SECRET
11/GS/SCI

Sweden

May 1973

NATIONAL INTELLIGENCE SURVEY

SECRET
NO FOREIGN DISSEM

NATIONAL INTELLIGENCE SURVEY PUBLICATIONS

The basic unit of the NIS is the *General Survey*, which is now published in a bound-by-chapter format so that topics of greater perishability can be updated on an individual basis. These chapters—Country Profile, The Society, Government and Politics, The Economy, Military Geography, Transportation and Telecommunications, Armed Forces, Science, and Intelligence and Security, provide the primary NIS coverage. Some chapters, particularly Science and Intelligence and Security, that are not pertinent to all countries, are produced selectively. For small countries requiring only minimal NIS treatment, the *General Survey* coverage may be bound into one volume.

Supplementing the *General Survey* is the NIS *Basic Intelligence Factbook*, a ready reference publication that semiannually updates key statistical data found in the Survey. An unclassified edition of the factbook omits some details on the economy, the defense forces, and the intelligence and security organizations.

Although detailed sections on many topics were part of the NIS Program, production of these sections has been phased out. Those previously produced will continue to be available as long as the major portion of the study is considered valid.

A quarterly listing of all active NIS units is published in the *Inventory of Available NIS Publications*, which is also bound into the concurrent classified Factbook. The Inventory lists all NIS units by area name and number and includes classification and date of issue; it thus facilitates the ordering of NIS units as well as their filing, cataloging, and utilization.

Initial dissemination, additional copies of NIS units, or separate chapters of the *General Surveys* can be obtained directly or through liaison channels from the Central Intelligence Agency.

The *General Survey* is prepared for the NIS by the Central Intelligence Agency and the Defense Intelligence Agency under the general direction of the NIS Committee. It is coordinated, edited, published, and disseminated by the Central Intelligence Agency.

APPROVED FOR RELEASE: 2009/06/16: CIA-RDP01-00707R000200090022-2

WARNING

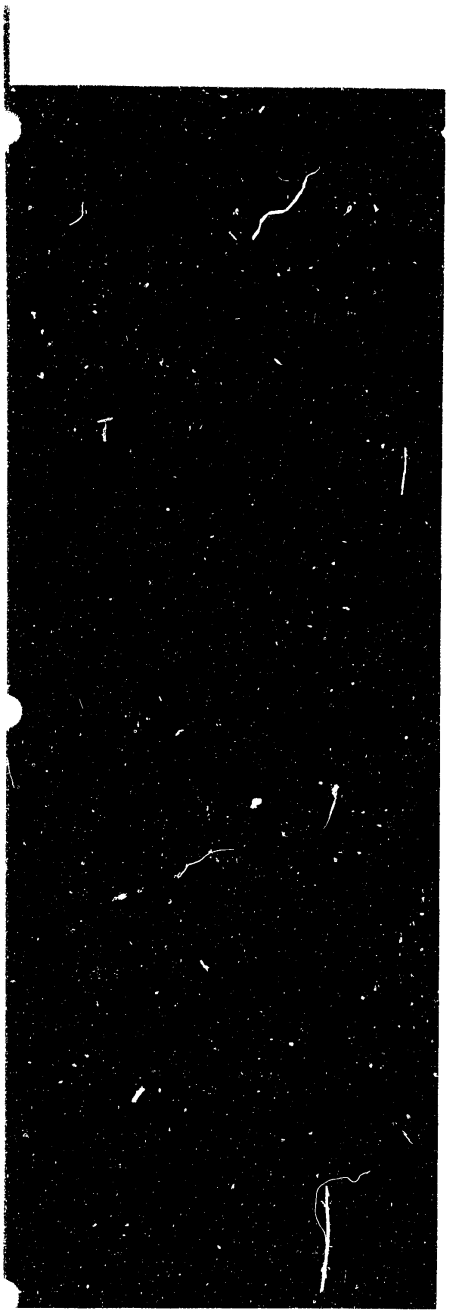
The NIS is National Intelligence and may not be released or shown to representatives of any foreign government or international body except by specific authorization of the Director of Central Intelligence in accordance with the provisions of National Security Council Intelligence Directive No. 1.

For NIS containing unclassified material, however, the portions so marked may be made available for official purposes to foreign nationals and nongovernment personnel provided no attribution is made to National Intelligence or the National Intelligence Survey.

Subsections and graphics are individually classified according to content. Classification/control designations are:

(U/OU) . . Unclassified/For Official Use Only
(C) . . . . . Confidential
(S) . . . . . Secret

This chapter was prepared for the NIS by the Central Intelligence Agency. It includes contributions by the Departments of the Air Force, Army, and Navy and the Defense Intelligence Agency. Research was substantially completed by November 1972.



SWEDEN

CONTENTS

FIGURES

Science

A. General (U/OU)

Sweden enjoys an impressive position in the field of science and technology, ranking well ahead of the other Scandinavian countries. It has made many important contributions to science, and several Swedish scientists have been recipients of the Nobel prizes, derived from funds provided by the Nobel Foundation of Sweden. Because of the rapid growth of scientific research in many other countries, the overall impact of the Swedish scientific effort on worldwide science and technology has decreased, but the quality of scientific research remains very high. A country of the size of Sweden with a population of 8 million cannot have the financial resources or the number of technically trained personnel to compete effectively in all scientific fields with such countries as the United States, the United Kingdom, the U.S.S.R., or West Germany. Nevertheless, efficient management of limited resources, well-equipped research facilities, and excellent scientific manpower have contributed to a strong research and development capacity.

Swedish leaders are aware of the rapid progress of science and technology and of the impact of advancing technology on social progress and economic development. Because the growth of the population is slow and the level of employment is high, further expansion of the economy must come mainly from more advanced technological methods, the development of new skills, and improved utilization of manpower. Research is being deliberately stimulated and directed toward meeting national needs, and both private industry and the government are cooperating in the endeavor. The government has set up a mechanism to give greater direction to the planning and coordinating of research and has undertaken programs for the expansion of higher educational facilities.

Most of the research is of an applied nature, although some excellent basic research is done in the medical, biological, and physical sciences. Outstanding research is underway in biochemistry and limnology. Sweden is close to attaining world leadership in these fields, paralleling its traditional prominence in the biomedical sciences.

Sweden cooperates internationally in scientific affairs on a bilateral basis as well as with multilateral organizations such as the International Atomic Energy Agency (IAEA), the European Nuclear Energy Agency (ENEA), the European Organization for Nuclear Research (CERN), and the Southern European Observatory. It is a member of the principal international astrogeophysical organizations. Sweden also participates in the European Space Research Organization (ESRO), but is not a member of the European Launcher Development Organization (ELDO). Although there have been some indications that Sweden might discontinue its ESRO membership and concentrate on a national program of space research, it has agreed to participate in the various programs at ESRO at least until 1974. Sweden is a member of the International Council of Scientific Unions (ICSU) and the Scandinavian Council for Applied Research, which was set up in 1947 to promote cooperation in scientific research and development among the Scandinavian countries. Swedish scientists take an active part in international scientific

conferences abroad, and many international scientific meetings are held in the country.

Sweden has numerous agreements for scientific and technical cooperation with Western and Communist countries. In 1967 the French initiated the formation of a Swedish-French Research Association as a means of furthering scientific contacts between the two countries. Several scientific agreements have been signed with the U.S.S.R.; in January 1970 Sweden and the U.S.S.R. signed an agreement relating to economic and technological-scientific cooperation. The agreement covered such areas as construction, shipbuilding, electrical equipment, transportation, and forestry, and provided for an increased exchange of researchers and scientific information. Individual agreements were signed with Hungary in 1969. Cooperation among the Scandinavian countries in all matters has been a long-standing tradition and is promoted by the Nordic Council, Nordic Cultural Commission, and the Scandinavian Council for Applied Research. One of the principal fields of cooperation is the peaceful use of atomic energy. As a result of action taken by the Nordic Council's Cultural Committee, the Nordic Institute of Theoretical Atomic Physics (NORDITA) was established in Copenhagen. Swedish scientists have participated in important fundamental research conducted at NORDITA.

Sweden was one of the first countries to use special attaches to follow scientific activities in other countries and has such positions in Washington, Paris, Moscow, Tokyo, and Frankfurt.

B. Organization, planning, and financing of research (S)

Research organization and guidance in Sweden, although diversified and decentralized, are effective. Government research councils, industrial research councils, and the universities and learned societies closely coordinate the scientific effort so that efficient use is made of the limited number of trained researchers and limited financial resources (Figure 1). Four types of organizations guide and coordinate research: 1) the research councils and research boards, operating under relevant ministries, which guide certain fields of research and allot government funds; 2) the ministries of the government, which oversee state research installations; 3) the scientific academies, which operate on government and private contributions; and 4) groups of scientists and industrialists, which often operate with some state aid.

The research councils are important government agencies which supervise and finance research. The councils usually have eight to 12 members and act as advisory agencies to the government on matters of science policy in their fields. The specific aims of each council are to oversee the research in its field, to initiate and review proposed projects, and to promote needed research by allocating government grants. The Ministry of Education and Ecclesiastical Affairs directs most of the important research councils, which are the Atomic Research Council, the Natural Science Research Council, the Medical Research Council, the Social Sciences Research Council, and the Humanistic Research Council. The Ministry of Agriculture has the Agricultural and Forestry Research Council subordinate to it. The Building Research Council is under the Ministry of the Interior.

An increasingly important agency for industrially oriented research is the Board for Technical Development (STU), established in July 1968. The STU is subordinate to the Ministry of Industrial Affairs and is concerned mainly with the support of applied research, the industrial exploitation of research results, and the adaptation of innovations to the needs of society. It also supports basic research insofar as it advances technological development. The STU essentially replaced and absorbed the functions of the following organizations: the Technical Research Council, which made grants for applied research, mainly to individuals; the Foundation for the Exploitation of Research Results (EFOR), which aided researchers and inventors in securing industrial support; the Institute for the Utilization of Research Results (INFOR), which provided financial support to industry for undertaking development of promising new methods and products; the Iron Ore Foundation (*Malmfonden*), which supported relatively large development projects, using funds (about US$2 million annually) received from the government-owned iron-ore mining company in Kiruna; and the Swedish Inventor's Office, which assisted inventors in patenting their discoveries and in making contact with industry. The STU supports the Scandinavian Council for Applied Research and directs the Council for Scientific Information and Documentation.

The Ministry of Defense directs one of the largest government scientific research groups in Sweden, the Defense Research Institute (FOA), Stockholm. It is supported by and serves the three armed services. The FOA coordinates the basic and much of the applied research effort of the entire military establishment and conducts research in its four departments, two divisions, and one laboratory: Department for

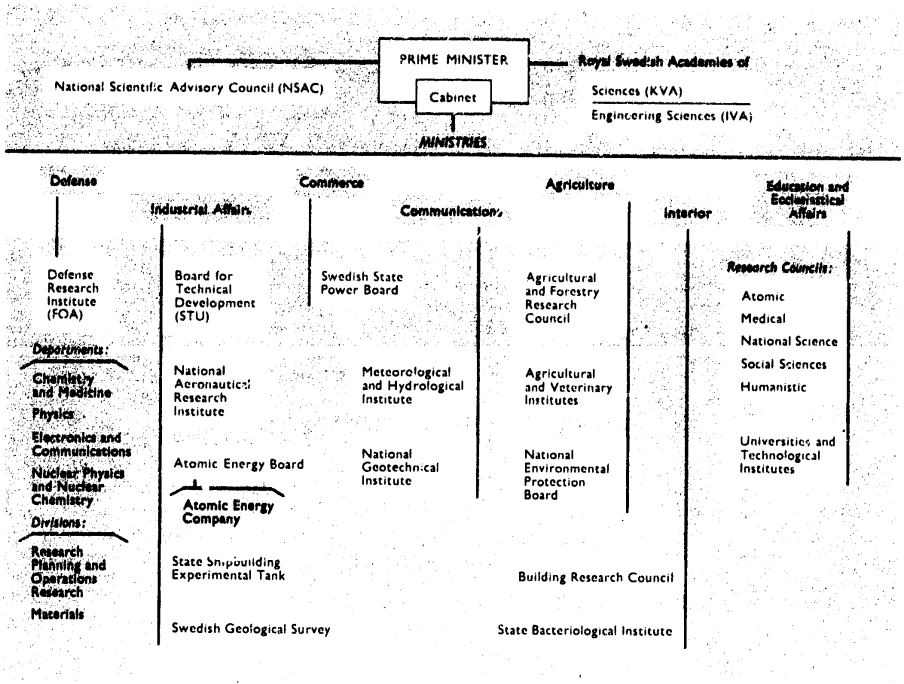


FIGURE 1. Government organization for scientific and technical activities, 1971 (C)

Chemistry and Medicine (FOA-1), at Sundbyberg, Department of Physics (FOA-2), Department of Electronics and Communications (FOA-3), Department of Nuclear Physics and Nuclear Chemistry (FOA-4), Materials Division (FOA-M), Division for Research Planning and Operations Research (FOA-P), and Military Electronics Laboratory (FTL). FOA-1 is concerned with chemical and biological warfare studies. FOA-2 undertakes research related to weapons systems. FOA-3 is engaged in all phases of transmission, transformation, and processing of communications information and systems, as well as basic radio research; special attention is given to wave propagation, antennas, and electron tube. It also does work on electronic warfare, radar, and sonar. The FTL is part of FOA-3, and its activities include electronics testing and standardization of electronic components and systems. FOA-4 cooperates with the universities in supporting research in nuclear physics and nuclear chemistry. The FOA cooperates with other organizations concerned with various aspects of defense research, including the Swedish Defense Staff, Defense Services, Royal Swedish Fortification Administration, Defense Medical Board, Medical Research Council, Directorate of the National Defense Factories, universities, and industries. Defense-oriented organizations which are subordinate to other ministries include the National Aeronautical Research Institute, Ulvsunda, and the State Shipbuilding Experimental Tank, Goteborg;[1] both are under the Ministry of Industrial Affairs.

The National Aeronautical Research Institute has wind tunnels for static and dynamic testing of airplane models in the range of subsonic to supersonic speeds. It also has equipment for testing complete structures, structural components, and test specimens under static and dynamic fatigue loading.

[1]For diacritics on place names see the list of names at the end of the chapter.

The Ministry of Industrial Affairs directs the Atomic Energy Board (AEB), whose functions are to advise the government on all matters pertaining to atomic energy, to plan for the development of atomic energy within the framework of the country's energy supply and requirements, to handle international cooperation in the field of atomic energy, and to deal with legal and safety questions. The AEB also makes recommendations to the Ministry of Industrial Affairs concerning appropriations of funds to the Atomic Energy Company, which was formed by the government and industry in 1947. The government assumed full ownership of the company in 1969. The company administers applied research and the atomic energy program; it also supports a significant amount of basic research in certain key areas of nuclear energy development. Basic nuclear research is supported by grants from the Atomic Research Council of the Ministry of Education and Ecclesiastical Affairs. The nuclear power program is directed by the Swedish State Power Board of the Ministry of Commerce.

The Ministry of Agriculture directs agricultural and veterinary research institutes, including the State Veterinary Medical Institute, Stockholm, and the Skara Veterinary Institute, Skara. Also subordinate to the ministry is the National Environmental Protection Board and its research committee. The Institute for Water and Air Pollution Research, Stockholm, was established in 1954 and is jointly supported by industry and the government. In 1970 the institute established the Foundation for Water and Air Pollution Research to reduce sharply the country's environmental pollution while retaining the industry's international competitiveness. The Ministry of Local Government and Communications directs the Meteorological and Hydrological Institute and the National Geotechnical Institute, both in Stockholm.

Coordination of both the national and international space programs is carried out by the State Delegation for Space Activities, which was appointed in July 1972 to replace the Space Research Committee. The latter, a joint committee of the STU, the Natural Science Research Council, and the Medical Research Council, resigned in protest against inadequate funding of the space program. The Swedish ESRO Committee, established in 1964, represents various ministries, the space research community, and industry, in the international organization.

A significant part of research, particularly fundamental research, is carried out in facilities for science and medicine of the universities which are operated by the government through the Ministry of Education and Ecclesiastical Affairs. The technical universities, also under the ministry, conduct considerable research with emphasis on the applied aspects. University research is supported by the national research councils, by various foundations, and by industry, as well as by funds directly appropriated by the government for the operation of the universities.

Several academies of science act as private sponsors in various areas of scientific development. All of them dispense public and private funds for research and for Swedish participation in international scientific and cultural conferences. Two academies are particularly influential: the Royal Academy of Sciences (KVA), founded in 1793, and the Royal Academy of Engineering Sciences (IVA), founded in 1919. Both academies are substantially private organizations, but receive a small amount of support from the government. Since 1947 a large part of the KVA's income had been derived from the printing of calendars, almanacs, and certain related publications; this source of funds was abruptly withdrawn in July 1972, and the government is considering a direct subsidy to replace the lost funds. The IVA's funds are derived mainly from industrial support. Although there is considerable overlap in their interests, membership, and activities, essentially the KVA promotes the basic sciences, while the IVA promotes research in engineering sciences to further industry and to improve utilization of natural resources. The KVA contributes to science planning and offers advice on science policy. It maintains an excellent scientific museum and library and directs several institutes in various parts of the country, the most important of which is the Nobel Institute, Stockholm, which is financed by the Nobel Foundation. The KVA awards the Nobel prizes in chemistry and physics. Membership in the KVA is restricted, and election to the academy is considered a high honor of scientific recognition by one's peers. The IVA's membership is larger than the KVA's, its resources are greater, and its activities are more diverse. It has a number of committees embracing virtually all engineering specialities, and it sponsors a variety of symposia, seminars, and publications. IVA shares with the STU the responsibility for selecting and administering Sweden's counterpart to the U.S. program of scientific attaches.

Industrial research is growing rapidly. A number of industrial enterprises have well-equipped laboratories and competent research staffs of their own. The greater part of industrial research and development is carried out within the big companies, especially the wood, pulp, paper, telecommunications, steel, and

machinery industries. The 98 largest enterprises (those with over 1,000 employees) account for more than three-fourths of total industrial research. Industrial applied research also is conducted in some of the universities, particularly the institutes of technology, in governmental laboratories, and in cooperative research institutes (*Branschforskningsinstitut*). These latter institutes have research programs of interest to a particular branch of industry and represent an effort on the part of Swedish industry to acquire the benefits of research through cooperative activity. In 1966 there were almost 40 of these institutes, some of which received partial financial support from the government. They play an important role in industrial research programs and are of particular importance to the smaller industrial organizations, which find it difficult to finance research programs in their own laboratories. The Swedish Institute for Metal Research, Stockholm, is one of the larger cooperative research institutes, employing about 55 people. The Swedish Forest Products Research Institute, Stockholm, also a cooperative institute, employs about 100 people in its main facility and 150 in special laboratories.

Sweden has no central organization responsible for coordination of research and for long-range planning. Informal coordination has been adequate for the small Swedish scientific community, and an intricate interlocking network of boards, committees, councils, and panels insure constant contact among key scientists of the country. Nevertheless, there is a growing sentiment within the government for the establishment of a formal body to be responsible for long-range planning, to establish priorities, to insure a balanced research and development program, and to provide for the allocation of resources to meet anticipated needs. The National Science Advisory Council (NSAC) was created in 1962 to provide long-range plans and counseling, but its role has been entirely advisory and without real authority. It has functioned mainly as a forum for discussion of research policy and consideration of research matters of broad interest to the scientific community. It is composed of highly respected individuals from higher education, the government, and commerce. In a reorganization in February 1969 its membership was reduced from 30 to 18, primarily by dropping industrial representatives. The Prime Minister is the chairman of the NSAC; there are two vice chairmen, the Minister of Education and the Minister of Industrial Affairs. The former is responsible for basic research and the latter for applied research and industrial development.

Since World War II, Swedish scientists have received steadily increasing and relatively generous financial support for their programs. However, during FY72 the amount approved by the government for research and development increased only 8% over the previous year; this is essentially a maintenance budget since mounting inflation and rising costs of research are expected to consume most of the apparent increase. Almost one-half of the total expenditure for research and development comes from nongovernment sources, indicating a growing interest by industry and private organizations in research and the industrial applications of research results.

Total expenditures for research and development during FY72, including that for private industry, amount to about US$500 million[2] or about 1.4% of Sweden's gross national product. Complete data on the government's support for research and development are not available; such funds are scattered among various agencies and are not in readily identifiable form as research and development funds. A partial breakdown of the government's support of research and development for FY71 and FY72 by major recipient is as follows, in millions of U.S. dollars:

	FY71	FY72
Office of the Chancellor of the Universities	$54.9	$60.1
Board for Technical Development	19.0	22.1
Defense Research Institute	16.6	19.8
Natural Science Research Council	8.4	9.3
Medical Research Council	8.0	8.6
Atomic Research Council	3.2	3.5
Agricultural and Forestry Research Council	1.9	2.1
Building Research Council	0.5	0.8
Atomic Energy Company	12.0	10.4
Environmental Protection Board Research Committee	2.2	2.4
Other state-owned research institutes	39.4	35.0

The amounts shown for the Office of the Chancellor of the Universities represent 30% of the total amounts appropriated for university operations; this is the percentage estimated that the higher schools spend on actual research activities. In addition to the amounts shown, the Building Research Council received an additional $7.9 million during FY71 and $8.1 million during FY72 from a special building research tax. Approximately $35 to $40 million is spent annually by other government organizations with research and development responsibilities, including the National Aeronautical Research Institute, Shipbuilding Experimental Tank, Geological Survey, National Institute of Public Health, and numerous smaller facilities.

[2]SKr5.01 = US$1.00.

The Atomic Research Council has requested a budget of US$6 million for FY73. In May 1971 the parliament placed the responsibility on the council for the additional costs of Swedish participation in the CERN program for a European 300 GeV accelator. This will amount to $1.3 million for FY73, an almost 50% increase over the FY72 allocation. High priority is given to plasma physics, and in FY72 the council received $320,000 for research in this field.

The higher educational institutions receive the major portion of their research funds from the Ministry of Education and Ecclesiastical Affairs. In recent years these funds have increased rapidly at the rate of 15% to 20% per year. In addition to the support received from the ministry, funds also are obtained from the research councils, private foundations, and industry for contract research. The national research councils comprise an important medium for the distribution of government funds to universities, technical universities, and research institutes. Of the US$47 million spent on research and development at the universities and other institutes of higher learning during FY68, $12.7 million was received from the national research councils, $3.9 million from foundations, $98,000 from contract research, and $195,000 from sources abroad.

Several private foundations provide about US$4 million annually for contract research at the institutes of technology and various research association laboratories. The most important foundations are the Wallenburg, Johnson, Bergwall, Dunkers, and Ericsson.

Although the FY72 budget provides only a modest increase for research activities in general, broad environmental protection activities have been accorded priority status, and the overall funds for this purpose have been substantially increased. The responsibility for these activities is centered primarily in the Ministry of Agriculture. The total environmental protection budgets for FY71 and FY72 amounted to US$38.3 million and $49.3 million, respectively. Of these sums, the specific allocations for research and development were $2.2 million and $2.4 million.

A 5-year budget (1970-75) for the Atomic Energy Company amounts to US$60 million. About $4.5 million is being spent annually by the company for research and development on thermal and fast reactors. The space budget has offered little consolation to the Swedish space scientists. The recommendation for a national satellite was rejected by the government as were the recommendations for increased space technological activities. National space activities are funded by the STU and the research councils. The Space Committee feels that $1.6 million is necessary for a viable program. The major space effort continues to be participation in the European Space Research Organization (ESRO). The appropriation for ESRO showed a modest increase in FY72, $5.6 million from $5 million the previous year. The Swedes consider this a practical investment since Swedish industry has been awarded a substantial portion of ESRO's developmental contracts.

The STU's budget has increased steadily since its establishment, but the appropriations have been consistently far less than the STU believed necessary to fulfill its responsibilities. Although for FY72 the STU requested almost double the US$18.9 million it had received during FY71, it received only $22 million.

C. Scientific education, manpower, and facilities (U/OU)

Sweden has a long tradition as a leading nation in the field of education at all levels of learning. With the exception of a few specialized schools, the educational institutions and their associated research institutes and laboratories are under the jurisdiction of the Ministry of Education and Ecclesiastical Affairs. The state maintains six universities and three technological institutes at the university level: the Universities of Stockholm, Goteborg, Uppsala, Lund, Umea, and Linkoping (the last established in 1970); the Royal Institute of Technology (KTH), Stockholm (Figure 2); the Chalmers Institute of Technology (CTH), Goteborg (Figure 3); and the Technological Institute of Lund. Supplementing the institutions of higher learning are a number of colleges, each covering a specialized field.

Students are not classified according to year as is customary in U.S. universities. A typical student will pass a general examination leading to the degree of *filosofie kandidat* or *filosofie magister* 3 to 5 years after admittance, and the degree of *filosofie licentiat* after several more years. The degrees of *filosofie magister* and *filosofie kandidat* are broadly equivalent, except the former signifies inclusion of pedagogy in the program. The degree of *doktor* is acquired several years after the *filosofie licentiat;* it is awarded in recognition of a major scientific contribution accomplished through independent research and represents a standing well above the average American doctorate degree. The excessive requirements of these degrees probably account for the relatively small number awarded. For instance, in 1963 only 600 *filosofie licentiat* and 80 *doktor* degrees were awarded

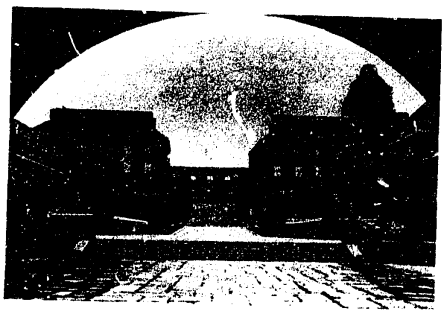


FIGURE 2. Royal Institute of Technology (KTH), Stockholm (C)

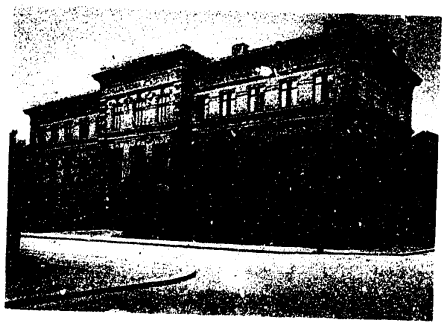


FIGURE 3. Chalmers Institute of Technology (CTH), Goteborg (C)

in the medical sciences and only 220 *filosofie licentiat* and 65 *doktor* degrees in the natural science and engineering fields. The exclusiveness of higher education seems to have had some beneficial byproducts. Students that go on to a higher education are strongly motivated and a career comparable with their education is expected by them. Also, a large number of students who are not qualified to enter universities enroll in vocational schools, and as a result the country is well supplied with technicians.

In spite of a rate of population growth of only about 0.6% per year, enrollment in institutions of higher education has continued to rise rapidly, as has the number of degrees granted. Enrollment in higher educational institutions rose from 36,500 in 1960 to 70,200 in 1965 and by 1970 had reached more than 110,000. The total enrollment of new students in 1970 was 24,700, 16% of which were enrolled in scientific subjects and 11% in engineering. The number of students desiring technical training in 1967 was nearly three times the number that could be admitted to the institutes of technology. Although expansion of the institutes was underway, facilities for technical education were expected to remain far below needs for several years. Scientific and technical manpower resources have improved considerably in recent years as a result of the increased enrollments in higher educational institutions, as well as by the immigration of scientists and engineers from other Scandinavian countries. Nevertheless, there is a continuing shortage of personnel with doctorate degrees despite an increase of 20% in doctoral candidates since 1967. A 1966 report prepared by a special government commission recommended the creation of a degree similar to the Ph.D. in the United States in order to shorten considerably the period of degree candidacy. The long period of study at a low level of recognition and compensation required for the traditional doctorate is felt to have restricted the number of individuals pursuing careers in science.

By 1971 approximately 20,000 persons were engaged in research in industrial facilities and another 7,700 in universities and government research institutes. Among the larger government facilities in 1968, the FOA had 1,600 employees, of whom about 400 were qualified scientists and engineers; the National Aeronautical Research Institute had about 230 scientists, engineers, and supporting personnel; and the Swedish Nuclear Research Center at Studsvik employed about 800 persons.

The Swedish public appreciates the relationship between science and economic and social progress, and has a high regard for scientific training. Scientists and engineers enjoy positions of respect and prestige and are generally well paid. The government pays scientists about as well as does industry and provides more freedom of action. Many professors receive extra income as consultants. The pay of Swedish scientists is substantially above the levels in Norway, Denmark, and Finland and in part accounts for the immigration of scientists from these countries to Sweden.

The opportunities for first-class research in Sweden are attractive. Laboratories are well equipped with modern instruments, many of which are of U.S. make. Throughout the years Sweden has procured modern and sophisticated instruments and equipment from leading manufacturers throughout the world. It also manufactures excellent laboratory research equipment of its own design. Researchers are well supported by laboratory space, shops, and technicians, although there is a general shortage of research assistants and associates. A scientist is generally free to exploit the

commercial benefits of his discoveries, and the government organizations will assist to make the exploitation effective. An atmosphere of freedom in the way a researcher works is typical of the Scandinavian countries. The response of industry to new discoveries is gratifying, and the IVA serves as a valuable link with industry between pure and applied sciences.

D. Major research fields

1. Air, ground, and naval weapons (S)

Sweden has a strong military research, development, and production capability. Although its weapons research program is limited in scope, the work being accomplished is of high quality. The level of progress achieved is attributable largely to adroit management of the nation's limited resources, well-equipped research facilities, and extremely competent scientists and engineers. Sweden's policy of strict neutrality, combined with the nation's geostrategic location along the access routes to the Baltic, have impelled the government to adopt a strategy of total defense. Such a strategy is designed to provide adequate defense against atomic or conventional attack, invasion by sea or by land, or offensive actions by foreign aircraft or missile penetrators. The effectiveness of the Swedish defensive forces is based on the good cooperation existing among the military forces, the government, and industry on a sound, well-regulated military research, development, and procurement program. Every factor of the Swedish economy and industry is a part of a totally integrated defense plan. For the past 25 years, the country has followed a plan that essentially calls for the government, in making its yearly appropriation to industry, to approve also a long-term program specifying what weapons and related equipment will be purchased for the ensuing 4-year period. This system of long-term procurements planning has given Swedish defense industry a healthy stability, which in turn has been reflected in the high standard of equipment turned out by its manufacturers. However, limited manpower and financial resources have made it necessary to conduct weapons research along specific lines with definite goals. Toward this end the focus is upon the development and production of defensive-type weapons; there is no discernible activity associated with the development of strictly offensive weapons, such as intercontinental ballistic missiles, intermediate or medium-range ballistic missiles, and medium and heavy bomber aircraft.

Major Swedish weapons are of indigenous design, and concerted efforts are made to continue an independent capability in the development and production of advanced weaponry. The maintenance of this capability has depended heavily on the acquisition of licenses and technology from abroad. All Swedish weapons research and development programs are planned, implemented, and conducted in a meticulous manner, and stringent cost analysis procedures are followed throughout each step of a given weapon system's development. Operating with little reserve and coupled with the growing complexity and costs of contemporary weaponry, the Swedish defense industry is becoming more vulnerable to any weakening of the country's economy. Spending limitations imposed in the 1968-72 defense budget have constituted the single major factor to slow progress in weapons research and development.

To offset the impact of military spending cutbacks, the Swedish aircraft industry, with government support, is vigorously attempting to improve its potential for civil aircraft development and production. In 1968 *SAAB-Scania AB* (SAAB), Linkoping, purchased *Malmo Flygindustri* in Malmo in order to acquire a light aircraft production capability. Of greater significance is the fact that, following several abortive attempts to initiate a Swedish commercial transport program, SAAB is joining with the British and West Germans in a collaborative effort to develop and market a quiet short-take-off-and-landing (STOL) transport. An agreement with the British Aircraft Corporation and *Messerschmitt-Boelkow-Blohm GmbH* has been negotiated, and development activity on the resulting aircraft has moved into the preliminary design phase. However, despite all efforts to improve the nation's potential in the civil aircraft field, the main commitment of the Swedish aeronautical industry in the foreseeable future will be to military programs, including both aircraft and tactical missiles. SAAB has developed several types of air-to-air and air-to-surface missiles which provide growth possibilities through the application of improved technology in the missile guidance, control, and propulsion fields.

The Swedish aeronautical industry, while relatively small in terms of total output, has one of the most advanced design, development, and production capabilities in Europe. The main aeronautical capability is represented in two organizations, the Aerospace Group of *SAAB-Scania AB* and the Flygmotor Division of Volvo at Trollhattan, producer of jet engines. SAAB has a highly successful history of jet fighter development and production, and generally

speaking its policy has been to have one major system in operation, one in production, and one system under development. Since the late 1940s, SAAB has developed four jet fighter or interceptor aircraft: the J-29 Flying Barrel, J-32 Lansen, J-35 Draken, and J-37 Viggen multirole combat aircraft. The Aerospace Group of *SAAB-Scania AB* employs about 5,800 workers, representing roughly 20% of the entire corporate work force. In production at Linkoping are the export version of the J-35 Draken supersonic fighter and Saab 105 trainer and light aircraft, as well as the initial production version of the AJ-37 Viggen. The production of Flygmotor, where 2,000 workers are employed, includes the RM-8 adaptation of the Pratt and Whitney JT-8D engine; production of the RM-6C Swedish version of the Rolls Royce Avon 300 series has been completed. Both of these engines are fitted with afterburners that are Swedish developments based on U.S. technology.

The development of fast interceptor and strike (ground attack) aircraft has been emphasized. The manned interceptor is considered to be the cornerstone of Swedish air defense, and the mainstay of the air defense system is the J-35 Draken aircraft. The Draken is an all-weather multipurpose (interceptor/reconnaissance/strike fighter) system capable of Mach 1.4 in sustained flight.

Flight testing of the AJ-37 Viggen essentially has been completed, and initial production of the system is underway. The Viggen is expected to absorb most of the Swedish aircraft production effort into the early 1980's. The Viggen is a multipurpose aircraft; its variants are intended to perform the attack, fighter/interceptor, reconnaissance, and training mission roles. The basic system is a canard-configured, double delta-winged aircraft capable of exceeding Mach-2 flight. Compared with the J-35 Draken, the Viggen has higher top speeds and better accelerations at all flight altitudes; it has better STOL-performance, including that of being able to operate from fields with runways under 1,600 feet in length.

The country has a small missile program confined mainly to the manufacture under license of foreign-developed, short-range, tactical weapons. Swedish technology is more than adequate to produce missiles of foreign design, to modify such weapons to meet particular needs, and in some cases to improve upon the original design. As a small country with limited financial and scientific resources, Sweden cannot develop a missile industry to meet all of its needs. Therefore, by means of independent, continuous study, the Swedes strive to keep themselves informed of the latest foreign missile research and are competent enough to recognize those developments abroad that have significance to their defense effort. The missile program includes the development and production of air-to-air, air-to-surface, an antiaircraft, and short-range ground and naval launched missiles.

In the air-to-air missile field, the Swedes have manufactured under license the U.S. Falcon missile, bearing the Swedish designations of RB-27 (with radar homing) and RB-28 (with infrared homing). The Swedes are developing an infrared homing air-to-air missile, the RB-29. This missile is to have a low-level capability, longer range, and a larger warhead than its two predecessors. Development testing of the RB-29 is projected for the spring of 1974; tooling up for production will be initiated following the end of RB-28 production that is being carried out to fulfill an order from the Finnish Air Force. Production of the RB-27 has already ended.

Air-to-surface missiles include the RB-04 and a modified version, the RB-04E, that is expected to enter production in 1973. The E modified system employs a higher thrust rocket motor and has improved guidance over the RB-04 model. Another missile program, the RB-05, has been under development for almost 10 years, but little success has been achieved.

An antiaircraft missile system is being developed by *AB Bofors* for the Royal Swedish Army. Designated the RB-70, the system is designed for use where optical identification of enemy aircraft is possible and reportedly is immune to jamming.

Sweden has an excellent capability for the design and development of army combat material. The country has designed and produced virtually all of its ground force material for many years, including fire-control equipment and tanks. Research on artillery weapons has been especially noteworthy. The Swedes have developed a rapid-firing 155-mm automatic self-propelled gun and are developing a 155-mm towed artillery weapon. Work on the latter weapon has progressed to the prototype stage. Work also is underway on the development of supporting ammunition.

Rocket technology has continued to advance, and several rocket-type weapons have been produced. In the design, development, and production of rocket-assisted projectiles and shoulder fired rockets, all necessary components have been produced indigenously.

Research is underway to improve the mobility and firepower of combat vehicles, an area of endeavor in which Sweden has an excellent capability. One of the more significant armored vehicles under development in a non-Communist country is the self-propelled gun

being tested by the Royal Swedish Army. Designated the IKV-91, or intantry gun vehicle (Figure 4), it consists of a turret-mounted, low-velocity 90-mm gun on a relatively large, lightly armored hull of simple design and construction. This vehicle is expected to fulfill Royal Swedish Army requirements for an amphibious armored vehicle with excellent mobility over marshy terrain and across water obstacles, as well as with the capability of combat with and in support of both the S-tank and infantry troops. Three prototypes of the IKV-91 are undergoing tests. If no major problems are encountered during the tests, delivery to army units is anticipated by 1974.

Research also is underway on two other armored vehicles, both of which employ the chassis of the Swedish designed and developed PBV-302, an amphibious armored personnel carrier. These are the BGBV-82, an armored recovery vehicle (Figure 5), and the BROBV-941, an armored bridge-launching vehicle (Figure 6). The bridge mounted on the latter vehicle is undergoing test and evaluation by the army.

Other research efforts are directed toward improved weapons and ammunition, specifically to improve kinetic energy performance, terminal effects, ranges, and fuzes. A 76-mm antitank weapon, designated Miniman, is a smooth-bore recoilless throwaway type and is intended for infantry use as additional firepower when combating armored vehicles. An 84-mm infantry recoilless weapon, the Carl Gustav, is being improved, and a 90-mm shaped-charge antitank projectile is under development. The Swedes also are developing radar-guided, light antiaircraft automatic weapons. The FOA has scheduled a research program to improve the performance of shaped charges to defeat bar armor arrays, to increase warhead lethality, to increase reliability, and to lenghen stand-off performance.

A new antitank mine and two new antipersonnel mines have been developed by *AB Bofors* for the Royal Swedish Army. The antitank mine is a shaped-charge mine designed to penetrate the hull of an armored vehicle and cause extensive damage internally to the vehicle and crew. One of the antipersonnel mines, nonmetallic and completely weatherproof, is a blast, contact, casualty-producing mine which is relatively shockproof; the other is a Claymore-type weapon that disperses lethal fragments over a 120° arc out to a maximum range of 400 meters.

Sweden has an impressive capability for the development and production of a wide range of transport vehicles, components, and related equipment. A number of tactical cross-country trucks in light, medimum, and heavy categories have been developed for the military. The principal companies involved in military vehicle research and development, *Volvo Penta AB* at Goteborg and SAAB have produced powerful high-mobility vehicles incorporating all-wheel drive, locking differentials, high ground clearance, flexible rough-terrain suspensions, and wide-profile tires. Amphibious versions are equipped with water-jet propulsion providing for operation in excess of 5 miles per hour in water. Swedish industry also has developed compact, high-torque hydraulic motors suitable for installation in terrain vehicles. Such motors are available in models of much greater specific power output than equivalent electric motors and in configurations suitable for wheel hub mounting.

In the field of vehicle diesel engine research, development, and production, SAAB is foremost and its products are noteworthy. Compactness, durability, and ease of maintenance are features which make the company's engines attractive to vehicle designers. United Stirling of Sweden, established in 1968, under license from Philips of the Netherlands, has undertaken an extensive program to perfect the Stirling engine and produce it in a range of sizes from 10 to 200 horsepower. Stirling's investigations cover both the rhombic drive engine, developed by Philips, and a double-acting V-type engine of unique design. Series production is planned for 1976, and applications include vehicle propulsion and miscellaneous special-purpose equipment.

The Swedish topographic equipment capability is small but of international importance, principally because of Swedish geodimeters. These electro-optical distance-measuring instruments, developed originally in Sweden by Eric Bergstand for geodetic and engineering surveys, are the best known and most widely used instruments in this equipment category. Because of their high accuracy, they are used in many countries as a standard for calibration of other electronic and electro-optical distance-instruments with a 40-mile range. The geodimeters are produced by AGA AB in Lidingo. The company also has developed a land navigation system for vehicles that has been demonstrated for the U.S. Army and is marketed to other non-Communist countries. Gyrotheodolite aiming circles used by the Royal Swedish Army are produced indigenously. Swedish research in photogrammetry, photo interpretation, and remote sensing has been recognized internationally.

Sweden has the capability to conduct research and development in the field of engineer construction equipment, but, because the country has no active

FIGURE 4. IKV-91, a self-propelled infantry gun vehicle mounting a 90-mm gun (U/OU)

FIGURE 5. Armored recovery vehicle, BGBV-82 (U/OU)

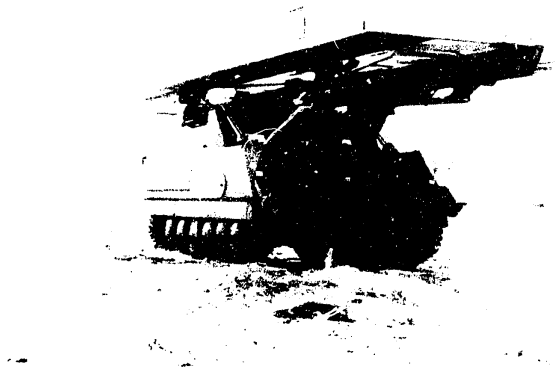


FIGURE 6. Armored bridge-launching vehicle (U/OU)

tactical army, very little research is directed toward military engineering equipment. However, many types of civil construction equipment, such as tractors, crane shovels, graders, road rollers, air compressors, and dump trucks, have been designed and produced in Sweden. Larger types of heavy earthworking equipment are imported from the West.

The country has an adequate capability for research, development, and production of a wide range of materials and POL-handling equipment. Research activities concern materials-handling vehicles for special cargo configurations, such as straddle carriers and a newly patented ISO (International Standard Organization) container-stacking system which utilizes special fastening devices to hold the containers within the stacking structure. Significant developments of POL-handling equipment include the "Liquitainer" and a semisubmersible bottomless tank. The Liquitainer is a collapsible 400-gallon container designed for the transport of liquid POL products by general-purpose vehicles; when empty, this container can be folded to one-third of its original height and can be used as a platform on the truck bed to hold solid goods or personnel on the return trip. The semisubmersible bottomless tank is constructed of fiberglass-reinforced unsaturated polyester plastic. It is designed for storing oil while anchored in the open sea, lakes, ponds, or harbor basins, and for servicing deep draft vessels that cannot enter shallow harbors. These tanks have capacities ranging from 528,400 gallons to more than 2,642,000 gallons and have been supplied to the Swedish armed forces.

An area in which the country possesses an appreciable capability is the research and development of naval weapons. The general design of warships is influenced by the defensive nature of Swedish military policy. Economic considerations have caused increased emphasis on coastal destroyers and smaller vessels, especially minesweepers and motor torpedo boats. The motor torpedo boats in the Royal Swedish Navy, displacing about 190 tons and capable of over 40 knots, are among the largest and fastest in the world. A comprehensive program to develop an improved version of their high-performance patrol craft is concentrating on research in hull form, supercavitating propellers, armament improvements, and engine design. Submarines are being designed for high submerged speeds, although a design of an advanced hull form, such as the U.S.S. *Albacore*, has not been seen. Research on submarine propulsion centers on the fuel cell concept of electric propulsion, and the Swedes are developing a 200-kilowatt cell, which will provide for an increased submerged capability. Much emphasis has been placed on deep-sea diving using mixed gases. Progress has been made on saturation diving techniques using submersible decompression chambers aboard ship. These efforts will greatly enhance Swedish capabilities in submarine rescue and ocean bottom searching.

Sweden is aware of the need for advanced underwater weapons systems, and research and development in this field are given high priority. Work on improved torpedoes is underway, and considerable progress has been made in the design of wire-guided torpedoes for use against submarines and surface ships. A small but competent sonar program exists.

2. Biological and chemical warfare (S)

In accordance with the terms of the 1925 Geneva Protocol, Sweden adheres to a formal policy of restricting its biological warfare (BW) and chemical warfare (CW) activities to the development of defensive capabilities. There have been unconfirmed indications, however, that the Swedes were doing some classified research which might be applicable to the development of an offensive BW capability. Sweden has the necessary organizational facilities, qualified professional and technical personnel, and funds to support an offensive BW research and development program. It is one of the best prepared of all nations in overall CW defense and is capable of supporting defensive military requirements. The country has a solid foundation for an offensive CW capability which has evolved from defensively oriented research.

The Swedes have conducted an active defensive BW program. The two principal organizations responsible for such work are FOA-1 of the FOA and the Bacteriological Institute of the Royal Caroline Medical-Surgical Institute. Defensive BW research and development have emphasized rapid detection and identification systems. Dr. Sven Johan Lundin of the FOA has done research on the use of ultraviolet absorption to measure the fluorescence of biological agents for rapid detection; he has been successful in detecting a single bacterium under laboratory conditions. Dr. Lundin also has studied the attachment of fluorescent antibodies to molecules of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) of microorganisms. The ultimate aim of such research is to develop an automated BW agent detection system that will collect a sample, fix, stain, read fluorescence photometrically, and provide specific identification. The Swedes also have demonstrated their familiarity with detection concepts

based upon the principle that biological material luminesces in the presence of luminolating luminol and upon the identification by gas chromatography of cellular metabolites likely to be present in disseminated samples of agents grown in cell culture. There is no indication that any biological detection system has been fielded.

According to FOA, cloud physics studies related to agent dissemination have clearly demonstrated the vulnerability of the country's coastal areas to BW attack. During Swedish studies on cloud travel, data were obtained concerning aerosol dissemination and sampling technologies. Intensive interest shown at the Stockholm International Peace Research Institute (SIPRI) concerning problems of chemical and biological warfare insures that Swedish scientists are thoroughly conversant with modern concepts and techniques for both defensive and offensive biological operations.

Swedish scientists are preeminent in the field of bioengineering, a technology which must be mastered if BW agents are to be produced for military applications. Fermentation equipment and related instrumentation of Swedish design and manufacture are of superior quality. A pilot-scale fermentation plant exists at the Royal Caroline Medical-Surgical Institute; other facilities equipped to support process research exist at the Microbiological Laboratory of the Swedish National Defense Laboratory and at the Kabi Company, Stockholm. There is no evidence that Sweden has produced or stockpiled either pathogens or microbial toxins for offensive warfare purposes.

Potential BW agents of tularemia, botulism and of foot-and-mouth disease have been studied in programs which emphasized rapid diagnosis and surveillance procedures, perhaps because these diseases have occurred within the country. A Swedish official has expressed an interest in the problem of stabilizing certain viruses, in particular those causing Venezuelan equine encephalitis (VEE) and eastern equine encephalitis (EEE), neither of which has ever occurred in Sweden. Toxins of *Clostridium tetanus* have been concentrated in a biphasic growth system which also would support the growth and elaboration of a protective antigen from the etiological agent of anthrax. All such studies could contribute data applicable to basic programs characterizing the potential of these various agents for biological warfare purposes.

The Swedish armed forces are not known to possess special organizations for BW purposes, and there is no evidence of any overt military training for such operations. The Royal Swedish Army maintains a chemical, biological, and radiological (CBR) school at Solna, near Stockholm, but courses are primarily designed to teach protection against CBR agents for both the individual and small units.

Sweden has an excellent CW research and development capability and is well ahead of other Scandinavian countries in CW research. All aspects are explored by highly qualified scientists at modern, well-equipped facilities and by a vigorous exchange of scientific information at international conferences. The FOA-1 is responsible for most of the CW research.

By virtue of its excellent defensive research and development program, Sweden has acquired much knowledge pertaining to CW offense. Swedish scientists have conducted CW agent research, including synthesis of the G- and V-nerve agents. Researchers feel that there is little possibility of synthesizing a nerve agent more toxic than those already in existence; consequently, they are investigating the possibility of increasing the lipid solubility of the existing nerve agents with a view toward increasing their speed of penetration. The Swedes also are interested in nonphosphorylated systemic poisons, such as galanthamines and carbamates; these substances contain no phosphorus but, like the G- and V-agents, can inhibit cholinesterase. Research has been conducted on natural poisons which could be candidate lethal CW agents. These include bacterial toxins (emphasizing botulinum toxin), marine poisons, and snake venom.

The Swedes apparently feel that the incapacitants show promise as successors to the lethal organophosphorous compounds as CW agents. Researchers have become interested in such compounds as psychochemicals, including lysergic acid diethylamide (LSD-25). Several years ago the Swedes conducted studies on glycolate incapacitants. Other incapacitating agents synthesized at FOA-1 were a series of glycolate esters with 3-quinuclidinol as a common moiety.

Processes for the production of nerve agents have been developed, and blueprints for manufacturing agents are available if the country should reverse its policy of maintaining a defensive posture only.

As in the BW field, cloud travel studies related to CW agent dissemination is of concern to Sweden. The cloud characteristics of aerosols disseminated by specific weapons including bombs, shells, and aerial spray devices are studied.

The Swedish detection effort does not differ significantly from the U.S. program, although variations in approach to the problem may produce data of interest. An effort is underway to exploit the

characteristics of the cholinesterase-anticholinesterase reaction in an attempt to develop a rapid-acting, sensitive, nerve agent detection system. This work involves the isolation and purification of cholinesterase from the plaice fish, which reportedly is as much as 10 times more sensitive to organophosphorous compounds than cholinesterase derived from other sources. FOA-1 is actively working on an automatic detection system using a combined gas chromatography-mass spectroscopy system; it is envisioned that the instrument would periodically sample the atmosphere, fractionate the sample in the chromatograph, and automatically characterize the components. The system would be amenable to computerization. An attempt also is being made to perfect point source manual detection methods. The most recent development is the "spin disc" detector. Each of the two to four small holes in the disc can be fitted for a different indicating or detecting capability. This device appears to have good potential for semiquantitative detection of single agents or qualitative detection of several agents.

Providing the capability for military personnel to operate successfully in a toxic environment is of foremost concern at FOA-1. The current military mask is becoming obsolete, and the Swedes are preparing for a new series to be introduced during the 1970's. The development of a new concept for individual troop protection was to begin in 1969; this concept may involve more throwaway items, such as clothing. The Swedes also plan to design new collective field shelters.

In keeping with national defense policy for a strong CW defense, the country is pursuing an intensive research effort in nerve agent prophylaxis and therapy. Although this effort has been extensive, no new antidotes have been found that surpass those already known. Scientists are studying fluorine substituted oximes as possible antidotes against refractory nerve agents, such as soman.

FOA-1 is investigating the distribution of the botulinum toxin in the body and the action mechanism that affects the acetylcholine level. Antibodies, tagged with fluorescent compounds, were used in this study. Swedish scientists believe that the Soviets have an antidote for botulinum toxin. Such an antidote has not yet been developed in Sweden, but the possibility exists that a chemical antidote may be found or that a modified antigen will be developed to produce an antitoxin effective against all types of botulinum toxin. FOA-1 also reportedly is researching antidotes for incapacitating agents such as psychochemicals. A strong Swedish interest in the U.S. incapacitating agent BZ is supported by efforts to develop an antidote for this agent, and a series of potential antidotes has been synthesized.

3. Atomic energy (C)

Sweden has a nuclear energy program of moderate size characterized by expanding electric power production facilities and a supporting research and development program emphasizing reactor physics and fuel development. The country has acceded to the nuclear nonproliferation treaty which, as a nonnuclear weapon state, prohibits it from developing nuclear weapons.

The Atomic Energy Company was established in 1947 as the central body for applied research and development in the nuclear energy field and is responsible for the construction and operation of nuclear research reactors, the production of uranium, the manufacture of fuel elements, and the production of radioactive isotopes. In addition, many industrial firms work closely with the Atomic Energy Company in the applications of nuclear energy. A group of private and municipal electric power concerns have formed the Atomic Power Group to cooperate with the Swedish State Power Board, under the Ministry of Commerce, in the development of nuclear power. The universities and technical institutes also support the nuclear energy program through research in fundamental nuclear physics and chemistry.

With the gradual commercializing of the nuclear power field, the Atomic Energy Company's tasks have changed. The company's activities are concentrated on research and development in close cooperation with industry and the power utilities and the latter two parties have taken over responsibility for the design and construction of nuclear power reactors. The change was emphasized in 1969 with the establishment of ASEA-ATOM, formed on a fifty-fifty basis between ASEA (*Allmanna Svenska Elektriska Aktiebolaget*) and the Swedish Government to construct nuclear power stations and to fabricate power reactor fuel. The present tasks of the Atomic Energy Company are to be an expert body to the government on nuclear matters, to represent the country in official international cooperation in the nuclear field, to supply expert knowledge on reactor safety matters, to be consultants to the power utilities, and to carry out research at the request of industry and other research organizations.

The Atomic Energy Company has constructed six small research reactors. The first reactor, named R-1, was constructed in Stockholm and began operation in 1954. All subsequent research reactors were

constructed at the Swedish Nuclear Research Center at Studsvik. Only three of the research reactors are still in operation—the R-2, R-2-0, and Kritz. The R-2 reactor is a 50-megawatt thermal (MWt), tank-type reactor, fueled with 90% enriched uranium and moderated with ordinary water. The R-2 reactor, which went into operation in 1960, is employed chiefly for materials testing and fuel development, and a large part of the company's income is derived from materials testing commissioned from abroad. The R-2-0 reactor is a 1-MWt swimming pool type reactor, fueled with 90% enriched uranium and moderated with ordinary water; it also began operation in 1960. The third research reactor, Kritz, went into operation in 1969. Originally constructed as a subcritical assembly, it was reconstructed twice as a zero-power reactor. The second reconstruction is used for experimentation on various types of uranium and plutonium fuel. All of the enriched uranium to fuel the research reactors was supplied by the United States. Three additional research reactors have been closed down; these were the R-1, the R-0, and the FR-0 reactors. The R-1 and R-0 reactors were heavy water moderated, natural uranium fueled reactors. The 1-MWt R-1 operated from 1954 to 1970, and the zero-power R-0 was in operation from 1959 to 1970. The FR-0, a 10-kilowatt critical assembly, was in operation from 1964 to 1972.

Although the Swedish State Power Board has overall responsibility for the nuclear power program, construction of the nuclear power stations is done by private industry under the supervision of the Atomic Energy Company. There are two nuclear power reactors in operation and an additional nine are either under construction or planned. The R-3 or Agesta, a small 75-MWt reactor, has been in operation since 1963 at Agesta, a suburb of Stockholm. It is a pressurized heavy water reactor and produces 10 MW of electricity as a byproduct of its principal use for space heating. Originally a demonstration project of the Atomic Energy Company, its operation was transferred to the Stockholm Electric Powerplant. The reactor has always operated at a loss and is scheduled to be closed down in 1974. A second heavy water moderated nuclear power reactor was constructed at Marviken but was never operated. The Marviken reactor has been abandoned, and the station will be converted to an oil-fired plant.

Sweden has abandoned the heavy water moderated type of reactors for its nuclear power program, and all subsequent reactors are to be Boiling Water Reactors (BWR) or Pressurized Water Reactors (PWR). The first truly commercial nuclear power reactor is the 440-MWe Oskarshamn-1 which went critical in 1971. Oskarshamn, originally named after the nearby small town of Simpvarp, is located on the east coast of the country south of Stockholm. Additional reactors will be sited at Oskarshamn, and three other power sites are at Ringhals, on the west coast south of Goteborg; Barseback, also on the west coast but north of Malmo; and Forsmark, on the east coast north of Stockholm. The schedule for construction of the additional BWR or PWR nuclear power reactors is as follows:

Facility and output (MWe)	Expected date	Type	Chief contractor	Status
Ringhals I 760	1974	BWR	ASEA-ATOM	Under Construction
Ringhals II 820	1974	PWR	Westinghouse	Do.
Oskarshamn II 580	1974	BWR	ASEA-ATOM	Do.
Barseback I 580	1975	BWR	ASEA-ATOM	Do.
Ringhals III 900	1977	PWR	Westinghouse	Ordered
Barseback II 580	1977	BWR	ASEA-ATOM	Do.
Forsmark I 900	1978	BWR	ASEA-ATOM	Do.
Ringhals IV 900	1979	PWR	Westinghouse	Do.
Forsmark II 900	1980	BWR	ASEA-ATOM	Planned

The slightly enriched uranium for fueling the BWR and PWR power reactors will be purchased from other countries; fuel for Oskarshamn I has been supplied by the United States. The Swedes have built pilot plants for fuel reprocessing and heavy water production. Since the heavy water moderated reactor type has been abandoned, Sweden has no plans to construct a heavy water production plant. The plan to construct an industrial size fuel reprocessing plant has been postponed until the nuclear power program is sufficiently large to permit economic operation, probably in the 1980's.

The uranium content of the oil shales of southwestern Sweden is estimated at about 1 million tons, one of the world's largest deposits. However, the ore is very low grade, containing only about 300 grams of uranium per ton of shale. Processing such a low grade ore is expensive compared with world market prices of uranium. The richest Swedish uranium deposits are in the shale of the Billingen area, where a uranium processing facility, the Ranstad Uranium Works, went into operation in 1965. The plant's present capacity is about 120 tons of uranium oxide per year, but the Swedes may well increase this capacity in the near future.

4. Electronics (S)

Electronics research and development activities, although somewhat restricted by decreasing fiscal allocations in recent years, are comparable in quality to those of other leading Western European countries. Highly competent scientists conduct electronics research at universities, industrial enterprises, and military establishments. Sweden is very active in military and commercial electronics development, and the government strongly supports laboratories and schools for this purpose. Applied research, some of it under contract for military agencies and for private industry, is done at laboratories attached to the various technical institutes and colleges. The two world-renowned technical institutes in Sweden, the KTH and CTH, have modern facilities where much electronics research and development are carried out. The most important industrial electronics research facility is the L.M. Ericsson Telephone Corporation, which has large modern research laboratories located at the site of the main factory in Midsommarkransen. A new development company, BELLEMTEL, has been formed to do specialized research and development, concentrating on advanced electronic communications systems and products; it is owned jointly by the L.M. Ericsson Corporation and the Swedish Telecommunications Administration, the government agency in charge of communications. Department FOA-3 is concerned exclusively with military electronics research and development and has done work in communications, electronic countermeasures (ECM), sonar, guidance, radar, lasers, and other electro-optic efforts, and in component developments.

The KTH has been investigating broadband countermeasure devices and reportedly is doing good work in plasma, Gunn, and avalanche semiconductor research. A considerable effort has been undertaken by KTH and others in fluidics research, but, because of failures of several ambitious programs, researchers are developing their technology from the basics. The field of fluidics is attracting the attention of control systems developers, and research is underway on such items as fluid amplifiers and vortex rate gyroscopes.

Sweden has made valuable contributions in instrumentation for macromolecular research, such as the Svedberg ultracentrifuge and the Tiselius electrophoresis apparatus. Other developments of significance have included Hannes Alfven's "trochotron," a stepping-beam switching tube; a three-level, solid-state maser; and ferrite one-way attenuators for wave guides and steerable antenna systems. Research also is being conducted on radar backscattering, medium gain antennas, and phased arrays.

An intensive development effort is underway on semiconductors. Sweden has made significant contributions to semiconductor technology through ion-implantation work with silicon and germanium. Considerable research is underway involving thin-films and flatpack miniaturized components for future communication systems.

Research is being conducted on cryotrons, microwave action in plasmas, methods of producing long-life electron tubes and transistors, and techniques of increasing the data rate to bandwidth ratio. Other projects have been concerned with analyzing and synthesizing p-n transistors, with low-noise amplifiers for radioastronomy applications, and with O-type carcinotrons with bifilar helices. Other subjects of interest have included parametric traveling-wave amplifiers, traveling-wave masers, very-low-frequency (VLF) propagation, and tropospheric scatter techniques.

A broad program of military electronics research and development is underway. Microwave tubes developed for military applications include L-band spin-tuned magnetrons for frequency-agile radar, high-power wide-band traveling-wave tubes and crossed-field amplifiers for advanced ECM applications, and phased-locked magnetrons for coherent intercept radar. Other military developments have included an improved airborne infrared camera; fuel cell power supplies; fire-control systems for air, ground, and sea applications; and missile-fuzing systems employing both optical and radar principles. Research and development are continuing on proximity fuzes, laser-diode fuzes, and an optical communications device.

Philips Teleindustri AB in Stockholm has undertaken extensive programs in the development of frequency-agile radars and is considered a leader in this particular field. Emphasis continues to be placed on improving system advantages to further reduce problems caused by sea/ground clutter, fading, jamming, and mutual interference. New programs have centered on developing frequency-agile equipment in gun fire-control systems. The FOA has developed a combination search-and-track radar used by the Swiss-produced fire-control system, Skyguard.

A number of Swedish-built laser devices are available for military use and are being evaluated, tested, and given limited deployment. These include a variety of ruby and neodymium-glass laser rangefinders for man-portable field artillery use, tank-mounted use, and airborne systems. The rangefinders'

capabilities and configurations are varied to accommodate specific task requirements and cover a range from 300 meters to 30 kilometers with an accuracy of plus or minus 10 meters. A cooperative agreement reportedly has been reached between a Swedish and a Yugoslav company for co-production of laser rangefinders for tank and field artillery applications in Yugoslavia. Swedish industry has been in the forefront of cloud height-measurement technology, an area which has potential for both military and commercial applications. Automatic laser equipment to measure ground-to-cloud level distance and to provide information on the thickness and structure of cloud formations has been developed. There has been some evidence of Swedish interest in plasma generation by laser and in controlled thermonuclear reaction (CTR) experiments at the University of Uppsala. An infrared communication system involving detectors operating at 10.6 micrometers and at 0.9 micrometers reportedly is under development for military applications.

Although the country has several hundred computers, most are small- to medium-scale types. The only significant manufacturer of computers is DATASAAB, the computer division of SAAB at Linkoping, which produces the medium-scale models, D 21 and D 22. It also developed small computers for airborne and industrial control applications. Sweden has, however, been an important supplier of peripheral devices, including magnetic tape units and punched tape equipment that are used with many foreign computers.

5. Medical sciences, including veterinary medicine (S)

Sweden has achieved and maintains a very high standard of excellence and productivity in biomedical research. This is founded on the competence and training of its personnel and generous financial support of basic and applied research. Medical investigations are linked closely with teaching. Most of the fundamental biomedical research is done in the university medical schools and in the KTH. A national policy foresees intensification of contacts between scientists of the northern countries, including Finland, Norway, Denmark, Iceland, and Greenland. The Medical Research Council coordinates Swedish biomedical research and stresses research in nutrition, cardiovascular diseases, environmental medicine, industrial medicine, pediatrics, alcoholism, pharmaceuticals, immunology, neural and psychiatric disorders, and diabetes.

Biochemistry and biophysics are research areas of particular excellence in Sweden. The biochemical approach pervades other areas of Swedish biomedical research and scientists emphasize the need for a fundamental understanding of the chemical and physical nature of physiological functions. Swedish scientists have developed an international reputation for competence in the biophysical separation of biologically important materials. Outstanding contributions are being made in the separation of proteins and other biopolymers, the characterization of antigens of cell membranes from human tumor strains, determination of the crystal structure of human enzymes, and the biochemistry of virus multiplication. Precise methods permit processing of single cells and biological materials on a microgram scale. Advanced techniques employed include X-ray diffraction, infrared spectroscopy, gas chromatography, electron microscopy, specialized absorbing agents, and mass spectroscopy. Attention is devoted to the study of the physicochemical properties of fats and fatty-acid derivatives, enzymes, peptides with extended aminoacid sequences, nucleotides, nucleic acids, and high polymer carbohydrates, especially dextrans. Study of energy exchange has included investigation of transport and energy conservation in photosynthesis and respiration, and the development of model systems of biological energy transfer.

Microbiological studies at the State Bacteriological Laboratory are undertaken to support diagnostic, bacteriological, virological, immunological, and parasitological examinations and to support production of sera, vaccines, and related substances. The Swedes have gained wide recognition for their germ-free studies with animals. Microbiologists are developing laboratory and bioengineering techniques for the continuous culture of micro-organisms. Procedures have been developed for the cultivation of bacteria and tissue cells and the preparation of crude enzyme systems. Practical interest includes research on biological fixation of atmospheric nitrogen and microbiological processing of vegetable wastes and the effect of environmental milieu on host-parasite relationships. Immunological research in the country is outstanding. A World Health Organization (WHO) Regional Reference Center for Genetic Factors of Human Immunoglobulins is located in Lund. Impressive research deals with the diverse aspects of cell-mediated immunity to tumors.

Fundamental research in physiology is closely associated with the application of biochemical and biophysical techniques. Investigators are examining the effect of chemical or physical intervention on

APPROVED FOR RELEASE: 2009/06/16: CIA-RDP01-00707R000200090022-2

sensory response, electrical and mechanical activities of single muscle fibers, intraocular pressure, and acoustic middle-ear reflexes. Clinical research in physiology is creative, adequately supported, and of high quality, with emphasis on circulation problems, pulmonary function, physiology of work and physical training, and evaluation of physiological testing and measurement procedures. Sweden is cooperating with Norway and also the U.S.S.R. in investigations of the physiology of deep sea diving. Research on alcoholism is concerned with the examination of morphological and functional changes after prolonged consumption, with the ultrastructural injuries of acute liver damage, and with vitamin therapy.

Cardiovascular research is at a high level of competence. Experimental hematology studies include pioneer work on the function of hemoglobin and the oxygen-binding capacity of blood corpuscles, the clinical aspects of coagulation and the fibrinolytic dissolution of blood clots, and the use of adenine additives for whole blood preservation. In a WHO-coordinated program, Sweden has contributed an investigation of the distribution and severity of atherosclerosis in the aorta and coronary arteries.

Productive research is underway in isotope labeling, a technique that is being applied to the analysis of derangements in cardiovascular tissues and related clinical problems, capillary blood flow, tissue oxidative metabolism and wound healing, thromboembolism, and cadaver kidney preservation. Projects are underway on the effects of radiation on biological objects varying from single cells to mammals with or without tumors, on radioecological problems, and on protection against radiation damage. Sweden is concerned about environmental contamination with radionuclides, and investigators are examining the hazards of radioisotope internal emitters and the prevention and treatment of exposure. Combined use of adsorbents and radioisotopes is assisting in the separation of fractions in immunological research.

The country has an excellent pharmaceutical industry, which is internationally recognized for the superior quality of its drugs. A WHO Reference Center for Authentic Chemical Substances is located in Stockholm. The National Pharmaceutical Laboratory in Stockholm undertakes research in the chemistry, pharmacy, pharmacology, and therapeutics of drugs. Pharmacologists are interested in psychopharmaceuticals for treatment of depressions, the effects of drugs on cholinergic mechanisms in the central nervous system, and drug regulation of circulatory mechanisms.

Growing interest in problems of pharmacology and toxicology has increased the national demand for trained personnel. University preparation of pharmacologists is excellent, but pharmaceutical and industrial toxicologists are in short supply. Solna is the site of a collaborating laboratory of the WHO International Reference Center for Air Pollution. The National Institute of Public Health is undertaking studies on the relation of exposure to environmental pollution and the incidence of respiratory diseases, as well as on the toxic action of trace elements in food and water. Excellent studies are underway on changes in metabolism following exposure to chlorinated pesticides.

Noteworthy investigations in psychiatry concern the development of psychiatric epidemiology, analysis of the social and clinical features of drug abuse, and study of the relation of cerebral brain flow during mental effort under normal and pathological conditions of the brain.

Basic and applied research on food and nutrition is expanding. Prophylactic and therapeutic studies deal with lipid deposition in cardiac muscle, and protein calorie requirements, primarily in foreign lands. Microbiologists are studying the biosynthesis of edible protein and development of bacteria-free packing systems for milk and fruit juice. Irradiation of food is being tested as a preservative technique. Sensory evaluation assay is being developed for control of food quality of preserved foods.

Capabilities for military medical research are excellent. Military medical scientists cooperate closely with their civilian counterparts and benefit from civilian scientific efforts while retaining a research capability within the military services. The Defense Medical Research Delegation, under the Ministry of Defense, plans, advises, and coordinates applied military medical research and provides grants to the Military Medical Research Center of the Royal Caroline Medical-Surgical Institute, the Naval Medical Research Center in Karlskrona, and the Aeromedical Research Institute in Malmslatt. The Military Medical Research Center is engaged in clinical, physiological, and BW investigations. The Naval Medical Research Center conducts research in submarine medicine and has a joint project with the U.S. National Institutes of Health. The Aeromedical Research Institute is concerned with general aviation medicine and is investigating the effects of low pressure and high altitudes on air force personnel. A Defense Medical Section within the Medical Research Council is concerned with coordinating and planning basic research and has six groups concerned with

research in aeromedicine, naval medicine, bacteriology, experimental psychology, toxicology, and burns. The FOA-1 coordinates military medical research with civilian agencies, in addition to conducting research in such areas as nutrition and psychology.

The veterinary research capability compares favorably with that of other major European countries. Sweden has long had effective research programs which have led to efficient animal disease control systems. The principal diseases still affecting the domestic animal population are actinomycosis, foot-and-mouth disease, parasitic infection, salmonellosis, and swine erysipelas. Major diseases such as brucellosis, anthrax, tuberculosis, and Newcastle disease have been eliminated or almost eliminated. Sweden has approximately 1,200 veterinarians, and a significant number are engaged in some form of basic or applied veterinary research. The major research facilities are the State Veterinary Institute and the Royal Veterinary College of Sweden, both in Stockholm; the Agricultural College of Sweden in Uppsala; and the Skara Veterinary College. Research programs at the State Veterinary Institute are directed primarily to those economically important animal diseases and conditions which limit animal production, and include studies on viral diseases, toxicology, parasitology, and leukemia. The Skara Veterinary College has been concerned with clinical and experimental diseases primarily related to deficiency diseases and infertility.

6. Other sciences (S)

a. Chemistry and metallurgy

Chemistry historically has been an important field of research in Sweden, and Swedish chemists have been awarded four Nobel prizes since 1903. The overall level of capability in chemical research and development is substantially higher in Sweden than in other Scandinavian countries, but lower than in the major countries of Western Europe. The strongest fields of research are biochemistry and physical chemistry. Industrial research is weak, except for research associated with the manufacture of paper. The chemical industry is dependent to a considerable extent on processes developed abroad. There is little applied synthetic organic research except for a modest effort in pharmaceuticals.

Research in biochemistry is broad and well supported at all of the country's leading educational institutions, particularly the Royal Caroline Medical-Surgical Institute. Much of the research has concentrated on proteins, enzymes, and amino acids. Specific studies have concerned the purification of proteins, size and structure of viral proteins, sequences of amino acids, and enzymic oxidation, transformation, and degradation.

The quality of physical chemical research is very good and centers on molecular structure, physical chemistry of polymers, and reaction kinetics. The Institute of Physical Chemistry at the University of Uppsala is one of the outstanding centers of physical chemical research in Europe. The institute, headed by Dr. Stig Claesson, is well staffed and very well equipped. It has done good experimental work on the physical properties of high-molecular-weight materials, such as cellulose and synthetic polymers. Research subjects are diversified and have included various types of diffusion experiments, light scattering, electron microscopy, flash photolysis, and the development of highly sophisticated instrumentation for studying polymeric materials. Good-quality research on polymers is being done at the KTH and CTH. Prof. Bengt Ranby of KTH has been active in research on polymer structure, degradation mechanisms, and radical polymerization.

A small amount of significant organic chemical research is being done in specific areas of interest to the pulp and paper industry, such as on cellulose, lignin, wood extractives, and the chemical reactions which occur during pulping of wood and bleaching of pulp. Broader subjects of research under study at the universities have included synthetic growth substances, terpenes, and organic sulfur and selenium compounds. Good research is underway at several of the universities in synthetic and physical organic chemical research. There has been some activity on the synthesis of pharmaceuticals. The Swedish universities apparently are well equipped with nuclear magnetic resonance instruments, mass spectrometers, and other apparatuses used in physical organic chemical studies.

High-quality inorganic chemical research is carried on at the universities and technical universities on a variety of problems involving metal complexes, solubility characteristics of complexes in organic solvents, hydrolysis of metal ions, and especially equilibrium phenomena. Although the work has been largely fundamental it has had a bearing on the practical recovery of uranium and other metals by solvent extraction techniques.

Very little analytical chemical research is undertaken, although Swedish chemists have up-to-date analytical equipment and are skilled in the use of the latest analytical techniques. In the area of physical

chemistry, electrochemistry is a subject of some importance, and considerable work has been done on stress corrosion, as well as batteries and fuel cells. A variety of other subjects have been studied, including inorganic complexes, the chemistry of uranium compounds, polyions, and the chemistry of seawater. The Institute of Inorganic Chemistry at the University of Stockholm has contributed greatly to the understanding of structural inorganic chemistry.

Richly endowed with iron ores but not with low-cost metallurgical fuels, Sweden traditionally has stressed quality rather than quantity in its metallurgical industries. A broad metallurgical research program is directed toward supporting the special steels and machine tool industries and is primarily developmental. Only a limited amount of basic research is pursued and fundamental research is generally neglected. The level of metallurgical technology is excellent and compares favorably with that of West Germany and France in ferrous metallurgy. Relatively little effort is directed toward nonferrous metals, although some research is conducted on aluminum and copper alloys.

The major metallurgical research facility is the Swedish Institute for Metals Research, a cooperative organization supported equally by industry and government. It undertakes research on analytical chemistry, physical metallurgy, corrosion, metals solidification, and powder metallurgy. The former director of the institute, Dr. Roland Kiessling, is world famous for his research on inclusions in steel, and the institute continues to perform excellent research on the subject. Other high-quality research is underway at the institute by Dr. Lennart Rahlin on metals behavior under combined creep and fatigue conditions, an area in which the Swedes excel. Considerable research is conducted on fracture mechanics. The institute also has conducted basic research on metal physics, chiefly stacking faults and transmission electron microscopy.

The KTH is active in metallurgical research and its effort has included research on electroslag refining, the fundamentals of arc behavior in gas metal-arc welding, the interaction of creep and fatigue in austenitic stainless steels, fatigue crack growth, and the formation of graphite in alloy cast iron. The KTH has done excellent research on creep mechanisms and fatigue crack growth. Extensive studies on fracture mechanics have been undertaken at the Technical University in Lund under the direction of Prof. K.B. Broberg.

Although the extent and scope of the metallurgical research conducted by governmental and academic facilities are impressive, the strength of the metallurgical effort rests almost entirely in the research conducted by private industrial laboratories. All of the metal producing companies have research facilities, which are well funded, equipped, and staffed. Most of the industrial effort is devoted to the development of improved refining methods and improved alloys. The Swedes have long been leaders in the development of advanced refining methods, and one of the first basic-oxygen steel production processes, the Kaldo process, was developed in Sweden. The process, developed by Dr. B.O. Kalling of *Stora Kopparberg Berslages AB* in Domnarvet, is an excellent steel production process for relatively small plants. The Swedish Electrical Corporation in Vasteras and the Swedish Ballbearing Works, Inc., in Goteborg, one of the world's leading producers of bearings, jointly developed a ladle refining process for inductive stirring of the melt in the ladle to produce high-quality steel. The Swedes have widely applied a Soviet development, electroslag refining, in their production of stainless steels and are more advanced in the use of electroslag refining than any other country in the West. Comprehensive research programs in this process are underway at various industrial firms. Other research on production processes has included work on heat-exchanger furnaces for magnetic reduction, sponge iron production, desulfurization of pig iron, and iron powder production. In addition, vacuum melting and vacuum treatment have been investigated thoroughly in connection with the production of heat-treatable alloy steels. Hydrogen cracking in high-strength steels has received extensive study.

The Swedes have long been leaders in the development of improved special-purpose steels. Sandviks Steel has developed several special-purpose corrosion-resistant stainless steels that are gaining wide acceptance in the U.S. petrochemical industry. *AB Bofors*, although not a metals producing company, has a metallurgical laboratory that has been studying hydrogen cracking of alloy steels, metals refining, fatigue creep, and corrosion fatigue. In addition to improved materials for weapons, the company has also developed materials for alloys for the pulp and paper industry.

The Atomic Energy Company has conducted appreciable metallurgical research directed toward support of the nuclear energy program. The research has centered on cladding materials (zirconium alloys and stainless steels), structural materials, pressure vessels, and materials for fast-breeder, liquid-metal cooled reactors, as well as welding and fabrication.

b. Physics and mathematics

The scope of Swedish research in physics is impressive for the size of the country. Most of the essential branches of physics are covered with the

greatest concentration in nuclear and solid-state physics. Other areas receiving a modest amount of attention are plasma, atomic and molecular physics, fluid dynamics, and superconductivity.

Research in solid-state physics is of good quality and mainly of a highly theoretical nature primarily due to the competency of the physicists engaged in the research. The departments of physics of the universities and technical institutes are extremely active in studying the electrical, thermal, magnetic, ferromagnetic, crystal, optical, and semiconducting properties of solids. In essence, most of the solid-state research is devoted to the study of materials on a broad scale. The KTH, CTH, and Lund Institute of Technology have conducted many advanced materials studies that have gained considerable recognition in Western Europe. Some of the outstanding research being done at these institutes involves studies of properties associated with dilute magnetic alloys and clustered magnetic ions by examining the energy spectrum and spin dependence. Other research is being done with such dilute magnetic alloys as cuprous ferrides and cobalts to determine their specific-heat values. Physicists at CTH are active in examining the optical properties of semiconductor materials. Photoemission studies are underway to examine the effects of structural disorders of silver-palladium alloys with regard to band structures of the pure compounds. At the Lund Institute of Technology, optical ionization cross sections of gallium phosphate crystals are being studied by using the charge storage and impurity photovoltaic effects measurements. A significant amount of research is being directed toward optical transmissions in cesium-coated copper. Although this work has been done only since 1970 in Western countries, the Swedish approach to using data from ultraviolet photoelectron energy spectra appears well advanced.

A significant portion of solid-state physics research is oriented toward advancing the country's semiconductor device capabilities. For example, mesa diodes are being studied to determine the mechanism that causes edge breakdown. Some of the results concern the contributing factors such as band bending or microplasma usually associated with point defects in semiconductor materials. Other indications of concentrated efforts in semiconductor device development are shown by research into such sandwiched structures as silicon and graphite and processes for thermal etching of the semiconductor surfaces. Swedish physicists show competency in third-order optical mixing, which they developed as a powerful diagnostic technique used in semiconductor physics at Umea University.

There is a general trend in the nuclear sciences toward concentrating efforts in low-energy nuclear physics and engineering at some sacrifice to the high-energy nuclear physics. The bulk of the low-energy nuclear research is being conducted in broad scope at the Swedish Nuclear Research Center at Studsvik at the FOA, and by the departments of CTH and the University of Uppsala. Much of the research has objectives aimed at determining the effects of prompt radiation exposures and at the study of nuclear decay schemes. This involves energy level studies of such radioactive isotopes as silver and cadmium which have importance because of their isomeric states. Transitions in decay are of interest for providing electron-gamma directional correlations. Of particular interest have been studies of nuclear particle detectors that are formed by ion implantation, which have been developed with fairly good resolutions. The Atomic Energy Company also concentrates its efforts in decay studies. At the University of Uppsala, a large amount of effort is being concentrated in the development of nuclear instrumentation. Although Swedish industry produces good nuclear detectors, it is continuing to develop some good-quality lithium drifted germanium detectors for studies related to absorption characteristics of materials subject to exposures at a broad spectrum of nuclear energies. The FOA is extremely active in nuclear research studies which appear to relate to defense against nuclear weapons and to radioactive characteristics of natural metal samples. The FOA has utilized germanium lithium detectors to conduct nuclear structure studies of inert gases via thermal neutron capture. It has done extensive research on neutral helium with regard to lifetimes of the excited levels of the gas. This involves a study of radioactive transition from doubly excited levels in helium and iodine.

Swedish research in high-energy nuclear physics is concentrated at the Nordic Institute of Theoretical Atomic Physics (NORDITA) in Copenhagen and at the University of Stockholm's Institute of Physics. Research is primarily theoretical and covers subjects concerned with elementary particles and cosmic ray emanations. High-energy nuclear research also is being conducted at the Universities of Lund and Umea. At the University of Lund the research deals with photomeson effects in efforts to probe reactions connected with the light nuclei. Based on the studies of reactions leading to meson production, physicists

have been able to determine the number of nucleons that contribute to a reaction on the basis of shell-model considerations. Physicists at the University of Umea are examining the field-model theory for scattering to determine relations associated with broken couplings between octet baryons and pseudoscalar octet mesons.

A major portion of plasma research is performed at the KTH. Other groups at the leading universities and the Atomic Energy Company have modest programs. Researchers at the KTH are examining experimental results and related theory dealing with rotating plasmas aimed at advancing Swedish capabilities for nuclear fusion, cosmic physics, and special applications such as the plasma centrifuge, condensers, propulsion, and the plasma gun. Some of the KTH's research relates to the separation of different species of elements and isotopes; the researchers are aided by their expertise in the development and use of mass spectrometry. Work is continuing on the confinement of plasma by using strong magnetic fields. Special plasma guns that produce magnetized plasma rings are under study at the FOA.

An impressive amount of laser research is being conducted at the KTH and CTH. A large portion of such research is oriented toward laser beam optics and holography. The research is aimed at restoring holograph images of a distorted or defocused nature by using extended range spatial filters. Ultra-short pulse lasers and the means for measuring the properties of the output pulses also are under study. Development of solid-state lasers is progressing well, based on Swedish capabilities for growing synthetic crystals and for research in relaxation effects.

The Swedes have always shown good capabilities in research related to atomic and molecular physics. Recent studies have concerned atomic and molecular structure of the benzene spectra and the isoelectronic series, such as thiophene, pyrrole, and furan. A major portion of such work is being conducted at the University of Uppsala. Some research is being devoted to the study and examination of hydrogen and helium atoms at the Institute of Physics of the University of Stockholm; the beam foil spectra of helium and oxygen are being studied, using a special spectrometer located in the beam tubes of the institute's Van de Graaff generator for the purpose of observing doubly excited levels of lifetimes of isotopic gases.

Fluid dynamics is a popular subject of physics research. The KTH is conducting limited studies of space charge conditions and Mach number in an electrostatic shock to note electron distributions that are continuous at the boundary between free and trapped electrons. Stratified fluids are of major interest to fluid dynamicists in connection with heat diffusion. Stratification involves a technique for arranging fluids in layers. Interest is in the mechanisms associated with basic stratification of fluid regions subject to thermal forcing, and the means for predicting properties for a wide class of boundary conditions.

Research in superconductivity is of high quality but narrow in scope. Other research involves specific heat measurements of zirconium compounds and the study of superconductivity properties and electron-phonon interactions in tantalum-vanadium alloys using resistant measurements to determine parameters connected with transition temperatures.

Sweden has been traditionally strong in mathematics. The quantity of research is substantial for a country of its size, and the quality is excellent. The Swedes are renowned for their work in statistics and are among the forerunners in data analysis and the use of computers in prediction theory and automation. Theoretical research centers on analysis, especially those branches of analysis dealing with the theory of partial differential equations, the theory of complex variables, and functional analysis. A minor but imaginative and competent research effort is underway in various branches of algebra, geometry, and topology.

Sweden is active in international mathematical affairs and participates in most of the international meetings. Since September 1970 at least 14 Swedish mathematicians have made extended visits to U.S. universities. An exceptional mathematical journal, *Acta Mathematica*, has been published in Sweden with the cooperation of Denmark, Norway, and Finland since 1882. It has become one of the most prominent mathematical journals, and its excellence is recognized internationally.

c. Astrogeophysical sciences

(1) *Astronomy and space sciences*—Although the Stockholm Astronomical Observatory of the KVA at Saltsjobaden was established in 1784, there has never been an appreciable effort in observational astronomy. However, significant theoretical contributions have been made. The country's northerly geographical position has motivated emphasis on auroral studies, and these in turn appear to have encouraged interest in other areas of aeronomy, notably upper atmospheric rocketry and ionospheric radiophysical research. The former has progressed into a more extended interest in space science, while the latter has developed into tropospheric and other environmentally related radiophysical research areas.

APPROVED FOR RELEASE: 2009/06/16: CIA-RDP01-00707R000200090022-2

Astronomical research is centered at the Stockholm Astronomical Observatory, observatories of the Universities of Uppsala and Lund, and at the Chalmers Institute of Technology. The University of Lund has established a new observatory at Romeleasen. The Stockholm Observatory engages principally in studies in celestial mechanics, stellar statistics, and solar physics. Since 1951 the observatory has had a solar research station at Anacapri, Italy, on the Isola di Capri, which participates in solar flare patrol activities. The University of Uppsala has three stations: the University Observatory in Uppsala, a modestly equipped observatory concerned with the study of stellar statistics and galactic structure; the Kristeborg Observatory at Malaren; and the Mount Stromlo station in Australia, operated in conjunction with the Australian National Observatory in Canberra. The University of Lund has a small observatory principally engaged in routine studies. Swedish radioastronomy appears to be confined to the Raon Space Research Observatory (also referred to as the Onsala Radio Wave Propagation Observatory), which is located on the island of Raon about 25 miles south of Goteborg and operated by the Electronics Research Laboratory of the CTH. The observatory has several radiotelescopes; the largest is a 25.6-meter parabola, which was erected about 1964. Research has been devoted to the study of galactic structure, and the large instrumentation permits reception of the very weak galactic signals.

Space research is limited mainly to firing foreign-supplied rockets for exploration of the upper atmosphere and ionosphere and for the study of solar phenomena. Space studies began in 1961 when the U.S. National Aeronautics and Space Administration and Sweden reached an agreement for the exploration of space. Sweden established a launching site in 1962, the Vidsel Military Firing Range, near Kronogard in Lapland, and furnished range support facilities and operations personnel. In 1966 ESRO established a sounding rocket launching range, known as ESRANGE, about 40 miles from Kiruna in Lapland. ESRO's decision to abandon its sounding rocket program made unjustifiable its continued operation of ESRANGE, and Sweden agreed to assume responsibility for its operation for a 5-year period beginning in mid-1972. Plans are underway to reduce the staff in order to cut down the high operating costs. Launches from the range have been restricted to low- and medium-altitude flights because of the small size of the range. Under the direction of the Space Technology Group of the Space Research Committee, the Flygmotor Company is developing a hybrid engine sounding rocket, SR-71, specifically for launching from the Kiruna range. The Ministries of Education and Ecclesiastical Affairs and Industrial Affairs have reported that the country will participate in ESRO's satellite projects for telecommunications, air traffic control, and meteorology.

Scientists at the Kiruna Geophysical Observatory provided a device on the ESRO 1A satellite to measure proton and electron energy in the 1-13 KeV range. Measurements from the satellite were correlated with ionospheric conditions at three Scandinavian sites and the observations from the all-sky camera and photometer recordings from the Kiruna observatory. A similar satellite experiment is being prepared for the ESRO IV satellite.

Cooperative agreements for space research have been concluded with other Scandinavian countries and with the Soviet Union. Sweden is a member of the European Telecommunications Satellite Conference (CETS) and the International Telecommunications Satellite Consortium (INTELSAT). Sweden participates to a limited extent in the Scandinavian Space Research Organization along with Denmark and Norway. A 1970 Swedish-Soviet agreement on space research provided for cooperation between the University of Lund and the Crimean Astrophysical Laboratory in the Soviet Union and for use of Swedish-built solar spectrographs on Soviet high-altitude balloons and Soviet satellites. Sweden participated in 1971 in the planning of a U.N. study of surveying earth resources, with special reference to the use of satellites. Some satellite tracking is carried out by the University of Uppsala, and in 1971 the country was considering the development of a Swedish scientific satellite for magnetospheric studies with a launching target of about 1975.

Sweden is active in a number of areas of aeronomy not associated directly with space activity. Ground-based aeronometric research is done in several fields. Cosmic ray observations are made by the Kiruna Geophysical Observatory and the Uppsala Ionospheric Observatory of the FOA. These observatories also are conducting auroral and radiophysics-related ionospheric research. The KTH is active in studying electric fields in the ionosphere.

(2) *Meteorology*—There are two separate meteorological facilities at the University of Stockholm that work in close collaboration, the Institute of Meteorology and the International Institute of Meteorology. The former institute has long been one of the leading institutes in the world in its field. Its research has encompassed numerical forecasting, theoretical and dyn[illegible]e meteorology, [illegible]nospheric

chemistry, air-sea boundary oceanography, and cloud physics. It has conducted studies of the global distribution of carbon dioxide. The International Institute is an independent organization affiliated with the University of Stockholm but granted direct support by the government. It was established after World War II to develop informal international cooperation in meteorological research. Its projects have included studies of circulation of chemical and radioactive substances in the atmosphere, cloud physics, and noctilucent clouds (clouds of unknown origin thought to be of dust, at altitudes of 50 miles, which may be observed at night in the reflected light of the sun). The institute participated in a sounding rocket project conducted from the Vidsel range in the early 1960's.

The Swedish Meteorological and Hydrological Institute, Stockholm, is the national weather service and has departments for climatology, hydrology, weather forecasting, and communications. The institute has announced plans for the complete automation, within 5 years, of weather observations and prognostic chart preparation activities. Operationally, the institute utilizes the same numerical weather prediction techniques as does the United States. The institute's research is principally applied.

Some meteorological research in the physics and dynamics of the atmosphere and in synoptic meteorology is done at the Institute of Meteorology of the University of Uppsala. The university has an Institute for High Tension Research which engages in the study of the basic nature of lightning and its physical manifestations. It has an observatory at Marsta near Uppsala, which is engaged in research in micrometeorology and atmospheric electricity and radioactivity.

(3) *Terrestrial geophysics and geology*—The Kiruna Geophysical Observatory engages in terrestrial geophysical research. It is apparently the principal Swedish geomagnetic observatory; observations often are coordinated with auroral studies. The observatory has conducted geomagnetic and telluric current observations. Other stations engaging in geomagnetic studies are located at Abisko, Lovo, Enkoping, Uppsala, Lycksele, and on Svalbard in the Arctic Ocean. In addition, temporary stations are established at various sites during field surveys to make both geomagnetic and telluric current observations. The station at Lovo records secular variations of the geomagnetic field and has investigated field transients and giant pulsations. Along with the station at Abisko, it also has participated in an international program in which these stations act as fixed reference points for artificial earth satellite measurements.

The Kiruna observatory also makes seismic observations, but the country's center for seismology is the Seismological Institute of the University of Uppsala, which has a participating station in the Worldwide Network of Standard Seismographs at Umea, on the Gulf of Bothnia. Other seismological stations are located at Karlskrona, Skalstugan, and Goteborg. At least since 1957 Sweden has seismically monitored Soviet and other nuclear explosions. There has been considerable interest in the Scandinavian Peninsula as a seismic nuclear detection site. A survey of Scandinavian interest in the establishment of a Large Aperture Seismic Array (LASA) system in Scandinavia was made in mid-1965. In 1968, 10 countries, including Sweden, the United States, and the U.S.S.R., participated in a seismic study group convened by the Stockholm International Institute for Peace and Conflict Research at which seismic methods for monitoring underground explosions were considered. A seismological observatory, under the direction of the FOA and located near Hagfors about 260 kilometers west of Stockholm, was inaugurated in May 1969. Its primary purpose is nuclear blast detection, but it will serve also for the international exchange of seismic data. The Nordic Cooperative Committee for Detection Seismology completed a study during 1969 for a cooperative effort by Denmark, Norway, and Sweden.

The Swedish Geological Survey conducts scientific geological research and does consulting work for government agencies and private companies. It prepared geological maps of the country in accordance with certain standard procedures. Southern Sweden is mapped to scales of 1:50,000 or 1:100,000, while central and northern Sweden are mapped to scales of 1:200,000 to 1:400,000. Regions of special interest may be mapped to the scale of 1:50,000. The survey is responsible for all mineral prospecting and exploration activities. It also engages in applied geophysics related to geological research. In particular, a 10-year program for the aeromagnetic mapping of northern Sweden is underway, and magnetic measurements have been made over the Baltic.

Due to successes in locating large offshore reserves of natural gas and petroleum in the North Sea, mainly by British and U.S. consortiums, interest in offshore exploration is increasing in the Scandinavian countries. Sweden has announced plans for initiating off-shore exploration for petroleum which will be conducted by Swedish teams since no concessions are to be made available to foreign firms.

The country stresses glacial geology, and from July to September 1966 a Swedish-led glaciological expedition with participants from Sweden, Norway,

Finland, and the Soviet Union made glaciological studies on Svalbard in the Arctic Ocean. The studies were an attempt to determine whether Svalbard was connected to the Scandinavian Peninsula by ice sheets during past glacial periods.

(4) *Geodesy*—The Geographical Survey Office, Stockholm, is the country's principal geodetic and mapping agency. It is responsible for geodetic, cartographic, aerial photogrammetry, and surveying projects, and also performs scientific investigations in geodetic and astronomic fields relative to measurements for the Swedish national network. Sweden has produced several outstanding personalities who are noted for research in geodesy. One of the foremost is Dr. Evert Arne Bjerhammar of the KHT, who has an international reputation for his theory of gravimetry.

The modern first-order triangulation network, begun in 1903, extends throughout the country and is tied to the networks of Denmark, Finland, and Norway. A lower order triangulation network was completed in 1964. During 1965 it was planned to continue work on the new first-order triangulation net in the region of Skane, Halland, and Kalmar. In preparation for the 1965 measurements, numerous towers were constructed in the areas of Skane and Kalmar. Second-order triangulation and tellurometer measurements were intended to cover the remainder of mountains in the Lapland area for which geodetic survey data are lacking. The Geographical Survey Office is undertaking second-order triangulation, with use of geodimeter and tellurometer measurements, in five provinces, and is planning to remeasure a north-south traverse through Sweden as part of the geodetic base line from Norway to Sicily. The Second Leveling began in 1951 and was completed in 1967. Results became available for Swedish general use and official mapping in 1970 and is referred to as the 1970 Leveling System.

In 1964 astronomic determinations with connection to Lovo were carried out on eight points in Jamtland. Recomputation of older astropoints and the establishment of new points along the coast of Vasternorrland from Harnosand to Aapua have been completed, and data processing of the previous field season measurements has started. Stellar triangulation experiments through satellite observation have been carried out on Lovo.

(5) *Hydrology, hydraulics, and coastal engineering research*—Hydrologic and hydraulic research is comparable to that of the most advanced Western European countries. Facilities are adequate, and scientists are well trained and competent. Most research is directed toward the production of hydroelectric power, river regulation, and timber flotation.

Hydraulic studies are performed in laboratories at Alvkarleby, Goteborg, and two centers in Stockholm; Alvkarleby is the principal center. Most hydraulic studies are conducted on scale models and are of an applied nature. Studies concern the design and remodeling of dams, with emphasis on spillways, log chutes, log flumes, and the location of energy dissipators. Hydrologic research is focused on the collection of river data. Swedish hydrologists and hydraulic engineers are active in national and international scientific organizations and conferences.

The coastal engineering research capability has grown through the initiative of the KHT and the CHT. The coastal engineering research program compares favorably with those of other Western European countries in terms of skilled manpower, adequate funds, and well-equipped research facilities.

Research programs by the institutes of technology are directed toward preventing shore erosion, engineering problems of shore structures, and methods of changing meteorological conditions over coastal and inland waters. Other projects include experimental and theoretical studies of coastal engineering, currents, sea level variations, and sedimentation. Many of the extensive underground civil defense projects in Sweden require new types of coastal engineering before they can be initiated.

(6) *Oceanography*—Oceanographic capabilities are relatively high, ranking next to those of Denmark among the Scandinavian countries. The research program is of a modest extent, limited by insufficient funds, personnel, and equipment for ocean area investigations. Research facilities are adequate for the coastal research effort. In an effort to increase the sources of protein in the country's food supply, the government has supported the development of marine fisheries. As a result, considerable emphasis is being given to biological oceanography. The Underwater Acoustics Section of the Royal Swedish Navy has increased research on underwater sound, and a good capability exists for the development of small-object sonar detection. Sweden is increasing exploration of its sea floor and is developing techniques and instruments for these investigations. During 1971 Swedish oceanographic research ships engaged in a program of data collection from deep basin areas in the Baltic Sea, fisheries investigations, and water pollution surveys. Development of underwater television is being pursued.

Goteborg is the center of the oceanographic effort and the major research facilities are located there. The

most important are the Oceanographic Institute of the University of Goteborg, the Marine Geological Laboratory, and the Research Institute for Marine Fisheries. The laboratory, formerly a division of the Oceanographic Institute, concentrates on studies of deep sea deposits, marine chemistry, paleo-oceanography, and marine pollution. The Research Institute for Marine Fisheries has undertaken biological surveys in the waters around Sweden, as well as investigations on the physiochemical characteristics of the sea as a biological environment.

Sweden is active in international oceanographic organizations and is a member of the International Association for the Physical Sciences of the Ocean (IAPSO), International Council for the Exploration of the Sea (ICES), Intergovernmental Oceanographic Commission (IOC), and the Conference of Baltic Oceanographers. It is also a member of the Nordic Commission to provide student training in oceanography and the Nordic Commission on Marine Biology. Sweden participates fully in arctic ice studies with other countries which have arctic interests.

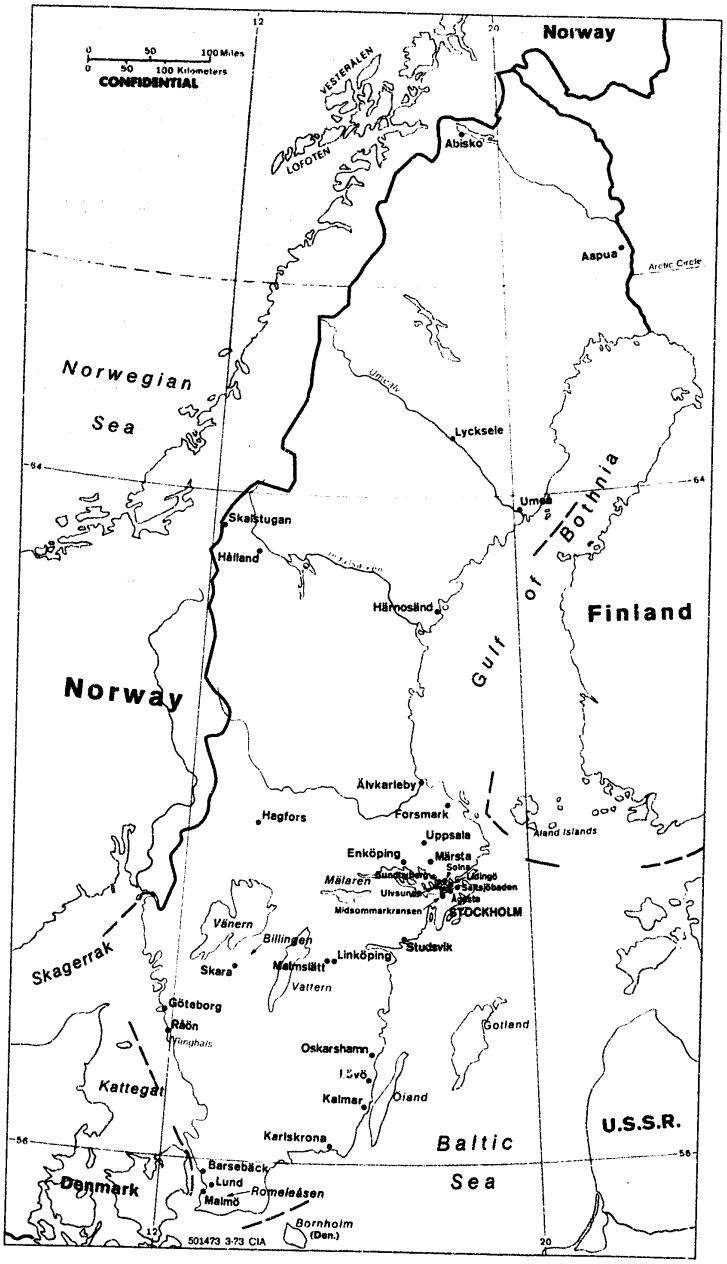


FIGURE 7. Selected sites of scientific activity (C)

Glossary (u/ou)

ABBREVIATION	FOREIGN	ENGLISH
AEB		Atomic Energy Board
ASEA	*Allmanna Svenska Elektriska Aktiebolaget*	Swedish General Electric Company
CTH	*Chalmers tekniska högskola*	Chalmers Institute of Technology
FOA	*Forsvarets Forskningsanstalt*	Defense Research Institute
IVA	*Ingenjorsvetenskapsakademien*	Royal Academy of Engineering Sciences
KTH	*Kungliga tekniska hogskolan*	Royal Institute of Technology
KVA	*Kungliga Vetenskapsakademien*	Royal Swedish Academy of Sciences
NSAC		National Science Advisory Council
SIPRI		Stockholm International Peace Research Institute
STU	*Styrelsen for teknisk utveckling*	Board for Technical Development

Places and features referred to in this chapter (u/ou)

	COORDINATES			
	°	'N.	°	'E.
Aapua	66	51	23	32
Abisko	68	20	18	51
Ågesta	59	14	18	05
Älvkarleby	60	34	17	27
Barsebäck (*estate*)	55	46	12	57
Billingen (*upland*)	58	24	13	45
Bofors	63	42	16	20
Copenhagen, Denmark	55	40	12	35
Domnarvet (*sec. of Borlänge*)	60	30	15	27
Enköping	59	38	17	04
Forsmark	60	22	18	09
Göteborg	57	43	11	58
Hagfors	60	02	13	42
Halland	63	19	13	19
Härnosänd	62	38	17	56
Kalmar	56	40	16	22
Karlskrona	56	10	15	35
Kiruna	67	51	20	13
Lidingö	59	22	18	08
Linköping	58	25	15	37
Lövö	56	59	16	28
Lund	55	42	13	11
Lycksele	64	36	18	40
Mälaren (*lake*)	59	30	17	12
Malmö	55	36	13	00
Malmslätt	58	25	15	30
Märsta	59	37	17	51
Marviken (*cove*)	60	07	18	49
Midsommarkransen (*sec. of Stockholm*)	59	18	18	00
Oskarshamn	57	16	16	26
Råö (*frm*)	57	24	11	56
Rå·on (*isl*)	57	24	11	56
Ringhals (*point*)	57	15	12	05
Romeleåsen (*hills*)	55	34	13	33
Saltsjöbaden	59	17	18	18
Simpvarp	57	25	16	40
Skalstugan (*farms*)	63	35	12	16
Skåne (*region*)	55	59	13	30
Skara	58	22	13	25
Solna	59	22	18	01
Stockholm	59	20	18	03
Studsvik	58	46	17	23
Sundbyberg	59	22	17	58
Trollhättan	58	16	12	18
Ulvsunda (*sec. of Stockholm*)	59	20	17	58
Umeå	63	50	20	15
Uppsala	59	52	17	38
Västerås	59	37	16	33

SECRET

NO FOREIGN DISSEM

SECRET

APPROVED FOR RELEASE: 2009/06/16: CIA-RDP01-00707R000200090022-2