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Final Report: Summer Research Fellowship Program

Compiled by
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National Aeronautics and
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Langley Research Center
Hampton, Virginia 23665

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AND

HAMPTON INSTITUTE

FINAL REPORT

of the

1979 SUMMER RESEARCH FELLOWSHIP PROGRAM

Compiled by:

GERALDINE C. DARDEN, Ph.D.

JUNE 4, 1979 thru AUGUST 10, 1979

LANGLEY RESEARCH CENTER

HAMPTON, VA 23665

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Rationale

Historically, the academic programs at traditionally Black institutions have not fostered active involvement in basic scientific research. College teachers with scientific backgrounds spend a substantial amount of time engaged in other activities which do not utilize their research capabilities and skills. The NASA-Hampton Institute Summer Research Fellowship Program offers capable scientists and engineers at traditionally Black institutions an opportunity to participate in research activities in an environment at the Langley Research Center where basic research is of primary importance.

The Summer Research Fellowship Program has been specifically designed to assist these faculty members in identifying areas of research which correlate positively with their individual interests and capabilities. It is also designed to help them to initiate viable research which increases their technical knowledge and expertise, and their knowledge about how research efforts at their institutions might be increased.

Programs similar to the Summer Research Fellowship Program also provide opportunities for university faculty members to engage in summer research activities, but these programs lack significant participation from faculty members representating predominantly Black institutions. This Program actively solicits minority institutional involvement by providing fellowships which allow selected faculty members to become engaged in on-going research for ten weeks during the summer at Langley Research Center. This experience should increase the quality and impact the quantity of research performed on these campuses, thus, giving more minority students the opportunity to participate in research activities. Through these activities, better research techniques will be developed by students and faculty members, therefore, a broader and more proficient base will be established from which capable scientists and engineers can be selected.

Objectives

The Summer Research Fellowship Program involves professors from predominantly Black colleges and universities in research activities at the Langley Research Center. The program is specifically designed to:

1) Provide faculty members from participating institutions the opportunity to identify active research areas appropriate to their interests and capabilities;

2) Impact the academic programs of participating institutions through modifications resulting from changing emphasis in an academic discipline due to research;

3) Promote more cooperative ventures between participating institutions and the Langley Research Center;

4) Increase the resource base which provides proficient scientists and engineers.

Participating Institutions

Initially, the Program was a pilot program and only twenty-five of the predominantly Black institutions were included. Since then three other institutions have participated and next year, all predominantly Black institutions will be asked to participate.

Atlanta University	Atlanta, Georgia
Bennett College	Greensboro, North Carolina
Clark College	Atlanta, Georgia
Elizabeth City State University	Elizabeth City, North Carolina
Fayetteville State University	Fayetteville, North Carolina
Fisk University	Nashville, Tennessee
Hampton Institute	Hampton, Virginia
Howard University	Washington, D. C.
Johnson C. Smith University	Charlotte, North Carolina
LeMoyne-Owen College	Memphis, Tennessee
Livingstone College	Salisbury, North Carolina
Morehouse College	Atlanta, Georgia
Morris Brown College	Atlanta, Georgia
Norfolk State College	Norfolk, Virginia
North Carolina A&T State University	Greensboro, North Carolina
North Carolina Central University	Durham, North Carolina
Prairie View A&M University	Prairie View, Texas
Saint Augustine's College	Raleigh, North Carolina
Saint Paul's College	Lawrenceville, Virginia
Shaw University	Raleigh, North Carolina
Spelman College	Atlanta, Georgia
Southern University	Baton Rouge, Louisiana
Tennessee State University	Nashville, Tennessee
Tuskegee Institute	Tuskegee Institute, Alabama
Virginia State College	Petersburg, Virginia
Virginia Union University	Richmond, Virginia
Winston-Salem State University	Winston-Salem, North Carolina

Program Statistics

	PROGRAM YEARS			
	1976	1977	1978	1979
Dollars Appropriated	42.5K	50K	43K	54K
Dollars Spent	42.5K	47.2K	41.7K	56K
Applicant Institutions	16	16	17	18
Fellow Institutions	8	9	8	9
Applicants	42	44	47	32
Females	(7)	(9)	(7)	(5)
Males	(35)	(35)	(40)	(27)
Fellows	9	11	8	11
Females	(1)	(2)	(2)	(2)
Males	(8)	(9)	(6)	(9)
Black	(4)	(4)	(6)	(4)
Caucasian	(5)	(5)	(1)	(5)
Asian	(0)	(2)	(1)	(2)
Fellow (Applicant) Disciplines				
Engineering	3(5)	0(3)	1(7)	1(4)
Mathematics-Computer Science	5(28)	5(16)	5(21)	7(16)
Chemistry-Physics	1(8)	5(13)	2(13)	2(10)
Others	0(5)	1*(12)	0(6)	1**(2)

*Biology **Physical Science

During the four years of the program faculty members from 25 of the 26 participating institutions have applied to the program and Fellows have been chosen from 18 of the twenty-six institutions. Also, there have been applicants from four institutions not included on the list and one Fellow has been selected from among the four.

Program Management

During the month of November 1978, the Vice-President of Academic Affairs or Academic Dean of each participating institution was sent the Final Report of the 1978 Summer Research Fellowship Program with a letter announcing the 1979 program and requesting a list of eligible faculty members. Because of a lack of sufficient possibilities for placement of biology professors at the Langley Research Center, the area of biology was deleted from the list of included disciplines.

As the lists were received from various institutions, letters and brochures were mailed to each faculty member whose name had been submitted. The letter included information on how to obtain an application form and a list of the problems submitted by the Langley Research Center. Applications began arriving in late December and were accepted thru January 1979. To obtain additional information about some of the promising applicants, they as well as some persons who knew them, were contacted by the program coordinator.

In early February 1979, the applications were reviewed and most were taken to the Langley Research Center for distribution to the various research divisions. On February 27, 1979, Dr. John E. Duberg, Dr. Wayne Erickson, Dr. William H. Michael, Mr. Ernald B. Graves, Mr. Franklin C. Owens (all at the Langley Research Center) and the program coordinator met to select ten participants and two alternates. The twelve persons were notified by letter of their status after each of the ten selected to participate had been notified by telephone. Written acceptances were received by the program coordinator before March 15, 1979. All ten persons accepted.

During April 1979, the program was awarded additional funds to support an eleventh participant and the first alternate accepted the invitation to participate. A letter containing more details about the summer was sent to each of the eleven Fellows. The letter included information such as the name of the Langley Associate, the title of the project to be investigated and housing availability. A final letter was sent in May 1979 to inform Fellows about time and place of the initial meeting.

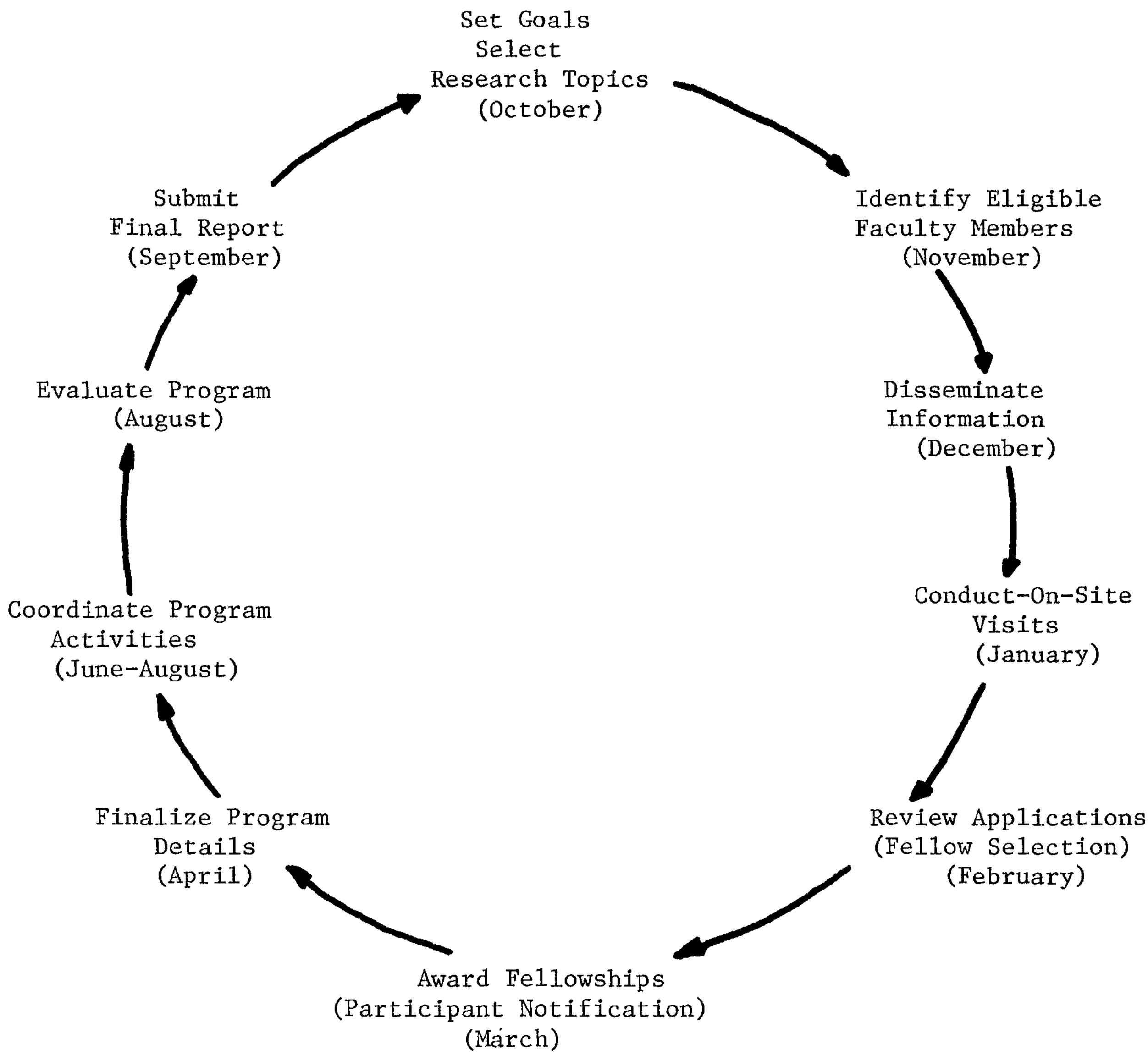
The initial meeting was held jointly with the ASEE groups on June 4, 1979, after which the Fellows went to their respective divisions to begin work on their projects. One Fellow was away from the Center for more than three weeks, but did make up for two weeks by arriving two weeks early.

The Fellows agreed to eat lunch together each Wednesday for the purpose of getting better acquainted and discussing mutual program and instructional concerns and achievements. During the first week, the program coordinator invited the Fellows to her home, along with a former participant in the program and a Langley employee, to discuss the objectives of the Program, how to avoid certain problems, the programs and activities at the Center which could impact the Fellows' various academic programs and any concerns which the Fellows voiced. The Fellows were also informed of the lectures which were a part of the ASEE Program.

During the fourth week of June the program coordinator began the first of two visits to each Fellow to ascertain the goals for the summer, progress being made and any problems which had developed. All reported progress and enthusiasm for their respective project during the first visit. The second visit was made during the eleventh week, again to ascertain the progress which had been made.

Each Fellow submitted a written synopsis of his work on August 1, 1979, and gave an oral presentation on August 6, 1979, to some Langley Research Center personnel, to other Fellows and Langley Associates. On August 10, 1979, the group conducted an evaluation of the program.

Summer Research Fellowship Activities Cycle



1979 SRFP FELLOW INFORMATION

Name & Address	Age	Education	Area	Institution & Title	LaRC Division	LaRC Research Unit	LaRC Contact Extension (804) 827-
Bales, John W. 2201 Crestview St. P. O. Box 361 Opelika, ALA 36801	35	B.A. - (1965) M.A. - (1967) University of Texas (Austin) Ph.D.- (1975) Auburn University	Mathematics Mathematics	Tuskegee Institute Assistant Professor	Flight Dynamics and Control Division	Flight Management Branch	L. Barker 2235
DeLoatch, Sandra J. 4766 Mandan Road Virginia Beach, VA 23462	30	B.S. - (1971) Howard University Ph.D.- (1977) Indiana University	Mathematics Mathematics Education	Norfolk State College Assistant Professor	Analysis and Computation Division	Computer Applications Branch	J. Shoosmith 3466
Dyer, John A. 2436 77th Ave. Baton Rouge, LA 70807	36	B.A. - (1963) Magdalen College Oxford University Ph.D.- (1967) Indiana University	Mathematics Mathematics	Southern University Associate Professor	Analysis and Computation Division	Computer Applications Branch	J. Lambiotte 4612
Hill, Tommie A. 7510 Brompton Blvd. #628 Houston, TX 77025	30	B.A. - (1969) Emory University M.S. - (1970) Northwestern University Ed.D.- (1976) University of Houston	Mathematics Mathematics Mathematics Education	Prairie View A&M University Assistant Professor	Marine and Applications Technology Division	Marine Environments Branch	J. Campbell 3645
Jones, Arthur M. 1133 Chatham Ave. Atlanta, GA 30311	40	B.S. - (1961) Morehouse College M.S. - (1961) Atlanta University Ph.D.- (1974) University of Iowa	Mathematics Mathematics Mathematical Statistics	Morehouse College Associate Professor	Materials Division	Materials Research Branch	S. Tompkins 2434

Name & Address	Age	Education	Area	Institution & Title	LaRC Division	LaRC Research Unit	LaRC Contact Extension(804)827-
Koons, Lawrence F. 103 Johnson St. Tuskegee, ALA 36088	51	B.S. - (1949) Ph.D.- (1956) Ohio State University	Chemistry Physical Chemistry	Tuskegee Institute Professor	Space Systems Division	Space Technology Branch	C. Byvik 3781
Matthews, Nathaniel 5485 Loch Lomond St. Memphis, TN 38116	43	B.S. - (1962) M.S. - (1967) Ed.D.- (1971) Memphis State University	Physical Science Administration Supervision Physical Science Education	LeMoyne-Owen College Associate Professor	Instrument Research Division	Aerosol Measurements Research Branch	D. Woods 2401
Munavalli Shekhar 131 Stonybrook Road Salisbury, NC 28144	47	B.S. - (1953) M.S. - (1955) Karnatak University M.A. - (1959) University of Kansas Ph.D.- (1962) University of Strasbourg D.Sc.- (1964) Institute of Chemistry	Chemistry/ Physics Organic Chemistry Biochemistry Organic Chemistry Organic Chemistry	Livingstone College Professor	Marine and Applications Technology Division	Marine Environments Branch	R. Harriss 3645
Perng, Shien-Sen 9327 Willow Pond Lane Burke, VA 22015	39	B.S. - (1965) National Tiawan Normal University M.S. - (1967) National Tsing-Hua University M.S. - (1971) Ph.D.- (1974) University of Illinois	Mathematics Mathematics Statistics	Howard University Assistant Professor	Marine and Applications Technology Division	Marine Environments Branch	J. Campbell 3645

1979 SRFP FELLOW INFORMATION (Cont'd.)

Name	Age	Education	Area	Institution & Title	LaRC Division	LaRC Research Unit	LaRC Contact Extension (804)827-
Reiss, Robert 18201 Mehrens Terrace Olney, MD 20832	37	Sc.B. - (1963) Brown University Ph.D. - (1967) Illinois Institute of Technology	Applied Mathematics Solid Mechanics	Howard University Associate Professor	Materials Division	Materials Research Branch	R. Clark 3386
Wiggs, John F. 906 Stephens Greensboro, NC 27406	37	B.S. - (1964) Oakland City College M.A. - (1966) Indiana University Ph.D. - (1975) North Carolina State University	Mathematics Physics Applied Mathematics Mathematics	Bennett College Assistant Professor	Flight Mechanics Division	Flight Systems Branch	C. Knox 3621

An Investigation of Robot Vision

John W. Bales
NASA-HI 1979 Fellow
Flight Dynamics and
Control Division

In anticipation of the construction of large space platforms for antenna arrays and scientific experiment packages, NASA is interested in the possible use of construction robots. It would be the task of such robots to assist human construction workers in the assembly of these large space structures. In order to handle such a complex task it will be necessary for such robots to have a sophisticated visual system, including depth perception. The research this summer has centered on two primary tasks: a survey of the state of the art in pattern recognition and computer-assisted scene analysis, and the identification of a candidate visual system for a space platform construction robot.

The most severe restriction on the visual system is the fact that it must operate in real-time. This eliminates many sophisticated approaches to the problem: they simply require too much computer time. The depth perception requirement places additional constraints. After a thorough survey of possible systems, attention was narrowed to a candidate system which provides the requisite depth information and simultaneously reduces the amount of data to be processed. This system operates with a single camera in conjunction with a lasar rangefinder. The first generation of "sighted" robots will probably operate with this type of system.

MACSYMA Usage
AT NASA-LaRC

Sandra J. DeLoatch
NASA-HI 1979 Fellow
Analysis and Computation
Division

MACSYMA is a large and versatile computer programing system written in LISP and is specifically designed for performing symbolic as well as numerical manipulations. MACSYMA has been under development since 1969 by MIT's Laboratory for Computer Science in Cambridge, Massachusetts, and it is processed on a PDP-10 computer. MACSYMA is accessible to NASA users by direct long distance telephone or via the Advanced Research Projects Agency (ARPA) Network. MACSYMA's numerous capabilities and features for symbolic processing of mathematical expressions include: two-dimensional display of expressions, differentiation, integration, polynomial factorization, solution of algebraic equations, trigonometric function manipulation, matrix and tensor manipulation, Taylor series expansion, Laplace transforms, and curve plotting.

This summer's objectives were to investigate the use of MACSYMA at NASA-LaRC and to examine the MACSYMA documentation available for NASA-LaRC users. More specifically, the fundamental tasks were to understand the capabilities of MACSYMA; uncover difficulties in accessing MACSYMA from NASA-LaRC terminals; examine MACSYMA usage in terms of the number of applications and capabilities employed; and recommend usage of additional features and documentation.

Pursuant to the first task, an intensive study of MACSYMA documentation was initiated. Attending the 1979 MACASYMA User's Conference (June 20-21, 1979) and assisting NASA-LaRC individuals in need of MACSYMA's capabilities provided additional experiences which proved beneficial in learning to use the system.

Experimentation with various features and capabilities of MACSYMA led to the discovery of a number of problems and inconsistencies encountered during the access and use of the system via NASA-LaRC terminals. As a result, a document was prepared which provides a detailed and accurate treatment of the MACSYMA LOGIN procedure.

In order to obtain data regarding the use of MACSYMA at NASA-LaRC, a survey instrument was prepared and distributed to experienced users. Although most ot the survey participants had previously employed MACSYMA's capabilities in a variety of applications, their use of the system in 1979 has been limited. The survey data also questions the adequacy of MACSYMA documentation, since the majority of respondents indicated that some portion of the documentation should be expanded or made clearer. Some of the respondents suggested that alternatives to the present documentation, and expansion of some capabilities might increase their use of MACSYMA.

The survey results and personal experimentation indicate that MACSYMA users at NASA-LaRC would benefit from the following additions to present MACSYMA documentation and capabilities:

- NASA-LaRC Users' Manual which focuses on frequently used capabilities and commands, using sophisticated examples and illustrations of syntax.
- A MACSYMA newsletter which features system updates, illustrations of current applications of MACSYMA at NASA-LaRC, and exchange of information among users.
- A more comprehensive set of integral solvers, and additional storage capacity.

The Conjugate Gradient Method

John A. Dyer
NASA-HI 1979 Fellow
Analysis and Computation Division

Let A be an n x n symmetric positive definite matrix and let b be a n-dimensional vector. The Conjugate Gradient Method is an iterative procedure for approximating the solution to Ax=b. At step k, the approximate solution, x_k is in the form: $x_k = C_0P_0 + C_1P_1 + \ldots + C_kP_k$, where $P_0, P_1, \ldots, P_k$ form a basis for the vector space spanned by b, Ab, ..., A^kb.

When k=n-1, x_k=x within rounding error, but generally x_k is a good approximation to x for much smaller values of k, typically for k between n/6 and n/3.

The number of operations required to compute x_k is slightly greater than the number of operations required to multiply k vectors by b. If A is sparse, i.e. most of the n^2 entries are zero, then a multiplication by A requires qn^2 operations, where q is the fraction of non-zero elements of A. Thus, computation of x_k requires qn^2k operations. Storage requirement is of the order of qn^2.

Direct methods for solving Ax=b take about $n^3/3$ operations if A is a full matrix. They can also benefit from the sparsity of A, but only to the extent that there are entries of A which remain zero throughout the Gaussian elimination process.

Problems can be designed to generate matrices with sparsity ideally suited to the conjugate gradient method, but very poorly suited to direct methods. Such work has been published and reflected favorably on the conjugate gradient method. That approach was not taken in this project. Instead, matrices that had already been generated by researchers at Langley were used. The results showed that the conjugate gradient method is generally slower than a direct method by a factor of 3 to 4. However, very substantial savings in storage requirements are obtained with the conjugate gradient method. This is because it is necessary to store only the non-zero entries of A whereas direct methods require storage of the factors after Gaussian elimination in which many zero entries of A were changed.

In an example with a 4834 x 4834 matrix in which about 8-10% of the entries are non-zero, Gaussian elimination changed about 6% of the zeros in A, and the following comparison of time and storage requirements was obtained:

	Conjugate Gradient	Gaussian Elimination
Time (secs.)	60	15
Storage	90,000	730,000

The conjugate gradient method has the advantage that the matrix can be stored in the core memory of the STAR computer.

Tommie Ann Hill
NASA-HI 1979 Fellow
Marine and Applications
Technology Division

Estimation of Spectral Signatures of Algae From the Airborne Lidar Oceanographic Probing Experiment (ALOPE)

Laboratory tests of a multiple wavelength laser fluorosensor system used in remote detection and quantification of algae produced the data analyzed in this project. An algae laser fluorosensor system consists of a laser, which is used to directly or indirectly excite the chlorophyll a pigment contained in algae, and a collocated telescope receiver system, which detects the emitted fluorescence from chlorophyll a at 685 nm. The quantification of chlorophyll a in vivo (chlorophyll a contained in living algal cells) represents a measure of the concentration and distribution of algae. The equation for the fluorescence power received by a laser fluorescence system used in this analysis is defined in the Appendix.

Five experiments of a four-wavelength system (454 nm, 539 nm, 598 nm and 617 nm) which selectively excites the algae contained in the four primary algal color groups (blue-green, golden-brown, green and red), provided the data for this research project. These experiments have been labeled M7, M8, M9, M10 and M11. Data from each experiment were available for each of the variables or constants written in the formula. Some had been determined through previous calculations from laboratory test data. The first, second and fourth factors in the equation for P_r are used to calculate a fluorescence term (F matrix). The $a_{f_i}(\lambda_i)$'s (A matrix) represent the spectral signatures of algae excited by a given wavelength λ_i. The η_j's (C matrix) represent the concentration of chlorophyll a in color group j. The concern for this project was to find the $a_{f_i}(\lambda_i)$'s, given the η_i's. Previously, the a's had been calculated by a different method. One purpose for this analysis of data was to see how well these estimates would agree with the present information.

In order to achieve an estimated set of values for the matrix of our concern, several small goals for the 10-week period were set. These were:

1. To become adequately familiar with the nature of the experiments and interactive computer terminal operation necessary to perform the project.
2. To perform algebraic manipulations in the vector equations so that the

form becomes F=AC, where A is the unknown matrix of values.

3. To edit the data sets.
4. To write a Fortran program that would; (a) read the stored data, (b) find the mean and standard deviation for a set of tests to be used as the data point for that day, (c) use existing subroutines to find a least square solution to the A matrix and print out the results, residuals and normalized signatures, and (d) store the results on tape.
5. To edit the Fortran program for flexibility in handling M7-M11 data under inside and outside conditions as well as other data sets.
6. To graphically represent the results.
7. To interpret the results and decide the next course of action.

Each of the subgoals one through six was achieved for the five sets of data, M7-M11, and the results were presented to other ALOPE team members involved in the project.

APPENDIX

FLUOROSENSOR EQUATION

Power received (at 685 nm) when excited at wavelength λ_i, $i = 1, \ldots, 4$

$$P_r(\lambda_i) = \left[\frac{\xi A \Delta\lambda_D f}{4\pi R^2 m^2 \Delta\lambda_f}\left(\frac{\theta_r}{\theta_L}\right)^2\right]\left[\frac{P_o(\lambda_i)}{(\alpha_f+\alpha_i)}\right]\left[\sigma_{f_1}(\lambda_i)\, n_1 + \ldots + \sigma_{f_4}(\lambda_i)\, n_4\right]\left[\frac{e^{d(\alpha_f+\alpha_i)} - (mR)^2/(mR+d)^2}{e^{d(\alpha_f+\alpha_i)}}\right]$$

Measureable constants related to sensor geometry, sensitivity, etc.	Parameters dependent on excitation wavelength λ_i	Linear partitioning of flucrescence from four algal color groups	Finite depth term
f ⇒ reflectance factor ξ = total optical efficiency A = effective area of receiving telescope primary mirror $\Delta\lambda_D$ = spectral width of detector $\Delta\lambda_f$ = spectral width of fluorescence θ_r = receiver field of view θ_L = beam divergence of laser R = distance from laser to water m = index of refraction	$P_o(\lambda_i)$ = laser power output at wavelength λ_i α_f = attenuation coefficient of water at 685 nm α_i = attenuation coefficient of water at wavelength λ_i	$\sigma_{f_j}(\lambda_i)$ = fluorescence cross section of color group j at λ_i n_j = molecular density of chlorophyll a in color group j	d = depth of culture

Quantitative Procedures for Burn and Impact Tests of Hybrid Polymeric Composites

Arthur M. Jones
NASA-HI 1979 Fellow
Materials Division

The major objective of this research is to assess the control, through material modification, of fiber-release when composite materials are damaged by fire. Minor objectives included the specification of statistical and operational procedures for conducting that assessment.

The reference composite material consists of carbon or graphite fibers embedded in a resin binder. The fibers used in the composite materials are finer than human hairs, extremely good electrical conductors, and can easily be transported by wind or currents. Comparison materials include boron and glass hybrids of the reference material.

Preliminary results indicate that the best among these modified materials may produce as much as a ninety-seven (97) percent reduction in the release of short fibers (<2mm) and a similar reduction in long fibers (>5mm). Tentative operational results indicate that the total number of short fibers or long fibers per experimental panel may be reasonable approximated by the number of those fibers contained on either the lower-right quarter or upper-left quarter of that panel.

Temperature Effect of the Photoelectrochemical Oxidation of Water on Semiconductor Electrodes

Lawrence F. Koons
NASA-HI 1979 Fellow
Space Systems Division

The use of solar irradiation for the (photo)electolysis of water to hydrogen, with the consequent synthesis of a valuable fuel, is, in principle, possible by means of a phenomenon first reported in 1972. Upon the irradiation of certain semiconductors(e.g. $SrTiO_3$, TiO_2) electrons are promoted to the conduction band at an energy level high enough for the reduction of water to H_2 , whereas the hole left at the level of the valence band can oxidize water to oxygen. Thus, there exists the possibility of constructing photoelectrochemical cells in which the energy is provided wholly or partly by sunlight. The disadvantages of the system are that the bandgaps of stable semiconductors are so large that much of the available energy is wasted and that the levels of the bands in the semiconductors do not well match those corresponding to the electrochemical reactions in solution. Temperature is among the factors that affect the positions of the various energy levels.

This work involved a study of the effect of temperature on the oxidation of water at TiO_2 and $SrTiO_3$ semiconductors. Specifically, it was the measurement of current-voltage curves for the oxidation of water on those electrodes while they were immersed in aqueous NaOH. The short duration of the program does not allow the design and the construction by specialists of a cell adequate for the making of current-voltage measurements in aqueous solutions at temperatures up to 210 C. Thus, such an aparatus from available material, partly scrap, was fabricated and developed.

The cell, in its present from, consists of a stainless steel vessel, originally intended for vacuum use, with a quartz window and with a heating element attached to its base. It has been modified to allow the feed-through of three electrical leads and to allow the connection of a source of inert gas by means of which controllable pressures up to 2.1×10^6 Pa(300 psi) can be applied to the system.

In the course of testing, problems such as condensation on the window and roof of the cell, thermal lag in the provision of heat to the solution and subsequently to the thermocouple, lack of integrity in the insulating system for the semiconductor, current loss and feedback via the thermocouple, and diverse comparable difficulties have been eliminated. In its present form the system requires that the semiconductor be in the shape of a disc approximately 0.008 m in diameter. Stock for the construction of these from $SrTiO_3$ is not presently available, but measurements with TiO_2 electrodes have been made at temperatures up to 206°C. Limited results obtained thus far do not support the expectation that the efficiency of photooxidation of water on TiO_2 would increase appreciably with increasing temperature. The feasibility of routinely obtaining measurements up to at least 200°C has been demonstrated. The work will continue with other semiconductors and with attention to the matter of the precise measurement of the intensity of light incident on the semiconductor.

Nathaniel Matthews
NASA-HI 1979 Fellow
Instrument Research
Division

Calibration of the Quartz Crystal Microbalance (QCM) As An Aerosol Impactor

In recent years there has been an increased interest among aerosol scientists in the in situ measurement of particulate aerosols. This interest is primarily in aerosol size distribution, concentration and chemical composition since these are the parameters important to the role aerosols play in radiative transfer. These parameters are also important to human health and they affect acceptable air quality conditions. For example, the size distribution governs weather particles that are capable of being inhaled and trapped in the human respiratory system or filtered out before reaching the lower respiratory tract. A variety of sensors developed to measure and characterize aerosols, and their measurement techniques can be found in the literature. A fairly unique sensor, a Quartz Crystal Microbalance (QCM) cascade impactor, has been used extensively in the Aerosol Measurement Research Branch (AMRB) at NASA's Langley Research Center. The QCM has been flown on several types of aircraft, including the NASA U-2 which reaches altitudes up to 70,000 ft. Measurements have been made on the stratospheric aerosols, on the ambient tropospheric aerosols, in the exhaust plumes from rocket motors and in the exhaust plumes from active volcanoes. The success of these measurements indicate that the QCM is useful under a wide variety of operating conditions.

The currently used values for sizing characteristics and mass sensitivity of the QCM are calculated from design parameters. Although these values are derived from fundamental physical principles it is still essential to perform laboratory calibrations on the instrument in order to validate experimental measurements, therefore, an effort was begun to develop calibration techniques for the QCM in the AMRB particle laboratory this summer.

The QCM is a multistage cascade impactor which measures the size distribution of particulate aerosols (mass concentration as a function of particle diameter) by combining the piezoelectric principle for sensing mass with the impaction technique for classifying aerosols by aerodynamic size. Each stage of the cascade collects particles over a different size interval starting at a mean diameter of approximately 25 μm in the first stage down to a 0.05 μm in the tenth stage for spherical particles with a mass density of 2 gm/cm^3. The impaction surface in each stage is a quartz crystal which is the collection element of a piezoelectric microbalance used for sensing the mass of the aerosols electronically.

The sizing characteristics of the QCM over a narrow size range (from 0.3μm diameter to 2-μm diameter) were determined in the laboratory by introducing monodisperse latex spherical particles of known size into the sensor and observing the response in each stage of the cascade. Latex particles with diameters of 0.312, 0.714, 1.011, and 2.020 micrometers were generated with a Royco 256 particle generator which employs the nebalizer method. The monodispersity of the generated particles was checked with an optical particle counter (Particle Data Systems FSSP-100) to assure that no doublets were present.

Natural Organics of the Dismal Swamp: A Profile of the Naturally Occurring Hydrocarbons

Shekhar Munavalli
NASA-HI 1979 Fellow
Marine and Applications Technology Division

In recent years, considerable attention has been focused on the presence of the natural organics in our environment and their overall impact on the delicate balance of our ecosystem. For millions of years, our environment has served as the "dumping ground" of natural organics emitted by natural processes. However, until 1970 the significance of their impact/contribution to our environmental problem was not recognized.

Maybe this was due to our preoccupation with anthropogenic organics. Recently, it has been estimated that total natural organics by far exceed the total anthropogenic organics, the natural organics amounting to 83 to 99.8 percent of the total organics of our environment.

The natural organics are derived from a variety of sources--namely, plants, biological activity and decay, forest fires, volcanoes, marine aerosol, and geochemical/geothermal pyrolysis. However, there is very little agreement on the estimates of the quantity emitted by the natural sources, particularly the plants. Plants are considered to be the principal contributors of the natural organics. In fact, the relative impact of the hydrocarbons given off by the plants has been questioned.

In one study, a striking similarity between the constituents of the natural and anthropogenic organics has been found. About 70 percent of the plants examined were found to be terpene emitters in another study. And again, a recently concluded study states that the insignificantly low levels of naturally occurring hydrocarbons cannot possibly contribute to the production of significant amounts of ozone. In light of these apparently contradictory opinions, the proposed photochemical mechanism for the reaction between the natural terpene hydrocarbons and the nitrogen oxides requires further investigation.

Another important aspect, not as yet answered, is the role and contribution of the green foliage to the natural hydrocarbon pool of our environment. The green foliage is covered with a waterproofing layer of higher hydrocarbons, more commonly known as leaf-wax. Very little is known about what happens to it when it is constantly irradiated by the sunlight and whether these hydrocarbons escape into our environment and enrich the overall pool of hydrocarbons. Although it has been observed that some simple hydrocarbons serve as the sole source of carbon for lower organisms like algae, practically very little information is available on the fate of these hydrocarbons and the nature of their biodegradation. Thus, our present day knowledge of the global cycle of the NMHC of our environment is very limited.

The present investigation is a part of the Dismal Swamp segment of the SEV-UP project being conducted by the NASA-LaRC. It is designed to answer some of the pertinent questions relative to the information of natural organics and their involvement in the photo-production of ozone, the influence of the biota on the levels and fate of these substances, the role of the moisture, particulate matter and other natural agents in the transportation of the natural hydrocarbons, and the composition and characterization of the individual species of the natural hydrocarbons.

Our goals for the 10-week period were to develop a reliable analytical arrangement, to organize sampling sites and sample collection protocols, and to coordinate our activities with the NASA SEV-UP project for monitoring air samples from 500 feet up in the air.

A. A Study in the Variation of Remote Radiance Measures and Sea-Truth Water-Quality Parameters in the James River

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For the purpose of environment assessment or marine life preservation, water-quality parameters, such as sediment, chlorophyll a, tannis and lignins, have to be constantly monitored in the river as well as in the ocean. Due to the overwhelming volume of water body, in situ measures of these parameters are costly and time consuming, even for a small sample size. It has been a large effort of NASA, EPA and other concerned agencies or institutions to develop effective remote sensor techniques and analysis methodologies to estimate the mix and densities of water-quality parameters.

Multispectral scanners were used to measure the radiance or reflectance under different wavelengths. This is incorporated with the in situ measures of water-quality parameters to establish the predicting model for the parameter.

So far, only one-parameter models have been considered. Linear (regression) models were assumed relating that parameter to one or more bands in radiance data.

To develop multiparameter models, the interrelationship of the water-quality parameters and their relationships with radiance measures need to be examined more closely. It is desired to find variables which cause the fluctuation of radiance intensities and to group the water-quality parameters according to their variation pattern.

We use the data of a James River experiment undertaken on May 17, 1977. Radiance intensities were remotely sensed under 10 bands, ranging from 380 to 1060 nm. Ground-truth measures were taken for 17 water-quality parameters. Both remote sensor and ground-truth data were taken simultaneously at six different hours of the day.

It was found that the time of the day explains a large portion of the variance of radiance intensities. The R-square values range from 0.511 (band 9) to as high as 0.865 (band 1) depending on band number (wavelength). As expected, some bands are more sensitive to specific water-quality parameters. For instance, bands 4 through 7 are very responsive to tannis and lignins.

It was further found that with 74.8% variance explained, 17 water-quality parameters can be reduced to five factors (dimensions). Thus, parameters can be divided into five groups according to their association with factors. For parameters in the same group the variation patterns are similar.

B. A Study in the Correlational Structures of Monthly Ozone Averages

Recently, concentration of ultraviolet-absorbing ozone in the stratosphere has been a great concern of atmospheric scientists. To understand the ozone layer better, it was decided to examine the correlational structures of monthly ozone averages of some ozone stations around the world.

First, the capability of reducing the dimensionality of the data was examined, then, the meaning represented by these lower dimension factors was determined. Two data sets consisting of 14 and 35 stations, respectively were analyzed.

It was found that the dimensionality of the data can be dramatically reduced. For instance, three factors accounted for 89.7 percent of the variance in the data of 14 stations and six factors accounted for 89.9 percent in 35 stations.

It was also found that, in the 14-station case, two most important factors represent, respectively, stations away from the equator and stations around the equator. In the 35-station case, the same is true for the first two factors, but there is a noticeable third factor representing those stations with somewhat irregular variations.

In addition, analysis of variance was undertaken among 35 stations. Except far a few stations, seasonal variation accounted for 60 to 93 percent of the total variance. The exceptional stations concide with those represented by the third factor in 35-station factor analysis of the last paragraph.

Effect of Load Introduction on Graphite-Epoxy Compression Specimens

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Experimental results from uniaxial compression tests of high-strength graphite-epoxy laminates show that both Young's modulus and fracture stress depend upon the dimensions of the specimen tested. The object of this research study is to develop an analytical model capable of explaining this observed phenomenon.

Laminate theory for fiber layups symmetric about the middle surface is assumed applicable. The specimen length and width are denoted by 2L and 2b, respectively. An expansion of the stress in a truncated Fourier series in the y-direction (transverse to the applied load) results in the espressions:

$$\sigma_x = -\sigma_o \{1 + \sum_1^N n \cos \frac{n\pi y}{b} \; F_n \left(\frac{\pi x}{b}\right)\}$$

$$\sigma_y = \sigma_o \sum_1^N \frac{1}{n} \{ \cos \frac{n\pi y}{b} + (-1)^{n+1} \} \; F_n{''} \left(\frac{\pi x}{b}\right)$$

$$\tau_{xy} = \sigma_o \sum_1^N \sin \frac{n\pi y}{b} F_n{'} \left(\frac{\pi x}{b}\right)$$

It should be noted that the foregoing stress-field is self-equilibrated and meets the traction-free boundary condition along the laterial edges $y=\pm b$ for any set of functions (F_n).

In an ideal compression test, the load is introduced through the edge surfaces $x=\pm L$ by requiring that these surfaces be rigidly displaced by an amount $\mp u^o$. Thus u^o/L represents the average axial strain.

The set of functions (F_n) is determined by minimizing the complementary energy using variational calculus. The resulting Euler equations are linear fourth-order coupled ordinary differential equations with constant coefficients. Natural boundary conditions are also determined.

After obtaining the functions (F_n), the resulting expressions for the stresses are only approximate because the Fourier series has been truncated. However, as N becomes large, the stresses approach the exact solution, with convergence in the mean square.

A method which can be fairly easily automated has been developed for determining (F_n, n = 1, ...N) assuming (F_n, n = 1, ...N-1) is known. The problem has been reduced to an equivalent eigenvalue (complex) problem with all but one of the eigenvalues known approximately.

Specific results have been determined for A) uniaxial fiber layups (N=1); B) quasi-isotropic $[0/\pm 45/90]_s$ laminates (N=1,2); C) cross-ply $[\pm 45]_s$ laminates. In all cases, the constrained edge effect of the clamps decays exponentially from $x=\pm L$. Moreover for case B, the exponential decay is independent of the material parameters characterizing the response. The tables below show the ratio E*/E, where E is the actual Young's modulus and E* the apparent modulus, obtained by assuming a uniaxial stress state and plotting applied stress (P/A) against average strain $1/2[\varepsilon_x(0,0) + \varepsilon_x(0,b/2)]$.

E*/E

N=1 $[0]_s$	N=1 $[0/\pm 45/90]_s$	N=2 $[0/\pm 45/90]_s$	N=1 $[\pm 45]_s$	N=2 $[\pm 45]_s$	$\frac{L}{b} = \zeta$
1.000	1.000	1.000	1.000	1.000	12
.9999	1.000	1.000	1.000	1.001	6
.9994	1.000	0.999	1.293	1.032	3
.9980	.974	.974	.719	1.130	1
.9990	1.004	1.013	1.520	12.34	0.5
.9999	1.089	1.066	1.984	6.72	0.25

1. It is apparent that just one term gives an adequate representation of the stresses for $[0]_s$. A uniaxial constant stress state is achieved along x=0 for all geometry ratios, ζ.

2. For the quasi-isotropic laminates, N=2 gives adequate results along the center line for $\zeta \geq 0.5$. An additional minor correction may be expected for $\zeta=0.25$ by taking an additional term. Nevertheless, experimental results show a 3% decrease in apparent modulus for $\zeta=1$ and a 7% increase for $\zeta=0.25$.

3. Results for $[\pm 45]_s$ are clearly not adequate except for the larger values of ζ. Considerably more terms will have to be considered. Experimental results show an apparent modulus ranging from 7% too low at $\zeta=1$ to 7% too high at $\zeta=0.25$.

OPTIM--A Computer Program for Generating Optimum Vertical Flight Profile

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This work was concerned with a sensitivity analysis of data changes made to a computer program which was developed at the Ames Research Center and modified for the Langley Research Center by Analytical Mechanics Associates, a NASA Contractor. This program, OPTIM, synthesizes various types of cost-optimal trajectories (1. Direct Operating Costs, 2. Fuel Costs, and 3. Time Costs) for the Boeing 727 aircraft.

The underlying theory of the program OPTIM is based on the application of methods of the calculus of variations and there are questions which are unresolved in this area. The program allows optimization utilizing one control (indicated airspeed) or two controls (indicated airspeed and thrust). It allows the input of a vertical wind profile, a 250-knot indicated airspeed limit below 10,000 ft and a two-part (cruise, descent) or a three-part (ascent, cruise, descent) trajectory. It also allows the input of the initial altitude and airspeed as well as the final altitude and airspeed. The airplane heading is also variable.

Analysis of the data generated by OPTIM has shown that the cost savings between using two controls and one control is negligible (less than \$0.01/nmi for ranges up to 1500 nmi). Thus analysis has been restricted to the two-control case. The analysis has also shown that the removal of the 250-knot indicated airspeed limit imposed by the Air Traffic Control System below 10,000 ft altitude would have a substantial effect on the cost per nautical mile (\$0.14/nmi at 100 mi range down to \$0.02/nmi at 1500 nmi range). The data have shown that flying an optimal profile rather than a standard profile can represent a savings of up to 2.6 percent in direct operating costs.

The most important aspect of the analysis is in the area of fuel optimal profiles. The study shows that over 1,000 lbs of fuel can be saved by flying a fuel optimal profile rather than the standard flight profile for a range of 250 n.mi. This fuel savings is increased to over 2,400 lbs. of fuel for a range of 1500 n.mi. Moreover, these profiles increase the direct operating costs for these two flights by less than 1% over the standard profile in most cases.

Future work with OPTIM will deal with changing engine data and aerodynamic data so that the program will yield optimal trajectories for the NASA 737 aircraft. Comparisons will then be made for several selected trajectories determined from this revised OPTIM program with flight tests of the NASA 737 Terminal Configured Vehicle.

Some Significant Accomplishments, 1976-1979

The Summer Research Fellowship Program was initiated at the Langley Research Center during the summer of 1976. Since that time, some significant technical contributions have been made by Summer Research Fellows. Only one from each Program year is briefly discussed below.

1976 Plans for the future utilization of space indicate the necessity for the construction of large space structures. Since strong gravitational forces will be absent, these structures can be assembled using light-weight materials which are generally flexible.

Dr. Taft H. Broome, a Fellow from Howard University, investigated the feasibility of stiffening flexible large area space structures by means of cables. The scope of his analysis included cantilevered booms of constant cross-section. During that summer, Dr. Broome studied six different cable stiffening schemes which provided acceptable results, and upon returning to Howard University for the 1976-1977 academic year, continued this research by studying additional schemes.

1977 During the past several decades, the use of the computer to solve research problems has increased to a level which in some cases demands optimal efficiency in computer utilization. One case is the solution of partial differential equations in steady-state time dependent problems.

Dr. William H, Lee, a Fellow from North Carolina Central University, developed a finite-difference numerical method which reduced, by a factor of ten, the amount of computer time generally necessary to solve this class of problems.

1978 Currently, there is international concern about pollution of the natural environment. The Marine Environments Branch at the Langley Research Center is developing methods of determining various levels of pollution in water. Although some data is gathered using remote-sensing techniques, an effort is also being made to develop mathematical models that may be used to predict pollution levels in water.

Dr. Demetrius D. Venable, a Fellow from St. Paul's College, developed a computer model using the Monte Carlo technique to evaluate solar radiation scattered from water for a non-homogeneous pollutant profile. The use of this model will reduce the amount of data gathered by aircraft to determine the levels of water pollution and improve the accuracy of predicting pollution levels in water.

1979 Graphite, a material formed from carbon and which because of its properties of durable strength, light weight, resistance to high temperatures and corrosive chemicals, is being used in the manufacture of aircraft, automobiles and various consumer goods. The Materials Research Branch of the Materials Division at Langley Research Center has been performing uniaxial compression tests of high strength graphite-epoxy laminates and have results showing that Young's modulus and fracture stress depend upon the specimen dimensions. Dr. Robert Reiss, a Fellow from Howard University developed an analytical model that explained the experimental results. This model is relatively easy to automate, therefore, some predictions will be possible with the use of the computer.

Program Evaluation

As a result of enthusiasm on the part of the Fellows and few problems to solve by the coordinator, the 1979 Summer Research Fellowship Program was one of the most stimulating. On each of the two visits to the Fellows by the Coordinator, minor problems had been encountered, if any, and solutions took very little effort.

All the Fellows made oral presentations to selected Langley Research Center personnel and some also made oral presentations to their respective Branches. The presentations were "excellent" as stated by some of those attending.

According to written and group evaluations, the Fellows think the program is a very good one because it brings together academicians and basic and applied research scientists and engineers to work together in an atmosphere conducive to learning and experimentation. As a result, the professors' students also benefit according to the Fellows. All reported that they had received excellent assistance and cooperation from Langley Associates.

The Fellows also stated that the program was very well administered and operated smoothly.

All reported interest in seeking an expanded research relationship with NASA and five of the Fellows reported having specifically talked with their respective Langley Associate about submitting a proposal to continue the work begun during the summer or initiating work in a new area.

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16. Abstract

This report summarizes a Summer Research Fellowship Program involving Professors from predominately Black Colleges and Universities at the Langley Research Center. The report outlines the rationale and objectives of the program. Brief reports of the work accomplished by the participants are included. An evaluation of the program is also given.

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