of uranium-235.

[redacted]

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[redacted]

Table 4

Estimated Soviet Production of Uranium-235 (93%)
(Cumulative, in Kilograms, rounded)

Mid-Year	Total	Available for Weapon Use
1950-1961	[redacted]	
1962		
1963		
1964		

C. Plutonium

Two major plutonium equivalent production sites have been identified in the USSR: the earlier and larger is located near Kyshtym in the Urals, and the second is co-located with the U-235 production complex north of Tomsk in central Siberia. The large atomic energy site northeast of Krasnoyarsk probably includes underground facilities for plutonium production. It is also possible that plutonium production facilities may exist at the Angarsk atomic energy site.

Construction at Kyshtym started shortly after World War II, and a small graphite-moderated, water-cooled production reactor went into operation about mid-1948. Additional reactors were built over the next several years, although the type and size of these reactors is not definitively known. They undoubtedly include several large graphite-moderated, water-cooled reactors, and probably include at least one heavy-water-moderated reactor. It is believed that the productive capacity of the site has increased since 1953, more from the increase in power levels of existing reactors due to advances in nuclear fuel and water-treatment technologies than from the construction of new reactors. [redacted]

[redacted]

The first Soviet plutonium chemical processing plant at Kyshtym is known to have used a sodium uranylacetate-lanthanum fluoride co-precipitation process. Soviet research on various solvent extraction processes started at least as early as 1950. However, the first Soviet plant using a solvent extraction process did not go into operation until at least [redacted] Post-1956 interest in the tributylphosphate solvent extraction process suggests that they may now be using a process much the same as the US "purex" process. Their apparent lack of interest in the newer separation techniques is generally consistent with the rather backward status of industrial chemistry in the USSR.

[redacted]

Table 5

Estimated Soviet Plutonium Equivalent Production
(Cumulative, in Kilograms, Rounded)

Mid-year	Total
1950-61	[redacted]
1962	
1963	
1964	

D. Other Nuclear Materials

Lithium. [redacted]t is believed that the USSR has sufficient amounts of both natural and enriched lithium to meet their weapons requirements.

Tritium. [redacted]

Heavy Water. Heavy water production in the USSR is believed to have started on a rather moderate scale in 1947. By the end of 1949 at least five plants were in production at a rate of approximately 45 metric tons per year. Since that time at least four more plants have been constructed and current production is estimated to be about 100 metric tons per year. This amount is believed to be ample for the reactor and weapons needs of the Soviet nuclear program.

[redacted]

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IV. Nuclear Weapons Program

A. Nuclear Weapons Research and Development Sites

The Soviet nuclear weapon program has been supported by a number of institutes and laboratories in the USSR, probably including the Institute of Atomic Energy of the Academy of Science, Moscow; the fast reactor installation at Obninsk where basic nuclear and metallurgical research is conducted; and the Institute of Chemical Physics, Moscow, which is concerned with the theory, design, and application of high explosives. Of all these institutes the last probably has the most important auxiliary role in Soviet nuclear weapon development.

[redacted]

[redacted] an installation near [redacted] in the Urals indicates that it also is concerned with nuclear weapon research and development. We estimate that the Kasli installation became operational during the latter half of 1959 and that it represents a major addition to the Soviet nuclear weapon development potential.

[redacted]

B. Weapon Test Sites

The original Soviet proving ground is located about 100 miles west of the city of Semipalatinsk in Central Asia. At least [redacted] tests have been conducted here since 1949 with yields ranging from [redacted] However, since the fall of 1957, the Soviets have tested at Semipalatinsk fission devices with yields no larger than [redacted]

[redacted]

[redacted]

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The Novaya Zemlya island area in the Barents Sea has been used for testing high yield thermonuclear devices as well as for conducting naval effects tests. In all, [redacted] tests have been detected here with yields ranging from several KT to 58 MT.

The majority of the high yield tests detonations took place a few miles inland from Mys Sukhoy Nos on the west coast of the island; low yields tests were held near the southern coast; and on several occasions, tests have occurred over the east coast of the island north of Matochtkin Shar.

[redacted]

[redacted]

[redacted]

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C. Weapon Fabrication Sites

A major nuclear weapon fabrication complex has been identified in the north Urals at [redacted] and a somewhat smaller one at [redacted] in the southern Urals. A probable third site is located in central Siberia near [redacted] National stockpile sites are co-located with these complexes, which come under the jurisdiction of the Ministry of Medium Machine Building.

D. Stockpile Facilities

National. In addition to the three national stockpile sites co-located with fabrication facilities, national assembly and stockpile sites have been identified at [redacted] These sites probably contain reserve weapons to support regional and operational storage sites. It is believed that they have a weapon modification and retrofit capability but do not have a basic fabrication function. They are also under the jurisdiction of the Ministry of Medium Machine Building.

Military. Nuclear weapon storage sites utilizing three standard designs have been identified at Soviet military air bases. These are all believed to come under the jurisdiction of the Ministry of Defense. Each type has been associated with air bases of various subordination, and their construction apparently has been coordinated with different stages of Soviet nuclear weapon development and strike capability.

In the period 1952-55 the USSR constructed three Type I (Stryy) sites at long-range air bases along its western periphery and one naval aviation base in the Crimea. Designed in the era of relatively low-yield fission weapons, they were only moderately protected against blast and were located adjacent to airfield runways. Pits were used for the strike-loading of bombers at these sites. The presence of a tactical bomber on a nuclear loading pit at Minsk/Machulishche in July 1956 strongly suggests that some weapons for tactical use were also stored at Type I sites in that period.

In the period 1956-59 eleven known Type II (Orsha) sites were constructed, all but one in the western USSR. The Type II design marked the introduction of site hardening and the beginning of a rapid expansion of storage capacity at Soviet air bases. Their construction coincided with the acquisition of jet bombers, and they primarily serve strategic requirements for nuclear weapons. All but two of these sites were fully operational by mid-1957; two of them are at naval aviation bases, and most of the remainder are at long-range aviation bases.

[redacted]

[redacted]

Starting in 1959 an additional storage bunker of somewhat modified design was built at many of the Type I and Type II sites.

Since 1959 at least nine and probably more sites of a cruciform (Dolon) type have been constructed near airfields. The cruciform design is hardened and reflects somewhat simplified weapon-servicing requirements and presumably has resulted in a reduction of response times. The apparent absence of the pit strike-loading system at airfields with cruciform sites is also consistent with reduced response times. Known sites include several at bases subordinate to the long-range aviation and at least three subordinate to tactical aviation located near the western perimeter. However, the cruciform sites near a number of airfields are difficult to justify solely in terms of the requirements of associated Soviet air force order of battle. Thus it seems likely that several of these airfield sites provide nuclear weapon support to other delivery means in their vicinity. Those located near the western border may provide support to Soviet forces deployed in the Satellites.

During the post-1958 period, known cruciform storage facilities have been under construction at seven military regional storage depots. Although the precise function of the storage depots themselves has not been determined, their deployment pattern suggests nuclear storage related to military districts, possibly including support of ground, rocket, and air defense forces located within these districts.

Two nuclear weapon storage facilities are located in the vicinity of major long-range aviation staging airfields in the Arctic, one near [redacted] on the Kola Peninsula, and the other near [redacted] on the Chukotsk Peninsula. These sites are more elaborate than the airfield operational storage sites, but less elaborate than the national sites. It is believed that no additional storage sites have been constructed near Arctic staging bases.

E. Allocation of Fission Materials to Soviet Nuclear Weapons Stockpile

Introduction. The 1961 Soviet test series included tests of stockpiled weapons as well as devices which could enter the stockpile in the near future. Other intelligence, together with the estimates on availability of fissionable material, permit the setting of some guidelines and boundaries for the alternatives open to Soviet planners in the current period.

For future projections, the evidence is much weaker. While the 1961 test series yielded much useful information on the status of Soviet nuclear technology and trends in weapons development, it could not, of course, indicate the numbers and types of weapons to be stockpiled. Moreover, projections of Soviet delivery systems available in future years are less reliable than current estimates. Finally, estimates of future Soviet fissionable materials stocks are necessarily subject to wider margins of error than are those for the current period.

Table III in Annex A gives two possible alternative allocations of fissionable materials to Soviet nuclear weapons stockpiles for 1962, [redacted]

As provided in the table, there are two alternative estimates for the allocation of fissionable material to nuclear weapons. From considerations based on evidence, it is believed that the USSR has given the largest allocation of fissionable material to its long-range striking forces. Thus, both of the alternative allocations assumed for mid-1962 are heavily weighted on the side of the Soviet long-range striking forces. Major differences between these allocations - termed Alternatives "A" and "B" - lie in the numbers of weapons allocated to Long Range Aviation and to support of Theater Field Forces. Allocation to Strategic Missile Forces, Air Defense, and Naval Operations are held relatively constant in both cases.

The assumed alternative allocations of materials to weapons stockpiles are computed on the basis of the U-235 and plutonium equivalent estimated to be available for weapons purposes. Within these limits it must be recognized that a number of other alternative allocations consistent with the available evidence can be made. These would result in numbers of weapons and total yields different from those presented.

Explanatory Details of Table III, Annex A

1. Long Range Attack Forces. The Long Range Attack Forces consist of Long Range Aviation and the Rocket Forces. The current weapons allocations to Long Range Aviation are based on the estimated total number of long range bombers, less those estimated to be serviceable and used as tankers, and provision has been made for restrike by surviving aircraft.

The Rocket Forces include the ICBM, IRBM, and MRBM missiles and ballistic missile submarines, less the MRBM's estimated to be allocated to theater operations.

2. Theater Field Forces. Theater Field Forces include Tactical Aviation, short range guided missiles, free rockets, and artillery. The current estimate depends on aircraft availability estimates, estimates of missiles on launcher, and assumptions as to allocations of nuclear warheads to free rockets and artillery.

3. Air Defense. The allocations to Air Defense depend on estimates and assumptions of the deployment of nuclear warheads to surface-to-air missile sites. Currently, there is little evidence of deployment of nuclear warheads to these sites, and future projections assume that extensive deployment is unlikely due to the lack of evidence of significant increase in plutonium production.

4. Naval Operations. Naval operations include air-to-surface missiles, short range cruise missiles for use by destroyers and submarines, and the assumed use of bombs, depth charges, torpedos, and mines with nuclear warheads. The number of weapons currently allocated depends on estimates of naval medium bomber strength equipped to handle the air to surface missile, the estimated number of destroyers and submarines equipped to launch cruise missiles, and assumptions on the use of other weapons.

Discussion

Alternative usages and allocations assumed for mid-1962 nearly all of the fissionable materials stocks estimated for this year. Production of large quantities of all-oralloy or high yield weapons might consume an excess U-235, but no requirement is seen for such large scale programs in these categories. Future deployment of antimissile systems will require large numbers of nuclear weapons, and many more such weapons could profitably be allocated to air defense systems than has been assumed. However, there is no evidence of all-oralloy weapons suitable for such uses. In view of the present state of Soviet weapons technology, weapons suitable for anti-missile and air defense use would incorporate plutonium equivalent. Allocations for an extensive deployment of such weapons, in addition to the other allocations already assumed, would require plutonium capacity over that presently estimated.

It has been estimated that new weapons based on designs tested in the 1961 series could begin to enter the stockpile in significant numbers within a year or more after testing. Thus, a wider variety of weapons, including improved, more economical types, will be available to Soviet planners in selecting weapons for delivery systems.

F. Trends in Soviet Weapon Development

The first Soviet nuclear test, conducted in August 1949, was in all probability, closely related to the first US fission design. [redacted] The [redacted] 1955. Later that month the Soviets also demonstrated their acquisition of the two-stage thermonuclear design. From this point in time the Soviets

[redacted]

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[redacted]

The Soviets tested at least 19 high-yield thermonuclear devices during the 1961 series, 14 of which had yields greater than one megaton. The spectrum of tested yields ranged from about 200 kilotons to 58 megatons, with a preponderance of tests in the 1-5 megaton region and an absence of tests between about 5 and 25 megatons. [redacted]

[redacted] Marshall Malinovskiy recently stated that they have nuclear warheads of several tens-of-tons yield and U-2 photography of the Semipalatinsk Proving Ground revealed craters from 9-10 low-yield tests which were undetected by the AEDS. Some of these could have been for developing even smaller sizes. [redacted]

It is quite apparent that the Soviets have achieved a rather extensive fission weapon stockpile. They have tested different unboosted cores in the same over-all geometry indicating a desire to achieve different yields from the same basic weapon. [redacted]

DOE b(3)

G. Advanced Nuclear Weapons Research

Judging by past accomplishments, the Soviets could, with continued unrestricted testing during the next 5 to 10 years, approach the practical upper limits of performance in both thermonuclear and fission designs. In addition, in the next few years, they could greatly increase their store of knowledge concerning the various effects of nuclear weapons and could optimize designs to enhance specific effects. [redacted] However, we do not know to which of these possibilities the Soviets are according priority.

DOE (b)(3)

Although the feasibility of a pure fusion weapon has not yet been conclusively demonstrated, we believe the Soviets are presently conducting research toward this end.

V. Peaceful Uses Program Other Than Power Production

A. Basic Philosophy

From mid-1956 until mid-1960, the Soviet Union probably derived more propaganda value than real value from its peaceful uses program. Excepting the nuclear power program, only a token effort seems to have been made to introduce atomic energy into Soviet industry, although a large amount of material has been published on the industrial benefits of atomic energy. Since mid-1960 when a higher priority was given to the peaceful uses program, there has been an effort to expand the field of nuclear research and technology and to hasten the development of the practical industrial applications which should be derived from the results of the research.

Originally the Soviets used their aid and exchange program to improve and tighten their relationship with Bloc nations while maintaining a substantial degree of control over the atomic energy activities in these countries. This concept has been extended under the direction of the Standing Committee for Peaceful Uses of Atomic Energy created by the Council for Mutual Economic Aid (CEMA) whose long range plan is to provide a single integrated atomic energy program by dividing the various tasks in Atomic Energy among the satellite nations. This type of inter-country collaboration will probably delay, if not prevent, the development of an independent nuclear capability, and therefore a nuclear military capability, by any of the participating countries.

The Soviets show no haste in fulfilling their commitments under bilateral agreements with other countries and appear to offer aid only when tangible political returns can be expected. Soviet participation in the exchange program and in international conferences with the Free World appears to be slanted toward propaganda purposes and collection of technical information on Western atomic energy developments.

B. Research in High-Energy Physics

The USSR after World War II initiated an intensive research program in high-energy physics funded and controlled by their atomic energy program. During the past eight years it has made highly significant contributions in this field, especially in its theoretical aspects. However, the experimental work in this field is considerably inferior to that in the West, due primarily to the poorly-engineered design of existing machines.

The Soviet theorists have done some pioneering work in the areas of week interactions, meso-molecular processes, dispersion theory, and transition radiation and are moving into the study of dispersion theory of strong interactions and becoming more proficient in the theory of elementary particles. Less attention is being paid to the areas of invariance and selection rules. The weakness in the experimental high-energy program in the USSR, however, places Soviet theorists at a disadvantage and often compels them to depend on second-hand data obtained from the West after publication.

Experimental research on the 10-Bev proton synchrotron at Dubna, the first proton accelerator operating above one Bev in the Soviet Union, is still severaly limited by a beam current fifty times lower than that of equivalent Western machines. A 7-Bev strong-focusing proton synchrotron which went into operation during 1961 is also plagued by low beam intensity and has yet to produce any worth-while experimental data. On the earlier 680-Mev synchrocyclotron, which has no such handicap, the quality of research, which previously was quite high, has degenerated during the last two years, due primarily to the unimaginativeness of the experimentalists currently assigned to this machine. The situation with respect to electron accelerators apparently compares favorably with similar work in the West. For unknown reasons, the Soviet program in this area continues to be highly classified. The Soviets have in operation three high-quality electron synchrotrons of 100, 260, and 680-Mev energy, and a fourth machine of 6 Bev under construction in Armenia. In addition to these, it is believed that three linear electron accelerators have recently been completed at a site north of Khar'kov, but the operating parameters of these linear accelerators are not known because of Soviet security measures.

C. Controlled Thermonuclear Reactions Research

Since 1956 prominent leaders in the Soviet government and in the Academy of Sciences have repeatedly stated that the achievement of commercially useful power from controlled thermonuclear reactions is a task of the highest priority for Soviet science.

Research on controlled thermonuclear reactions (CTR) was initiated in 1950 in the USSR and since then has been pursued on a continuously increasing scale. At present, there are approximately 700 scientists and engineers engaged in this program. The general level of competence of the scientists involved is very high, and the number of outstanding senior physicists in the program exceeds that in the West.

The Soviet CTR program is supported by an extensive, high-quality research effort in plasma physics, traditionally a strong area of research in the Soviet Union and which has attracted the best scientific talent and technical resources available in the USSR.

Except for differences in emphasis, the Soviets have attacked the problem of CTR along the same lines as the US. In past years Soviet interest in toroidal and fast magnetic compression devices has been limited, whereas Cusp magnetic field geometry and the use of radio-frequency electromagnetic fields for heating and confining plasma have been extensively developed. In addition to these general methods of approach, they have concentrated on developing high-current ion sources, studying the interaction of charged particle beams and electromagnetic waves with plasma, and investigating collision ionization processes. Their plasma diagnostic methods have leaned heavily on microwave and optical spectroscopy, whereas in the West the tendency has been to rely on plasma probes and photography. With the exception of an enhanced effort on fast magnetic compression experiments, the Soviets will probably continue to direct their research effort along these same lines.

In general, the Soviets have recently reoriented their controlled fusion program away from their earlier large-scale, brute-force experiments and are concentrating on research directed towards exploring the fundamental properties of high-temperature plasmas. The current program is not likely to result in the attainment of a commercially useful thermonuclear reactor within the next ten years. However, the scientific knowledge acquired in the interim from this research has been and will continue to be of extreme value to other vital areas of Soviet technology.

D. Plowshare Program

The Soviet Union is not known to have a program for investigating the peaceful uses of nuclear explosions per se, although the feasibility and practicality of using nuclear charges in place of massive amounts of conventional explosives have been discussed in Soviet literature. On the other hand, the Soviets have used kiloton amounts of high explosives (HE) for industrial projects since the early 1930's and have developed sophisticated and reliable directed explosion techniques. In the mid-to-late 1950's, Soviet scientists and explosives experts conducted a series of experiments using HE in yields up to 1 KT to study cratering. Nearly all this massive explosives work has provided the USSR with data applicable to a PLOWSHARE-like program. According to US experts, it is clear that in the sphere of massive HE explosions the Soviets have done much more work on a much larger scale than the US.

E. International Cooperation

In 1955 the USSR began its program for international cooperation in nuclear energy by establishing the Joint Institute for Nuclear Research (JINR) at Dubna, near Moscow. All of the Satellite countries and China are members and contribute to its support. At the same time, bilateral agreements were concluded with most of the satellites and subsequently concluded or are being negotiated with 14 other countries. The amount of aid and type of assistance differ with each country. Support provided by the Soviets under the bilaterals have included research reactors, electric power reactors, accelerators, nuclear physics and radiochemistry laboratories, assistance in prospecting for uranium, and training of technical personnel.

Although the USSR is a member of the IAEA, it has provided very litt assistance to either the IAEA or to other countries through the IAEA, but prefers to provide assistance to other countries through independent or bilateral programs.

Table 6 shows the status and type of aid the USSR is supplying to other countries.

Table 6

Soviet Atomic Energy Aid to Other Countries

I. Research Reactors

COUNTRY	REACTOR TYPE (MW)	LOCATION	STATUS
Afghanistan	unknown	unknown	Proposed
Bulgaria	IRT (1-2 MW)	Atomic Scientific Experimental Base, 7 km SE of Sofia	Critical, Sept. 61
China	TVR-S (7-10 MW)	Institute of Atomic Energy, 20 miles SW of Peiping	Critical, Oct. 58
Czechoslovakia	VVR-S (2 MW)	Institute of Nuclear Research, 10 miles N of Prague	Critical, Sept. 57
Egypt	VVR-S (2 MW)	Atomic Energy Establishment, Inshass, 30 miles NE of Cairo	Critical, July 61
East Germany	VVR-S (2 MW)	Central Institute for Nuclear Research, Rossendorf, 12 km E of Dresden	Critical, Dec. 57

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COUNTRY	REACTOR TYPE (MW)	LOCATION	STATUS
Ghana	IRT (2 MW)	Possibly Kumasi College of Technology, Kumasi	Contract sigr Oct. 61. Expected operat by 1964.
Hungary	VVR-S (2 MW)	Central Physics Research Institute, Czilleberc Hill, W suburb of Budapest	Critical, Mar. 59
Indonesia	Subcritical Assembly (zero power)	Gasjah Mada University, Djogjakarta	In operation Nov. 61
	IRT (1-2 MW)	University of Indonesia, Serpong, suburb of Djakarta	Contract sig Jan. 62. Expected opera by 1965
Iraq	IRT (2 MW)	Tammuz Reactor Project, S suburb of Baghdad	Under constru tion, expecte operation by 1963-64.
North Korea	unknown	Kim Il-Sung University, Pyongyang	Under constru tion.
Poland	VVR-S (2 MW)	Institute of Nuclear Research, Swierk, 10 miles SE of Warsaw	Critical, May 58.
	Subcritical Assembly (zero power)	Institute of Nuclear Research, Swierk, 10 miles SE of Warsaw	Under constru tion.
Rumania	VVR-S (3 MW)	Institute for Nuclear Physics, Magurele, 6 miles SW of Bucharest	Critical, July 57.
Yugoslavia	TVR-S (7-10 MW)	Boris Kidric Institute of Nuclear Science, Vinca, S of Belgrade	Critical, Oct. 59

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COUNTRY	REACTOR TYPE (MW)	LOCATION	STATUS
Czechoslovakia	150 MWE	Bohunice	Expected 1964
East Germany	70 MWE	Neuglobsow	Expected 1963

III. Cyclotrons

COUNTRY	CYCLOTRON (MEV)	LOCATION	STATUS
China	y-120 (25 MEV)	Institute of Atomic Energy, Peiping	1958
	y-150 (25 MEV)	Institute of Atomic Energy, Peiping	1959
Rumania	y-120 (25 MEV)	Institute for Nuclear Physics, Magurele, 6 miles SW of Bucharest	1958
German Democratic Republic	y-120 (25 MEV)	Central Institute for Nuclear Research, Rossendorf, 12 km E of Dresden	1958
Poland	y-120 (25 MEV)	Institute of Nuclear Physics, Krakow	1958
Czechoslovakia	y-120 (25 MEV)	Institute of Nuclear Research, 10 miles N of Prague	1958

IV. Electrostatic Generator

COUNTRY	GENERATOR(MEV)	LOCATION	STATUS
Egypt	2.5 MEV	Atomic Energy Establishment, Inshass, 30 miles NE of Cairo	1959

V. Completely Equipped Laboratories

COUNTRY	LABORATORY	LOCATION	STATUS
Egypt	Nuclear Physics Laboratory	Atomic Energy Establishment, Inshass, 30 miles NE of Cairo	1958

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COUNTRY	LABORATORY	LOCATION	STATUS
Egypt (cont.)	Radiochemistry Laboratory		
Rumania	Radiochemistry Laboratory	Institute for Nuclear Physics, Magurele, 6 miles SW of Bucharest	1959
Iraq	Radiochemistry Laboratory	Tammuz Reactor Project S suburb of Baghdad	To be installed
Indonesia	Radiochemistry Laboratory	University of Indonesia, Serpong, Suburb of Djakarta	To be installed
Ghana	Radiochemistry Laboratory	Possibly Kumasi College of Technology, Kumasi	To be installed

F. Medical and Biological Research

Prior to 1956 Soviet medical and biological scientists made little use of the major tools and resources available from the atomic energy effort. The two International Conferences on Peaceful Uses of Atomic Energy sparked major Soviet efforts along these lines and the present volume of projects in the USSR is large. Thus the Soviets are using isotopes or radiation for medical diagnosis and therapy, sterilization of foods and medicinal products, tracers in biological and chemical systems to provide clues about metabolism, sources of radiation for plant and animal studies, studies on effects of fallout, studies on waste disposal and problems of biological shielding, and other purposes.

Not until 1961 was any important Soviet biological work noted at atomic energy controlled institutes, but the trend is evident. We now expect to see emphasis on cooperation between physical scientists and biomedical investigators, with increasing biological use of the facilities at atomic energy institutes. So far Soviet biomedical research has produced no notable contribution to uses of atomic energy. They have, however, pursued many ideas suggested elsewhere. One example of this is the extensive development of potato irradiation to prevent sprouting and spoilage. This program is currently producing multi-ton lots of potatos for storage and later use.

Soviet radiobiologists believe that very low doses of radiation are more harmful, especially to the central nervous system, than their Western

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counterparts. Although research on this problem in the last 5 years ha brought the Soviet and Western views closer together, differences still exist. In spite of these views of the radiobiologists and the apparent more restrictive regulations as compared to those of the US, early Sovi health physics practice has been noteworthy in its carelessness and hap hazard application. Several moderately serious accidents have occurred during the past five years, necessitating drastic cleanup operations an have brought about a more effective enforcement of the rules. It is ex pected that the future Soviet radiation safety record will be on par wi the US.

G. Isotope Development

The application of radioisotopes for industrial purposes has recei considerable support in the USSR. The most extensive application is in the form of process control equipment particularly for ore concentratio and petroleum plants. The heavy machine industry is using gamma-ray de toscopy on a large scale for casting and weld inspections. For this pu pose, gamma-ray equipment with a source strength up to 2,000 gram-equiv radium have been used. Gamma irradiation facilities are also being use to study the effects of irradiation on chemical processes. The true ex to which radioisotopes are used throughout the USSR has not been determ on a quantitative basis.

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