Optics at the Electronics Research Center

L. W. Roberts

Areas of optical research conducted at the NASA Electronics Research Center are identified by subject matter and also by organizational element in this paper. Basic NASA requirements for optical research are briefly discussed and indications given as to how this research might benefit the space agency.

The optical program at the Electronics Research Center has been arranged to examine in depth, and hopefully to provide solutions, to some of the more fundamental questions that confront NASA mission planners in the area of optical astronomy, optical communication, and optical physics. Optical research has been an integral and important part of the Electronics Research Center's research and development effort since it was first formally established in 1964.

Under the present organizational arrangement, the majority of the optical research is carried out in three branches of the Optics and Microwave Laboratory of the Research Directorate. However, additional efforts of a somewhat more applied nature may be found in the Advanced Technology Directorate and in the Technical Programs Directorate.

The relationship of the ERC optics mission to that of other NASA centers is perhaps best characterized by the fact that ERC's end product is usually a technical report, a feasibility study or demonstration, or a breadboard model of a device or equipment. If considered suitable for further development, the device or equipment is turned over to one of the several NASA centers for engineering development and integration into a spacecraft, aircraft, or ground station. Consultation during the engineering phase may be provided by the ERC scientist to the NASA engineer to assist him in rapid implementation and installation of a given optical equipment.

The importance of optical research in space technology at ERC is reflected in the vast number of work units involving wholly, or in part, an optical related technology. The Optics and Microwave Laboratory is the focal point of the optical research at ERC and handles approximately 50% of the center's optical research tasks. Approximately forty personnel of its permanent and temporary staff are currently engaged in some facet of optical research activity. Some thirty to forty additional personnel from the Advanced Technology Directorate and the Technical Programs Directorate are engaged in somewhat more applied research.

At the present time, the Optics and Microwave Laboratory is housed, along with the rest of ERC, in rented quarters in Technology Square in Cambridge. However, construction of its permanent quarters is well under way in Kendall Square (two blocks away) and should be ready for partial occupancy by the end of 1969. Among the special facilities to be incorporated at the new site and peripheral areas are a 2-m mirror grinding, polishing, and figure sensing capability and a 21-m vertical test tank for the evaluation of 2-m and 3-m telescope mirrors under a simulated space atmosphere environment. Also, a series of special experiments of ERC, JPL, and GSFC are now just under way at an elevated test site on Mt. Hopkins, Arizona, which is maintained by the Smithsonian Astrophysical Laboratory but managed by ERC.

Because of the great variety and magnitude of the optical tasks conducted at ERC, it is not practical to discuss them on a work unit or individual basis. Instead, the generalized work areas are listed which should give a bird's eye view of the existing program in optical research. The effort in some of the areas listed is relatively new while other efforts are very well instrumented and staffed.

Optical Telesope Research

Submillimeter techniques for observational astronomy; techniques for ir astronomy site evaluation; control and structural analysis for large active and passive optics; optical figure sensors and actuators for large astronomical mirrors; diffraction performance of different optical systems and apertures; generation of optical surfaces in different mirror materials.

The author is with the NASA Electronics Research Center, Cambridge, Massachusetts 02139.

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Optical Techniques Research

Air pollution measurement techniques; modulation of optical radiation; development of space qualified CO_2 and He–Ne lasers; research into new lasers; holographic instrumentation.

Optical Physics

Absolute measurement of optical frequencies; parametric wave generation; generation of submillimeter radiation using quantum electronics, microwave and electron beam techniques; Raman processes; stimulated processes; high-intensity radiation research; ultrashort pulses; fundamental interactions; microelectronic fields in plasmas.

Optical Communications

Modulation techniques; pulse formation; atmospheric transmission and scattering; optical component research; communication systems research; optical detection research; optical ranging.

Applied Optics and Instrumentation

Pilot warning indicator systems; radiation intensity instrumentation; ir radiometric instrumentation; pollution control and detection; star field mapper; laser gyro; uv horizon sensor.

Earth Resource Instrumentation

Multispectral imagery; ir detector array technology; photocathode material research; uv detector technology; tracking sensors.

The Materials Laboratory of the Research Directorate also conducts work in the areas of optical materials, components, and computation techniques. This includes the manufacture of materials that sometime may be used for the generation, detection, and modulation of optical radiation. Many of the optical properties of these and similar materials are also being studied in the Electronic Components Laboratory of the Research Directorate, using a variety of research techniques such as Raman scattering, Brillouin scattering, ir absorption and reflectivity, dielectric constant measurements, and multiphon absorption. In related programs, this laboratory also investigates new techniques for the pumping, modulating, beam deflection, and tuning of solid state lasers, primarily of gallium arsenide, and the use of liquid crystals for tunable filtering and displays.

Supplementing the modest analog image processing program of the Optics and Microwave Laboratory is the application of digital imagery being studied in the Computer Research Laboratory of the Research Directorate. A transformation of imagery (TRIM) system, consisting of a computer controlled flying spot scanner, is being installed by the laboratory as a research tool for imagery processing. The objectives of this work are to transform images to forms which enhance human interpretations or are suitable for machine classification. Related studies are concerned with the problem of providing extreme storage systems for future NASA missions. Research at this stage is concerned with the read/write properties of a number of candidate storage materials, e.g., photochromic, ferroelectric, magnetooptic. The system considerations and configuration possibilities are the subject of additional research efforts.

The preponderance of optical efforts outside the Research Directorate are conducted in the Optical Technology Branch of the Electromagnetic Technology Division—a part of the Advanced Technology Directorate. It is here that systems projects in optical communication, laser ranging and atmospheric transmission and scattering are conceived and developed. In addition, work is carried out on detector calibration technology for the soft x-ray and extreme uv regions; on laser altimetry; and on several optical aspects of aircraft collision warning systems and clear air turbulence detectors in the ir region. A demonstrable feasibility model of a proximity warning indicator system has been test flown and appears to offer great promise for the general aviation industry. This branch also handles the bulk of the optically related technology requirements emanating from the Earth Resources Survey Office—a part of the Electromagnetic Technology Division. This office approaches its projects as parts of encompassing concepts, such as meteorology, oceanography, geography, cartography, etc., and in this connection also evaluates sensor systems and imaging devices for space instrumentation, and multiband spectroscopic and advanced optical data processing techniques for the establishment of refined models of the atmospheric and terrestrial environment.

In the Microcircuit Technology Division of the Advanced Technology Directorate, use is made of spatial filtering and holographic microscopy techniques for the control of the manufacture, as well as for test and automated inspection, of integrated circuits and other precision components, as part of a continuing program in component standardization and quality control. Optical techniques and instrumentation are also made use of in this division. Included is instrumentation for star tracking, horizon and sun sensing, and star field recognition, along with laser technology for the determination of spacecraft attitude, acceleration and space velocity, and the associated optical display techniques. With a number of studies in peripheral seeing and in color transmission and discrimination, the area of optical display research also touches on the general field of physiological optics.

Biomedical optics is another area receiving general attention and has become an important part of the program of the Biotechnology Division of the Advanced Technology Directorate. In preparation for the development of sophisticated control and monitoring techniques which are expected to be required in the future, this division has extended its interest toward performing nonevasive studies of human eye motions and dynamic vascular phenomena. Specifically, these studies are related to the development of advanced optical instrumentation and measurement techniques for real-time quantization and application of eye motion and for *in vivo* determination of various blood gas and

other blood constituent concentrations. Other work includes a significant effort toward development of a hybrid optical/digital correlation computer for the purpose of real-time acquisition and analysis of both imaged and on-imaged biomedical data. Related studies in the areas of electrooptical and magnetooptical effects and high resolution solid state imaging are being conducted in support of this effort. Holographic techniques for the determination of the size and shape of aerosols and microparticles are also being investigated in this division.

The remainder of the optical research work conducted at ERC takes place in the Technical Programs Directorate. Flight tests of a proximity warning indicator are currently in progress. This unit works on the ability of a silicon detector to detect in the near ir pulsed emissions from a xenon lamp. Highly theoretical studies are being made of the scattering of light in the 1-μ region by fog particles. Close collaboration is maintained between the Technical Programs Directorate and the Advanced Technology Directorate in this effort. In addition, research is conducted on laser gyros as possible replacements or additions to other types of gyros, and studies are being conducted on the use of lasers in the doppler navigation measurement of ground speed. Application of active optical image reflection systems and concepts for extracting initial, partial, or total docking data from illuminated projections of the dock vehicle are being considered and compared with the rather successful radar docking system currently in use on the Apollo flights.

Direction and guidance of optical research at ERC is formulated as a result of close collaboration with scientists and management personnel at NASA Headquarters in the Office of Advanced Research and Technology and in the Office of Space Science and Applications. Numerous planning and steering groups are in existence and are composed of representatives from ERC, NASA Headquarters, and several other centers. It is the function of these several committees and/or groups to examine the state of technology in the areas previously discussed in this paper and to equate them against requirements for future NASA missions and to the requirements of the country. Scientists at ERC, as well as at other NASA centers, are well represented as members of numerous professional groups affiliated with the American Institute of Physics and the Institute of Electrical and Electronic Engineers. It is through this medium, in addition to the several grants and contracts which NASA monitors, that the results of its research efforts are disseminated. Seminars and symposia are often entertained and/or sponsored by NASA/ERC and serve to provide dialogue between researchers in the same or related fields. Typical of recent conferences in the optical area are the ERC Symposium on Submillimeter Wave Technology in 1965, the 1968 Joint NASA/MIT Optical Space Communication Workshop, and the Seminar on the Evaluation of Motion Degraded Images in December 1968.* In addition, the Research Directorate sponsors a research colloquium series of talks utilizing outstanding researchers throughout the continental United States. So far in 1969, a total of eleven have been held of which two were concerned with the application of optical research efforts toward accomplishment of a specific task.

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Meetings Calendar *continued from page 316*

25–31 EUCHEM Conf. on Primary Processes of Organic Compounds in Condensed Phases, Schloss Elmau/Mittenwald *Ges. Deut. Chem., Geschäftsstelle, 6000 Frankfurt (M), Postfach 119075, Germany*

26–29 ISA 25th Ann. Conf. & Exhibit, Philadelphia *ISA HQ, 530 Wm. Penn Pl., Pittsburgh, Pa. 15219*

November

3–6 Acoustical Soc. of Amer., Houston *D. Muster, U. of Houston, Houston, Tex. 77004*

1971

January

24–29 ASTM, Chicago *ASTM, 1916 Race St., Phila., Pa. 19103*

February

1–4 APS–AAPT, N.Y. Hilton *W. W. Havens, Jr., 335 E. 45th St., New York, N.Y. 10017*

March

7–12 ASP-ACSM Ann. Conv., Washington Hilton, Washington, D.C. *E. J. Fennell, 430 Woodward Bldg., 733 15th St., N.W., Washington, D.C. 20005*

10–12 Photographic Sci. Symp., Ryerson Inst., Toronto *H. J. Hall, 10 Maguire Rd., Lexington, Mass. 02173*

Spring

ISA 12th Nat. Chem. and Petroleum Instrumentation Symp., Houston, Tex. *W. A. Bajek, UOP Process Div., 30 Algonquin Rd., Des Plains, Ill. 60016*

April

5–8 Optical Society of America, U. of Ariz., Tucson *J. Quinn, OSA, 2100 Pa. Ave., N.W., Wash., D.C. 20037*

21–May 1 SMPTE 109th Semiann. Conf., Los Angeles *D. A. Courtney, 9 E. 41st St., New York, N.Y. 10017*

? Soc. for Exp. Stress Analysis, Salt Lake City, Utah *SESA, 21 Bridge Sq., Westport, Conn. 06880*

June

9–12 Internat. Fed. of Assoc. of Textile Chemists and Colourists, Baden Baden *Verein der Textilchemiker und Coloristen VTCC, D-69, Heidelberg, Rohrbachstr. 76, Germany*

14–18 Molecular Spectroscopy Symp., OSU *K. N. Rao, Phys. Dept., OSU, 174 W. 18 St., Columbus, Ohio 43210*

21–25 ISA-AIP 5th Temperature Measurement and Control in Sci. and Industry Symp., Washington, D.C. *O. L. Roberson, Owens-Ctr., Granville, Ohio 43023*

27–July 2 ASTM, Atlantic City, N.J. *ASTM, 1916 Race St., Phila., Pa. 19103*

? 17th Internat. Comm. on Illumination Conf., Barcelona *25 rue de la Pepiniere, Paris 8, France*

Summer 3rd Internat. Conf. on Crystal Growth, Marseilles *B. Mutaftshiev, Lab. de Mineralogie-crystallographie, U. d'Aix-Marseille, Marseilles, France*

2nd Dijon Colloq. on High Resolution Molecular Spectroscopy *I. M. Mills, U. of Reading, Whiteknights, Reading, U.K.*

August

15–19 IES, Palmer House, Chicago *P. C. Ringgold, 345 E. 47 St., New York, N.Y. 10017*

17–27 7th Internat. Conf. on Acoustics, Budapest *T. Tarnoczy, c/o Fotvos Lorand Soc. of Phys. Szabadsag ter 17, Budapest V, Hungary*