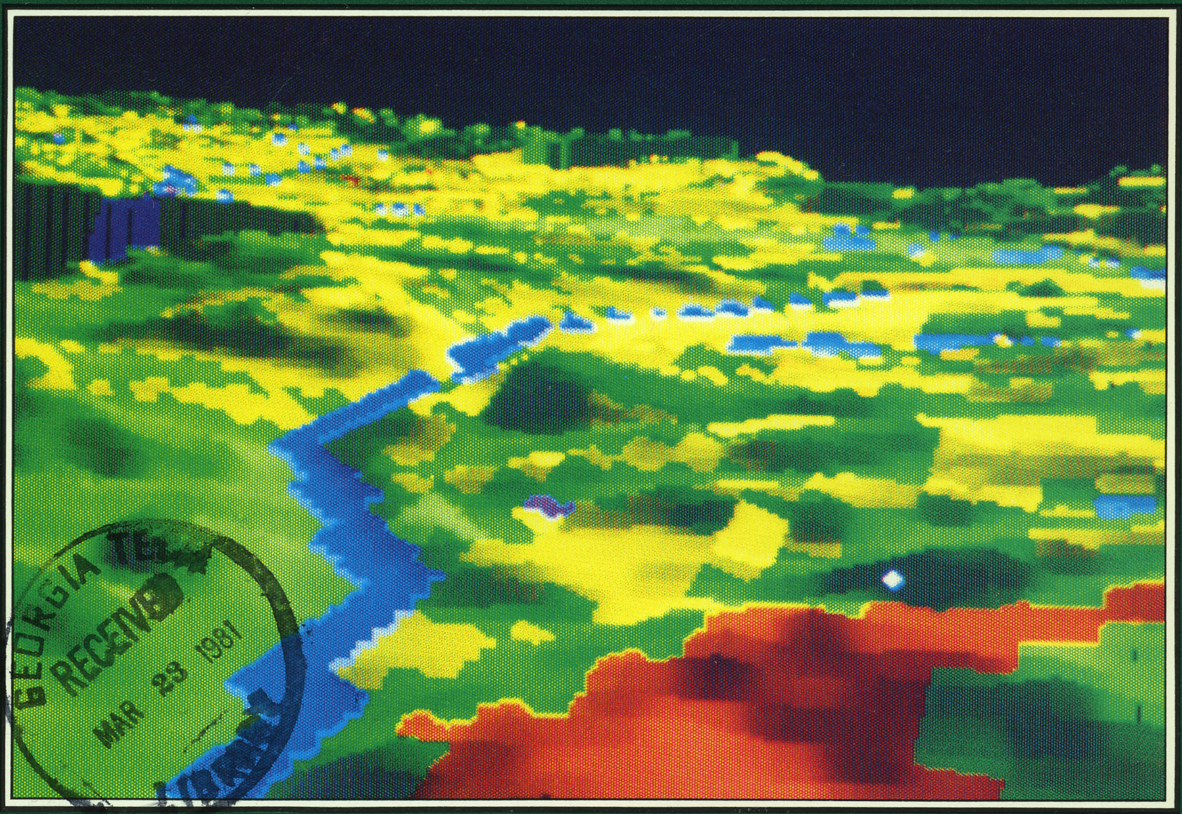
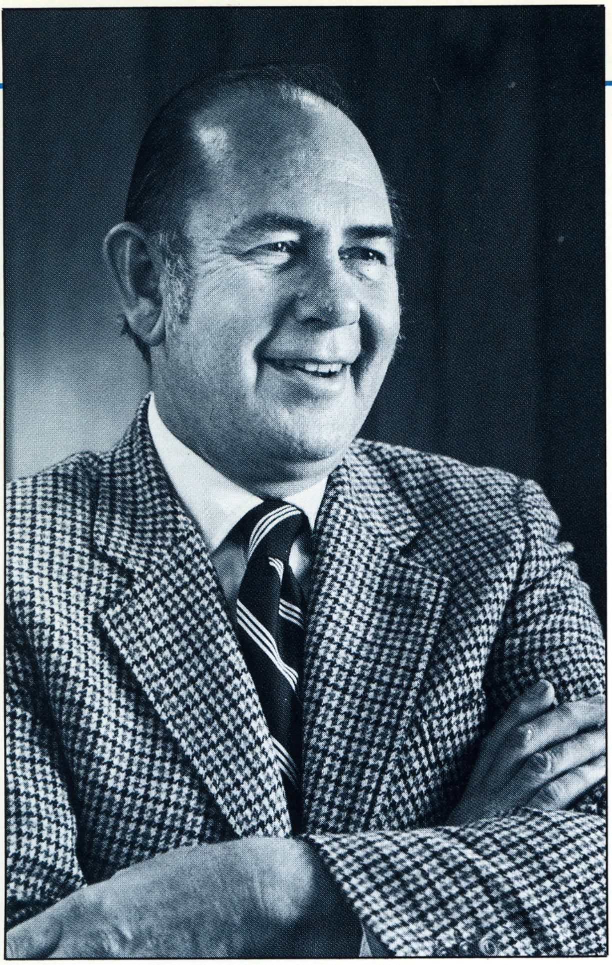
Annual Report
1979-80



GEORGIA TE
RECEIVED
MAR 23 1981

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332



EES Director Dr. Donald J. Grace

Observations of the Director

With America facing increasingly strong competition in the world's economic and military arenas, one of the United States' chief hopes for security and continued prosperity is the lead it holds in the development of advanced technologies. In this context, the country's research and development centers will play critically important roles in the closing years of the 20th Century.

As one of the nation's most respected applied research institutions, Georgia Tech's Engineering Experiment Station (EES) is making significant contributions to the drive for technological excellence.

EES has served the State of Georgia and the nation for nearly 50 years as a non-profit research organization. While the Station stresses practical applications of technology, it has also remained in the technological forefront in a variety of research fields for much of its history.

In the 1950's, the Station pioneered research in electronics equipment designed to improve America's military defenses and to make space exploration possible. The development of new technologies for the nation's defense continues as a major research thrust within EES. The Station broadened its mission during the 1960's to encompass economic development and opened a field office network which assists local governments, businesses and industries throughout Georgia. This outreach program has become a national model for similar operations which have begun in other states.

In the 1970's, energy shortages cried out for technological solutions and EES researchers focused increasing attention on economical methods for utilizing alternative energy sources, such as solar collector systems and the production of ethanol for gasohol from biomass resources.

For the last five years, the Station's growth has continued at a compounded annual rate of approximately 30%. During the past year, a research staff of more than 500 full-time professionals conducted research sponsored at a funding level of $32.4 million.

In 1979-80, six Electronics Laboratories within EES conducted a variety of civilian and military programs, ranging from the use of electromagnetic radiation to thaw frozen body organs to the development of radar systems with ever-increasing capabilities.

The Station's five Resources Laboratories were equally active, with engineers doing research as varied as the investigation of techniques for producing synthetic fuels from wood to a search for ways to recycle wastes during future long-term space voyages.

This report chronicles the Station's activities, its growth and development, and many of the outstanding research programs conducted during the 12-month period from July 1, 1979 to June 30, 1980. Its contents are drawn from among the many individual and team achievements of EES' dynamic and dedicated staff.

Donald J. Grace

Dr. Donald J. Grace, Director
Engineering Experiment Station

Table of Contents

B-475

Cover Photograph: This radiometric image of the Chattahoochee River in Georgia was taken from a satellite and displayed on EES' LANDSAT Image Analysis System.

The Year In Review

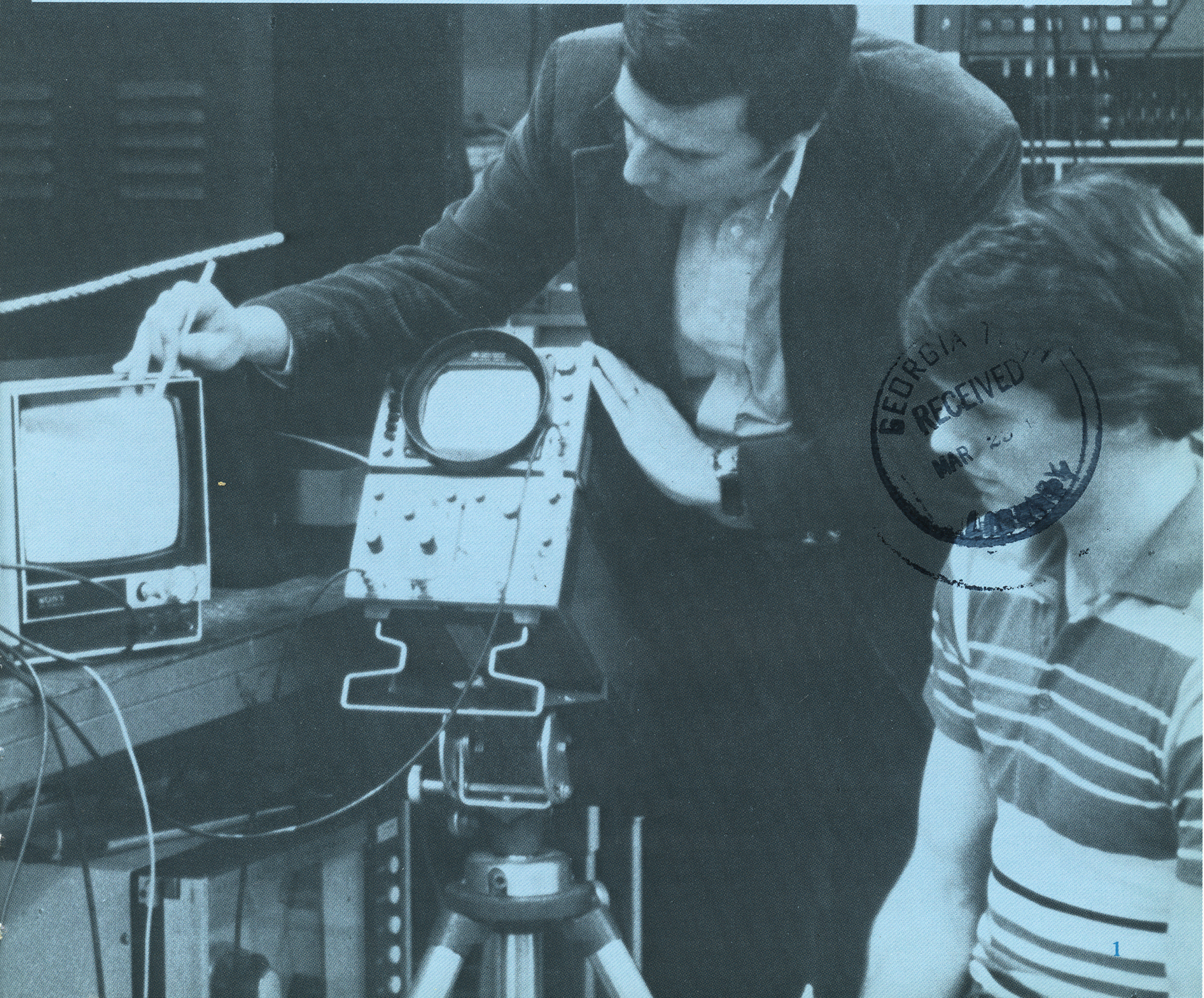
The Engineering Experiment Station (EES) is a center for applied research and development which serves its sponsors on a non-profit basis. During 1979-80, EES continued its traditional missions, while extending its services to Georgia and a variety of clients throughout the nation and overseas. Its staff of engineers and scientists handles about two-thirds of all the research performed at Georgia Tech, an institution which ranks fourth among all colleges and universities in engineering research and development expenditures. The remaining third is performed within academic units.

The Station's operations are overseen by Georgia Tech's vice president for research, and contracts are administered through the Georgia Tech Research Institute, a non-profit Georgia corporation organized to support Tech's research program.

EES was created in 1919 by the Georgia State Legislature to promote engineering and industrial research for the benefit of the state. In 1960, its mission was broadened and the Station now:

- Participates in national programs of science, technology and preparedness;
- Promotes business and economic development in Georgia, the United States and overseas;
- Encourages the utilization of Georgia's natural resources; and
- Provides technological support to the state's industry and local governments.

In 1979-80, EES fulfilled these commitments through an organization consisting of 11 laboratories, five devoted to resources research and six dedicated to electronics. The Station worked in the forefront in fields as diverse as alternate energy sources, industrial development, millimeter wave technology and electronic defense.



GEORGIA
RECEIVED
MAR

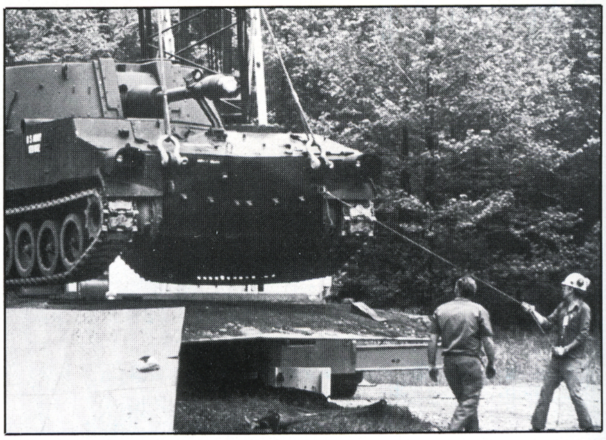
Research and Development Growth

In 1979-80, the Station achieved a 26% growth over the previous year in sponsored personal services (salaries and wages). During the year, 498 new research awards boosted the Station's overall income to $32.4 million. Contracts and grants from private industries and government agencies accounted for $27.4 million of EES' total income last year. Interdepartmental services provided $1.2 million and the State of Georgia allocated $3.8 million to research and development projects within the Station.

Staff-generated proposals topped all previous records in 1979-80. More than 800 new contract proposals valued in excess of $100 million were written. At year's end, 276 of these proposals were still outstanding for a potential contract value of $43.2 million.

Last year, 70% of EES' total sponsored personal services was in the broad area of electronics research. Staff research involving the development of the nation's natural, human and manufacturing resources accounted for 30% of EES' total activity. Major growth was achieved in two distinct program areas. Support for EES' electronic defense research rose to 43% of the total funding last year. The Station's economic development and technical assistance programs garnered 13% of all research awards, a 6% rise over 1978-79. Figure 1 details the distribution of EES' total sponsored personal services in 1979-80.

Sponsors



Agencies of the Department of Defense continued to be major sponsors of EES research and development programs in 1979-80.

Of the total sponsored research volume, agencies of the Department of the Defense continued to be the largest contributors. Department of Defense agencies sponsored 57% of all EES research in 1979-80. Within these agencies, the amount of work from the Army and Navy increased, although their share of EES' total research volume actually declined slightly. Contracts from the Air Force increased somewhat. These changes were accompanied by corresponding slight decreases in the level of sponsorship from NASA, the Department of Energy and other federal government agencies. Industry sponsorship rose from 13% to a total of 16%, while state and local government funding declined from 7% to 5% of EES' support in 1979-80.

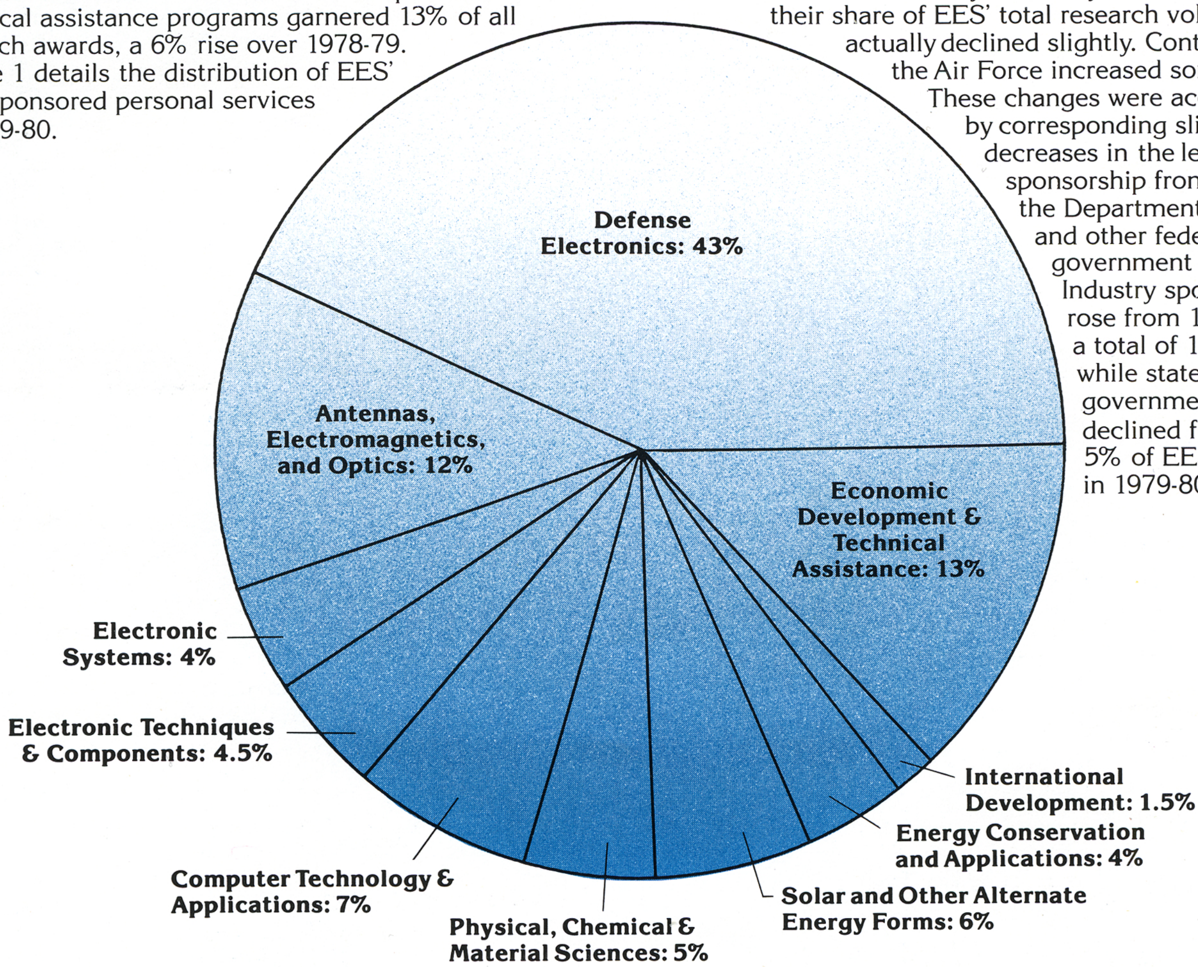


Figure 1

EES 1979-80 SPONSORED PERSONAL SERVICES

Distribution by Research Areas

New Technical Thrusts

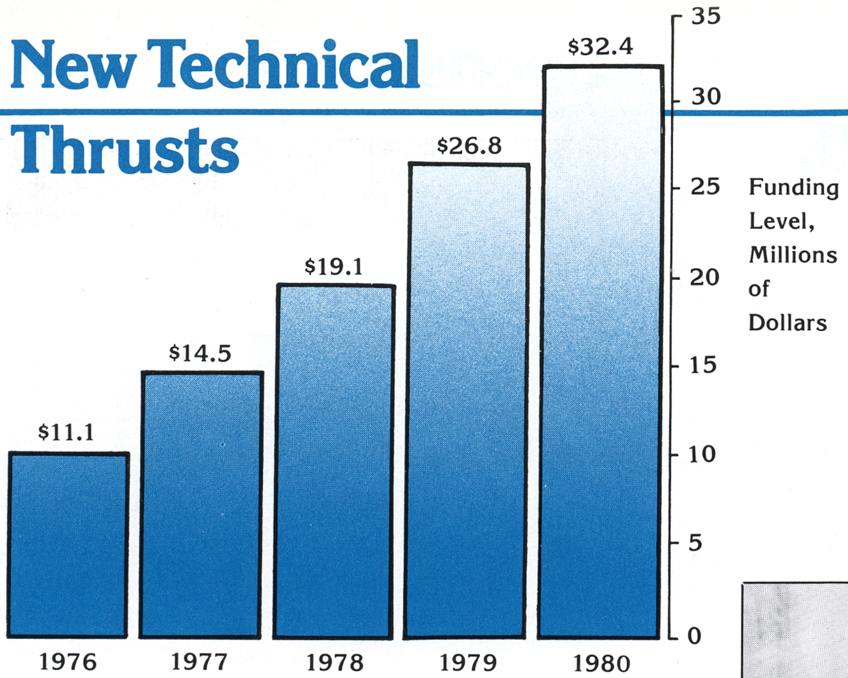


Figure 2

FIVE-YEAR FISCAL GROWTH IN EES RESEARCH VOLUME

During the past five years, EES has dramatically stimulated the growth of new research programs by allocating internal funds for equipment and seed support of innovative research leaders and entrepreneurs. These funds are given in addition to those regularly available to laboratories for on-going administrative and research support needs. The success of these investments is evidenced by the continuing growth in EES' research volume (Figure 2).

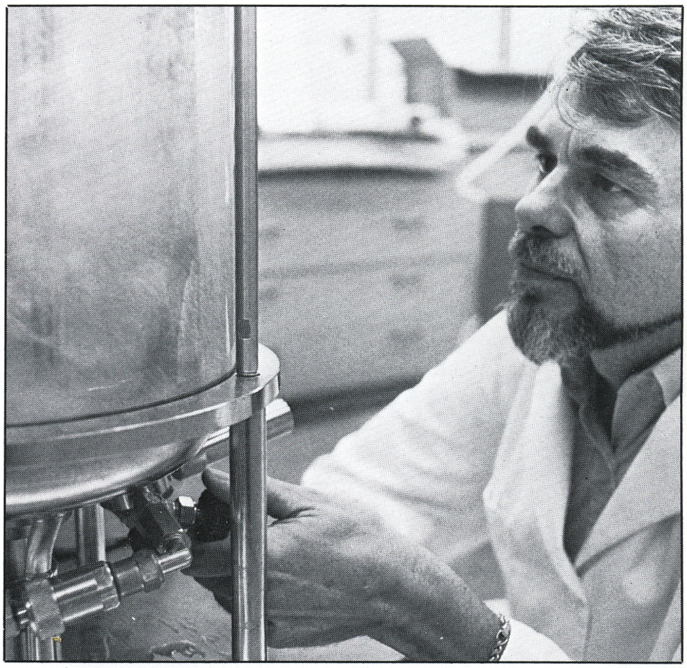
This past year, the investment plan had to be altered to accommodate heavy expenses for leased off-campus laboratory space. Discretionary funds were thus restricted to major equipment purchases and prior program commitments. Significant equipment purchases were made during the year which enhanced EES' overall research capabilities. Among the most important purchases were:

- Measurement instruments for upgrading the testing capabilities of the solar Advanced Components Test Facility;
- Equipment for a new transportation fuels testing laboratory;
- A cylindrical near-field range indoor measurements facility;
- A mobile radar electronic measurements facility;
- A radar signal processing facility; and
- New VAX computers.

The Station's overall equipment inventory is now valued in excess of $17.7 million.

Despite the lack of customary internal funding last year, several programs which had been fostered in the past received sharply increased emphasis and external support.

Particularly noteworthy were efforts in millimeter and submillimeter wave technologies. One key project involved the development of an Army-funded Mobile Measurement Facility which will incorporate fully automated state-of-the-art millimeter transmitter/receiver systems. Another program focused on the development of a new millimeter wave tracking radar. It will be a major sub-system of a helicopter-borne instrumentation sensor for millimeter wave terminal homing studies.



A major technical thrust during the year was the development of a new process for converting woody biomass to ethanol, the alcohol component of gasohol.

Of equal importance was an increased emphasis on the use of wood, Georgia's most plentiful natural resource, for the production of alternate energy fuels. The Station developed a unique process for converting woody biomass and other cellulosic wastes to ethanol, an alcohol fuel which can partially substitute for gasoline. Station engineers also devised an entrained pyrolysis process for converting woody biomass to a synthetic gas. Both programs have received extensive funding for on-going research and development.

EES research is varied and broad in scope, ranging from a $300 contract with a small businessman to multi-million dollar programs for agencies of the federal government. All of EES' major programs, and the research highlights of 1979-80, are summarized in the succeeding pages of this report.

Services to Georgia

The Station extended its services to Georgia last year by opening its eighth industrial development field office. Located in Gainesville, this area office serves the northeast portion of the state. EES' field office network has now provided technical information and direct assistance to more than 900 firms in Georgia.

Under the leadership of Governor George Busbee, EES played an important role in the organization of a new Advanced Technology Development Center for Georgia. The ATDC will be the focus of efforts to stimulate a thriving high-technology industry in the state. Located on the Georgia Tech campus, the ATDC will offer extensive assistance from Tech engineers to companies specializing in high-technology products.

Several major multi-year programs of assistance to Georgia business and industry were initiated or expanded during 1979-80:

- The first full year of operation of an in-plant consultation service in safety and health for Georgia firms drew national attention for its approach and effectiveness.
- EES was chosen by the U.S. Department of Commerce as the Southeastern Regional Trade Adjustment Center and through this program provided comprehensive services to strengthen companies in Georgia and the Southeast that have been adversely affected by imports.
- In 1979-80, EES was designated as the Southeastern headquarters of the Minority Business Development Agency's Technology Utilization and Commercialization Center. EES engineers evaluated innovative products and processes and, where possible, assisted in matching them with minority entrepreneurs or with established minority-owned businesses.
- For the fourteenth consecutive year, EES was funded by the Economic Development Administration as an EDA University Center to provide general management and technical assistance to businesses and communities in 153 of Georgia's 159 counties.
- Assistance in energy-related problems became an even more significant portion of EES' service to Georgia activities. During the year, the staff of the Industrial Energy Extension Service visited 286 Georgia plants, conducted 113 company energy audits and presented 29 energy conservation workshops throughout Georgia.

Major Activities

A major highlight of the year was the visit to the Georgia Tech campus by President Jimmy Carter. The president and his top science advisor, Dr. Frank Press, participated in an in-depth energy briefing, which included discussions of programs under development at the Station. Energy also brought Senator Herman Talmadge to Georgia Tech for the opening of EES' Biomass Fermentation Facility. Talmadge returned to Tech later in the year to announce a major legislative push to develop agricultural energy and wood fuels. On another occasion, members of the Georgia General Assembly visited Georgia Tech to hear presentations on major energy research projects.

1979-80 was also the year when Georgia Tech further extended its presence in the federal government with the loan for one year of Dr. Thomas Stelson, vice president for research at Tech, as assistant secretary for conservation and solar energy at the U.S. Department of Energy. Assuming his position at Georgia Tech on an acting basis was Dr. Albert Sheppard, associate vice president for research.

A nationally-televised energy briefing for President Jimmy Carter (center) was held at Georgia Tech last year. Tech President Joseph M. Pettit (far right) served on the president's panel.

The Station also dramatically broadened its industrial development program in foreign countries. Negotiations were undertaken to establish a European Research Institute of Ireland (ERII) on behalf of the Irish government. EES' relationship with the Korean Credit Guarantee Fund, an organization similar to the United States' Small Business Administration, was also extended. The Station is working with the Fund to help set up an industrial extension service in South Korea similar to that operated by EES. The Station's extensive work in Asia resulted in the establishment of an EES administrative office in the Philippines, a move intended to make it easier for Station engineers to operate more effectively in that part of the world.

Several major conferences received attention from EES during the year. Participants from throughout the world convened in Atlanta for Bio-Energy '80. One of the meeting's activities consisted of a tour of the Station's main energy research facility. The Station also helped the Georgia Solar

EES' international outreach programs brought delegations of important visitors to Tech's campus, including Fang Yi (center right), vice premier of the People's Republic of China.

Energy Association host the Silver Jubilee Congress of the International Solar Energy Society. Preparations also began for Southcon/81, the first of a planned continuum of regional electronics conventions, to be held in Atlanta in January, 1981. Georgia Tech co-sponsored the event with several Southeastern units of the Institute of Electrical and Electronics Engineers and the Electronic Representatives Association. Many EES staff members assisted in the planning effort.

Station engineers extended their expertise through a number of continuing education courses. Potential producers of gasohol got valuable information at several Tech-conducted workshops on alcohol fuels. Under the sponsorship of the Association of Old Crows, electronics specialists from EES prepared a course on "Electronic Warfare Software Principles" for audiences in various cities.

EES' rapidly expanding programs drew record numbers of distinguished international visitors. A group of Norwegian businessmen came to Tech for assistance from EES industrial development experts to prepare for their entry into the American economy. African government agency heads visited Tech to learn more about alternate energy research at the Station. Officials from Sweden, France and Luxembourg came to EES to discuss industrial development with specialists in the field. Delegations of German and British businessmen visited in connection with the Station's work in radar. Groups from Korea, Japan and China, including a delegation led by Fang Yi, vice premier of the People's Republic, came to Tech for tours.

EES also sent several of its administrators on international missions. EES Director Dr. Donald Grace, Associate Director Dr. James Wiltse and Laboratory Director J. W. Dees toured microwave facilities in the Soviet Union and several nations in Western Europe. The visit was made under the auspices of People to People International, an American-based group which works to bring together professionals from various countries to promote international understanding. Dees and Wiltse organized the trip for the American delegation. EES senior staff member Richard Johnson also led a delegation of electrical engineers into the People's Republic of China for a tour lasting several weeks. The tour was conducted under the auspices of the Institute of Electrical and Electronics Engineers.

Another major activity of 1979-80 consisted of an in-depth examination of EES itself. The Station called in its External Advisory Board, composed of nationally recognized leaders from industry, universities and government, to critique EES' performance and make suggestions for future growth. The visit by the Board was its fourth since 1976.

EES Publications

In response to increased demands for information, EES published a series of booklets on significant campus-wide research activities and capabilities. Titles currently available include: *Research at EES; Research in Computer Science and Technology; Energy Research at Georgia Tech; Engineering Research for Agriculture; Wood: An Alternate Energy Resource; Biomass Research at Georgia Tech; Gasohol: One Key to Energy Independence; Science at Georgia Tech; Solar Energy Research;* and *Applied Research in Command and Control Support.* Capabilities brochures for the Radiation Systems and Electro-Optics Divisions of the Electromagnetics Laboratory and the Radar and Instrumentation Laboratory were produced. EES activities were also communicated through two newsletters, *EES Report* and *Station News,* and dozens of press releases on individual projects, extensive radio and television coverage, and this report of EES activities for 1979-80.

EES conducts and organizes its research on a project basis and presents the results of each project in one or more publications or reports in a format and distribution agreeable to the sponsor of the project. During the year, there were more than 500 such projects and associated reports. Much of the research work resulted in papers and presentations by EES researchers at professional technical symposia and conferences.

Press interviews, like this one between Terry Anzur of WSB-TV and engineer Bill Bulpitt, focused public attention on the Station's research programs.

The Challenges of 1979-80

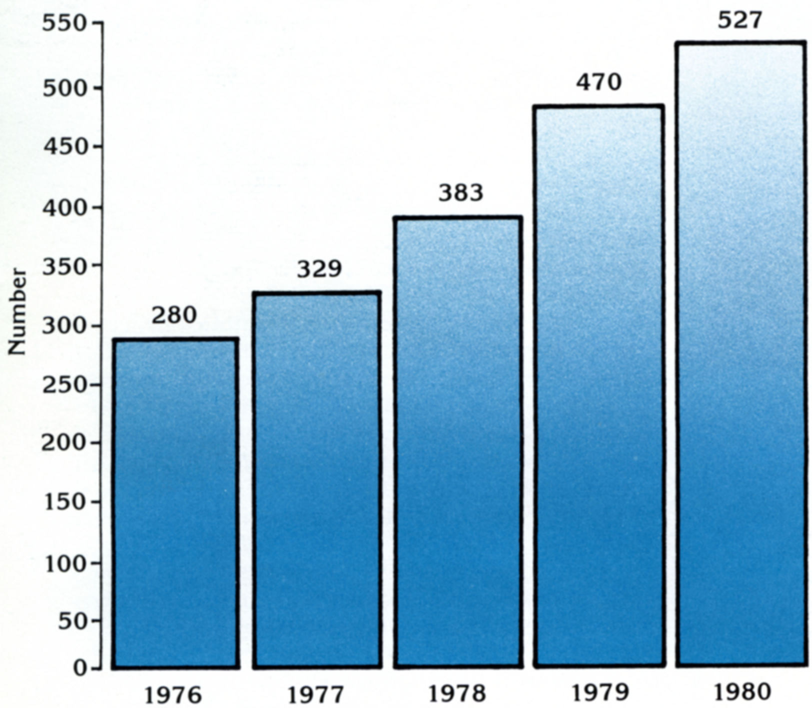


Figure 3

FIVE YEAR FISCAL GROWTH IN FULL-TIME RESEARCH PROFESSIONALS

The continuing proliferation of new and diverse research programs at EES stimulated a growth in personnel and subsequent needs for additional research laboratory space.

The Station achieved a total staff in excess of 1,100 employees in 1979-80. Fifty-seven new full-time researchers joined EES' staff during the year, swelling the number of professionals to 527, a 12% increase over the preceding year (Figure 3). At year's end, 89 full-time professionals held Ph.D. degrees, 213 held Masters degrees and 198 held at least one Baccalaureate degree. During the year, EES also continued its lead in the state as the largest single employer of Georgia Tech cooperative students.

One of the greatest challenges facing EES' administration in the past fiscal year was acquiring additional space for research and personnel. Temporary relief was provided by leasing five floors of the nearby C&S Bank Building in Atlanta.

Recognizing the critical need to acquire more space for personnel, the administration began its plans to renovate a former high school located within the boundaries of the Georgia Tech campus. At year's end, Phase I, consisting of one and a half floors of the building, was nearing completion. It is expected that the renovation of the O'Keefe High School will provide only short term relief, as an additional 50,000 square feet per year are required to sustain EES' projected growth rate.

Keeping pace with salaries offered to researchers by industries was another challenge addressed by the administration during the past fiscal year. Although salaries have certainly improved over the last two years, EES is under continuing pressure to remain competitive with industry for professional personnel in some of its research fields.

Future Outlook

EES' reputation for quality research in a variety of fields is the cornerstone for the rapid growth the Station has achieved. It is also the foundation that will enable EES to continue growing at an annual rate of 20 to 30 percent.

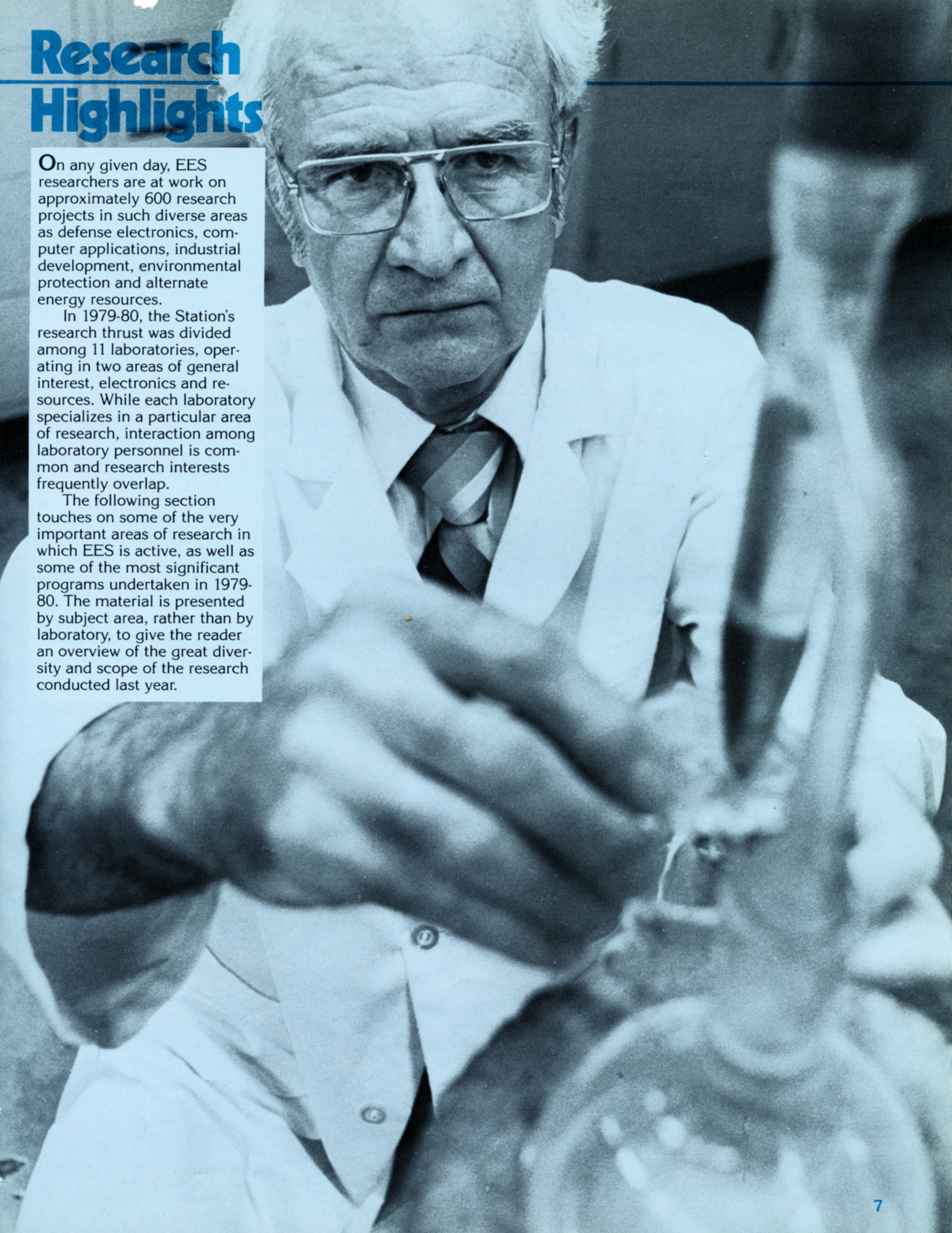
By continuing to attract the highest caliber of researchers, and contracts of state and national importance, we look toward an expanding horizon. Without question, the Station's emphasis on developing new defense technologies and alternate energy sources will dominate the coming years.

To move into new research areas, additional funding for space and salaries will be required. The pressures of rapid growth have emphasized the need for sophisticated computer-based management information systems of all kinds. And, there is an ever-increasing demand for more modern research facilities and equipment to avoid obsolescence.

The Station has devised a five-year plan to meet these challenges. Based on the accomplishments of the past fiscal year, we hope to double EES' size, research volume and services by 1985. With continued enthusiastic support from Georgia Tech President Joseph M. Pettit, Tech's research administrators and our dedicated staff, there's every reason to believe the Station will accomplish its goals.

A part of the O'Keefe School was renovated in 1980 to help alleviate the Station's need for additional laboratory space.

Research Highlights

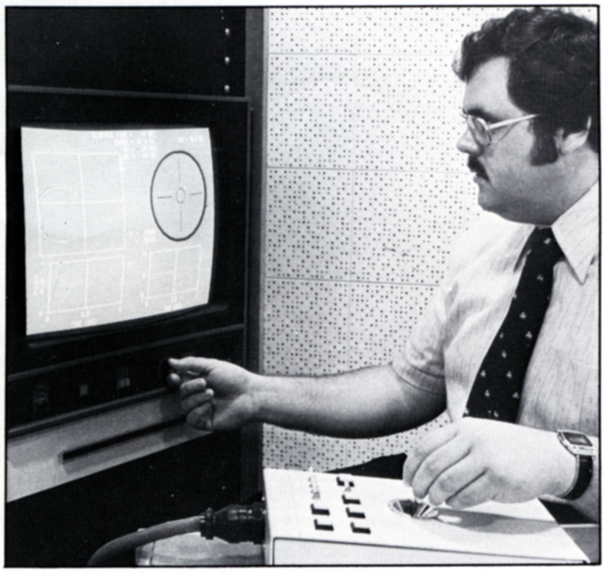


On any given day, EES researchers are at work on approximately 600 research projects in such diverse areas as defense electronics, computer applications, industrial development, environmental protection and alternate energy resources.

In 1979-80, the Station's research thrust was divided among 11 laboratories, operating in two areas of general interest, electronics and resources. While each laboratory specializes in a particular area of research, interaction among laboratory personnel is common and research interests frequently overlap.

The following section touches on some of the very important areas of research in which EES is active, as well as some of the most significant programs undertaken in 1979-80. The material is presented by subject area, rather than by laboratory, to give the reader an overview of the great diversity and scope of the research conducted last year.

Electronic Defense



Electronic countermeasures systems like the one Armand Masse is using allow researchers to test methods for jamming enemy radar.

EES enjoys a reputation as one of the nation's finest research institutions in the field of electronic defense. The Station has broad expertise in specialized radar systems of potential hostile use against our country, as well as electronic support measures, countermeasures and counter-countermeasures.

EES engineers have worked in these specialized systems for more than a decade and today have an excellent standing in the nation for work of this nature. EES services range from abstract mathematical, analytical studies to development, fabrication and testing of radar systems.

EES is also recognized as perhaps the country's leading expert in countermeasures against potentially hostile radar systems. In the past year, engineers at the Station have continued work on complex analysis systems involving radar jamming efforts. One such analysis is called TEAM—Threat Error Analysis Model. It incorporates computer programs to test methods for causing errors in tracking capabilities of potentially hostile radars.

In the fields of electronic support, countermeasures and counter-countermeasures, EES offers services to defense contractors ranging from printed circuit design and construction to broad scale studies of tactics, logistics and strategy. The Station also was active in the past year as an educator in electronic defense. Engineers from EES were selected by the Association of Old Crows, an organization which promotes effective national security, to prepare and conduct a short course for national audiences on "Electronic Warfare Software Principles."

Millimeter Wave Technology

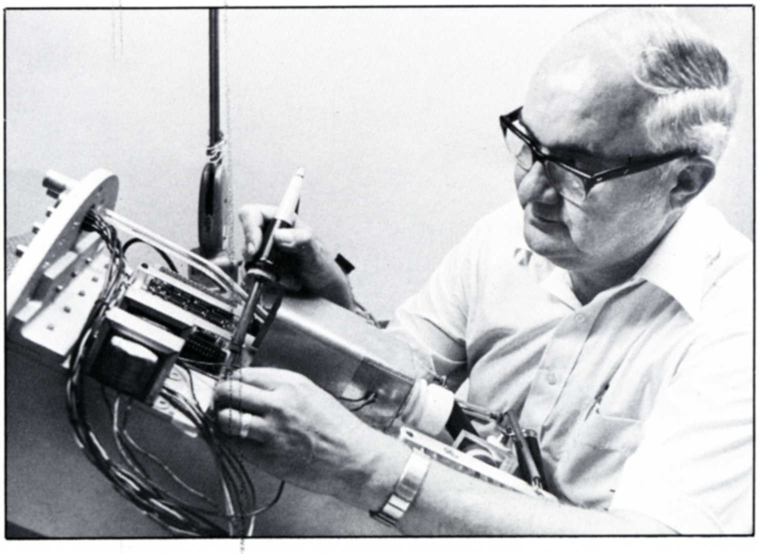
Twenty-five years ago, millimeter wave technology was a curiosity in the initial stage of research and development. Today its practical importance has expanded substantially, thanks to work by engineers at pioneering institutions like Georgia Tech. The Station is in the vanguard of this country's efforts to develop millimeter wave hardware for military purposes. EES is internationally recognized for its millimeter wave radar programs. Engineers at the Station also are using this band of the spectrum for satellite communications and weather research.

During the past year, EES radar specialists have continued to develop technologies for radar homing devices which can seek out targets and function in helicopters, close air support aircraft and air-to-ground missiles. EES also is using millimeter waves in reflectivity studies, which make it possible for detection systems to distinguish between targets and other objects in an environment. A knowledge of armored vehicle millimeter wave signatures is necessary for design of guided weapons and EES has used radiometers to make extensive measurements. A library of images obtained by EES of several types of armored vehicles now is kept at a computer simulation facility at an Air Force base in Florida.

EES is completing a Mobile Measurement Facility (MMF) for the Army which will be used to measure both atmospheric propagation and target reflection parameters simultaneously for millimeter systems operating at 94, 140 and 220 GHz. Operating in conjunction with a Mobile Meteorology Facility developed by the Army, this system can be transported anywhere in the world to gather data under realistic battlefield environmental conditions. In support of the MMF program, a Fourier Transform Spectrometer is being developed by EES under Army Research Office funding to extend the atmospheric propagation measurements to cover the continuous frequency range from 90 to 400 GHz. Wideband spectroscopic measurements will be performed over a wide range of weather conditions.

In meteorology, EES engineers have designed a new millimeter wave radiometer to study thunderstorms and gather critical information on storms from weather observation planes. A new program began to develop a sub-millimeter flight spectrometer to acquire meteorological sounding data in the 150 to 2,000 GHz range. The Station also helped NASA analyze the reliability and cost effectiveness of using millimeter wave signals from a communications satellite.

The millimeter wave spectrum demands high-powered compact transmitters like this extended interaction oscillator (right) which was designed for the Army by EES engineer Clark Butterworth.



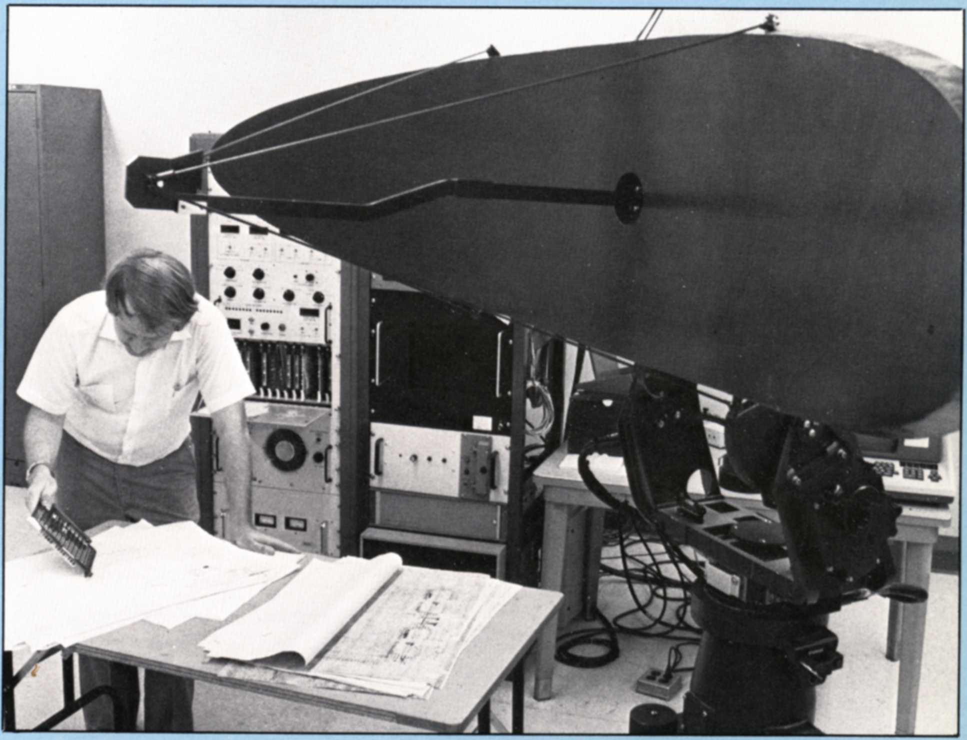
Radar

In the field of radar, more than 30 years of research and development have made EES an international center for excellence in this technology. The Station has designed, built and evaluated radar systems for ground vehicles, mobile vans, ships and airplanes located throughout the Western world. One important program conducted in the last year called for up to 10 individual radar systems to be linked together by computers to protect military sites scattered over hundreds of miles. From 100-foot towers, this surveillance system can pick out targets such as small animals and detect intruders at ranges of several miles.

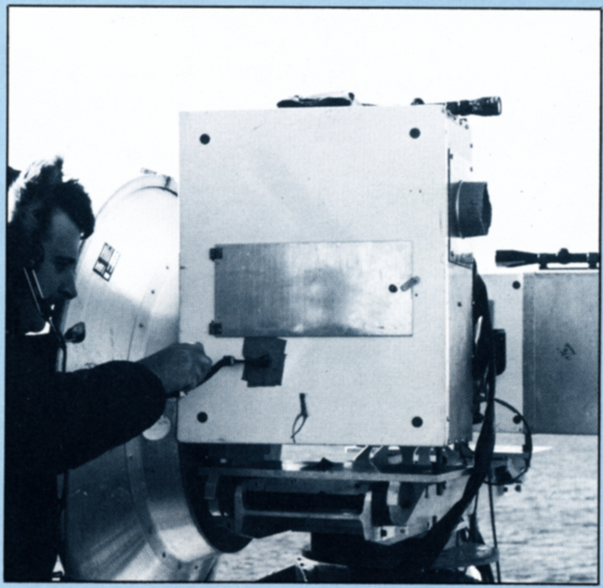
Other EES programs are developing technology to support a Department of Defense effort which may produce a "smart" missile capable of homing in on enemy targets in the field of battle. Station engineers are doing target measurement and identification work which could contribute to the eventual production of this missile's computerized radar system.

Radar specialists at the Station are also doing research aimed at improving the performance of systems in the face of high levels of background clutter. In the military area, this work would upgrade the capability of radar systems to distinguish legitimate military targets from objects in the background. In another field, EES engineers are performing research to conceal military targets from enemy radar installations.

In the non-military realm, the Station has developed radar techniques for locating cavities in interstate highways which are not visible on road surfaces. EES also is helping the U.S. Department of Transportation to develop a training course for law officers so they can use highway speed timing radar more accurately and effectively.

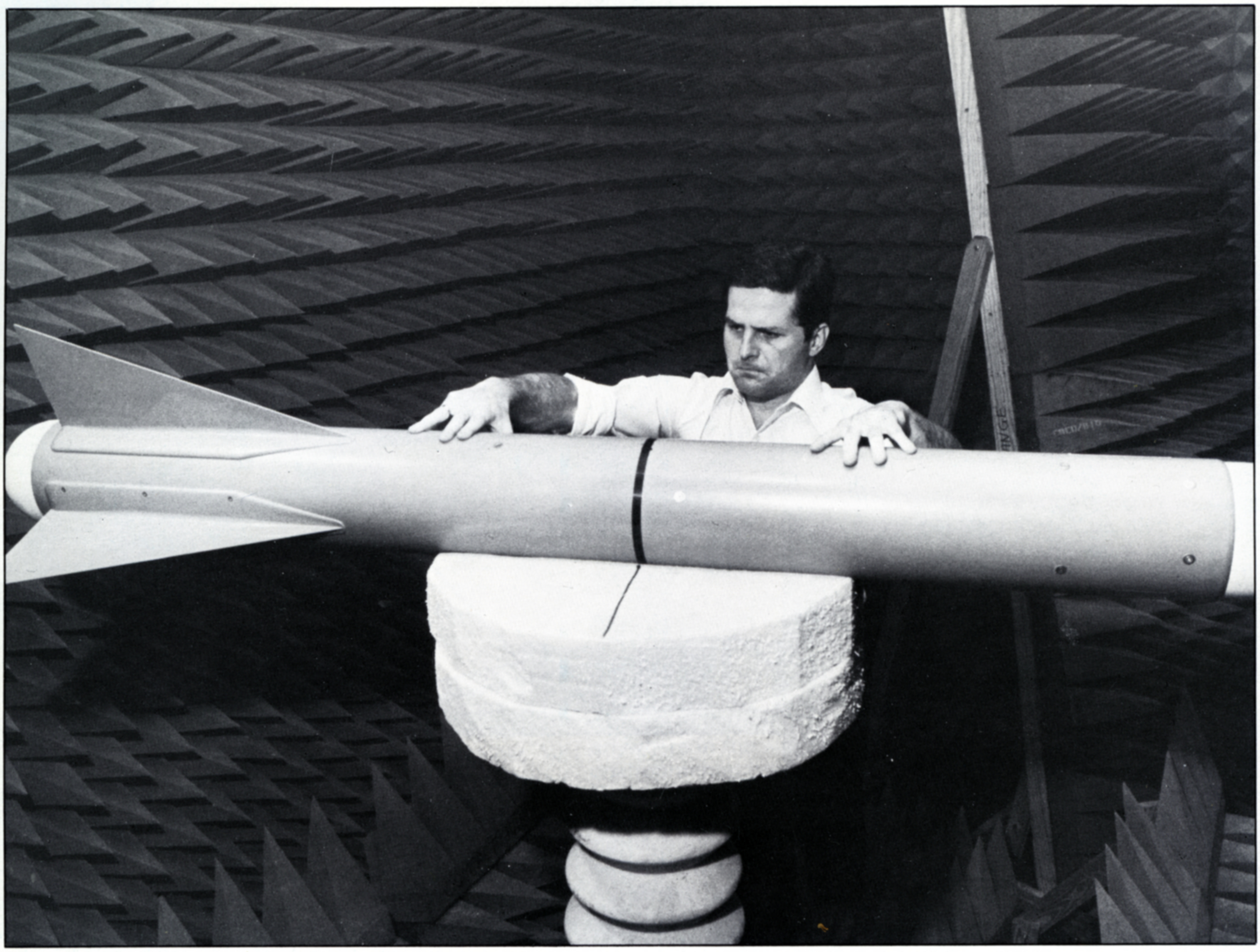


EES developed a strategically important radar called ASTAR in 1979-80. This "Antiarmor Surveillance and Target Acquisition Radar" can survey a battlefield and give an instant map of the scenario.



Using advanced system design and analysis, engineer Nick Currie measures the backscatter properties of radar waves reflected from the sea.

Antennas



EES researcher Chris Papanicolopulos tests the specifications of a military target in one of EES' echoless, indoor antenna and radar measurement facilities.

Antenna research constitutes one of EES' most active and varied programs. The Station performs both basic and applied research involving design, analysis, fabrication, testing and siting of antennas. Nearly all work in this area is done for the military and the Federal Communications Commission. EES is considered an international authority in near-field antenna research.

Under Army sponsorship in 1979-80, the Station conducted programs which will significantly affect antenna design specifications in the future. One such effort involved phased-array antenna studies and analyses, an area in which EES has considerable experience. The Station has developed a specialized computer program that can be used to analyze how a full-scale array would perform.

The Air Force funded research during the year which will contribute to better measurement and analytical techniques for antenna siting, scattering phenomena and electronic warfare evaluations. Programs undertaken for the Navy involved developing models for ship radar system design and for assessment of the systems' combat capabilities.

During the year, EES used internally-generated funds to improve and update its antenna and radar cross-section measurement facilities to support future research thrusts.

Radiometry

This EES-designed subharmonic mixer represents a significant advance in radar hardware.

Few research institutions in the U.S. do more contract work in radiometry applications than EES. The Station's efforts last year focused on the development of radiometers operating at millimeter wave frequencies. These systems were designed primarily for military and meteorological uses.

Through one program in the military area, EES engineers worked jointly with the Air Force to develop a new sensor which operates simultaneously at two frequencies and two orthogonal polarizations. The sensor, now owned by the Station, is used to measure target and background signatures for particular applications. In 1979-80, the Station also performed studies to aid the Army in testing millimeter wave missile guidance systems which use radiometers in sensing. The results will be used to design a new Army facility to be built in 1985.

In the meteorological area, one recent example of EES work is the design of a new dual frequency sensor for use by NASA in high altitude weather observation aircraft. A state-of-the-art subharmonic mixer is used in this radiometer for remote measurements. The mixer was designed to withstand the vibrations of flight on a NASA aircraft and is the only unit of its type. One frequency of the radiometer is sensitive to high altitude rain and ice while the other measures low-level surface rain. Both work in concert to give an observer a detailed interior profile of a storm. The hardware should lead to better techniques of predicting and tracking dangerous storms.

The space shuttle program has involved EES in another kind of task, using 35 and 95 GHz radiometers to determine when ice formations may have reached dangerous thicknesses on liquid oxygen tanks. Such a sensor is necessary since even small chunks of ice flaking off during liftoff could seriously damage the shuttle craft.

Joe Gagliano uses a microprocessor to translate millimeter wave radiometric data into color graphics which help to predict and track severe storms.

Infrared/ Electro-Optics

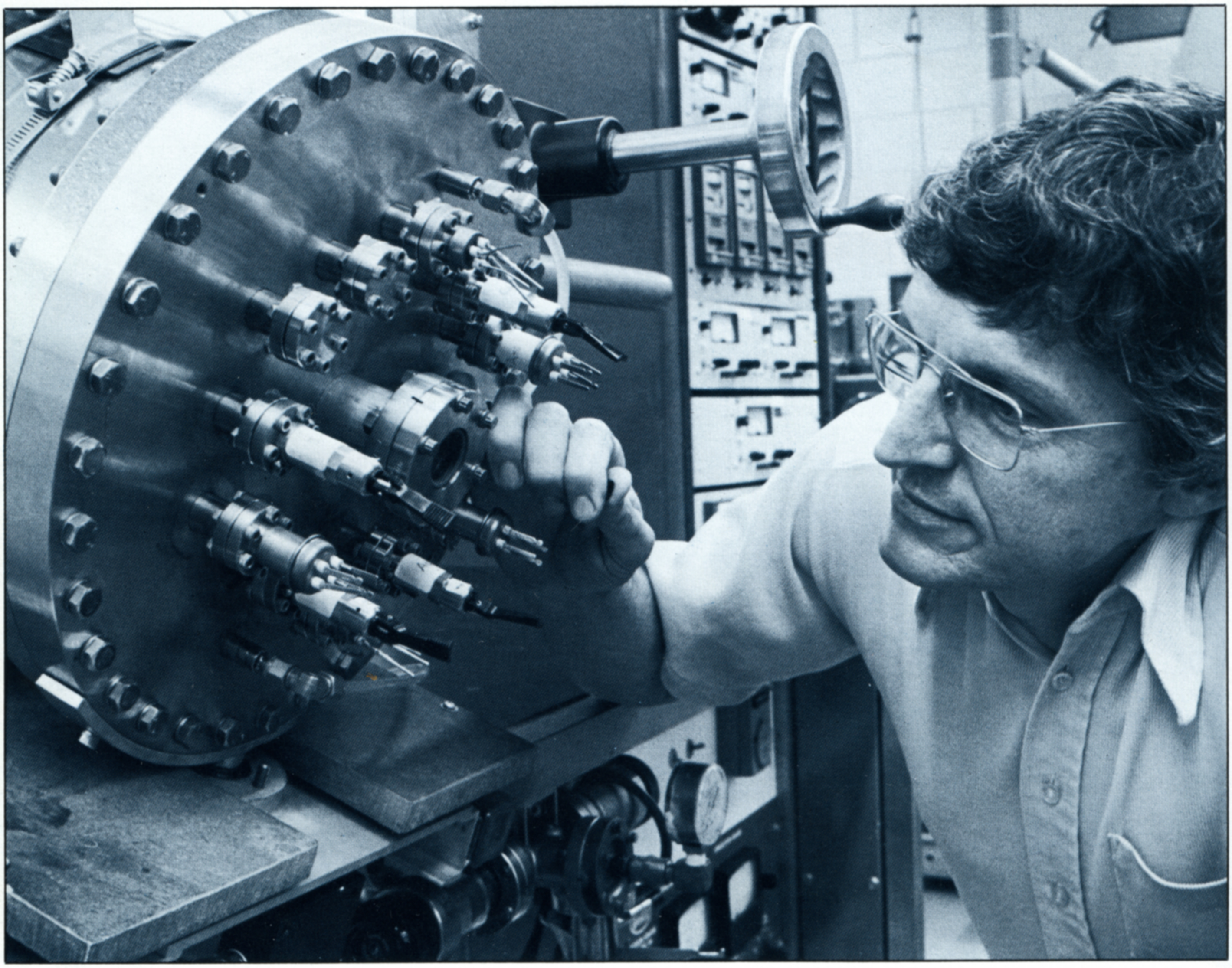
The infrared/electro-optics program at EES is oriented to our nation's defense needs, and research is divided into three general categories: systems analysis, modeling and simulation.

In the past year, systems analysis programs involved work to assess the survivability of advanced technology cruise missiles (ATCM's) against both present and second generation infrared air-to-air missile seekers. This effort required EES to work closely with the Air Force ASD/XRT Program Office at Wright-Patterson Air Force Base in Dayton, Ohio, and with the Air Force Armament and Test Laboratory at Eglin Air Force Base, Florida.

Modeling work spans a broad range of technologies and applications from missile guidance systems to target acquisition systems. Operational missile seekers have been mathematically modeled under contract with the Naval Research Laboratory. The purpose of this work is to provide an analytical tool for evaluating the effectiveness of various countermeasure concepts. Target acquisition systems were also modeled, including the IIR Maverick and Pave Tack. These models are being developed for the Air Force Air Weather Service.

The delivery of simulation hardware and associated software to the Army Missile Command at Redstone Arsenal highlighted the year's activities. The delivered system comprised a complex missile guidance simulator designed to simulate the operation of infrared seeker heads. The successful design and construction of a system with this complexity represents a unique achievement in the research community.

Solid State Electronics



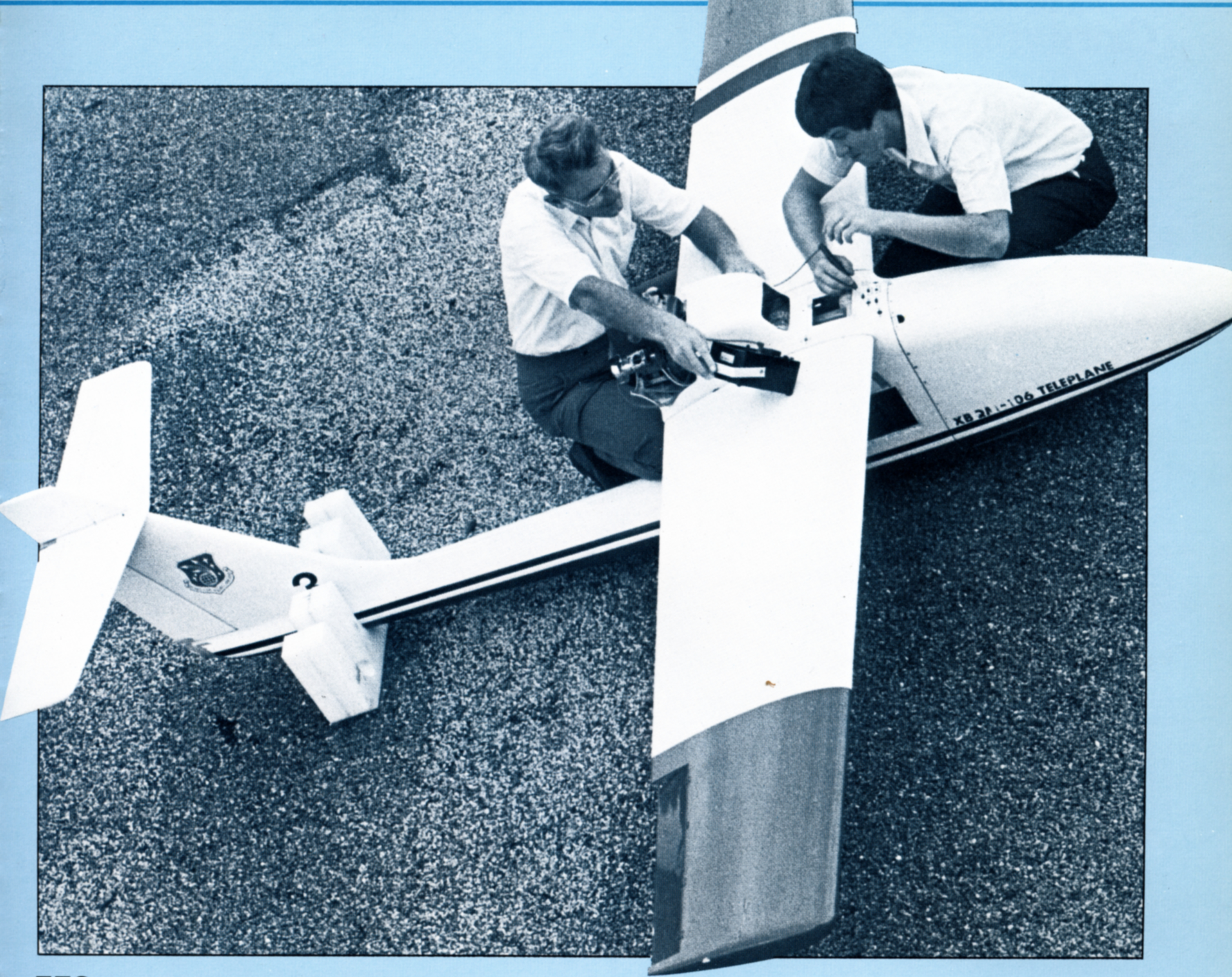
In the past year, solid state researchers at the Station neared completion of a Navy-sponsored program involving basic research in the growth of semi-conductor materials. The work involved a molecular beam epitaxy system. Primary emphasis in 1979-80 was to develop new growth techniques and to characterize ternary and quaternary materials for use in higher performance microwave and millimeter wave devices required for military systems.

Success in chip-level power combining at X-band during the previous year promoted an effort to demonstrate the same technology at millimeter wavelengths in 1979-80. Engineers at EES conducted studies of chip-level power combining of IMPATT diodes at 40 GHz for the Air Force. This research made it possible for solid state devices to achieve the higher transmitter power levels required for military systems. This thrust received widespread recognition, as evidenced by the industrial sponsorship of related work.

Earl Meeks examines a molecular beam epitaxy system developed by EES for growing thin semi-conductor films that are two 10-thousandths of an inch thick.

The strong interest in millimeter wavelength systems resulted in several research and development programs dealing with gallium arsenide Schottky barrier mixer diodes. Beam lead diodes have been developed and high-reliability, space-qualified honeycomb diodes are currently under development for millimeter wavelength mixers.

Communications



EES researchers test lightweight antennas which can disrupt enemy communication links when attached to small, pilotless aircraft.

EES is a recognized center for research excellence in communications, with capabilities in the electronics of conveying, disrupting, locating and intercepting information signals. Communications research conducted for the Department of Defense comprises a major share of the Station's activity in this field. One important program started during the last year was a three-year Basic Ordering Agreement with the U.S. Army Signal Center at Ft. Gordon, Georgia. In connection with this agreement, EES engineers are evaluating tactical Army communications architecture—the structure of communications systems.

For statewide application, Station engineers designed a comprehensive load management system for Oglethorpe Power Corporation of Georgia, a major supplier of electric power to rural cooperatives. Through a network of interconnected computers, this system will regulate power usage during periods of peak use in the service areas of the state's 39 local electric membership cooperatives. Peak load shedding is expected to result in substantial energy savings.

Through another project, the Station gave the Tennessee Volunteer Electric Cooperative recommendations for land mobile radio communications, computer-to-computer links and data acquisition.

For the Federal Communications Commission, EES also completed a study recommending that the government phase out some regulations in areas relating to technical quality.

Command and Control

Computer analysts John Passafiume and Bennett Teates help sponsors like the U.S. Army to evaluate computer configurations used in command and control systems.

In times of international crisis, U.S. leaders rely heavily in their decision making on the information made available to them by the Worldwide Military Command and Control System (WWMCCS). This enormous computer network has malfunctioned several times because of breakdowns in old or outdated hardware. At present, time-consuming government regulations for acquiring new equipment virtually guarantee that the WWMCCS will contain, at any given moment, a considerable number of outmoded computers.

To help eliminate this overall problem, EES computer specialists are working with the Navy to develop a new method of making computer purchases. The method is called accreditation. Through it, the military could buy replacement hardware for networks like WWMCCS through a pool of accredited vendors and avoid lengthy purchase procedures.

Engineers at the Station also are involved in a long-term program with the Army to insure that its command and control systems continue to reflect advances in computer technology through the rest of the 20th Century. In another program, EES will determine the kind of computer equipment necessary for the Army's electronic test range driver system at Ft. Huachuca, Arizona.

Computer Applications

Computer science at Georgia Tech has moved from a support function for other disciplines at EES to a research field in itself. Station engineers are performing important work in the application of computer technology to areas such as military defense, energy conservation, nuclear plant security and school planning.

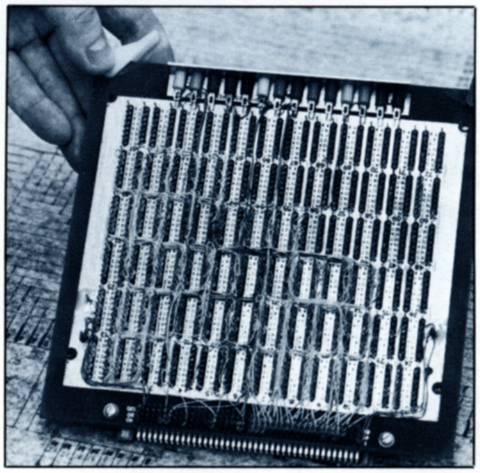
In the last year, EES continued to rely on computers to refine radar and electronic warfare systems necessary to defend this country. The Station also worked with the Navy to develop a software and hardware system capable of detecting and tracking waterborne intruders which could sabotage seacoast facilities such as naval bases and power plants.

In another sphere, EES engineers have installed a facilities management system run by computers which controls and monitors power usage at various buildings on the Georgia Tech campus. An operator can sit at a computer terminal and change the programming of the system, rather than having to purchase an entirely new software program.

The Station also worked in the past year to find applications for an emerging field of computer science known as geoprocessing. Information systems of this kind, which are geographically-oriented, add a spatial dimension to many kinds of data such as census information or remote sensing. In this regard, work continued on a LANDSAT program which gives land use planners extremely detailed computer models of geographical zones obtained by satellite transmissions. EES engineers also developed a minicomputer to help a Georgia school district assign students by geographic boundaries to use its various school buildings with more efficiency.

In another research thrust, Station researchers worked in 1979-80 to help the Department of Defense formulate a new computer language called "Ada." EES coordinated approximately 100 independent research and development Ada test projects and translated pertinent elements of radar software systems into Ada.

In 1979-80, EES designed a computerized facilities management system for reducing Georgia Tech's energy use.



Last year, EES engineers developed a computer system using fast, bit-slice technology for the Navy's Waterborne Intrusion Detection project.

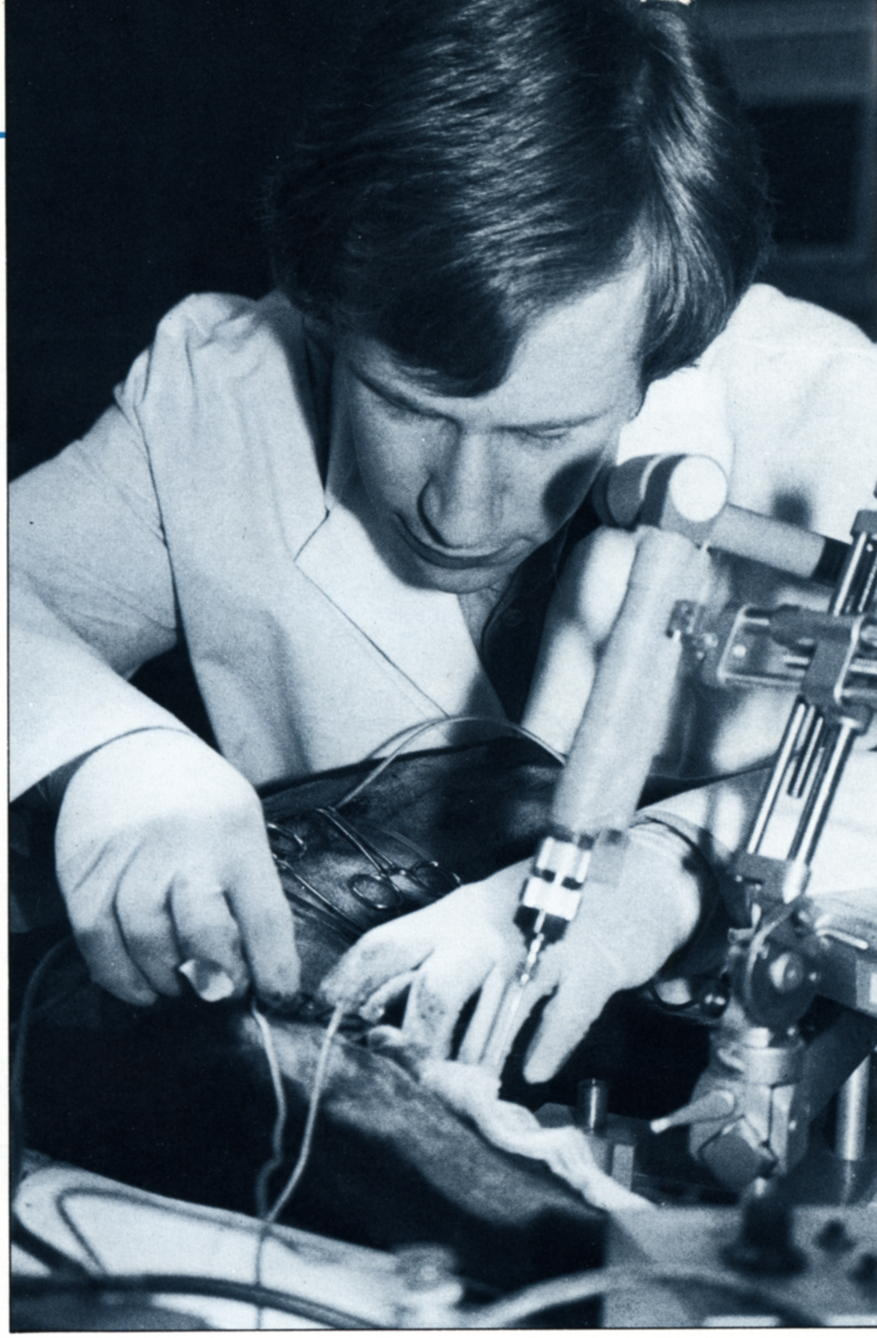
Biomedical Electronics

EES is one of the nation's leaders in investigating the effects of microwave radiation on living creatures. Researchers at the Station have gained international recognition for their work in developing an antenna which measures exactly the body's absorption of radiation. This instrument has made it possible to use microwaves in medical treatment with unprecedented precision.

In the last year, one of Georgia Tech's most promising biomedical research programs has involved the application of microwaves to thaw frozen kidneys. Station engineers are attempting to find a technique for thawing large organs without irreparably damaging them. Such an accomplishment would make nationwide organ banks a possibility. To succeed in this project, researchers must calculate the exact level of radiation necessary to thaw with safety different layers of a living kidney. Researchers are now able to thaw a kidney and keep it functioning in a laboratory setting. Their next step will be to successfully transplant the organ into an animal.

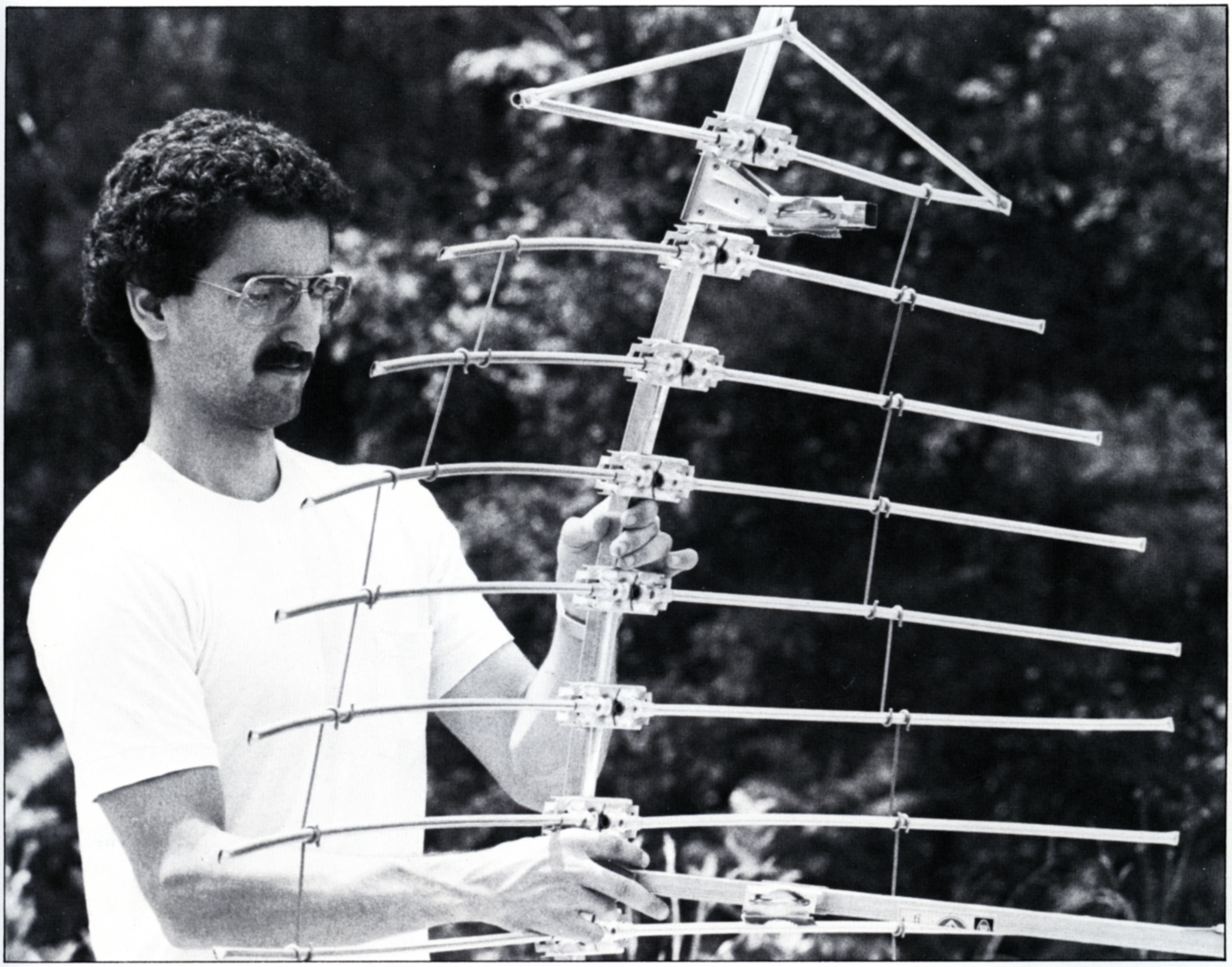
In another active program, microwaves are being tested for their effectiveness in the detection and treatment of cancer. The electrical characteristics of malignant tumors are quite different from those of normal tissues. So Tech engineers believe they can distinguish diseased from healthy tissue with the antenna they have developed.

At the same time, the Station is exploring the hazardous effects of microwaves on human health. EES recently won contracts from the Air Force School of Medicine and the Environmental Protection Agency to develop facilities and instruments for measuring the biological effects of prolonged exposure to low-level radiation. Claims that this kind of radiation is harmful have been a topic of considerable controversy in the scientific world for many years. Tech is one of two American universities which the government has funded to do chronic radiation research on large rodent populations.



Cliff Burdette studies electromagnetic waves as a tool for thawing organs, blocking pain signals to the brain and treating cancerous tumors.

Electromagnetic Compatibility



Engineers like John Daher helped the FCC to improve UHF-TV reception by testing the quality of different combinations of UHF equipment.

EES helped pioneer electromagnetic compatibility studies and the Station continues to work in the forefront in this important electronics field. Most of the research done at Georgia Tech in this discipline involves military applications. The Station's principal emphasis centers on the development of management procedures and technical tools necessary to protect sensitive and critical electronics from interruption and damage caused by high-level radiated electromagnetic energy.

For example, engineers at EES are helping the Rome Air Development Center in Rome, New York, in a long-range effort to keep the electromagnetic systems in Air Force aircraft well-defended against enemy disruption. The Station also is working with the Air Force to develop a technique for improving the performance of communications equipment on airplanes. EES also is preparing management techniques for integrating electromagnetic testing needs into the development and procurement of Navy systems.

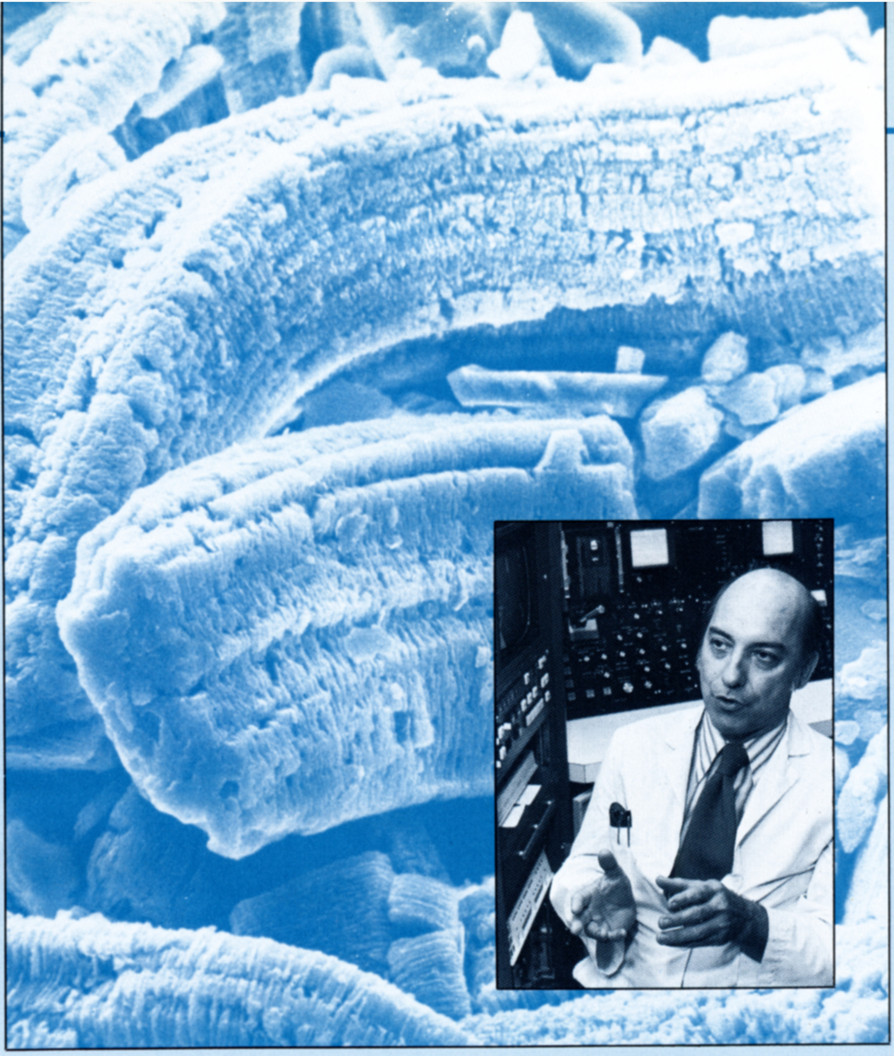
In the non-military domain, EES is working for the Federal Communications Commission to find the best ways to bring UHF television reception up to the quality of VHF reception. In this program, researchers have compiled data on the typical performance of a variety of UHF components normally installed by homeowners. The Station also completed a program for General Motors aimed at improving the performance of facilities used in the development of electronic components for automobiles.

Chemical and Material Sciences

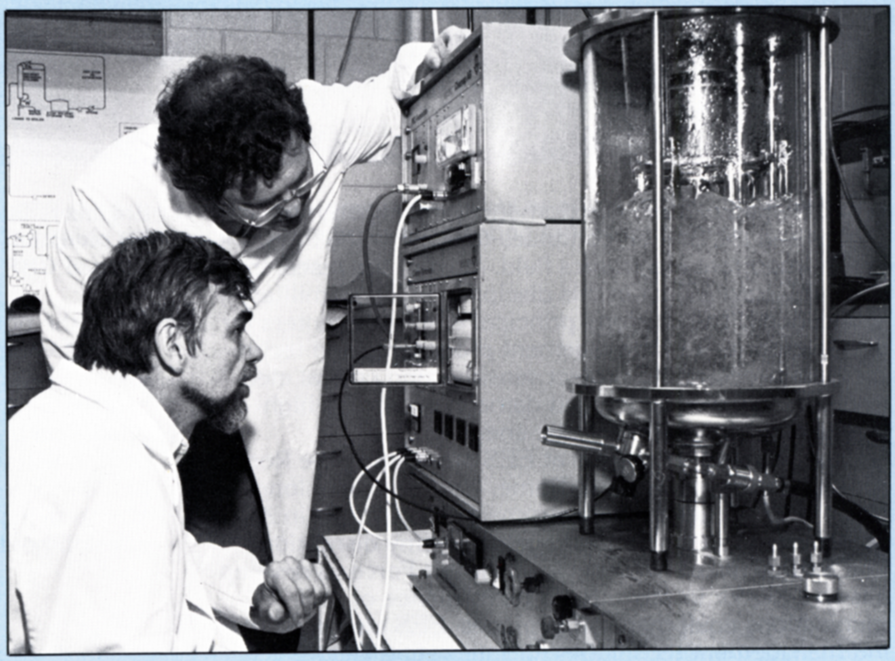
EES' chemical and material sciences program entered the forefront of research in alternate energy sources with the government's new emphasis on synthetic fuel development. The Station's major project in this area in 1979-80 was a continuing effort to perfect a chemical process for economically converting cellulosic materials to ethanol, an essential ingredient in gasohol mixtures. These investigations are expected to climax in 1981 with the construction of a large-scale pilot plant on the Georgia Tech campus for the production of ethanol from cellulosic wastes. In the past, ethanol manufacturers have relied on food crops such as corn as a feedstock, but if inedible cellulose proves to be an acceptable substitute, then valuable crops can be saved for food consumption.

Other significant chemical and material sciences work involved the identification and solution of potential health hazards from asbestos insulation. EES researchers helped school systems in Georgia and other states to define the extent of this problem in older school buildings. They also began investigations of materials which could keep decaying insulation from spreading into the atmosphere.

Other research thrusts in the past fiscal year focused on the development of industrial coating materials which resist corrosion and high temperatures, methods to recycle wastes in space colonies, and techniques for disposing of hazardous wastes from laboratories in the Georgia university system.



John Brown (above) explains how this scanning electron microscope is used by EES to determine why materials fail to function in specific applications. These kaolin clay particles were magnified 2,000 times to evaluate the chemical characteristics of clay taken from 120 sites in Georgia.



In 1979-80, EES engineers designed a state-of-the art process for converting wood into ethanol.

Solar Research

During 1979-80, EES continued its effort to make solar energy an economically acceptable option to conventional fossil fuels. The Station made impressive strides in designing solar systems for an ever-increasing variety of residential, commercial and industrial uses.

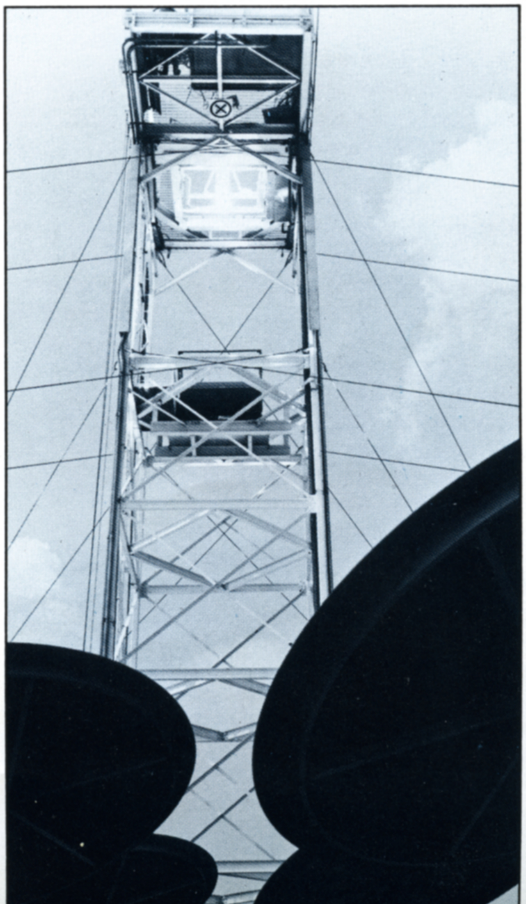
EES operates a 325 kW thermal solar furnace on the Georgia Tech campus for the Department of Energy. Use of the Advanced Components Test Facility was dramatically increased last year, due to the facility's low operating cost and the staff's overall support capabilities in data acquisition, specialized instrumentation and chemical analysis. Several important tests successfully applied solar heating to processes which could result in efficient synthetic fuel production. One experiment, for example, used a fluidized bed reactor to determine if solar energy could heat carbon-based material to a temperature high enough to bring about a syngas reaction. Another test, begun in 1980 and completed shortly after the end of the fiscal year, showed that the sun's heat can gasify biomass and create a high-grade synthetic gas.

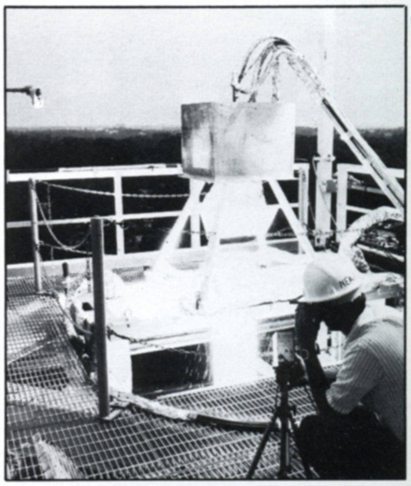
Station engineers spent considerable time performing research at the Centre National de la Recherche Scientifique's 1000 kW solar furnace in southern France. A primary task was to determine the effects of nuclear explosions through high temperature solar experiments.

EES also submitted an application for a patent on a low-cost solar concentrator invented by a cooperative student assistant working at the Station. The concentrator is made of a metal strip which is twisted into a spiral. It may have applications for solar cooking, power generation, microwave communications or solar photovoltaics.

Other EES solar programs involved design studies for receivers and the development of systems to heat classrooms, farm operations and businesses.

EES engineer Rick Steenblik (above) designed this solar concentrator which can generate temperatures of 2000°F.





EES uses the Advanced Components Test Facility to test promising solar technologies, such as this Westinghouse-owned fluidized bed reactor.

Located on the Georgia Tech campus, the Advanced Components Test facility is operated by EES for DOE.

Biomass

Designed by EES engineer Tom McGowan (above), this updraft gasifier produces one half million Btu/hour.

It is fitting that EES has become one of the nation's leading research institutions in the conversion of biomass to usable energy. Georgia leads the nation in forested acreage and experts estimate that the state has enough biomass available in the form of wood waste alone to supply 20 to 25 percent of Georgia's annual energy needs.

Biomass is a term which applies to organic materials such as trees, crops, algae, manure and seaweed, all of which have energy potential. EES is conducting a number of biomass programs to improve conversion technologies and to promote the commercialization of these new methods.

Over the past several years, the Station's primary thrust in this research field has been to use wood to fire industrial boilers and to heat residences. In the case of home heating, EES engineers have written booklets and performed demonstrations on wood stove safety. They also have conducted a number of workshops to train Tennessee Valley Authority energy auditors to do wood stove inspections.

Another research program in 1979-80 involved continued investigations of the technologies best suited to produce ethanol from biomass for gasohol. EES engineers have decided to emphasize a process to convert inedible woody cellulosic wastes into ethanol. An experimental plant will be built, beginning in 1981, to test this process and prepare it for commercialization.

Another significant project has been the design and construction of a one million BTU gasifier which converts wood into a liquid gas. Now undergoing testing, the gasifier is expected to produce clean-burning and economically competitive fuels from wood.

Another primary thrust in 1979-80 was the design of a new thermal conversion process for biomass. A three-year research program based on an EES concept for entrained pyrolysis/gasification of biomass was approved by the Department of Energy in 1980.

Energy Conservation and Applications

As fuel costs continued to rise and energy supplies remained uncertain, EES' energy conservation and application programs increased in variety and comprehensiveness. These efforts were aimed primarily at finding ways to lower energy usage in an economical fashion. These goals were attained, for the most part, through use of existing technologies. More efficient techniques were sought for using energy in industry, business, the home and on the farm.

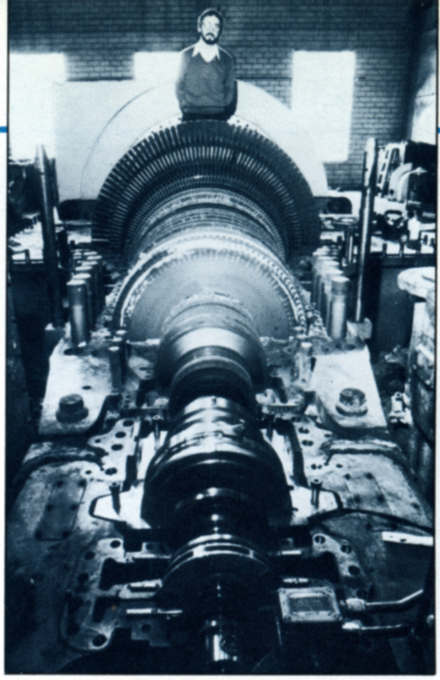
Last year alone, EES researchers conducted more than 200 energy management surveys of commercial, industrial and government facilities in Georgia and the Southeast. These surveys identified potential energy savings equivalent to 8.1 million barrels of oil, at a dollar savings of approximately $130 million.

Another noteworthy accomplishment was the completion of a two-year program to make poultry industry technologies more energy efficient. The project was chosen as one of the nation's 10 most promising energy conservation technologies for near-term commercialization in the agriculture and food processing sector.

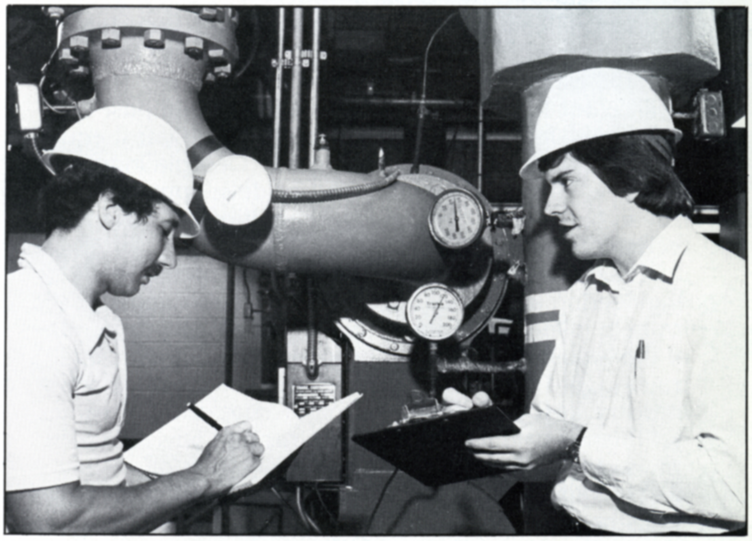
Station solar engineers surveyed Georgia industry to determine their willingness to convert some processes to solar energy. This program will conclude with the selection of several Georgia plants to serve as test sites for solar conversion. The Station also started work to design a passive solar heating system for modular classrooms.

As a result of preliminary technical feasibility studies performed by EES engineers, the Department of Energy selected for further funding a project in Piqua, Ohio, whereby a downtown business district will be heated by steam diverted from a nearby electric plant.

In the wood energy area, Station researchers conducted a feasibility study for a wood-fired cogeneration plant at an industrial park in LaGrange, Georgia. Through cogeneration, the steam used to make electricity will be employed for another industrial process.



Through cogeneration, the heat in waste steam from an electric plant in Piqua, Ohio, will be recovered to heat water, homes and businesses. Much of the waste heat is recovered from equipment like this utility steam turbine.



Last year, EES engineers surveyed 200 industries and recommended more energy-efficient technologies.

Ben Trammell and Jim Walsh study ways to convert an industrial park into an energy self-sufficient entity.

Industrial Extension

With economic conditions worsening and government regulations becoming more complex, small to medium sized businesses face a bewildering array of problems. EES' innovative field office program was set up in 1961 to take Georgia Tech's expertise in business, marketing and technology to the state's industrial community. The success of this outreach network has made the Station's approach a model for extension programs in other states.

In 1979-80, EES maintained field offices in eight Georgia cities: Savannah, Albany, Augusta, Carrollton, Douglas, Macon, Gainesville and Rome. Each office is staffed by resident engineers from EES. They helped fledgling industries get started and assisted existing businesses with technological problems which could not be solved by managers. Last year, 425 industries were given direct technical assistance and more than 1,000 requests for information were filled.

A significant initiative was taken toward accelerating the transfer of more advanced technologies to industries with the establishment of a new Manufacturing Technology Center. Located on the Georgia Tech campus, the Center will facilitate the introduction of the latest equipment and manufacturing practices to Georgia industries. It also will serve as a focal point for developmental research, conferences and demonstrations of advanced technologies.

Field office expertise is not solely confined to engineering assistance. The staff routinely handled calls for help involving most areas of business. Most members of the industrial extension program are engineers by training, but all have practical experience in business or industry. Last year, Station engineers helped companies get financial aid for their enterprises and advised them on ways to meet government safety regulations. They also recommended energy conservation practices to industry along with suggestions for improving plant productivity. The field offices also worked to bolster local economies in Georgia—by helping communities get industrial parks, advising development groups on strategies for attracting industry, and then helping cities in the state to sell themselves to companies in the process of relocation.

Area Office Director Sherman Dudley (left) conducts a product/cost analysis to help in a major expansion effort by Haynes Industries, Inc.

EES has been designated by the Georgia General Assembly as the state's Productivity Center and the field offices carried out many of these activities in 1979-80. A good example of this work was a project sponsored by a granite association aimed at increasing productivity and reducing noise pollution in the industry. With the association's backing, EES designed a water jet which could cut through granite at an acceptably low sound level while working at several times the speed of conventional cutting methods.

Improving the efficiency and productivity of the General Box Company in Waycross, Georgia, was the object of one plant study conducted last year by Area Office engineer Harris Johnson (left).

Economic Analysis/ Business Development

EES has served as one of the Southeast's major centers for applied economic research and business development for more than 20 years. Last year, continuing economic distresses in the United States created an increased demand for EES' services from businesses, industries and government agencies.

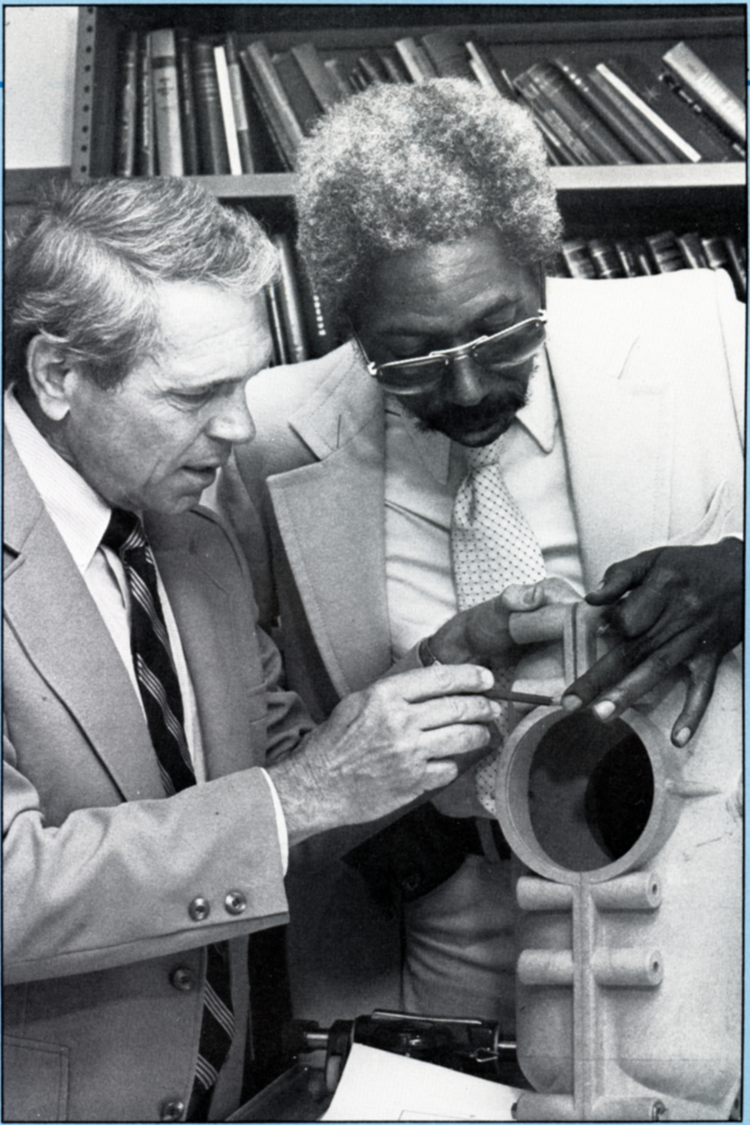
The importance of energy costs in economics resulted in a number of innovative assistance programs for businesses and industries in 1979-80. The roster included studies on fuel alcohol, end-use demand modeling and demands for public transportation.

Established programs were expanded and diversified in areas involving safety and health regulations, minority business development and employee productivity. Special assistance also was given to inventors and small businesses, as well as Georgia counties with depressed economies and Southeastern firms hurt by competition from imported products.

To facilitate these and other programs, EES serves as the Southeastern headquarters for:

- *The Economic Development Administration's Management and Technical Assistance Program.* Last year, 56 research projects under this program generated 148 jobs in Georgia.
- *The Minority Business Development Agency's Technology Utilization and Commercialization Center* (TUCC). Now in its third year, TUCC helped minority inventors and entrepreneurs to develop and commercialize new products. In 1979-80, Georgia Tech's TUCC was selected as the Technical and Engineering Evaluation Center for all eight TUCC offices in the nation.
- *The Southeastern Trade Adjustment Assistance Center* (TAAC). Last year, 117 clients hurt by foreign imports were given technical and managerial assistance through TAAC.
- *Occupational Safety and Health.* Under this program, Tech offered free, on-site occupational safety and health consultations to Georgia employers. In 1979-80, 251 businesses and industries received assistance in meeting safety and health regulations.

One very significant program extended state-of-the-art approaches in forecasting energy demand and determining the impact of new energy-using technologies. The results of this study will be used as a model by both federal and state agencies in evaluating the impacts of load management programs on energy demand. Another important project assessed the impact of three coal-using technologies on energy demand in the commercial sector.



Engineer John Murphy (left) and TUCC Director Ed Bethea evaluate a new minority-owned invention.

Businesses, industries and communities with financial and managerial problems were assisted last year by EES' staff of 40 economic development analysts.

International Assistance

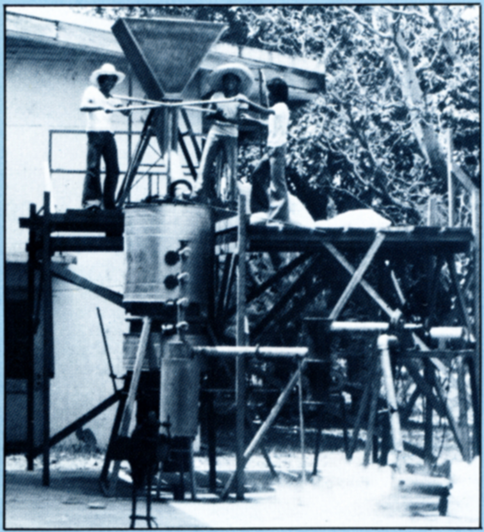
For more than a decade, EES has provided technical and managerial assistance to developing nations to help bridge the economic barriers separating them from the industrialized world. In the past year alone, EES researchers were active in the Philippines, Sri Lanka, Barbados, South Korea, Costa Rica, Nicaragua, the Dominican Republic, Indonesia and Panama.

One of the Station's principal programs involved continuation of an effort to make clean drinking water more accessible to Third World countries. One grant from the Agency for International Development called for EES engineers to test the appropriateness of a hand-operated water pump for underdeveloped nations such as Nicaragua, Costa Rica and Indonesia. Station researchers set up procedures for training local workers to install, maintain and use these pumps. Another thrust in this area involved water treatment equipment testing in the Philippines.

EES also performed work designed to improve sanitation, find and develop alternate energy sources and provide technical and managerial assistance to small-scale industries.

Another highlight of the 1979-80 year was the establishment of a full-time EES office in Manila in the Philippines to meet the demands for Station assistance in Southeast Asia.

To help underdeveloped countries obtain clean water supplies, EES staff members taught native engineers to install and maintain hand-operated water pumps.



Philippine laborers now use an EES-designed pyrolytic converter to transform rice hulls into powder, char, pyrolytic oil and gas.

EES and its Laboratories

Howard Dean, EES associate director.

At the close of 1979-80, the Engineering Experiment Station was organized into 11 laboratories, each operating in an area of highly specialized interest. In September of 1980, the Station created a more streamlined organization consisting of eight laboratories. Five laboratories now conduct electronics research; three are concentrating on developing the nation's human, natural and manufacturing resources.

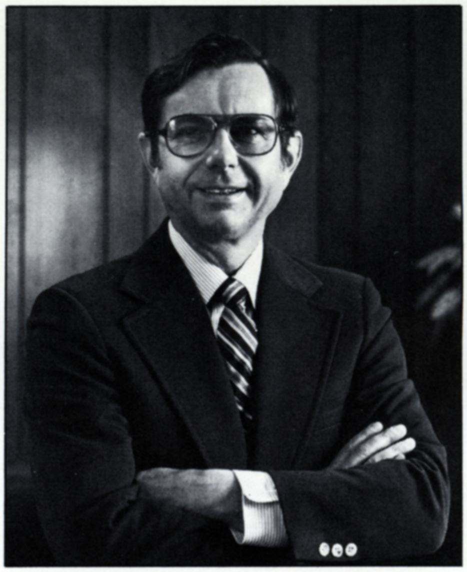
For information on specific programs of the Engineering Experiment Station, contact:

EES DIRECTOR
Dr. Donald J. Grace
(404) 894-3400

EES ASSOCIATE DIRECTORS
Howard G. Dean, Jr.
Associate Director
(404) 894-3492

Dr. James C. Wiltse, Jr.
Associate Director, Electronics Laboratories
(404) 894-3494

Rudolph L. Yobs
Associate Director, Resources Laboratories
(404) 894-3404



James Wiltse, EES associate director for electronics laboratories.

ELECTRONICS LABORATORIES

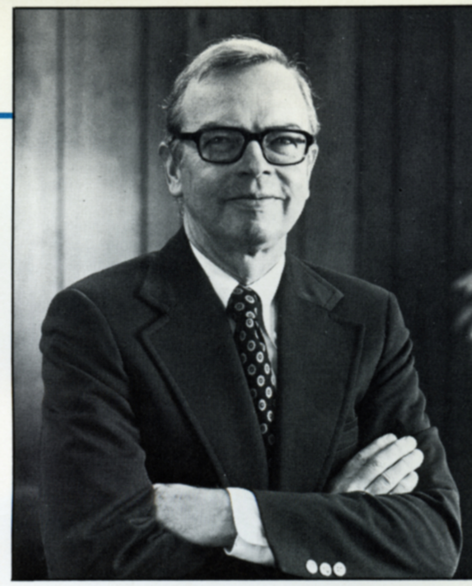
Electromagnetics Laboratory
Dr. James C. Wiltse, Jr., Acting Director
Electro-Optics, Radiation Systems, Physical Sciences
(404) 894-3494

Electronics & Computer Systems Laboratory
Fred Cain, Director
Electromagnetic Effectiveness, Communications Systems, Computer Systems, Information Systems, Electromagnetic Compatibility, Biomedical Research
(404) 894-3542

Radar & Instrumentation Laboratory
Dr. Edward K. Reedy, Director
Radar Development, Radar Experimentation, Modeling & Analysis, Radar Applications, Operations Research
(404) 424-9621

Systems Engineering Laboratory
Robert P. Zimmer, Director
Countermeasures, Defense Systems, Electronic Support Measures, Concepts Analysis
(404) 894-3519

Systems & Techniques Laboratory
Robert M. Goodman, Jr., Director
Defense Electronics, Systems Development, Microwave Systems
(404) 424-9611



Rudolph Yobs, EES associate director for resources laboratories.

RESOURCES LABORATORIES

Economic Development Laboratory
Dr. David Clifton, Director
Applied Economic Research, Business Development, Industrial Extension
(404) 894-3841

Energy & Materials Sciences Laboratory
Dr. Hans O. Spauschus, Director
Energy Sciences, Materials Sciences, Environmental Sciences
(404) 894-3530

Technology Applications Laboratory
Jerry Birchfield, Director
Applied Engineering, Energy Conservation, International Programs, Technology Transfer, Manufacturing Technology Center, Wood Energy Systems
(404) 894-3475

For more information on EES programs, contact:

**Research Public Relations Office
226 Hinman Building
Georgia Institute of Technology
Atlanta, Georgia 30332
(404) 894-3444**

4M/$5,985/February, 1981