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DEFENSE INTELLIGENCE AGENCY

SCIENTIFIC AND TECHNOLOGICAL BASE OF SELECTED FOREIGN COUNTRIES VOLUME II

AUGUST 1977

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SCIENTIFIC AND TECHNOLOGICAL BASE

OF

SELECTED FOREIGN COUNTRIES

VOLUME II

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PREFACE

(C) The object of this study is to define, describe and assess the scientific and technological capabilities of Brazil, Taiwan and Iran, in order to determine nuclear weapons development potential of these countries. Scientific and Technology profiles were developed for each country through detailed study and analysis of scientific manpower, education, research and development management, facilities, resources allocations, and political motivations as applied to nuclear programs. These profiles were used to assess current nuclear weapon potentials and establish future areas of emphasis in the subject nations.

(b)(3):50 USC 3024(i)

(U) [redacted] The document is the second of a series of reports being prepared for DIA on the S&T capabilities of selected countries.

(U)Constructive criticism, comments, or suggested changes are encouraged and should be forwarded to the Defense Intelligence Agency [redacted] Washington, D.C. 20301.

(b)(3):10 USC 424

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SUMMARY

PART I - BRAZIL

Brazil has the inherent scientific and technological capability to support a nuclear weapons program in the near future. Within 5-7 years, Brazil will be less dependent on the United States, and through technology acquisitions from West Germany and other countries be nearly self-sufficient in the nuclear arena. Many factors mitigate against massing of Brazil's resources for weapons; marginal facilities, a thin S&T work force, economic pressures, political unrest, and a unique combination of national and individual goals are some of the factors that deter Brazil from nuclear weapons development. The government will keep its options open, however, and strive to improve quantity and quality of S&T manpower; expand facilities; and aim toward a high level of nuclear power generation by the late 1980's. Only then will thoughts and S&T emphasis shift to nuclear weapons development.

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PART I

BRAZIL

SCIENTIFIC AND TECHNOLOGICAL BASE OF BRAZIL

I. BASIC RESEARCH AND DEVELOPMENT GOALS

In order to identify and understand Brazil's goals in regard to research and development, particularly as applied to nuclear science, one must first have an historical perspective on Brazil's political culture and how the government plays a key role in high level technology R&D. Second, economic considerations must be examined, as they will suggest alternatives which the government faces. Third, it is necessary to study the condition of Brazil's society to give us a better idea how the government and the scientific work force will integrate and establish priorities. Finally, a look at current military programs will complete the analysis of Brazil's R&D goals and nuclear posture.

A. Political Background

Without any real revolutionary or liberal traditions, Brazilian politics have remained essentially conservative in temper with a strong penchant for "social peace" except for occasional currents of violence, liberalism and repression.

Brazil's political history over the last 150 years might indicate much turmoil and ideological dislocation; however, significant changes have come about slowly and subtly. Some social turmoil existed including peasant revolts, demands by intellectuals for social and economic change, dissatisfaction among urban and rural workers, and quarrels over power of the military in the government. In 1930, a coup propelled the armed forces into the center of Brazilian politics where the locus of power has since resided. Getulio Domelles Vargas then assumed almost dictatorial powers, presiding over seven years of agitation. Unable to extricate himself from the influence of the new military elite, who favored speedy modernization, Vargas expanded the federal bureaucracy and assumed more power for the central government. Liberal demands for less centralized, more democratic government continued, but until his suicide in 1954, the unifying force of nationalism remained intact, with the assistance of the armed forces.

During the fifties and early sixties, the more liberal politicians attempted to operate under a more democractic constitution, but Congress was always divided on economic policy, and the pressure of inflation became overwhelming. Brazilians became aware of the awesome potential for internal conflict and responded by expressing sympathy for a strong, authoritarian government to establish control. Disillusioned with the "republic experiment", the public was almost happy to have the military step in. In 1964 at the height of political tension, President Goulart was unable to enact his reform programs, and strikes and demonstrations were organized in his support. Conservative members of Congress were unreachable; and, fearing the militant behavior of Goulart's supporters, the military overthrew the civil government in another bloodless coup. Army Chief of Staff Marshal Humberto Castelo Branco was chosen President and the Supreme Revolutionary Council moved quickly to arrest 1,000 alleged "elements of subversion and corruption". Declaration of the right to suspend the Constitution, power to dismiss public servants at will, declaration of a state of siege without the consent of Congress, and complete control of the budget were among powers given to the president.

After abolition of political parties in 1965 the only opposition left were groups of clandestine urban guerillas and liberal members of the Catholic Church. By 1970, strict security measures, including arrest; torture and murder of dissident leaders had silenced opposition except for some of the clergy. In the name of "Progress and Order" the military had put an end to the disruptive democratic experiment of the 1950's.

The election of General Ernesto Geisel in March of 1974 was a farce since the opposition party was not allowed to campaign, and Geisel's party controlled the machinery of the electoral college. An unexpected Congressional victory by the opposition party suggested that the military government needed to reconsider some of its policies. Geisel had tried to give the impression that he was in favor of "distensao", or a "loosening up"; few of the military elite are moved by this tendency and are still motivated by a primitive anti-liberalism (or hysterical anti-communism) plus a desire to build Brazil into a great world power.

Most scholars feel that the national sentiment views the military as a "moderating" power, which is temporarily filling Brazil's need for a paternalistic, authoritarian government in an unstable world. The people are not apathetic, but seek order and stability, and liberal element successes are unlikely in the future. The government, after all, has succeeded in doing what most Brazilians wanted. Hamstrung by internal problems a decade ago, Brazil now has a growing economy, a good trade network, and has become a major influence in Latin America.

Democratic processes are highly valued, but so is heirarchical order resulting in limited popular participation in government. Political friction has generally resulted from differing ideas on how to achieve order and economic development. When liberal opposition threatened, political consensus, public support and authoritarian control by the armed forces maintained the status quo. Brazil's historical perspective on research and development results from (1) that the military government has established firm control of the nation's policy decision making process; (2) that there is no significant subversive efforts to divert resources and governmental attention; (3) that the Positivist impulse to value science and technology has and will remain an important ideological base for Brazilian politics; (4) that a source of government power is its display of competency manifested by technological success; (5) that strong nationalistic sentiment will steer research and development efforts in an independent direction. Historical perspective shows that Brazilian political leaders are seeking "order", "progress", "social peace", and a respectable place in the world, and these larger goals will shape research and development goals.

B. Economic Background

Since the 1930's, Brazil has become increasingly industrialized as the government sought to break Brazil's dependency upon an agricultural economy. Consequently, the government has played a significant role in the economic sector to make Brazil a modern nation and a world power.

The military government of the last decade has been moderately successful keeping inflation down and GNP up in spite of disagreement over strategy. Conservative policies, including wage freezes and concessions to foreign enterprises, have brought the inflation rate down to 15% in 1973 from 100% in 1964.

Between 1968 and 1974, GNP real growth averaged 10% per year. Exports in 1973 were U. S. $6.6 billion as opposed to U. S. $1.4 billion in 1964. Industrial expansion in the Sao Paulo region has increased dramatically as a result of two national development plans begun in 1974. The oil crisis has threatened this growth because Brazil had been importing 3/4 of its oil up to 1975.

In response, Geisel announced in February of 1975 that one of the government's goals would be to reduce Brazil's dependency on foreign technology, capital and energy, and to make the nation self-sufficient in energy by 1985. Because hydroelectric power would only be enough for the next 10 years, and newly discovered oil reserves would not be sufficient to meet demands, nuclear power is seen as the key ingredient to continued controlled economic growth.

Brazil hopes to produce enriched uranium by 1981 to take full advantage of its large uranium reserves and to produce 6,000 MW of nuclear power by 1985. Brazilian industry is aiming for 64%-70% of reactor construction by 1980, and 100% by 2000 by planning to construct about 5 reactors a year after 1980, or 63 by 2000 to produce 35,000 MW of energy.

Economic pressures are providing a key goal for research and development: independence in reactor construction and fuel enrichment technology. Determination is evident in II Plano Nacional de Desenvolvimento of 1974 which committed Brazil to providing U. S. $3.1 billion over the next 5 years for graduate level education and technological research.

C. Social Considerations

There is a potential for danger amidst Brazilians' confidence in their ability to attain world economic power. In 1974, the inflation rate was back up to 30%, and 70% of the population still living in appalling poverty was not sharing in the economic growth, and also losing further because of inflation. In spite of the economic boom, Brazil has one of the lowest per capita incomes of any Latin American country. The government must soon choose between maintaining economic growth or to meeting human needs of Brazilians. Geisel is expected to lean toward the latter as evidenced by Ministry of Education programs in primary education, agricultural research, and university student training and work programs in remote areas. Therefore, while the nuclear power program may have the sympathy of the military government, it may not be fully implemented if other priorities demand more of the nation's attention.

D. Military Policy

Brazilian cultural values and international position do not allow the government to devote an extraordinary amount of resources for military objectives. Although the military budget has been increasing at greater rates than any other budget (see section 5), it still remains one of the lowest among the emerging Third World nations.

Observable domestic insurgency is limited to urban guerilla activities which receive little public support. Opposition from the liberal wing of the Church has not yet inspired military counterinsurgency operations, but the government is prepared for disruptions by including the development of an anti-insurgency component.

A more serious military concern is reliance upon the United States for protection. This suggests both a dependence which may restrict the Brazilian thrust toward international prestige, and a fruitless course in light of apparent American reluctance to insure the long-term security of its allies. Becoming a world military power is currently beyond the reach of Brazil for the national mood is not to allow dependence upon the U. S. Military independence and self-sufficiency may seem like belligerency to other neighboring nations like Argentina, but Brazil's inclination is in that direction. This will exert pressure on military policy making, and consequently in terms of research and development. Regional rivalries will have less to do with military policy than many observers might think, and motives will be more subtle, even though the actions--steady development of strategic military power--may appear to be the same.

Two tasks face the military leadership: development of a counterinsurgency force and pursuit of a stronger international military position while not being able to separate military policy from governmental policy. To strike a balance between domestic social objectives and purely military goals is the overall task of the military government, and will cause a great degree of strain by taking on the two tasks simultaneously.

Brazil's basic political, economic, social and military goals, then, will be the major determinants of the nation's research and development goals. Where the government is the only body which can afford to provide the facilities for a certain kind of research such as nuclear technology, the physical needs of Brazil's society as a whole may preclude such extensive efforts. In the name of "Progress and Order" Brazilian leaders may soon forsake some of their more ambitious technological pursuits that they may cope with the social problems of the nation.

II. RESEARCH AND DEVELOPMENT MANPOWER

A. Higher Education in Science and Technology Fields

1. Enrollments

Relatively few of Brazil's young people are enrolled in institutions of higher learning. In 1968 only about 2.4% of the 19-24 year olds were enrolled, and more recent statistics indicate very little increase. Only 30% of the undergraduates and 45% of the post-graduates are enrolled in the federal universities where serious scientific programs are conducted. Table 1 shows that enrollment in courses concerning the natural sciences and engineering has been increasing over the last decade at about the same rate of increase of total enrollment.

Data and trends for total university enrollments, natural science and engineering and medicine are shown in Graph 1.

2. Graduates - 1st Degree

The number of undergraduates has increased steadily each year over the past decade as indicated in Graph 2 and graduates in science and engineering have been increasing at a greater rate than in other fields.

3. Graduates - Advanced Degrees

Table 1 shows that the enrollments for advanced degrees has increased although the number of graduates dropped in 1973; no reliable data was available beyond 1973.

Table 1

Brazil--Advanced Degrees

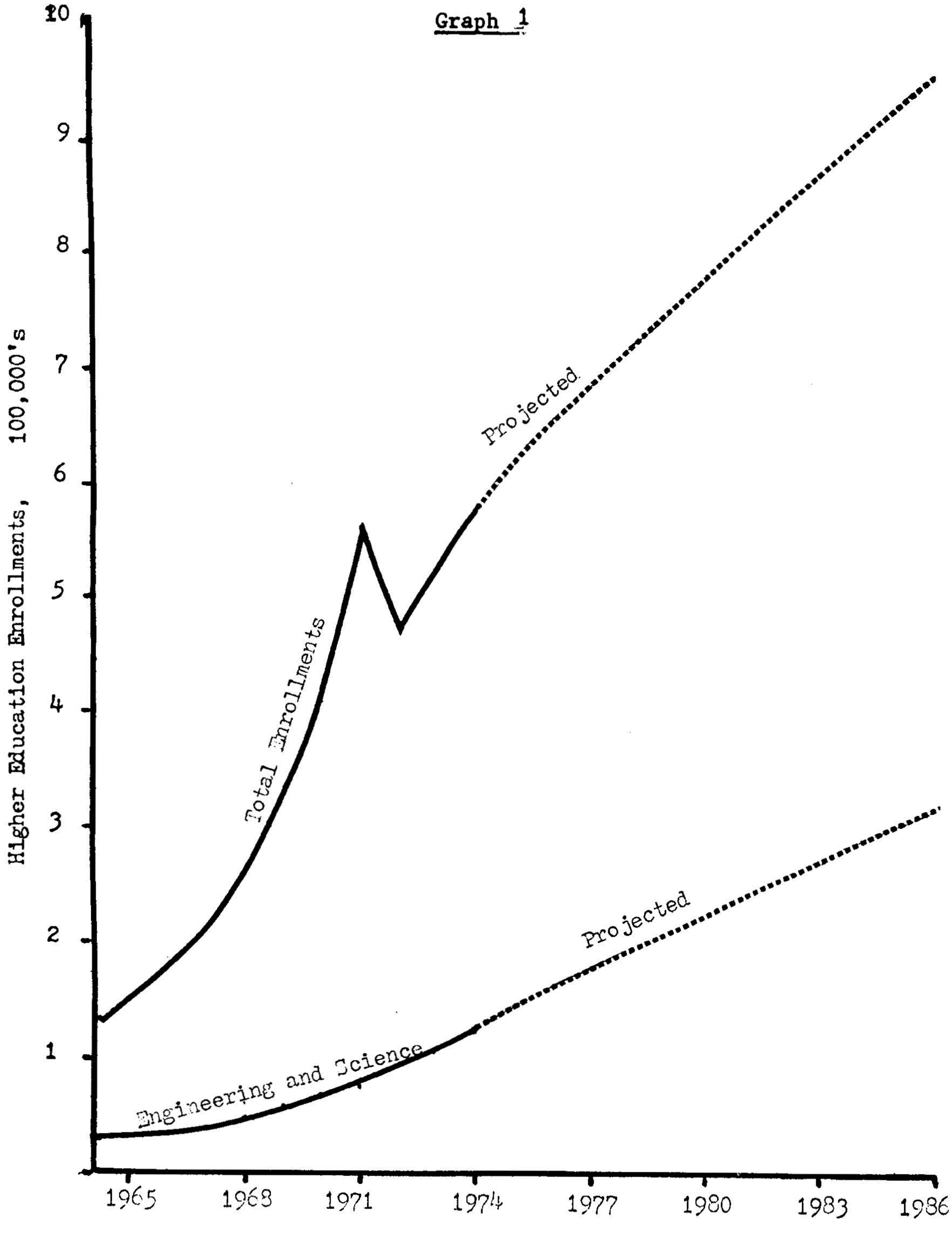
Enrolled

Year	Total	Nat. Sci. Gen.	Eng.	Nuc. Eng.	Phys.	Chem.	Geol.	Comp. Sci.
1971	7,833	1,062	2,720	122	390	520	196	-
1973	11,846	2,522	2,638	108	251	357	249	298

Graduated

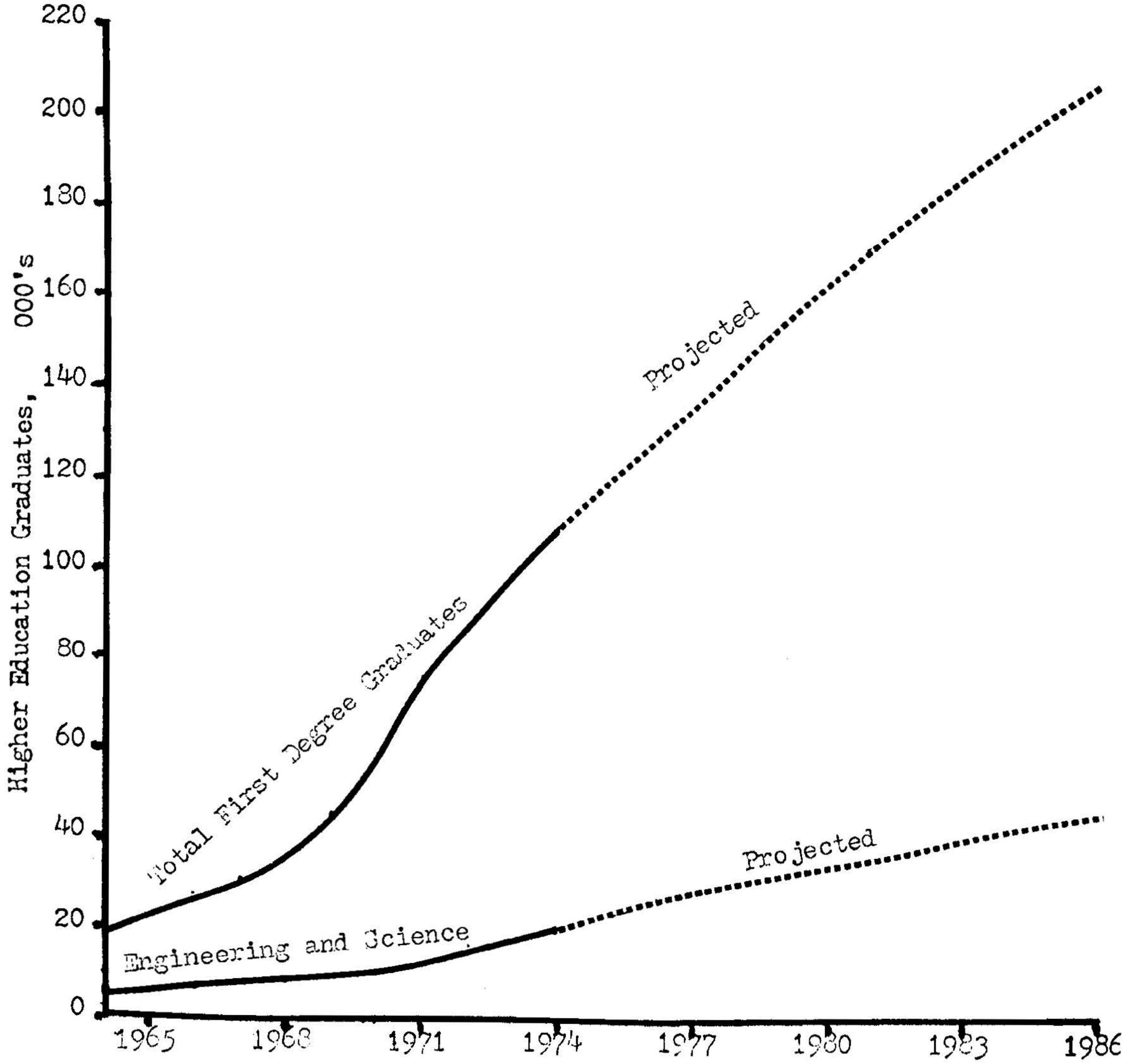
Year	Total	Eng.	Nuc. Eng.	Med.	Geol.	Phys.	Chem.	Bio. Chem.	Comp. Sci.
1969	1,151	18	-	538	-	-	-	-	-
1971	1,439	415	58	218	39	154	19	5	-
1972	1,557	317	30	99	33	20	29	-	29
1973	1,097	65	-	397	8	12	34	7	16

Graph 1



Brazil Enrollments in Higher Education vs. Year

Graph 2



Brazil Higher Education Graduates vs. Year

4. Foreign Trained

Brazil relies heavily upon foreign universities for training because Brazil's universities have extremely limited programs for advanced degrees and in the natural sciences. Even as the capacities of the universities have improved, the flow of students to foreign training sites has increased, most of which has occurred in the U. S. Table 2 provides data on enrollment and significant countries involved.

Table 2

Brazilians Trained Abroad

Year	Total Students
1964	2,722
1965	2,792
1966	2,751
1967	2,921
1968	2,412
1970	5,172
1971	6,402

Selected Countries Training Brazilian Students

	1964	1965	1966	1967	1968	1971
U.S.A.	691	772	885	1,101	1,169	1,502
Canada	24	29	22	29	30	66
Japan	20	21	53	31	47	77
West Germany	127	135	126	155	141	238
U.K.	28	25	39	44	49	124

The most dramatic increases have been in nations offering the best facilities for scientific and technological training. The number of students studying science in the U.S. increased from 263 in 1966 to 475 in 1971. Also, the number of students training abroad has continued to increase significantly since 1968 following a level trend for many years.

Although Brazil's universities are able to offer more advanced degrees and facilities are improving (see Section 3a), more and more students are seeking training abroad. In 1971 there were 836 students which is over one-eighth of all the post-graduate students in all of Brazil's universities pursuing advanced degrees in the U.S.

As a result, many scientists and faculty members are foreign trained, and foreign nationals are welcome at Brazil's universities and research institutions. In 1972 there were 105 U.S. faculty members teaching in Brazil, and in the last three years Brazil has been attracting Argentine nuclear scientists and technologists by offering high salaries.

In summary, higher education facilities in Brazil are increasing their capacities to train students at all levels in many fields. Scientific and technological graduates are increasing and more able to acquire more advanced training. There is no significant "brain drain," as there is in Argentina, for example. Most students trained elsewhere return to Brazil and, in fact, Brazil has managed to attract qualified people to conduct research and assist in improving indigenous educational facilities. Still, numbers of qualified people remain small in comparison with industrial nations, and the demand for better facilities is increasing faster than growth.

As research investigations become more sophisticated and the demand for trained technicians, engineers and scientists grows, Brazil's universities will need to accelerate their expansion since current capacity falls far short of that needed to support a powerful industrial nation.

Especially this is true in nuclear research. The more sophisticated equipment is not readily available to most university students, and the absence of a large number of qualified instructors in nuclear physics and engineering makes it more difficult for Brazilian universities to train scientists in nuclear science than in any other.

B. Leading Universities/Colleges in Science and Technology Fields

Higher education is valued in Brazil and esteem of the cultured individual has been picked up by a growing middle class. Only one-half of those who take private intensive preparation courses after finishing secondary school pass entrance exams so that opportunities for pursuing higher education are limited.

The federal government has assumed the responsibility for higher education and the 28 federal universities are best endowed with facilities and funds. Brazilian higher education has always been based on the faculty, but in the late 1969's, the government began to discourage isolated and autonomous groups so that higher education is now more centralized and integrated.

Institutions of higher education operate with considerable administrative autonomy. Standards for their curricula are set by the federal government, but many important decisions are made on the university level. Each university has university council and a rector who is chosen by the President of the Republic after being nominated by the University Council (consisting of faculty heads, alumni and student organization leaders).

Greatest progress in overcoming the inefficiency of the old faculty system has been made in the federal university science and technology programs, but much duplication and lack of cooperation remains. Following is a list of the major universities which offer the most significant science and technology programs.

Pontifica Universidad Catolica do Rio de Janeiro

Year	Enrollment	Staff Size
1969	5,777	530
1970	4,013	559
1972	6,400	700

Instituto "Costa Ribeiro" de Fisica e Matematica is located on campus. There is a Chemistry Institute, and data processing instruction is offered.

Universidade Federal da Bahia

Year	Enrollment	Staff Size
1969	5,538	1,155
1971	5,500	1,260
1972	5,538	1,155

Four "Central Institutes" for the teaching of science have been created. The natural science library is weak and receives practically no journals and no abstracts. Atomic research is conducted by the chemistry faculty.

Universidade Federal de Minas Gerais (in Belo Horizinte)

Year	Enrollment	Staff Size
1969	5,689	843
1970	7,000	1,000
1972	14,892	2,194

The Instituto de Pesquisas Radioactivas, which is still affiliated with the university, was once a part of the engineering school; for further information on this institute see Section 3a. Atomic research is conducted in the engineering faculties and at the Institute of Mathematics and Physics; research is also conducted in chemistry, physics, isotopes, geology and thorium studies.

Universidade do Recife

Year	Enrollment	Staff Size
1969	3,175	524

Atomic research is conducted by the chemistry faculty.

Universidade Federal do Rio Grande do Sul

Year	Enrollment	Staff Size
1969	7,265	1,258
1970	9,000	1,400
1972	33,722	1,309

At the Instituto de Fisica (see section 3a) research is conducted in solid state physics, nuclear physics, quantum field theory and astronomy. The library has a good collection of abstracts.

Universidade Federal do Rio de Janeiro

Year	Enrollment	Staff Size
1969	16,273	2,622
1970	20,000	2,700
1972	21,813	2,850

Centro Brasileiro de Pesquisas Fisica functions as the university's graduate department of physics. Here studies are done in nuclear physics, radiobiology, atomic research in medicine, chemistry, engineering and biophysics. For the university itself, an Institute of Physics and Mathematics was created in 1965. The Institute of Chemistry also does nuclear research with assistance from foreign foundations. The School of Chemistry had 700 undergraduate students in 1969 and 90 graduate students.

Universidade de Sao Paulo

Year	Enrollment	Staff Size
1969	20,889	2,707
1970	19,914	2,707
1972	28,081	3,264

Most research conscious in science of any of the universities in Brazil, the University of Sao Paulo trains its scientists under the Faculty of Philosophy, Science and Letters. Research is conducted in nuclear applications to medicine, physics, agriculture and engineering, and the facilities of The Nuclear Energy Commission, Comissao Nacional de Energia Nuclear (CNEN) are available to the university (see Section 3a).

Universidade Federal do Parana

Year	Enrollment	Staff Size
1970	7,000	800
1972	10,305	1,326

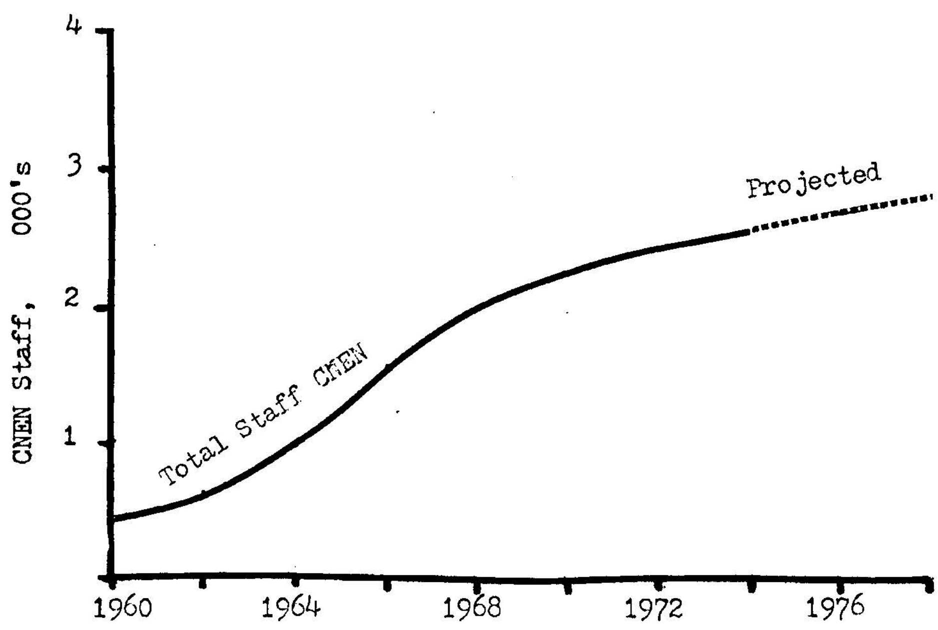
The university has institutes of biochemistry, physics, mathematics, physical chemistry, mechanics, social science and law.

C. Science and Technology Professional Work Force

Brazil is in the early stages of using its intellectual resources as research and development grows. At a recent meeting of Brazilian Scientists for Progress of Science there were 4,000 participants although most of active population are engaged in agriculture. In 1964 the Ministry of Education and Culture estimated that to maintain a satisfactory pace of industrialization, the country required 2,500 additional engineers, 5,000 industrial technicians, and 10,000 supervisors and administrative workers yearly. Preceding 1970, Brazil did not come close to these figures, even though job openings in these fields doubled every year in industrial areas.

It is unknown how many scientists are currently engaged in general research and development projects. The Nuclear Energy Commission (CNEN) nuclear research personnel, especially of scientists and engineers, increased greatly as shown in Graph 3.

Graph 3



Brazil CNEN Staff vs. Year

Most of the increase was in geological research which carried on into the 70's; by 1973 42 geologists were engaged in 37 uranium exploration projects.

In spite of growth of the research and development establishment, the numbers are not impressive for a nation that is seeking speedy industrialization. The government has recognized this weakness and plans increased training of a large scientific work force. This is an expensive pursuit, however, and lack of success meeting goals set a decade ago indicates that a large, capable scientific work force will probably remain outside the grasp of Brazil's research and development management for some time.

III. RESEARCH AND DEVELOPMENT FACILITIES AND INSTITUTIONS

A. Leading Facilities and Institutes

The following facilities and institutions for nuclear research and development has been categorized by the organization which sponsors the work:

Comissao Nacional de Energia Nuclear (CNEN) The purpose of the CNEN is to develop research into "peaceful uses of atomic energy"; to produce radioisotopes for study and experiment; to contribute to the training in nuclear science and technology; and to establish bases, constructive data and prototype reactors designed for the utilization of atomic energy for industrial purposes. At present the CNEN operates the following research reactors:

IPR-RI Belo Horizonte, Minas Gerais, 250kW (see below)
IEA-RI Sào Paulo, 10MW
IEN-RI Rio de Janeiro
URANIE Belo Horizonte
RESUCO Recife, Pernambuco
NC9000 San Jose dos Campos, Sao Paulo
"Capito" Belo Horizonte - under construction
"Sublime" and "Cobra" - planned for Rio de Janeiro

Instituto de Energia Atomica (IEA) The CNEN's principal research branch is the IEA, located at the University of Sao Paulo, and includes Nuclear Physics, Reactor Physics, Reactor Operations and Maintenance, Radiobiology, Radio-Chemistry, Nuclear Metallurgy, Nuclear Engineering, and Chemical Engineering. The Institute 10MW (Thermal) Pool Reactor was built in 1957 as a 5MW reactor under a grant from the United States. The reactor is fueled with enriched uranium fuel elements leased from the USERDA. Primary uses of the reactor has been production of radioisotopes, cross-section measurements, activation analysis, and training. Other facilities at the IEA include uranium refining and fabrication laboratories, a 20MeV Van de Graaff Pelletronic Accelerator, and a cyclotron constructed in 1973 in the Jacarepagua lowlands. The emphasis at the agency had been on natural uranium fueled, heavy water reactor research, although recent researchers have appeared more interested in thorium studies; a survey of publications indicates an increase in studies of industrial and urban application of atomic energy.

The IEA also operates a Radioisotope Laboratory at the Clinical Hospital in Sao Paulo, where the University's Faculty of Medicine also has a nuclear program.

Centro de Medicina Nuclear, Faculdade De Medicina, University of Sao Paulo

The purpose of the center is the development of the use of radioactive and heavy isotopes, in biology and medicine, and to provide post-graduate courses, conferences and lectures.

Conselho Nacional de Pesquisas (CNPq) CNPq is attached to the Presidency, but has scientific, administrative and financial autonomy, since it is supported heavily by grants from the Ford Foundation and the Rockefeller Foundation. It functions as a national research council and as Brazil's official foreign representative in scientific and technological matters.

CNPq also maintains four other institutes: Instituto Brasileiro de Bibliografia e Documentacao, Instituto de Matematics Pura e Aplicada, Instituto de Pesquisas Radoviareas, and Instituto Nacional de Pesquisas da Amazonia.

Centro Brasileiro de Pesquisas Fisicas Although serving as the graduate department of physics at the Federal University of Rio de Janeiro, the Center was set up in 1949 as an independent, private, non-profit organization subsidized by the Ministry of Education and grants from other science and technology organizations. It has its own staff independent of the University working on theoretical nuclear physics, elementary particle and theoretical high-energy physics; electrodynamics; nuclear emulsion technique for the study of elementary particle events, nuclear reactions, spontaneous fission of U^{238} and Th^{232} and other even-even elements, and photofission produced by nonenergetic gamma-rays and by "bremsstrahlung" in uranium and thorium. The Center is investigating separation of rare-earths and plutonium nitrate complexes in different oxidation degrees. A group is now involved in investigation on molecular and metallic alloy structures by means of the Mössbauer effect; and another in the study of electric and magnetic properties of materials, including semiconductors.

Institute of Nuclear Engineering Also at the Federal University of Rio de Janeiro, this institute, a research brance of CNEN, has a 10KW Brazilian built Argonaut-type research reactor which achieved criticality in 1965. Fuel elements for the reactor were fabricated by the Nuclear Metallurgy Laboratory of the IEA in Sao Paulo. The U. S. leased 6Kg of contained U-235 as 20% enriched uranium oxide for the production of the fuel elements. The reactor is used principally as a training device.

Instituto de Biofisica Also located at the Federal University of Rio de Janeiro, this institute's activities include investigations of areas of Brazil with high natural radioactivity. Such studies comprise radiochemical analysis of food, human teeth and excreta, vegetation, animal bones; radioecology of isolated high background non-inhabited areas such as Morro do Ferro in the state of Minas Gerais and at Guara pari in Esprito Santo State; estimation of daily intake and the body burden of inhabitants of high background areas; and studies of frequency of chromosome aberrations. The institute is under contract with USERDA's Division of Biology and Medicine and has a related contract with the Pontifical Catholic University.

Academie Brasileira de Ciencias A private organization which receives financial assistance from the Rockefeller and Ford Foundations, the Academy is the focal point of scientific conferences. It has five sections: physics, chemistry, mathematics, earth science, and biological sciences.

Instituto de Pesquisas Tecnologia This institute is operated directly by the University of Sao Paulo, and has a nuclear physics program and an associated accelerator laboratory.

Instituto Militar de Engenharia Located in Rio de Janeiro, this section of the army also has a nuclear energy program. Recent publications of IME give little indication of its nuclear research. Most concern conventional weapons, and metals research. The only recently published nuclear research has involved atomic analysis of the atmosphere.

Institute de Pesquisas Radioactivas IPR, another research arm of CNEN, located at the University of Minas Gerais near Belo Horizonte, is concerned with heavy water-thorium power reactors; mechanical properties of nuclear materials; radiometric analysis of atomic minerals; industrial applications of radioisotopes; isotope geology, radiation damage in ionic solids, E.P. and N.M. resonance, and Szilard-Chalmers effect. The IPR publishes technical and scientific reports and bulletins on these activities. The main facility is a 250kW Triga Mark I reactor. This reactor achieved criticality in November 1960 and is usually operated at 30kW or less. It is used for training, radioisotope production and research. The reactor is fueled with 2 Kgs of contained U^{235} in 20% enriched uranium-zirconium alloy fuel elements leased from the USERDA. An increase in power level is planned. Other IPR facilities include a 14 MeV Neutron Generator and a subcritical assembly. USERDA natural uranium feel elements have recently been leased to CNEN for subcritical experiments using D_2O at IPR. The main thrust of IPR research is in the development of thorium fueled reactors. Little of the research has been published.

Nucleo de Estudos e Pesquisas Cientificas (NEPEC) NEPEC is concerned with research in physics and mathematics and teaching and learning systems in physical sciences.

Instituto Tecnologico de Aeronautica (ITA) Located at Sao Jose dos Campos, ITA has a Nuclear Physics Laboratory with a subcritical assembly which was obtained under a U.S. equipment grant made in FY 1959. The Institute has received assistance from the University of Michigan under sponsorship of USAID. The ITA has a well-developed curriculum in electrical engineering and publishes ITA Engenharia.

Escola Naval offers reactor control courses.

Instituto "Costa Ribeiro" de Fisica e Matematica Affiliated with the Pontifical Catholic University of Rio De Janeiro, the Institute of Physics is involved in research in solid state, nuclear and particle physics, nuclear spectroscopy, and environmental radioactivity. The institute has contracted for a KN 4000 Van de Graaff accelerator from the High Voltage Engineering Corporation, USA. Much of the equipment for the institute is U.S. Army surplus, and the library operates on a grant from Sears-Roebuck & Company.

Rio Grande Do Sul University, Instituto de Fisica Nuclear activities include nuclear reaction theory, applications of nuclear angular correlations and Mössbauer effect to solid state physics, quantum electrodynamics and current algebra.

Luiz de Queirroz Agricultural College Located in the State of Sao Paulo at Piracicaba, the College signed a contract with CNEN in 1962 for the establishment of the Center for Nuclear Energy in Agriculture. The Center offers post-graduate instruction in the application of nuclear energy to agriculture but research in the main, long-range objective of the Center.

Instituto Nacional de Tecnologia, Electronics and Electric Measurements Division Nuclear activities include radiation effects in solid.dielectrics; gamma dosimetry; and compton current measurements and theory.

Babcock and Wilcox (Caldeiras) S.A. This is a private corporation representing Babcock and Wilcox Ltd., London, on all propositions for utilization of nuclear energy power plant, experimental installations, etc., in Brazil.

Ministerio Da Saude D.N.S. - Servico Nacional de Cancer, Instituto de Cancer, Radioisotope Laboratory Nuclear activities include a number of specific medical applications of nuclear technology.

Companhia Brasileira de Tecnologia Nuclear (CBTN) CBTN is a government organization (see Section 4a) which is responsible for the development of the nuclear fuel cycle and reactor industry in Brazil. The company is planning the exploration of uranium deposits and has developed a process with 75% extraction at a milling plant. It is estimated that the plant has the capacity to extract 190MT per year.

CBTN fosters Brazil's nuclear power plant program. In 1971, Westinghouse was selected to contruct Brazil's first nuclear power plant. The plant, with a capacity of 634MW, is located at Angra dos Reis, about 95 miles from Rio de Janeiro. Commercial operation is now scheduled to begin in 1978. Brazil has announced it will begin construction on its second power reactor, a 1200MW PWR unit, purchased from KWU of West Germany, at the Angra site beginning in 1981 (see Section 6b).

According to Brazilian projections, nuclear capacity will grow from 634MW in 1978 to at least 35,000 and hopefully 75,000MW by the end of the century. To achieve this goal, an average of 1100MW will need to be installed yearly during the 80's and an average of 6300MW during the 90's. The majority of nuclear power stations installed will be concentrated in the Southeast region, which is the most developed part of the country but comprises only 10% of the total area of Brazil.

B. Research and Development Emphasis

Two recent developments indicate things to come. First, the Brazilian government, between 1967 and 1973, has poured ever increasing funds into research in nuclear reactor physics and technology. The intent is clearly to create an enormous supply of nuclear power to support a fast growing industrial economy. As the government assists nuclear research and development, it encourages institutions to undertake projects which will contribute toward this industrial-oriented goal.

The second development is more recent and less noticeable as Institutes have become increasingly involved in the applications of atomic research to medicine and agriculture. This reflects both the continued autonomy of scientists in and around Brazil's universities, and the resignation of the government to concern itself with Brazil's enormous social problems.

The government is committed to building a strong nuclear energy program, but at the same time seeks all the foreign help it can get but yet remain independent.

However, indigenous R&D Institutes do not appear able to effectively fulfill the ambitious inclinations of the government. Lately, the government has been successful in getting at least two of its three major institutes, IEA and IPR, to concentrate on thorium studies, which may prove valuable even for weapons studies, but progress is slow and institutional growth lags far behind that needed for a truly productive, independent nuclear energy program.

It is not clear to what extent research into development of nuclear weapons has progressed. The emphasis on thorium studies, the existence of a nuclear program in Instituto Militar de Engenharia, and the sudden interest in satellite rocket development suggests some weaponry orientation. However, facilities and manpower for a full scale weapons development program are even less satisfactory than those supporting industrial, medical, agricultural and theoretical research. If the Brazilian research and development establishment creates a nuclear device, it will not be as a result of well-equipped institutes and/or large mobilized workforce dedicated to nuclear weapons development.

The government presently strongly denies any intention of development of a nuclear weapon with its new nuclear technology. The emphasis is to pursue the peaceful uses of atomic research, and it appears Brazil will have difficulty in accomplishing even that objective.

IV. RESEARCH AND DEVELOPMENT ORGANIZATION AND MANAGEMENT

A. R&D Organizational Structure

Brazil's research and development efforts in nuclear fields are not centralized. Many of the institutions operate with some degree of autonomy from the government, and obtain funds from sources other than public revenues. Nevertheless, the government is organized to run a reasonably effective nuclear program. Figure 1 is a diagram of government organization for scientific and technological activities as related to nuclear programs. R&D is carried on in all of the ministries, councils and commissions listed. Note that even the federal universities, which sponsor much atomic research, are considered part of this structure even though government control over their activities in minimal.

The principal nuclear energy activities in Brazil are developed under the Ministry of Mines and Energy, with overall coordination by the National Nuclear Energy Commission (CNEN) and the participation of four government-owned companies: CBTN, Electrobras, CPRM and Nuclebras.

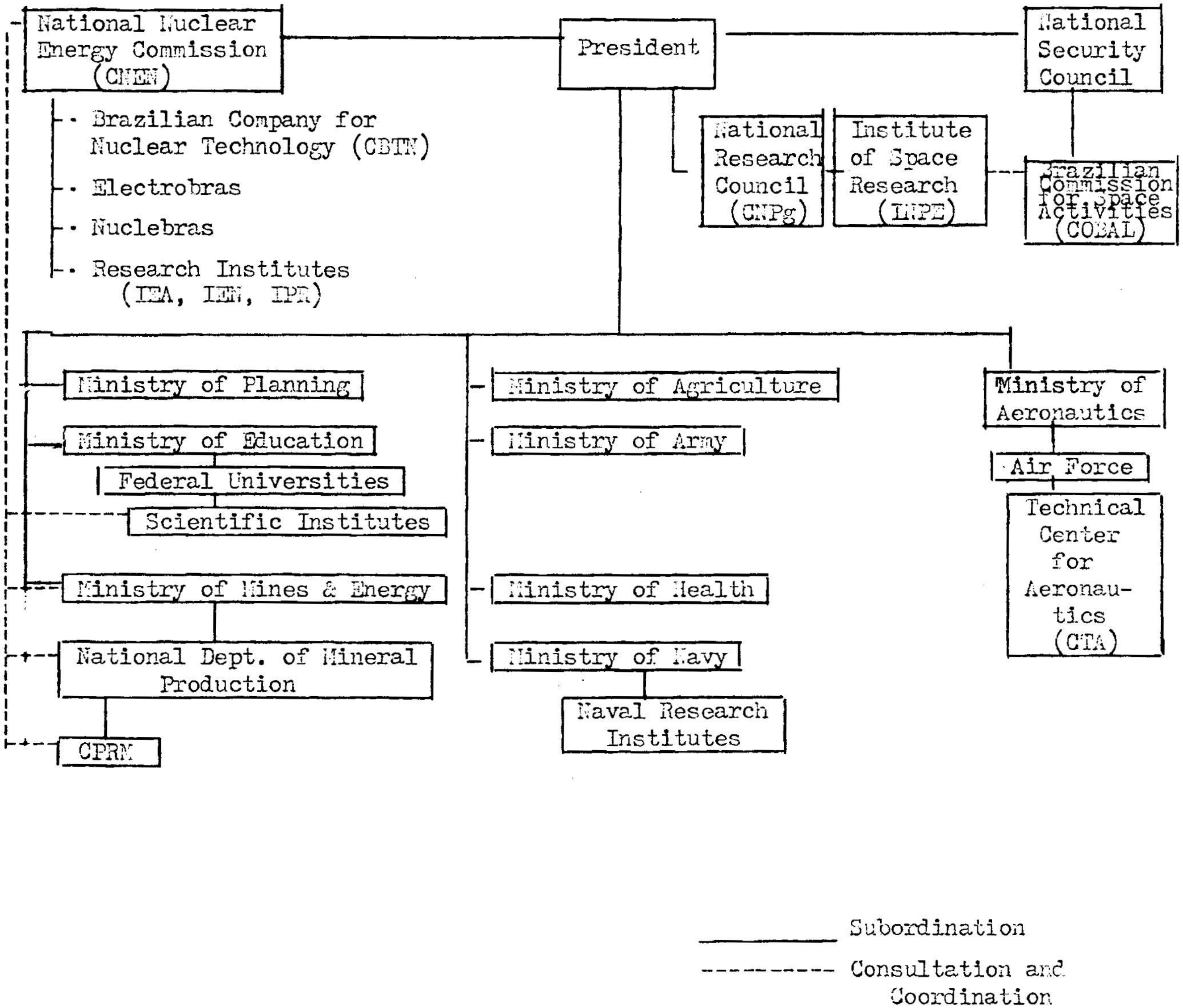
National Nuclear Energy Commission (CNEN)-headquarters, Rio de Janeiro. Responsible for the development of nuclear policy, licensing and regulatory matters, safeguards, and basic nuclear research. Its main research institutes, IEA, IEN and IPR, are decentralized and autonomous and stress different types of research. An organizational chart of CNEN is shown in Figure 2.

Brazilian Nuclear Technology Company (CBTN)-formed in December 1971 CBTN was designed to be the executive branch of CNEN with responsibility for the development of the fuel cycle industry covering all phases from the production of ore concentrated to the reprocessing of spent fuel elements. CBTN is also responsible for the promotion of private nuclear industry, and the importation of research and development programs. For the latter objective CBTN has three research reactors operating (all with enriched uranium from the U.S.).

Brazilian Electric Holding Company (ELECTROBRAS-founded 1962) ELECTROBRAS is responsible for the general power program in Brazil and the nuclear power station program including financing, coordination and the construction and operation of nuclear power stations. Present

Figure 1

Government Organization for Scientific and Technological Activities



capital endowment is U.S. $1,450 million, an expansion program of U.S. $1,350 million per year for the new generation of 1,500,000,000KW per year has started.

Mineral Resources Prospecting Company (CPRM)-CPRM is under the National Department of Mineral Production (DNPM-founded 1964), and is responsible for the prospecting of mineral resources in general and for uranium in particular. Uranium ore prospecting is done exclusively on behalf of CNEN or CBTN.

Empresas Nucleares Brasileiras SA (Nuclebras-founded October 1975) Nuclebras was set up to implement Brazil's agreement with West Germany in 1975. The company will have a majority holding in four companies which will be called Nuclebras Engenharia SA (Nuclen), Nuclebras Equipamentos Nucleares RA (Nuclep), Nuclebras Enriqueceimento Isotipico SA (Nuclei), and Nuclebras Auxiliar de Mineracao SA (Nuclam).

Nuclen, in which Kraftwerk Union AG (KWU) will take a 25% share, will be responsible for gathering all the nuclear engineering technology for Brazil's stations and related projects.

Nuclep, in which KWU, Guthoffnungshuette Sterkrade AG and Verneignigte Desterreichiache Eisen und Stahlwerke Alpine Montan AG will together hold a 25% share, will develop, produce and sell heavy nuclear plant components.

Steag and Interatom (International Atomereaktorbau GmbH) will together take a 25% share in Nuclei, which will build a demonstration uranium enrichment factory in Brazil, using the jet nozzle principle.

Nuclam's role will be to research and exploit uranium deposits in areas specified by Nuclebras; Uranggesellschaft will take a 49% share in the company.

Other organizations which may, from time to time, have important roles in research and development include:

Banco Nacional de Desenvolviment o Economica, which has a special fund, FUNTEC (Fundo de Desenvolvimento Tecnico-Cientifica-founded 1964), for financing science and technology research, secondary and higher education, and special research programs.

Instituto Nacional da Propiedade Industrial (INPI-headquarters Rio de Janeiro), which regulates the flow of technology into Brazil by controlling royalties and technical assistance fees.

Commission for Coordination of Data Processing Activities (CAPRE) Under the Ministry of Planning and General Coordination, CAPRE coordinates, develops, and rationalizes data processing usage, and maintains a census of the computer industry and a technical training program.

B. Leading Scientists and Research and Development Policy Makers

Antunes, Ivan M. - Assistant Professor at Institute of Physics, Pontifical Catholic University of Rio de Janeiro. Interested in Radiation and Health Physics. Trained at NYU (M.S. 1969).

Batista, Paulo Nogueira - President of NUCLEBRAS.

Bhering, Mario - President of ELECTROBRAS.

Braga, Ney - Minister of Culture and Education.

Caldes, Luiz Renato Carneiro da Silva - Associate Professor at Federal University of Rio de Janeiro 1929. Member of the United Nations Radiological Commission; former member of CNEN (1964-5).

Campos, Prof. Milton - Director of the Institute of Research in Radio-activity, Minas Gerais Federal University.

Cintra do Prado, Luiz - Professor of Experimental Physics, Sao Paulo University. Nuclear management, power reactors, economics of nuclear power and nuclear engineering. Civil Engineer, Physics - trained at Sao Paulo and Paris. Memberships in national nuclear agencies.

Costa, Jose Jesus de Serra - Head of Inspection Department for Radio-active Materials, CNEN.

Cullen, Thomas L. - Chairman, Institute of Physics, Pontifical Catholic University of Rio de Janeiro. Specializes in nuclear physics, radiation and health physics. Trained at Fordham (PhD 1951).

da Silva, Arthur Gerbasi - Assistant Professor Centro Brasileiro de Pesquisas Fisicas. Head, Nuclear Physics Division, Institute of Nuclear Engineering. Interested in nuclear physics, fission, spectroscopy, geochronology. Educated at Louisiana State University.

da Silveira, Antonio Azeredo - Foreign Minister.

de Almedia, Dr. Luiz - Director of Exploration, CNEN, Trained in U.S., and is good friends with personnel in the USERDA Raw Materials Department.

de Almeida, Yvone G. - Assistant Professor, Department of Nuclear Chemistry, Centro Brasiliero de Pesquisas Fisicas.

de Andrade, Ayres Cunha - member CNEN. Brazilian advisor to IAEA.

de Araujo Penna, Monier - Lecturer, Department of Radioactivity, Centro Brasileiro de Pesquisas Fisicas.

de Arruda, Paulo Ribeiro - member CNEN. Professor of Applied Electronics and Lecturer in Applied Electronics, Polytechnic School, Sao Paulo University. Director of Research, Electronic Microscopy Department, Sao Paulo University. Member of the Brazilian National Research Council, Brazilian Academy of Science and the U.S. Institute of Radio Engineering.

de Barros, Solange M.C. - Assistant Professor, Department of Radioactivity, Centro Brasileiro de Pesquisas Fisicas.

de Carmago, Eng. Pedro Bento - Head of Nuclear Engineering Division, CNEN (at University of Sao Paulo).

de Carvalho, Prof. Hervasio Guimares - Chairman of CNEN and President CBTN until 1974. Scientific Director of Centro Brasileiro de Pesquisas Fisicas and Chairman of its Radioactivity Department. Interested in nuclear physics, engineering and fission. Educated at Recife University, Assistant to the Technical and Scientific Division, National Research Council.

de Carvalho, Dr. Yvan Barreto - Director of DNPM.

de Carvalho e Souza, H.E. Madame Odette - Head, Brazilian Mission to Euratom.

de Carvalho Franco, Paulo - Director of Institute of Radioactivity, Sao Paulo University.

de Castro, Irene Emygdio - Involved in measurement of radioactivity, Electronics and Electronic Measurements Division, National Institute of Technology.

de Castro de Paria, Nelson V. - Assistant Professor of Corpuscular Physics Department, Centro Brasileiro de Pesquisas Fisicas.

de Mendonca, Dr. Fernando - Director of Institute of Space Research.

de Oliveira, C.G. - Assistant Professor of Theoretical Physics Department, Centro Brasiliero de Pesquisas Fisicas.

de Resenda, Gen. Paulo L. - Director Instituto Militar de Engenharia, which has a nuclear program.

de Salvo Brito, Sergio - Technical advisor to the President of the CNEN since 1960. In charge of the Economic Branch, Power Reactors work group. Interested in nuclear engineering, economic aspects of nuclear power. A nuclear civil engineer, educated at University of Sao Paulo, Institute of Military Engineering, Rio de Janeiro, and Paris University.

de Souza Santos, Prof. Dr. Marcello Damy - Head of Nuclear Physics Division, CNEN (at Univ. of Sao Paulo). Director of Institute of Atomic Energy, Professor of Physics. Interested in reactor physics and reactor design. Educated at Sao Paulo and Cambridge Universities.

de Souza Santos, Tharcisco Damy - Head of Nuclear Metallurgy Division, Institute of Atomic Energy; Full Professor of Non-Ferrous Metal, Polytechnic School of University of Sao Paulo. Interested in metallurgy and fuel element fabrication. A Metallurgical Engineer, educated at Sao Paulo University.

do Amaral, C.M. - Assistant Professor of Theoretical Physics Department, Centro Brasileiro de Pesquisas Fisicas.

Estonde Eston, Dr. Tede - Director, Centro de Medicina Nuclear. Interested in biological and medical uses of radioisotopes.

Ferreira, Erasmo - Assoicate Professor, Institute of Physics, Pontifical Catholic University of Rio de Janeiro. Interested in high energy particle physics. PhD University of London 1961.

Franca, Dr. Eduardo Penna - Head of Radioisotopes Laboratory, Brazil University Institute of Biophysics.

Galvao de Moraes, Prof. Henrique Alfredo - Executive Director, NEPEC.

Geisel, Ernesto - currently President of Brazil. Attended U.S. Army General Staff and Command School in Kansas during World War II.

Gomes, Harry - Professor, Institute of Research in Radioactivity, Minas Gerais Federal University.

Gross, Bernhard - Head of Technological and Scientific Research Department, CNEN.

Guimares Ferri, Prof. Dr. Mario - Director, Faculty of Philosophy, Science and Letters, Sao Paulo University.

Lima, Fausto Walter - Head of Radiochemical Division, Institute of Atomic Energy and Sao Paulo. Professor of Chemical Engineering, Sao Paulo University; M.Sc (Wisconsin); Dr. of Chemical Engineering, Sao Paulo. Member of Brazilian Academy of Science, Brazilian Society for the Advancement of Science, and the Brazilian Chemical Society.

Magalhaes, Dr. Luis Claudio de Almeida - President, FURNAS.

Marques de Oliveira, Alfredo - Director, Centro Brazileiro de Pesquisas Fisicas.

Meyer, Prof. Edgard - Formerly in Research and Measurement of fall-out, Electronics and Electronic Measurement Department, National Institute of Technology.

Mundt, Prof. Weiner Arthur - Director of Institute of Physics, Federal University of Rio Grande do Sol.

Pieroni, Dr. Romulo Ribeiro - Former director of Institute of Atomic Energy, University of Sao Paulo.

Pinho, Alceu G. - Director of Institute of Nuclear Physics, Pontifical Catholic University of Rio de Janeiro. Assistant Professor (on leave) in Theoretical Physics, Department Centro Brasileiro de Pesquisas Fisicas. Interested in Nuclear Spectroscopy, Nuclear Reaction and Scattering, Educated at University of Paris, PhD 1963.

Ramos, Jose Raymundo de Andrade - Member CNEN. Head of Mineral Exploitation Department, CNEN. Trained in U.S. and good friends with the USERDA Raw Materials Staff.

Ribeiro, Alvaro Vidal Leite - Public Relations Assessor, CNEN. Educated at Escola Naval and Werneck College.

Ribeiro, Professor Uriel ca Costa - Chairman, CNEN and Brazilian Governor in IAEA.

Rodrigues de Mattosh, Rear Adm. Jose - Director of Escola Naval, which offers courses in reactor control.

Saraiva de Toledo, Professor Dr. Paulo - Head of Reactor Physics Division CNEN (at Sao Paulo University).

Simonsen, Prof. Mario Henrique - well-known economist, now Minister of Finance. His appointment is indicative that Brazil is still willing to accept foreign capital.

Tavares, Professor Armando Dias - President of NEPEC.

Ueki, Shigeaki - Minister of Mines and Energy and an increasingly powerful voice in the administration. Japanese-Brazilian technocrat, who served on Geisel's staff when Geisel was president of Brazil's oil monopoly, PETROBRAS.

Videira, Antonio L. - Associate Professor, Institute of Physics, Pontifical Catholic University of Rio de Janeiro. Interested in high energy particle physics. PhD. University of Sao Paulo, 1967.

C. Political Climate for Research and Development

In Section I factors which formed the political climate for research and development were mentioned. The first was government control of the nation's policy-making process in spite of the continued autonomy of many of the so-called "federal" universities. This could cause universities, the centers of most research, to be less than fully cooperative with ambitious government development plans. However, the military government has little opposition in pursuing its decision to develop a nuclear power program and support nuclear research at the universities.

The lack of significant subversion was cited as a key factor, and the only truly vocal opposition to the government is the liberal wing of the Catholic Church. The government is not hampered by civil disturbances in establishing its research and development programs.

The prevailing Positivist impulse, which places a premium on technical competence, and the continued need for the government to display its competence in order to remain tolerated by the people were named as key factors to shape the future of research and development in Brazil. Brazil is attempting to build a solid base of competent leaders and social planners, who will continue to insure continued Progress and Order in Brazil.

Finally, a strong sense of nationalism was cited as a factor in the future of research and development in Brazil. The Brazil that matters is tough-minded, energetic and imbued with a sense of "manifest destiny" which is reminiscent of the United States generations ago. Economic growth is the symbol of success in Brazil and whatever will insure and secure this goal is the probable policy of the government.

The last consideration is worrisome, because of the international situation at the moment. A disturbing number of nations, Brazil included, have not ratified the Nuclear Proliferation Treaty. The moving forces here include (1) an enormous worldwide appetite for nuclear-generated electric power (which raises the ugly possibility of diversion of leftover plutonium and enriched uranium for weapons use); (2) the persistent notion that nuclear weapons bring greater security; and (3) exaggerated claims for potential benefits of nuclear explosives for peaceful purposes (PNEs). That Latin America could be a nuclear-free zone has been discussed, but with Argentina, Brazil and Cuba refusing to sign the NPT, this proposal is probably visionary. Since India's test of a nuclear explosive, Brazil's claims that PNEs may be proper and necessary gains renewed credibility. If these nations feel that American foreign policy is becoming more isolationist, they have all the more reason to argue against being denied the right to build nuclear weapons.

Argentine officials have stated that they believe that Brazil has decided to build a bomb and will produce one in eight years. In response, Brazil's leading newspaper O Estado de Sao Paulo, said in 1975, that Brazil should have a bomb if other nations do.

The international political climate provides good growing weather for the development of nuclear explosives and weapons. The Brazilian political situation would not hinder the government from adopting such a policy. Whether it could pass as "Progress" in the eyes of the scientists and engineers is another matter. The maintenance of the competent image becomes very important at that point, and there is a consensus in Brazil about what is proper for a society to do, and what is irresponsible. The people will have to feel threatened before they tolerate extensive military application of nuclear power.

V. RESEARCH AND DEVELOPMENT EXPENDITURES

Figures regarding funds spent for research and development in nuclear fields are difficult to obtain because of the decentralized nature of the Brazilian program. The government allocates money to different ministries for the contribution each can make to the nuclear program, but how each ministry uses its budget is unclear. Substantial funds for research, particularly in institutes affiliated with universities, are obtained from outside sources, such as the Rockefeller and Ford Foundations.

Nevertheless, allocations which are reported by the government, when viewed together, provide indications of trends in emphasis, if not the exact amount devoted to research and development.

Table 3 shows that military expenditures have increased although the budget for 73-74 was cut drastically. The bulk of expenditures in the late sixties and early seventies involved purchases of foreign equipment, increasing from $350 million in 1970 to $475 million in 1974. In 1974, purchases dropped off substantially due more indigenous arms production and budget cuts.

Table 3

Budgets of Selected Ministries*

Year	Military	Ministry of Cult. & Ed.	Min. Mines & Energy	Ministry of Aeronautics
1965	(2.5)	61.6 (1.0)		
1966	(2.2)			
1967	222 (2.9)			
1968	341 (2.6)	128.2 (0.8)	46.8 (0.3)	98.2 (0.7)
1969	1228 (2.6)			
1970	1609 (2.2)			
1971	2476 (2.8)	237.8	122.0 (.3)	
1972	4175 (2.2)	94.1 (0.2)	107.6 (0.2)	25.9 (0.1)
1973	4523 (2.0)	112.6 (0.2)	147.9 (0.2)	34.9 (0.1)
1974	3619 (1.0)	123.2 (0.1)	93.6 (0.1)	18.7 (0.02)

*(In millions of U.S. $ and with percentage of GNP in parentheses)

The Ministry of Culture and Education has allocated 40-50% of its funds to higher education, especially for expansion of physical facilities, but is changing as emphasis increases on agricultural and primary education.

In spite of the proportionate lack of increase in the Ministry of Mines and Energy's budget, the amount of money being devoted to uranium exploration and extraction has been increasing dramatically, as indicated below:

Table 4

Expenditures for Uranium Exploration and Extraction

Year	Expenditure (000's of U.S. $)
1969	380
1970	1,900
1971	3,100
1972	5,100
1973	8,500
1974	11,000
1975	22,000

Research and development expenditures, as stated, are difficult to obtain. CNP's 1970 budget was $43.1 million, of which $9.1 million went to the Brazilian Academy of Sciences.

The agency which is most directly concerned with nuclear research and development, of course, is CNEN. Table 5 shows the commission's recent budget trends.

Table 5

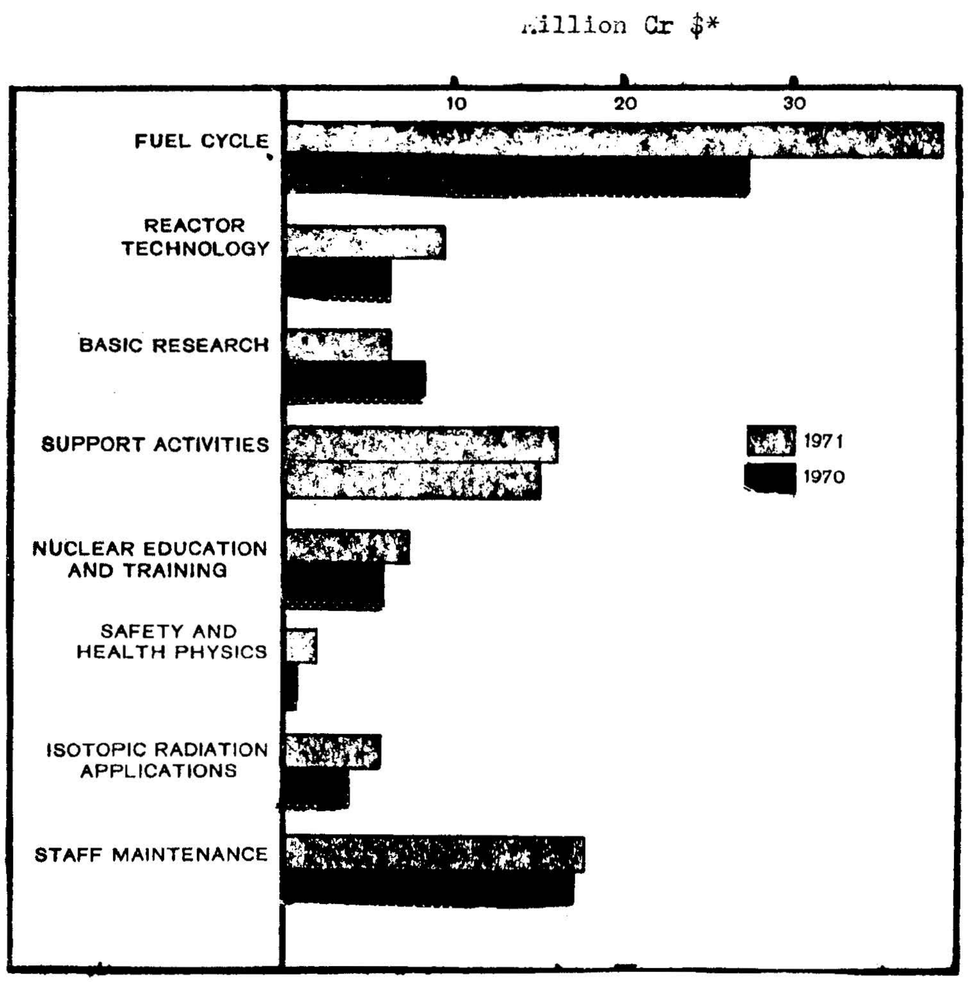
CNEN Expenditures for Research and Development

Year	CNEN Expenditure (millions of U.S. $ with % GNP)
1966	4.4 (.1)
1967	5.5 (.1)
1968	8.5 (.2)
1969	12.0 (.2)
1970	15.9 (.4)
1971	20.0 (.3)
1973	33.8 (.1)

These figures do not include expenditures by CBTN on the Angra dos Reis plant. Distribution of the CNEN budget in 1971 is illustrated in Figure 2.

The CNEN has spent much effort and money on education, training and scientific interchange for the personnel necessary for nuclear energy program. Sixty-six courses in nuclear energy are given in 29 different institutions spanning training courses for technicians to doctoral degree courses. Figure 3 shows expenditures by CNEN for training grants.

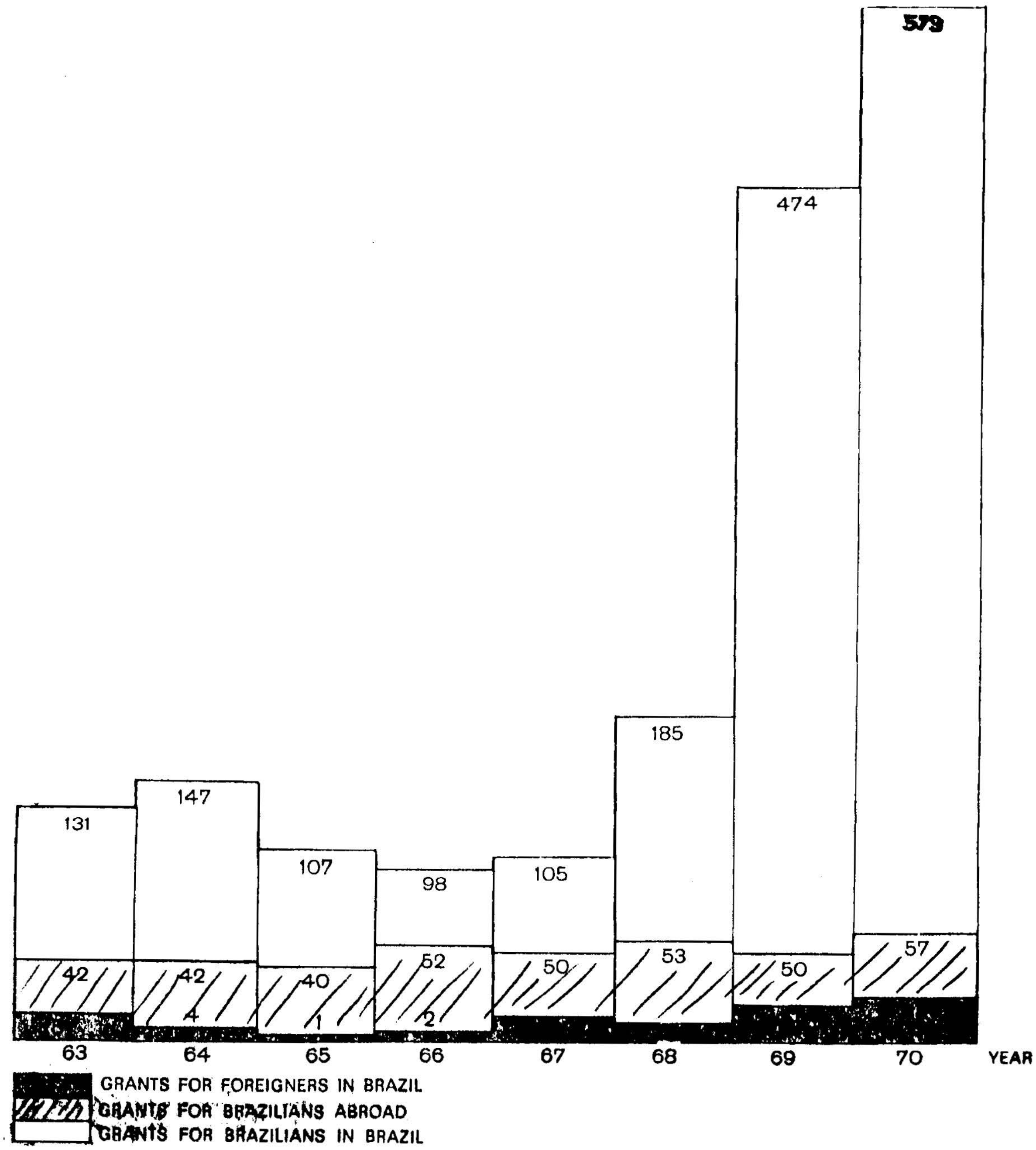
Figure 2



* 1 Brazilian Cr $ (Cruzeiro) = U.S. $6.43

Brazil 1971 Nuclear Budget Distribution

Figure 3



Brazil CNEN Research and Study Grants by Year

Total Brazilian research and development figures have been released (1971: U.S. $57.8 million (.1% GNP); 1972: U.S. $92.1 million (.1% GNP); and 1973: U.S. $114.6 million (.1% GNP)), but it is not clear how this money has been spent. Most of it, apparently, is devoted to "administrative purposes".

The impression suggests caution is necessary in predicting the future of Brazilian expenditures for research and development, particularly in nuclear science. Recent changes of course in the military budget, education policies, and activities of the CNEN have shown that the government is aware that it needs to (1) give more attention to social concerns and (2) work toward building its own centralized base of technological and scientific proficiency.

VI. FOREIGN ASSISTANCE IN SCIENCE AND TECHNOLOGY

A. Foreign Influence or Presence on Weapons Research and Development

Various agreements with other nations and the increasing internal technical know-how are giving Brazil the facilities and knowledge necessary for nuclear weapons development. There is no evidence that any nation is assisting Brazil in nuclear weapons technology. In fact, Brazil's long standing determination to be independent of other nuclear powers suggests that the government would avoid outside help unless there was an immediate threat to national security.

There is concern, especially in the United States, that Brazil has not signed the Nuclear Proliferation Treaty; and, therefore, the U.S. has been wary of Brazil purchasing nuclear technology from other nations.

No State review.

(b)(1),Sec. 1.4(d)

B. Imports and Purchases of Foreign Technology

A number of factors make the importation of nuclear technology into Brazil a key issue at this time. The first is Brazil's need for a growing energy supply which relies on importing three-fourths of its oil demand. Domestic oil reserves are small, but uranium reserves are considerable and the supply of thorium is second only to India's resulting in Brazil considering nuclear energy as a means of maintaining its rate of economic growth. The second factor is the OPEC oil price rise which makes oil power a less realistic alternative in Brazil and European nations more eager to seek cheap fuel for their nuclear reactors from countries like Brazil in exchange for technological assistance. The third factor is the determination of the Brazilian government to reduce its dependency on foreign technology as quickly as possible.

These factors point to a Brazilian policy which takes advantage of the willingness of nuclear nations to sell reactor hardware and all the elements of a complete fuel cycle.

1. Imports from United Kingdom. 1971

Order of six research reactors from the firm Fairly Engineering, Ltd. Five are Herald type for university training, and a Herald 5 MW for advanced work at Brazilia.

2. Imports from France

On July 5, 1975 Brazil and France signed a $2.5 million agreement for the construction of a research reactor, designated COBRA, in Brazil. At the signing, Brazilian officials implied that other related agreements would follow.

3. Imports from the United States

Westinghouse is currently building a 626 MW nuclear power plant at Angra dos Reis I which is part of a $5 billion deal which contracted Westinghouse to build eight or nine power stations over the next 12-15 years. However, in 1975 the United States USERDA informed Brazil that Brazil had been placed on the list of foreign enriched uranium customers to receive conditional fuel supply contracts. Brazilians then dropped talks with Westinghouse and turned to German manufacturers for future reactor imports. Brazil still needs U.S. fuel to get the Westinghouse power station (perhaps 2-3 reactors when complete) into operation, and some officials have expressed hopes of obtaining high temperature reactors from the U.S. in order to take advantage of Brazil's large thorium reserves. Other technological imports from the U.S. have included:

FY1959 - $140,550 subcritical assembly and fuel (Aeronautical Institute of Technology)
FY1960 - $163,300 dic laboratory irradiators (CNEN)
FY1961 - $11,000 equipment for agricultural research with radioisotopes (CNEN)
FY1962 - $2,160 three plutonium-beryllium sources (Aeronautical Institute of Technology)
$12,000 cobalt-60 irradiator (Institute of Biophysics, University of Rio de Janeiro).
Nearly all of the nation's computer hardware, maintenance and training (mostly purchased from IBM and Burroughs)

4. Imports from West Germany

The reluctance of the United States to supply Brazil with enriched uranium or the technology to produce it is possibly the force behind a recent agreement concluded between Brazil and West Germany. Signed on June 27, 1975, the agreement includes the following technology and resource exchanges:

a. Purchase by Brazil of at least eight enriched uranium plants (1200 MW capacity each), a reprocessing plant for extracting plutonium from spent fuel, a fuel fabrication plant, and an isotope separation plant for uranium enrichment ("jet nozzle" process developed by STEAG AG, of Essen). Total package price fixed at 10 billion marks.

b. Brazil to sell uranium ore to West Germany.

This agreement is an indication that, in spite of U.S. fear of its nuclear intentions, Brazil's government will seek the material it wants elsewhere if turned down in the United States.

C. Cooperative Programs

Brazilian foreign policy is rather pragmatic; recently trade agreements with Czechoslovakia and the People's Republic of China have illustrated that Brazil adheres to no traditional position in the world, and will maintain trade relations with communist nations while it vigorously oppresses leftists on the home front. Nor will it discourage heavy American, German, Japanese and Italian investment in Brazil which serves to help Brazil's economy.

In the nuclear field, Brazil has cooperative agreements with the nuclear energy authorities of the Federal Republic of Germany, France, Italy, United States, Israel, Spain, United Kingdom, Argentina, Japan, Portugal, Paraguay, Chile, Peru, Bolivia, Switzerland, India and Euratom. The government has received from the United Nations U.S. $5.6 million for a science and technology project, and holds memberships in the World Meteorological Organization, the International Union of Geology and Geophysics, the International Oceanographic Commission, the Commission on Space Research, and since 1959, the International Atomic Energy Association. IAEA assistance to Brazil as of January 1, 1974, totalled U.S. $1,734,500 in the form of equipment, technical experts and fellowships. An IAEA Expert Team headed by James Lane of ORNL prepared a report in June 1968 which forms the foundation of Brazil's nuclear power program. A second four-man IAEA team headed by Mr. Lane completed a two-month assignment in the spring of 1971 to evaluate the potential of Brazilian industry to participate in the future construction of equipment for nuclear power plants. Yet with all this participation in international nuclear agreements, Brazil has steadfastly refused to sign the Nuclear Proliferation Treaty, claiming that it places unfair limits upon the non-nuclear nations. Thus, Brazil will take what help it can get, and still keep open a very important option for the maintenance of its independence and establishment of its regional power nuclear nation.

1. Cooperation with Argentina

1966 - bilateral exchange of personnel and information on atomic energy, communication of research progress, planning of long-range research for mutual benefit.

2. Cooperation with France

Assistance in geological research (June, 1975, French geologists discovered large deposits of uranium in Brazil); July, 1975 - agreement to purchase a research reactor. Although France has not signed the NPT, they have indicated their intention to require adequate international safeguards on exported nuclear technology.

3. Cooperation with Japan

1970 - agreement for technical training, fellowships, supplies and equipment, and technological support for Brazil's nuclear energy program.

4. Cooperation with the United States

Relations with the United States are currently strained, for Brazil, like many Latin American countries is suspicious of U.S. policy concern with local and economic interests. Financial aid from the U.S. has fallen from $15 million per year in the 60's to $8 - 9 million in 1972, but this is more a reflection of better conditions in Brazil than a deterioration of relations. Strain on relationships has been due to the U.S. policy concerning transfer of sensitive nuclear technology.

The U.S. and Brazil entered into a research Agreement for Cooperation in August, 1955, and amendments in 1958, 1960, 1962, and 1965. The Trilateral Safeguards Agreement for IAEA implementation of safeguards under the Agreement for Cooperation entered into force October 31, 1968. A superseding 30 - year power Agreement for Cooperation was signed on July 17, 1972, and entered into force on September 21, 1972. A proposed amendment to this Agreement was presented to the Brazilians on July 26, 1973, which takes into account the present power reactor fuel supply policy of the USERDA. The Brazilian Embassy verbally informed USERDA in June, 1974, on an informal basis, that its government approved of the draft.

The USERDA's Division of Biomedical and Environmental Research has supported a research contract concerned with high level natural background radiation for $414,049 since 1960.

Under an AID-IEU University of Sao Paulo Agreement, and support from the OAS, three ORNL engineers spent two months at IEA on teaching and analysis assignments in 1969 and 1970. Three additional ORNL personnel participated in a Health Physics course held at the University of Sao Paulo during 1971.

Under the U.S. leader grant program, Prof. Andrade Ramos and ex-Minister of Mines and Energy Jose Costa Cavalacanti visited U.S. nuclear installations in 1968, and IPR Director Milton Campos visited the U.S. in 1970, CNEN Chairman de Carvalho has visited ERDA Headquarters several times.

The USERDA Atoms in Action Nuclear Science Demonstration Center was presented in Rio de Janeiro in 1961 and in Sao Paulo in 1969.

Visits were made to Brazil by USERDA Chairman Seaborg and by Commissioner Johnson in 1967, and by Commissioner Thompson in 1969.

As of January 1, 1974, Brazil had the following quantities of U.S. supplied special nuclear material: 26.593 kgs of U-235, 7,734 kgs of normal uranium and 161 grams of plutonium.

As part of the United States Government's program of international cooperation in energy R&D, a USERDA geologist, Dr. John W. Gableman, visited the Northeast Brazil area in June of 1975 to help map out a plan of investigation, and suggested continuing future visits of USERDA geologists to investigate the recovery of uranium from the low-grade granites.

In addition to the R&D cooperation the USERDA plans to be available for short advisory visits on Brazil's exploration program and to receive their technical people for familiarization visits and technical instruction in the U.S. A number of the top CNEN geologists and geophysicists visited USERDA's Grand Junction Office during the past five years and received extensive assistance in aerial prospecting and procurement and use of their drilling hole logging equipment. With the help of ERDA, arrangements were made through AID for a several months' geological assistance project by a U.S. Geological Survey geologist.

Difficulties developed in relationships when the USERDA announced that Brazil had been placed on the list of foreign enriched uranium customers to receive conditional fuel supply contracts. The Brazilians asserted that this went against the understanding that was reached when they signed the contracts in June 1974 and pointed out that Brazil had already begun programming construction of their second and third power reactors, which might collapse and bring heavy financial loss to Brazil. CNEN President Carvalho believed the ERDA decision might affect future Brazilian nuclear policy and force Brazil to adopt a different line in future reactors.

(b)(1),Sec. 1.4(d)

[redacted]

No DOE or State reviews.

5. Cooperation with West Germany

1969 - agreement emphasizing cooperation in nuclear energy, space aeronautics, oceanography and data processing.

In 1975 Brazil and West Germany signed an agreement which concerned all aspects of nuclear technology: prospecting, enrichment, reactor production and fuel processing. German officials have stressed the treaty's requirement that Brazil accept IAEA safeguards, provide assurances that fuel and equipment not be used for explosives, and agree not to reexport items so as to evade the Nuclear Proliferation Treaty. Still, the package which West Germany has promised Brazil (see Section 6B) will give Brazil the technological equipment, knowledge and materials to create nuclear explosives. The terms of the agreement include:

(1) Brazilian purchase of technology from West Germany.

(2) West German purchase of uranium from Brazil.

(3) Formation of a company by Nuclebras and Germany's Kraftwerk Union to oversee reactor construction, fabrication of fuel elements and develop uranium reserves (already a joint research and exploration body has been established).

(4) Brazilian firms will set up separate companies to manufacture heavy compnents locally.

(5) Construction of reactors was to have begun in 1976, but had not started by mid 1977.

(6) Brazilian share in work to increase to 90% by 1990.

(7) Credit for the Brazilian purchases will be provided by Kreditanstalt fur Wiederaufbad and by a German banking consortium.

6. Cooperation with Mauretia

An agreement was signed in early 1976 for Brazilian general prospecting in Mauretia's minerals exploration program. Brazil will have first option in the minerals developed. The Brazilian government has not confirmed nor denied suggestions that uranium will be one of those minerals.

(b)(1),Sec. 1.4 (d)

[redacted] With great skill, the Brazilian government has exploited its own opportunities and through agreements is reaching its goal of self-sufficiency through nuclear energy. [redacted] (b)(1),Sec. 1.4(d) (b)(1),Sec. 1.4 (d)

[redacted] The nuclear market may not grow as quickly in the U.S. as abroad, and American manufacturers will need the foreign market to keep their businesses alive. Overall, U.S. foreign policy is to discourage nuclear proliferation by extending as much cooperation as possible to countries developing a nuclear program resulting in better control of the nuclear technology.

VII. ASSESSMENT

A. Present and Projected Capabilities

Many sources agree that Brazil has the S & T capability to support atomic bomb development: The Senate Government Operations Committee, Senate Arms Control Sub-Committee, the "Washington Post", and the Argentine government. The "Bulletin of Atomic Scientists" has named Brazil as being one of seven countries with or soon to have "the technical capacity to build nuclear weapons, and may be under some political pressure to do so." With the conclusion of the nuclear agreement with West Germany, Brazil will become less and less dependent upon the U.S. for enriched uranium which would be supplied only under strict regulations. Once Brazil's technology enters the self-sufficiency stage toward the end of the century, restrictions under the German agreement, will no longer be effective. That the acquisition of this technology has been accelerated by the agreement is without question.

The capability to support nuclear weapons development, both technologically and diplomatically, does not mean that nuclear weapons will be produced. Weapons programs are expensive in terms of money and manpower, and may draw these resources away from other areas which may require special commitment for political and economic reasons.

Brazil's potential nuclear weapons capability is currently dependent upon United States and West German technical assistance, although the Brazilians have demonstrated a remarkable affinity for negotiating the technology transfer and training which each country may have been reluctant to provide at first.

The United States' insistance on IAEA safeguards could retard technology transfer from other nations which would enhance Brazil's nuclear weapons capability.

In terms of material resources and extraction capability, Brazil is very close to independence. In late 1975, Nuclebras estimated its U_3O_8 reserves at 10,000-18,000 tons based on explorations by airborne radiometry, airborne Gamma spectrometry, geochemistry and carbon radiometry. With some of these techniques, the Brazilians have been able to estimate their thorium reserves at a level second only to India's.

The capability to conduct nuclear and technological research at a sophisticated level has been slow in arriving. While scientists in various institutions are conducting reactor, thorium and centrifuge studies, significant numbers (about 400 per year) of engineers and scientists are seeking the use of nuclear facilities in other nations to conduct research and receive training. The facilities in Brazil are just not expanding fast enough to meet the needs of the nation's scientific work force. Research capability, while improving, remains limited, including areas related to weapons development.

B. Weaknesses

A list of the weaknesses of Brazil's scientific and technological research and development encompasses practically all factors. Manpower, facilities, financial commitments, organizational structure, and the political conditions all lack the quality or size to support rapid development of technological capacity and proficiency. What has saved Brazil's research and development ambitions has been foreign assistance and Brazil's imports of foreign technology.

Manpower weaknesses encompass the paucity of students in training as well as the lack of substantial scientists and engineers in the productive sector. Universities are expanding their enrollments, but not to any great extent in science and technology areas. Training for advanced degrees in the natural sciences, continues to occupy a few hundred people per year, which is about the same as the number that train outside Brazil. The staff of the CNEN institutes, while increasing from year to year, is still limited for the type of research that must be done to meet the government's goal of nuclear independence and heavy use of nuclear energy.

Facilities are improving with the acquisition of new equipment and more concentrated funding by the government. But the pace of improvement is slow in relation to the projected needs of the program. University facilities are remarkably limited and have received very little attention in the nuclear field.

Allocation of funds has become more realistic when the government found that it could not hope to achieve everything at once and began concentrating on priority areas; e.g., more ambitious projects that may have matured in the 1980's suffered from the loss of funds to projects involving uranium prospecting. Large expenditures for rapid technological development seem beyond the means of the Brazilian government at this time.

Although efforts have turned toward a more centralized structure for nuclear research and development, many institutes continue to operate more or less on their own. Universities have limited contacts with the CNEN and with the IAE, and there is a lack of direction to the nuclear program.

With the constant political background noise of underground liberal dissent, it is necessary for the government to carefully consider its policy on research and development. Brazil does not need not be quite so inhibited about pursuing occasional unpopular goals, but there is a subtle pressure upon the government not to appear too arbitrary. This, combined with President Geisel's concern for social problems, weakens the justification of research and development programs. Brazil may have the capability to engage in certain types of research and to develop a certain level of technology, but is hamstrung by a very weak scientific and technological base.

C. Present and Projected Areas of Emphasis

In the early 1970's the Brazilians hoped that their scientific community could establish proficiency in a great number of areas: power plant technology, computers, fuel cycle development, thorium application, rocketry and perhaps even weapons applications. Lately, however, indications are that a policy of limited concentration has been adopted. The most important area of emphasis at present is uranium exploration.

Brazilian policymakers realize that the most productive efforts have been in pursuing assistance from industrialized nations in exchange for nuclear raw materials.

Second in empahsis has been development of thorium technology. The IEA and IPR have been studying thorium reactor physics for the last two years with French and American help. While other nations are still bound to uranium, which Brazil will sell to them, Brazil will be moving into thorium, which it has in great quantities.

Other areas of emphasis in research programs include applications of atomic research to agriculture, medicine, urban problems, and space research in meteorology, extraterrestial radiation and rocketry. The satellite booster program has faired the best in maintaining its priority among research and development policies.

It is not certain to what extent nuclear weapons development fits into the priority technology scheme. Conventional weapons which are effective in anti-insurgency campaigns have been judged as "must have" items, and Brazilians are content to buy them rather than wait until their industry and technicians are capable of producing them. Recent trends have been to make as many agreements as possible to produce some of the equipment in Brazil and gradually to have Brazilians assume more responsibility for design and production. This pattern may show up in nuclear weapons development, although it would be more difficult diplomatically for other countries to assist them. The general emphasis has been to focus on areas which will quickly develop Brazilian scientific and technological proficiency.

D. Indicators of Nuclear and Other Weapons Development

Emphasis on thorium, rocket and centrifuge research are, perhaps, disturbing indications of possible weapons development interests, when taken out of context; but when viewed with other programs, these pursuits also make sense in terms of more practical goals. Brazilian policy makers see a direct link between these areas of technological development and the economic development that would lead to international status and internal stability. It is believed that it is not the intent of the government to develop a nuclear weapon as soon as possible.

Peaceful nuclear explosives (PNE's) are another matter, however. Brazil has constantly claimed that its efforts in the nuclear area are directed toward the "peaceful" applications of nuclear technology, but also extends effort to remain as unrestricted as possible. Brazil's refusal to sign the Nuclear Proliferation Treaty, and their obstructionist tactics during negotiations over the Treaty of Tlatelolco (which is not in force in Brazil) are further indications of a desire to keep the option of PNE's. The government has suggested that canal digging, connection of hydrographic basins, recovery of oil fields, release of natural gas and the development of the Amazon frontier are possible applications for nuclear technology. Still, there is little indication that the government actually has a well-developed explosive program.

Brazil is not a nation intensively involved in an explosive program, peaceful or otherwise at present. The government is interested in keeping its options open, and in making steady progress toward eventual explosive technology. Aside from intentions, though, there are few indications of progress or success in PNE development. In eight or ten years Brazil may be ready to test an explosive device, but whether or not such a test will be politically or diplomatically feasible is another question. For the time being weapons research is not top priority.

END responsive portion on Brazil.

The remainder of the document (80 pages) is not responsive to the request, and not provided.