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SUMMER FACULTY FELLOWSHIP PROGRAM 1982

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HAMPTON INSTITUTE
Hampton, Virginia

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

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ORGANIZATION AND MANAGEMENT

The 1982 Summer Faculty Fellowship Program, sponsored by NASA-Langley Research Center, Hampton Institute, Old Dominion University, and the American Society for Engineering Education (ASEE), is the nineteenth such institute to be held at Langley Research Center (LaRC).

The 1982 program was planned by a committee consisting of codirectors from both Hampton Institute and Langley Research Center and of LaRC staff members from the research divisions and the Educational Services Branch. The applicants' credentials were reviewed by this committee, and the appointments of the research fellows were made by the codirector, Mr. John H. Spencer, professor and chairperson, Department of Architecture, Hampton Institute. All the fiscal matters such as honoria, stipends, and travel reimbursements were administered by John H. Spencer through Hampton Institute. Dr. G. Goglia of Old Dominion University, ASEE codirector and consultant to the 1982 program, did the initial review of the applications and the matching of applicant skills to LaRC research areas. Dr. Goglia also organized a lecture series for the research fellows.

The Langley codirector, Mr. Robert Tolson, chief scientist, along with Mr. Pat Clark and Mr. Frank Owens from the LaRC Training and Educational Services Branch, and John H. Spencer of Hampton Institute, assumed responsibility for providing the research assignment for each research fellow and for making all necessary scheduling arrangements.

All program applicants received a 1500-hundred word commentary describing the mission and facilities of the Langley Research Center. The qualifications of the applicants were judged by the codirectors. The desire to provide the research fellows with an appropriate research opportunity in the areas of their choice carried the most weight in the final selection of the new research fellows. Langley Research Center supervisors participated in this aspect of the selection and assignment process. All applicants were supplied with a list of research problems available to the Langley research fellows, and the applicants indicated their research preferences by letter or by phone to the codirectors. Information on local housing was supplied to the research fellows by John H. Spencer and Frank Owens.

As in the previous programs, the LaRC Training and Educational Services Branch gave much effort to the program. Pat Clark, head of the Branch, and Frank Owens, employee development officer, participated in the preliminary deliberations and planning sessions. Frank Owens was the principal liaison officer during the program, and he had frequent contacts with the research fellows.

The program convened on June 1, 1982 with an assembly at which the research fellows were welcomed to LaRC by Robert Tolson. Mr. John K. B. LeDeaux, Langley Security Office, briefed the research fellows regarding security at LaRC. Mrs. Jane Hess, head of the Technical Library, discussed the use of the LaRC library. Mr. Robert V. Butler, assistant head, Computer Management Branch, gave an orientation to the Analysis and Computation Division.

At the conclusion of the Summer Faculty Fellowship Program, each research fellow submitted an abstract describing his or her research accomplishments and also gave a 15-minute presentation of these accomplishments as part of a lecture series. In addition, each research fellow completed a program evaluation questionnaire. A final meeting was held at which the research fellows discussed the program with program codirectors and with representatives from the Langley Research Center staff.

RECRUITMENT AND SELECTION OF RESEARCH FELLOWS

Promotional materials for the program were prepared, printed, and distributed by ASEE. The combined brochure/application form was sent to all schools of engineering and science in the U.S.A. In addition to the above, personal letters were sent and phone calls made to the academic deans and heads of engineering and science programs to request that they bring the Summer Faculty Fellowship Program to the attention of their faculties. Minority schools throughout the South and the Southwest were included in the mailing.

A tabulation of the applications and of the final selection of applicants is shown below.

APPLICATIONS

Total Appl.	First Choice Langley	Second Choice Langley	Minority Schools	Blacks	Male	Female
116	84	32	9	14	110	6

SELECTED APPLICANTS

First Choice Langley	Second Choice Langley	Minority Schools	Blacks	Male	Female
37	1	5	7	35	3

Returning Fellows 7

New Fellows 31

STIPENDS AND TRAVEL

A 10-week stipend of $5500 was awarded to all research fellows. Although an increase was provided this year, the stipend still fell short (for most of the research fellows) of matching the equivalent salaries of their university academic year. This was a clear indication of the excellent reputation of the program and the willingness on the part of the research fellows to make some financial sacrifice in order to participate in this program. Other tangible benefits included contacts with researchers, future contacts with LaRC, and possible future research grants from NASA.

Travel expenses incurred by the research fellows to and from their homes to Hampton, Virginia, were reimbursed in accordance with current Hampton Institute regulations.

Funds that remained in the travel budget were used to send two research fellows to seminars related to their areas of research. Combined funds from travel and lecture honoraria were used to pay stipens for a 1-week extension for 14 research fellows.

LECTURE SERIES

The lecture series for the 1982 Summer Faculty Fellowship Program was patterned after the programs from previous years. This year, however, in order to give the research fellows a broader view of research at Langley, all speakers were chosen from the Langley scientists (table 1).

The speakers were selected on the basis that they had distinguished themselves in their fields and that their topics for discussion would appeal to a majority of the participants. The lectures were scheduled on Mondays and Wednesdays and were well attended although attendance was on a voluntary basis. Each lecture was followed by a question and answer period with very good input by the research fellows.

BRIEFINGS AND TOURS

The research fellows were notified of all NASA-Langley briefings and the ICASE seminars and were invited to attend.

All-day tours of the Langley facilities were arranged by Frank Owens. These tours were designed to add to the participants' knowledge of Langley Research Center. As a part of the tour program, Dr. Donald P. Hearth, director of the Langley Research Center, spoke to the research fellows on the importance of university relationships to the Agency.

TABLE 1.- LECTURE SPEAKERS AND TOPICS

Date	Speaker	Topic
June 9	Charles H. Elred (NASA-LaRC) SSD-Vehicle Analysis Branch	Space Shuttle
June 14	Dr. Joel S. Levine (NASA-LaRC) ASD-Theoretical Studies Branch	Atmospheric Sciences Pollution
June 16	Mr. Donald Baals (NASA-LaRC) Distinguished Research Associate	Wind Tunnels-NACA
June 21	Mr. Homer G. Morgan (NASA-LaRC) Acoustics & Noise Reduction Division	Acoustics and Noise
June 28	Mr. Ray V. Hood, Jr. (NASA-LaRC) FCSD-Systems Applications Office	Flight Dynamics and Controls
July 12	Mr. Cary R. Spitzer (NASA-LaRC) FCSD-Systems Applications Office	Planetary Exploration
July 19	Dr. Olaf O. Storaasli (NASA-LaRC) SSD-IPAD Project Office	Computer-Aided Design Programming
July 26	Dr. Edward V. Browell (NASA-LaRC) ASD-Chemistry and Dynamics Branch	Future Use of Lasers
Aug. 2	Presentation by Research Fellows Bldg. 1194A/Rms. 110, 203-204, 206 - 9:00 a.m. - 12:00 noon	
Aug. 3	Presentation by Research Fellows Bldg. 1194A/Rms. 110, 203-204, 206 - 8:30 - 12:00 noon	

RESEARCH PARTICIPATION

The 1982 program, as in past years, placed greatest emphasis on the research aspects of the program. Mr. John H. Spencer, codirector for the 1982 program, contacted each research associate for comments regarding the research being done by the research fellows. These comments from the Langley supervisors, together with the abstracts prepared by the research fellows, provided convincing evidence of the continued success of this part of the program. The abstracts are included at the end of this report.

The research projects were greatly diversified with the highest concentration in the Flight Dynamics and Control Division.

Division	Numbers of Researchers
.Analysis and Computation Division	5
.Instrument Research Division	4
.Flight Dynamics and Control Division	6
.Materials Division	1
.Acoustics and Noise Reduction Division	1
.Structures and Dynamics Division	3
.Loads and Aeroelasticity Division	1
.Transonic Aerodynamics Division	1
.High-Speed Aerodynamics Division	1
.Aeronautical Systems Office	1
.Atmospheric Sciences Division	2
.Space Systems Division	5
.Atmospheric Sciences Division	1
.Systems Engineering Division	1
.Facilities Engineering Division	1
.Personnel Division	2
.Office of Educational Services	1
.Flight Electronics Division	1

Background of Fellows

Aerospace Engineering	3
Architectural Engineering	1
Biomedical Engineering	1
Chemistry	4
Civil Engineering	1
Communications	1
Computer Science	4
Electrical Engineering	1
Industrial Engineering	1
Mathematics	10
Mechanical Engineering	5
Microbiology/Pathology	1
Oceanography	1
Physics	2
Psychology/Education	1
Statistics	1

No. of Participants	Ph. D. Degree	Masters Degree
38	32	6

PARTICIPATION INFORMATION

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOC.
Dr. Iris C. Anderson Professor & Dept. Head Biology Thomas Nelson Community College Hampton, VA 23607	42	Atmospheric Sciences Div.	J. Levine
Mr. Ronnie S. Bailey Assistant Professor Architectural Eng. NC A&T State University Greensboro, NC 27411	32	Facilities Engineering Div.	C. Schilling
Dr. Patrick G. Barber Associate Professor Chemistry Longwood College Farmville, VA 23901	39	Instrument Research Div.	P. Hayes
Dr. Morris A. Blount Coordinator Mathematics Fayetteville State Univ. Fayetteville, NC 28301	46	Analysis & Computation Div.	G. Haigler
Dr. Luke A. Burke Assistant Professor Chemistry Rutgers U. Camden College Camden, NJ 08102	34	Materials Div.	T. StClair
Dr. Daniel R. Collins Associate Professor Psychology Hampton Institute Hampton, VA 23668	39	Personnel Div.	S. Massenberg
Dr. Sandra J. DeLoatch Associate Professor Mathematics Norfolk State Univ. Norfolk, VA 23504	33	Analysis & Computation Div.	J. Shoosmith
Dr. Stefan Feyock Associate Professor Math & Computer Sci. College of Willaim & Mary Williamsburg, VA 23185	40	Flight Dynamics & Control Div.	W. Hankins
Dr. Ahmed A. Hassan Assistant Professor Aerospace Engr. & Engr. Science Arizona State Univ. Tempe, Arizona 85287	29	Transonic Aerodynamics Div.	J. South

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOC.
Mr. Kenneth W. Hunter, Sr. Instructor Mechanical Engineering Tennessee Tech. Univ. Cookeville, TN 28501	29	Acoustics & Noise Reduction Div.	D. Chestnutt
Dr. Yogendra P. Kakad Assistant Professor Engr. Analysis & Design Univ. of NC at Charlotte Charlotte, NC 28223	38	Structures & Dynamics Div.	B. Hanks
Ms. Jacquelyn E. Long Assistant Professor Mathematics Norfolk State Univ. Norfolk, VA 23462	35	Analysis & Computation Div.	J. Shoosmith
Dr. William E. Maddox Professor Physics Murray State University Murray, KY 42071	44	Instrument Research Div.	W. Kelliher
Mr. John R. McCravy, Jr. Associate Professor Engineering Tech Clemson Univ. Clemson, SC 29631	49	Structures & Dynamics Div.	M. Mikulas
Dr. Griffith J. McRee Associate Professor Electrical Engineering Old Dominion Univ. Norfolk, VA 23451	47	Flight Dynamics and Control Div.	R. Montgomery
Dr. Zane C. Motteler Professor Mathematics & Computer Science Michigan Tech. Univ. Houghton, MI 49931	47	Instrument Research Div.	H. Holmes
Dr. John W. Nazemetz Assistant Professor Industrial Engineering Oklahoma State Univ. Stillwater, OK 74078	30	Space Systems Div.	U. Lovelace
Dr. Paul Nichols Assistant Professor Aeronautical Arizona State Univ. Tempe, AZ 85287	46	Aeronautical Systems Office	L. Williams
Dr. Jerry L. Potter Associate Professor Math Sciences Kent State University Kent, Ohio 44242	40	Flight Dynamics and Control Div.	E. Foudriat

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOC.
Dr. Frank P. Primiano, Jr. Assistant Professor Biomedical/Mech & Aerospace Engineering Case Western Reserve Univ. Cleveland, OH 44124	43	Flight Dynamics and Control Div.	A. Meintel
Dr. Zia Razzaq Assistant Professor Civil Engineering Univ. of Notre Dame Notre Dame, Ind. 46556	37	Space Systems Div.	M. Mikulas
Dr. David Rudd Associate Professor Mathematics Hampton Institute Hampton, VA 23668	38	Analysis and Computation Div.	S. Voight
Dr. Antony Saturno Professor Chemistry State Univ. of NY at Albany Albany, NY 12222	51	Structures and Dynamics Div.	J. Jones
Dr. Charles H. Scanlon Associate Professor Mathematics Arkansas State Univ. State University, Arkansas	44	Flight Dynamics and Control Div.	C. Knox
Dr. Finis E. Schneider Chairman Mass Media Arts Hampton Institute Hampton, VA 23668	50	Personnel Div.	F. Owens
Dr. James L. Schwing Assistant Professor & Chairman Computer Science Old Dominion University Norfolk, VA 23508	33	Space Systems Div.	A. Wilhite
Dr. Shantilal N. Shah Professor Math & Computer Science Hampton Institute Hampton, VA 23668	45	Atmospheric Sciences Div.	G. Young
Dr. Stewart Shen Professor Computer Science Computer Science Old Dominion Univ. Norfolk, VA 23508	40	Space Systems Div.	D. Morris
Dr. Donald D. Shillady Associate Professor Chemistry Virginia Commonwealth Univ. Richmond, VA 23284	44	Instrument Research Div.	D. Phillips

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOC.
Dr. Victor Shtern Associate Professor Computer Science Boston University Boston, MA 02215	48	Analysis & Computation Div.	E. Senn
Mr. Michael H. Sims Graduate Student Mathematics Rutgers University New Brunswick, NJ 08903	33	Flight Dynamics and Control Div.	K. Barker
Mr. Willard A. Stanback Assistant Professor Mathematics Norfolk State Univ. Norfolk, VA 23504	51	Systems Engineering Div.	B. Pegg
Mr. John J. Stith Assistant Professor Physics Virginia State Univ. Petersburg, VA 23803	37	Space Systems Div.	G. Walker
Dr. Charlie D. Turner Assistant Professor Mech. & Aerospace Eng. North Carolina State Univ. Raleigh, NC 27605	36	Low-Speed Aerodynamics Div.	R. Doggett
Mr. Wallace Venable Associate Professor Mech & Aerospace Eng. West Virginia University Morgantown, WV 26506	42	Office of Educational Services	H. Mehrens
Dr. Terry L. Wade Assistant Professor Oceanography Old Dominion University Norfolk, VA 23518	33	Atmospheric Services Div.	R. Harriss
Dr. Larry Wilson Assistant Professor Computer Science Old Dominion University Norfolk, VA 23508	39	Flight Electronics Div.	B. Lupton
Dr. Charlie L. Yates Associate Professor Mechanical Engineering Virginia Polytechnic Institute & State Univ. Blacksburg, VA 24061	46	High-Speed Aerodynamics Div.	B. Northam

PROGRAM EVALUATION SUMMARY

Program evaluation forms were sent to 37 research fellows (one person left at the end of 5 weeks in response to a family emergency). Thirty-five responses were received (a 94.59 percent return).

A majority of the research fellows (Yes 33 - No 2) indicated that they were able to obtain sufficient information about the program.

Thirty-three of the respondents indicated an early contact with the research associate had allowed some time for preparation for the research assignment.

Twenty of the 35 research fellows stated they were given a choice of research topics. Only two persons stated they would have chosen another topic. However, all of the research fellows stated that they found the research challenging and within their chosen field of interest.

The research fellows in general agreed that the research associates and other Langley personnel were helpful and supportive.

When questioned regarding the length of time it took to get a basic understanding of the project and project expectations, the responses were as follows:

Before Arr.	Immediately	1 wk.	1½ wk.	2 wk.	1 mo.	Cont. of prev. work
4	8	10	2	4	2	1

There was some indication that the early contact with the research associate was instrumental in a high number of research fellows being able to get an early understanding of their research projects.

Most of the research fellows expressed intentions to undertake research of a similar nature upon their return to their home institution. Most of the research fellows made inquiries about a continuing association between the Langley Research Center and their home institution; however no commitments have been made by LaRC at this time.

The participants agreed that the lecture series was of interest and should be continued. Most of the research fellows approved of having lectures by Langley scientists because the speakers gave them a greater insight into LaRC programs. The lectures were well attended and usually generated some discussion during the question and answer period.

Seventy-four percent of the respondents considered the stipend to be adequate; this was qualified to mean adequate if the stipend was tax exempt.

Only five of the respondents indicated difficulty in locating suitable housing. Because 16 of the 1982 research fellows were from the immediate vicinity, the adequacy of the stipend and the lack of difficulty in finding housing had to be considered.

The Langley research associates have been quite supportive of the program, and all responses from the associates have been positive. Each research associate was complimentary of the program and the research fellow assigned to him or her.

Research fellows cited the following benefits from the program: (1) enhancement of professional abilities, (2) contact with professionals in a chosen area of research, (3) familiarity with research facilities, and (4) development of new research techniques and their adaptation to an academic setting.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Comments made by the research fellows indicated satisfaction with the program and their summer experiences.

The overall quality of the participants was excellent and received praise by several research associates.

Contact with the research associate, prior to arrival, was considered essential. A visit to Langley to discuss the research project, in advance of the arrival for summer, was recommended.

The stipend was considered adequate only when considering the peripheral benefits associated with this program. Specific information concerning the tax status of the stipend should be disseminated.

Recommendations

The opening session should be utilized to a greater degree to give further orientation to the LaRC facilities, especially the types of programs and ongoing research.

Summer intern students that are participating in other LaRC programs should also attend the scheduled lectures with the research fellows.

Research fellows should give a briefing on their research problem midway in the 10-week period.

More flexibility should exist on start and stop dates.

Paycheck tax deductions should be withheld in subsequent programs.

RESEARCH ABSTRACTS

BIOGENIC PRODUCTION

OF NITROGEN OXIDES

by

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Human activities can cause large and potentially hazardous perturbations to the composition and chemistry of the atmosphere. Anthropogenic species can affect health, crop productivity, and climate. Predictive computer models have been developed to analyze the kinetic and photochemical behavior of atmospheric species. These models require accurate input of the sources and sinks of natural and anthropogenic species.

The nitrogen oxides play a key role in atmospheric chemistry. Within the troposphere, nitric oxide (NO) and nitrogen dioxide (NO_2), collectively called NO_x, control the levels of reactive species such as ozone and hydroxyl radicals, formation of photochemical oxidants, carcinogens, and acid rain, and climatic changes due to a greenhouse effect. In the stratosphere, nitrogen oxides destroy ozone, which shields life on Earth from lethal ultraviolet radiation emitted from the Sun.

While it has been assumed that anthropogenic emissions may be the largest source of nitrogen oxides to the atmosphere, lightning, oxidation of ammonia, and biogenic activity are other potentially important sources, especially in areas remote from industrial development. Of the nitrogen oxide sources, biogenic production is probably the least understood.

Two groups of bacteria, nitrifiers and denitrifiers, are capable of producing nitrogen oxides. Both groups of organisms coexist in soil. Nitrifiers, which convert ammonium to nitrite and nitrate, operate primarily under aerobic conditions, while denitrifiers, which convert nitrate to molecular nitrogen, operate anaerobically. Under normal growth conditions nitrification and denitrification reactions go to completion with no accumulation of intermediate products. However, under low oxygen (microaerophilic) conditions, it is possible to isolate N_2O and perhaps NO.

Work performed this summer in the Atmospheric Sciences Division utilized Nitrosomonas europeae, a soil bacterium and nitrifier capable of converting ammonium to nitrite. The organism was grown under microaerophilic conditions with ammonium sulfate as the energy source at 25 - 28°C in a batch-culture device with nitrogen gas containing 300 ppm CO_2 and 0.5 percent O_2, supplied at a flow rate of approximately 150 ml/min. Head space gas was vented directly into a chemiluminescence detector for analysis of NO concentration. In addition, head space samples were taked by syringe and analyzed for N_2O using a gas chromatograph equipped with electron-capture detector. Samples of medium were taken by syringe for determinations of nitrite, nitrate, cell concentration, and pH. Both nitrite and nitrate concentrations were measured using an autoanalyzer. Studies were made at various initial pH levels and with two different media, one highly buffered.

At 28°C in a lightly buffered medium, N. europeae grew with a generation time of 14 - 17 hours. Over a 140-hour time span, the pH changed from 8.2 to 6.2. Maximum production of NO and N_2O occurred only while organisms were growing at an exponential rate. This exponential phase could be maintained for 48 hours while pH was optimal. The concentration of N_2O paralleled that of NO with the ratio of NO/N_2O ranging from 1.4 - 3.8. Maximum production of NO (1.2 ppm/min) and of N_2O (0.66 ppm/min) occurred at a cell concentration of 6×10^6 cells/ml.

In a highly buffered medium at 25°C, the generation time of the culture increased to 25 hours; however, the culture could be maintained in exponential phase for a longer period (5 days). Maximum production of NO (2.6 ppm/min) occurred at a cell density of 4.2×10^7 cells/ml. The NO/N_2O ratio ranged from 2.3 - 4.9. The per-cell production rate of NO ranged from 1.4×10^{-11} mmole/cell/day in lightly buffered medium at 28°C to 0.44×10^{-11} mmole/cell/day in highly buffered medium at 25°C.

Based upon the above, we calculated annual production rates per m^2 soil, assuming an average cell density of 10^5 cells/ml in a productive crust 1-cm thick. Preliminary calculations suggest rates ranging from 0.5 - 0.15 g NO produced per m^2 soil per year. These rates are in agreement with those derived from fluxes observed in Australian soils. Based on their observations, Galbally and Roy (ref. 1) estimated that biogenic activity could supply as much as 10×10^{12} g N per year to the atmosphere, which is about half of the global NO_x production rate due to anthropogenic activities. Experiments carried out this summer suggest that nitrifying bacteria in soil are a significant source of NO_x to the atmosphere.

References

1. Galbally, I. E.; and Roy, C. R.: Loss of Fixed Nitrogen From Soils by Nitric Oxide Exhalation. Nature, vol. 275, October 26, 1978, pp. 734-735.

FACILITY PLANNING AND DEVELOPMENT AND
CoF BUDGET DEVELOPMENT FOR
LANGLEY RESEARCH CENTER

by

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The Facilities Program Development Office (FPDO) at NASA-Langley Research Center (LaRC) is responsible for coordination, planning, and development of research and institutional facilities and for the preparation of the construction of facilities (CoF) budget. FPDO has two types of facilities planning projects, minor and major.

MINOR PROJECTS	MAJOR PROJECTS
Rehabilitation and Modifications to Facilities Repair (75K to $500K)	Rehabilitation, Modification, and Repairs Greater Than $500K
Minor Construction ($75K to $250K)	New Construction Greater Than $250K

(K=,000)

The minor and major projects undergo a nine-stage process before money is allocated for construction. This process includes:

1. A call for projects to all researchers
2. Proposal submittals by researchers
3. Projects reviewed by LaRC and NASA Headquarters in Washington, DC
4. Another NASA Headquarters review
5. Final budget review
6. Final budget review by NASA Headquarters
7. Office of Management and Budget review
8. Congress for appropriations
9. Funding

After the funding stage, the projects undergo the construction-bid process. Then projects are monitored throughout construction by FPDO. Usually, it takes 4 to 5 years to complete a NASA-LaRC project. For emergency cases, such as immediate need for building repair, funds are set aside to shorten the nine-stage process.

From stage two through nine, FPDO begins the documentation to help those projects that meet NASA's future objectives to receive adequate funding for construction. The documentation for a project includes the following:

1. <u>Scope of project</u> - relates this particular project to NASA's overall objectives
2. <u>Description of project</u> - gives all necessary construction details

3. Cost Estimate - gives cost of land acquisition, construction, and equipment
4. Site Plan - is a graphical description of the location of the site
5. Plan View - is a graphical layout of the building; it may not necessarily be drawn to scale
6. Photo - is taken in order to show existing conditions. As an architectural engineering professor working with FPDO, one would get an opportunity to discover facility needs for different forms of scientific research. Projects such as the Modifications for Advanced Space Energetics Laboratory require conferences with scientists and researchers to determine estimated space needs. From conferences and site visits, one could write and do graphic proposals that could be included in the documentation process

FPDO is working on a study to speed up the present nine-stage process by listing the future funding needs in advance. This study (LaRC Facilities Upgrade Program 1989 through 1991) is designed to establish a priority list for the funding of projects. The study will be undertaken by a team of representatives from each research directorate and from the Management Operations directorate. The team will seek to categorize projects by priorities according to the following criteria:

1. Productivity Improvement
2. Measurement Acquisition Systems
3. Operational Integrity
4. Utility System
5. Plant Safety
6. Institutional Upgrade

Once the LaRC Facilities Upgrade Program study is completed by FPDO, it will become a vehicle to seek additional funding to accomplish plant upgrade on a timely basis.

INVESTIGATIONS OF THE COMPOSITION AND STRUCTURE OF FERROELECTRIC BISMUTH TITANATE THIN FILMS

by
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The National Aeronautics and Space Administration (NASA) has been in the forefront of modern developments in small, lightweight, reliable computer components. To anticipate future developments in this area, there is a program at NASA-Langley to investigate the use of electrical analogs to the present magnetic devices, and ferroelectic materials are a promising class of substances for this purpose. As a pyroelectric substance, these ferroelectric materials spontaneously develop an electric dipole moment when subjected to stress. Ferroelectrics have the additional characteristic that this moment can be reoriented. A reoriented electric dipole moment is a perfect candidate for a memory device since one orientation could designate binary 1, while the other would designate binary 0. Further, this orientation can be altered simply by the application of a small voltage, and the orientation will remain stable even in the event of a power failure. Because the optical properties of ferroelectrics change with this electric moment, reading the orientation becomes possible optically. This offers the promise for rapid, reliable, high-density memories using electro-optical rather than magnetic properties.

Although there are many ferroelectric materials available, bismuth titanate, i.e., BiTan or $Bi_4Ti_3O_{12}$, is one with a favorable set of properties. It is a cheap, readily fabricated ceramic with an optic axis that varies dramatically with a reversal of the electric field orientation. Bismuth titanate has been shown to exhibit suitable ferroelectric behavior when it is grown as a single crystal. For numerous applications it is desirable to have the ferroelectric material in the form of a thin film rather than as a bulk single crystal, since as a thin film it would be both smaller and lighter. To be effective as a thin film, however, the ceramic must have the correct composition, structure, and orientation.

Previously at NASA-Langley, bismuth titanate had been deposited as a thin film on a quartz substrate which had been previously coated with a thin, transparent film of metal. For physical reasons such as poor film adherence and integrity on quartz, silicon was used as an alternative substrate in the work described in this report. The films were prepared by radiofrequency (RF) sputtering the bismuth titanate for 300 minutes onto polished and cleaned single-crystal silicon wafers that had been cut in the (111) orientation. The resulting films are about 10 000 Å, i.e., 1-um thick; and they have good physical integrity at least up to a deposition temperature of 300°C. The present research studied the film properties as a function of the temperature of deposition.

After the deposition and the initial analysis, the films were annealed by placing them in a furnace and slowly raising the temperature over a 4-hour period to 520°C and then holding the temperature there for 30 minutes. The furnace was then allowed to cool overnight.

Energy dispersive analysis attached to the scanning electron microscope (SEM-EDAX) and X-ray fluorescence were the two methods used to analyze the composition of the films. The SEM-EDAX was used on a series of specimens prepared earlier on quartz substrates as well as on those prepared this summer on silicon wafers. The results show that in both cases the film deposited as the desired bismuth titanate; however, annealing seemed to have caused the loss of bismuth. This loss upon annealing was confirmed by the X-ray fluorescence measurements. The fluorescence measurements were not accurate enough, however, to quantify the actual percentages of the elements.

X-ray diffraction was used on both the raw and the annealed films. This data indicates that there is a temperature dependence in the deposited films with higher deposition temperatures favoring larger crystallite size and some small changes in unit-cell parameters and the extent of orientation.

A detailed analysis of this data is in progress. Several techniques are being used for this analysis including Lotgering's preferred-orientation parameter, peak-width analysis, and detailed-line profile analysis.

In spite of the above compositional and orientational analyses, the real proof is whether the films are ferroelectric and whether they can be poled. This stage in the testing will be initiated in the time remaining.

EXPERIMENTATION WITH LSODI SOFTWARE

FOR SOLVING SYSTEMS OF ORDINARY DIFFERENTIAL EQUATIONS

by

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LSODI (Livermore solver for ordinary differential equations-implicit form) is a subroutine designed for solving a system of ordinary differential equations of stiff and nonstiff initial value problems. This ODE (ordinary differential equation) solver has the capacity to solve linearly implicit systems, i.e., $A(t,y)\,\dot{y} = g(t,y)$ where A is a square matrix and $\dot{y}$ denotes d/dt. It is written in the FORTRAN language and requires that the user supply a subroutine for computing the residual function, $R - g(t,y) - A(t,y)s$, and a subroutine for computing the matrix A. Optionally, the user may supply the Jacobian, $\frac{\partial R_i}{\partial Y_j}$, with another subroutine or have LSODI approximate the Jacobian matrix. LSODI is a companion solver to LSODE (Livermore solver for ordinary differential equations). LSODE was used in this experiment for comparison with LSODI.

Experimentation with the LSODI software involved three considerations: 1) comparison with LSODE, 2) condition of the matrix of coefficients, and 3) stiffness of the system.

LSODE requires that the user supply a subroutine that evaluates a vector-valued function. The user may supply the Jacobian matrix (via another subroutine) or have LSODE generate it. Both LSODE and LSODI software packages are designed to solve ODE systems (stiff and nonstiff); however, LSODE is limited to systems in explicit form, i.e., $\dot{Y} = f(t,y)$ while LSODI has the capability for solving systems in implicit form. The advantage is that it is usually possible to treat the system more efficiently in the given implicit form than to convert it to the explicit form. Both packages of software were used to solve identical nonstiff (4 X 4) and stiff (3 x 3) systems given in explicit form. In regard to the nonstiff system, there was no significant difference in solution results for either subroutine when compared with the actual solution. LSODE required 80 steps, 91 vector evaluations, and no Jacobian evaluations, while LSODI required 48 steps, 58 residual evaluations, and 5 Jacobian evaluations. As for the stiff system, the solution results were, as expected, the same; the amount of work required was 330 steps, 405 vector evaluations, and 69 Jacobian evaluations for

LSODE, and 330 steps, 404 residual evaluations, and 69 Jacobian evaluations for LSODI. Normally, the choice of the subroutine is determined by the form of the system of equations; however, this experiment was conducted to see if there were significant differences when either subroutine was used on equations in explicit form. It was determined that there were no significant differences in solution results and in the amount of work required by either routine.

A 2 x 2 implicit system was employed to experiment with the condition of the matrix of coefficients, $A = \begin{bmatrix} 2-t & 1 \\ 1 & 1 \end{bmatrix}$, as the determinant of A was forced to go through a zero value when the value of t became one. Various choices of step size, relative error tolerance, and absolute error tolerance were used in the attempt; however, on each try the routine at the point when t became one would stop computations, and the same error flag was printed. It appears that as determinate of A goes to zero, an undefined calculation is presented.

The eigenvalue (-1.E+1) of the Jacobian $\begin{bmatrix} -1.E+1 & 1 & 1 \\ 0 & 1.E-4 & 0 \\ 0 & 1 & 1 \end{bmatrix}$ for a 3 x 3 implicit system of ODE's was varied to see how LSODI solved a system with different degrees of stiffness. As the eigenvalue was changed by a multiple of 10 each time through -1.E+9, the number of steps taken, number of residual evaluations, and number of Jacobian evaluations increased rapidly. Also, for the same nonsingular system, the numerical integration algorithm for use with nonstiff systems (implicit Adams) was used for this stiff system instead of the proper algorithm (backward differentiation formulas-BDFs) for eigenvalues -1.E+2 and -1.E+8. It was found that for the Adams method more steps and more residual and Jacobian evaluations were required in each case than those required for the BDFs algorithm. In addition, the solution results for the variable whose coefficient is the eigenvalue which determined stiffness were very different from solution results arrived at when the correct method was used. Other solution results changed slightly. This was still true when different step sizes over the same interval $[0,12]$ were used.

When the same experiment was applied using a system with a singular matrix of coefficients, computations were halted and an error flag was given. Use of the stiff option seems to provide for more efficiency for stiff systems of ordinary differential equations.

ELECTRONIC STRUCTURES OF CONDUCTING POLYMERS

by

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<u>Objectives</u>: Computer programs will be written and modified to calculate electronic and structural properties of polymers from model potentials.

<u>Approach</u>: Band structures will be calculated for several series of conducting polymers. Electronic properties such as ionization potentials and conductivity will be obtained from these bands. The calculations involve the use of model potentials of atoms within particular molecular environments; the potentials are developed for small pattern molecules which represent the repeating unit cell of the polymer.

Method of optimization of the parameters for the potentials are not now adequate in their present form for complex pattern molecules. The optimization programs at NASA Langley are very suitable to the problem and will be employed.

<u>Expected Results</u>: The use of model potentials will permit the calculation of electrical properties of polymers in a matter of minutes rather than the hours of computer time now needed.

Using preliminary results, it was suggested that the copolymer PMDA-fluorenediamine might have higher conductance than the 30-some related copolymers already synthesized. The conductivity of this material was measured as 10^{-11} S/cm compared to around 10^{-16} for the others. This copolymer will now serve as a basis for a study of doped-semiconducting polymers.

CAREER DEVELOPMENT SERVICES

FOR LARC EMPLOYEES

by

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The Langley Research Center (LaRC) Career Development Center (CDC) began as a pilot project on July 1, 1981, and has been approved for continuation. The purpose of the CDC is to foster individual and organizational growth and effectiveness through the provision of specific services: workshops for supervisors and employees; interest, ability, and personality assessment for career counseling; individual counseling for vocational and life management concerns; work performance consultation for supervisors; and the operation of a career resource library.

The projects to be accomplished as an ASEE fellow included:

1. To conduct a survey research study of the effectiveness of the CDC
2. To rewrite the Career Planning Resource Handbook, updating the material on jobs and careers at LaRC, and adding a component concerned with self-directed career development
3. To provide assessment and counseling for LaRC employees
4. To develop a workshop for new LaRC employees

All of the objectives were accomplished: interest, aptitude, and personality tests were administered, scored, and interpreted, and counseling provided; the content of the workshop was defined; a draft of the Handbook was prepared; however, size and comprehensiveness of the draft prevented final preparation; and the survey research study was completed. The latter deserves special recognition.

A survey was designed and administered to all LaRC employees utilizing the CDC during the period from January 1, 1982 through June 30, 1982. An analysis of the data revealed statistically significant findings.

- The services and the staff of the CDC are positively perceived
- The services of the CDC are thought to be of benefit to all LaRC employees
- The CDC provides insight into the perception of and communication with supervisors by employees receiving assistance from the CDC
- The survey data provides insight concerning the motives for seeking assistance from the staff of the CDC
- Utilization of the services of the CDC results in numerous changes including more realistic self- and job-perception, and increased productivity

Additional findings will be presented elsewhere, as appropriate. It is apparent that the stated mission is being fulfilled and that additional services may be offered to LaRC employees through the Career Development Center.

EVALUATION OF INTEGRALS USING COMPUTER ALGEBRA

by

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Computer algebra is the use of computers to perform symbolic mathematical computations. There are a number of programming languages for performing computer algebra, and such a language implemented on a specific computer using a specific operating system is called a computer algebra system. Computer algebra systems have been under development and in use by a small community of researchers for over 30 years. Recent developments have made the systems highly practical for many scientists and engineers. Problems once thought to be impossible or intractable can now be solved with the aid of a computer algebra system.

One of the most important algorithms developed for computer algebra systems is an algorithm that can solve problems in indefinite integration. This algorithm, formulated by Robert Risch, is one in which if an integral can be solved in closed form, then it is possible to predict the general algebraic form of the solution and then work backward by differentiation to determine the exact solution. This algorithm in conjunction with other procedures has yielded routines which essentially solve the integration problem for the usual elementary functions. This summer, the integration routines of the computer algebra system called MACSYMA were investigated and used to evaluate a variety of integrals.

MACSYMA was developed by the Laboratory for Computer Science at the Massachusetts Institute of Technology. It is accessible to NASA users by direct long-distance telephone or via the Advanced Research Projects Agency (ARPA) Network. For a large class of expressions, the system will find an indefinite integral if one exists. This class includes rational functions and functions that can be built upon from the rationals using exponential, logarithmic, trigonometric, and inverse trigonometric operations. There are three distinct stages involved in MACSYMA's evaluation of an indefinite integral. During the first stage, a test is made to determine if the integrand is of the form

$$f(g(x)) \cdot g'(x)$$

This is accomplished by checking to see if the derivative of some subexpression divides the integral. The method of solution, if the integrand is found to be of this form, is to search an integral table for an entry corresponding to f and substitute $g(x)$ for x in the integral of f. If the first stage fails, an attempt is made to match the integrand to a form for which a specific method (for example, trigonometric substitution) can be used. Failure at the second stage dictates that the general Risch decision procedure be used.

One group of integrals examined using MACSYMA includes a large class of nonstandard integrals which arise in the mathematical representations of aerodynamic configurations. These integrals have the following forms:

$$\int \frac{dv}{(v^2 + e^2)\,(av^2 + 2bv + c)^{1/2}}$$

$$\int \frac{vdv}{(v^2 + e^2)\,(av^2 + 2bv + c)^{1/2}}$$

Previously, very tedious and lengthy integration procedures had been employed to evaluate these integrals. However, what appear to be very reasonable solutions to the integrals were obtained using MACSYMA in a matter of minutes. The MACSYMA solutions are not in the same form as those previously calculated, and attempts are being made to verify that the results are identical.

Integrals involving equations of sound propagation in the presence of flow were also examined. A representative integral is:

$$\int \eta_1(k_1u + k_2u')\, d\xi$$

where

$$\eta_1 = (1 - \xi)/2$$

$$\eta_2 = (1 + \xi)/2$$

$$u = (\eta_1u_1 + \eta_2u_2)e^{i(\eta_1a_1 + \eta_2a_2)}$$

$$u' = \frac{du}{d\xi}$$

Evaluation of this class of integrals reveals one of the shortcomings of MACSYMA--integration problems often exhaust the available storage allocation before a solution is obtained. In this particular case, a series of MACSYMA commands, which cause a reformulation of the problem, yields the desired solution.

Experimentation with the aforementioned classes of integrals indicates that the integration available, apart from storage problems, is very sophisticated and powerful. When closed-form solutions cannot be obtained, there also exist MACSYMA features for determining series solutions.

TOWARD A TECHNOLOGY OF SELF-AWARE SYSTEMS

by

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The Intelligent Systems Laboratory (ISL) operated by the Automation Technology Branch is exploring the application of artificial intelligence (AI) techniques to robotics. The major programming language in use for AI applications is LISP; part of the work performed in connection with the fellowship accordingly consisted of teaching a short course on LISP to the NASA personnel concerned. In addition, several AI-oriented software tools were brought up on the ISL VAX computer and evaluated with respect to their usefulness to the goals of the ISL. These tools included a natural language interface system and OPS-5, a production system interpreter oriented toward the creation of expert systems. The usefulness of these tools proved to be limited; work is continuing to establish whether these limitations can be overcome.

In addition to the above-mentioned support functions, a line of research was pursued in an existing area of AI that has only begun to be explored, the concept of self-aware systems, i.e., of programming systems that have access to most of all aspects of their own internal operations. While this capability has been present since the earliest days of computers (data and program are both encoded in memory as conceptually indistinguishable bit patterns), it is only recently that the full implications of this capability for AI have been realized.

The systems of the type under consideration have the structure of production or rule-based systems. Such systems typically consist of two parts: a set of productions or rules, and a "data base" containing facts about the domain of discourse. A model of self-awareness is obtained when these sets are merged, so that the rules of operation that drive the system are present in the data base just as are the facts regarding the domain of discourse. It then becomes possible for the system to examine and operate on its own rules of operation. This capability brings into being the concept of meta-rule, of meta-meta-rule, etc. A body of research exists regarding how such meta-rules can be used to determine system strategy, data representation, and other meta information.

The research performed at NASA/Langley entailed exploring the usefulness of relational data base (RDB) technology for implementing these ideas. In particular, the "behavior" of the data base, i.e., its response to inputs from the world, was to be stored in the data base on the same basis as any other data.

The RDB approach offered several significant advantages. RDBs allowed the specification of access languages featuring the full power of the predicate calculus, yet based this capability on a set of simple primitives. These features appeared well suited to the goal of storing the operational primitives as data.

The basic operations defining a RDB system were programmed in LISP, and a first-level bootstrap of the system (i.e., storing in the RDB the rules for higher level behavior) was completed. The results were encouraging and merit further investigation.

SOLUTION OF THE EULER EQUATIONS BY FINITE-VOLUME METHODS USING RUNGE-KUTTA THREE-STAGE TIME-STEPPING SCHEME

by

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One of the purposes of the Summer Faculty Fellowship Program was to explore the capabilities of a finite-volume computational procedure developed by Jameson (ref. 1) for the explicit solution of the two-dimensional, time-dependent Euler equations

$$\frac{\partial}{\partial t} \iint_R w\,dx\,dy + \oint_S (F\,dy - G\,dx) = 0$$

where

$$W = \begin{vmatrix} \rho \\ \rho u \\ \rho v \\ \rho E \end{vmatrix} \qquad F = \begin{vmatrix} \rho u \\ \rho u^2 + p \\ \rho uv \\ \rho uH \end{vmatrix} \qquad G = \begin{vmatrix} \rho v \\ \rho uv \\ \rho v^2 + p \\ \rho vH \end{vmatrix}$$

and

$$H = E + \frac{p}{\rho} = \frac{p}{\rho(\gamma-1)} + \frac{1}{2}(u^2 + v^2)$$

The procedure utilizes a variable time step determined by the local Courant number and a forcing term which is proportional to the difference between the local total enthalpy, H, and its free-stream value, H_∞, to accelerate convergence to steady state.

In order to assess the performance of the accelerating portion of the method, a model problem for which an exact solution exists was chosen and tested by Mr. M. D. Salas of the Theoretical Aerodynamics Branch (TAD). The compressible flow around an edge (Ringleb Flow, ref. 2 and 3), exluding the region of the flow where limit lines occur, was chosen for the model problem. The exact solution computed at the nodes of an orthogonal mesh composed of equipotential lines and streamlines was used by the numerical algorithm to generate the initial data for the finite-volume calculations. Numerical results obtained were found to be in agreement with the exact solution within the truncation error of the finite-difference scheme. However, the accelerating technique (based on adding a term that is $\alpha(H_\infty - H)$) described by Jameson failed to work as described in his paper.

The main goals of the present study are thus twofold: (1) the modification of the Ringleb-Flow algorithm so that it can be utilized for computing flows past airfoils (a Karman-Trefftz airfoil is used as an example) and hence verifying Jameson's convergency acceleration technique for the airfoil problem; (2) a study of the effect of different coordinate stretchings on the accuracy of the numerical results and the convergence rate of the finite-volume calculations. A future goal consists of applying the multigrid techniques to the numerical scheme as an alternative for accelerating the rate of convergence of the finite-volume calculations.

Results were obtained for the flow past the Karman-Trefftz airfoil ($M_\infty = 0.25$) with and without including the damping term (added to the governing equations to suppress any fluctuations in the solution in regions of high-pressure gradients). It was found out that with no damping the solution converged for a few iterations (65) and suddenly started to diverge due to numerical instabilities. For an identical case but adding the damping term, the solution seemed to continuously converge toward the steady-state solution.

References:

1. Jameson, A.; Schmidt, W.; Turkel, E.: Numerical Solutions of the Euler Equations by Runge-Kutta Time-Stepping Schemes. AIAA Paper 81-1259, 1981.
2. Von Mises, R.: Mathematical Theory of Compressible Fluid Flow. Academic Press Inc., 1958, pp. 335-340
3. Sears, W. R.: General Theory of High-Speed Aerodynamics. Princeton University Press, 1954, pp. 512-515.

INVESTIGATION OF TECHNIQUES FOR THE MEASUREMENT OF ACOUSTIC MODES IN CYLINDRICAL DUCTS

by

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The ability to measure acoustic modes in a cylindrical duct is an important aspect of aircraft engine noise reduction research. Accurate measurement of the modal spectrum in the engine inlet makes it possible to diagnose noise sources within the engine and to design effective noise reduction liners. A literature search has been conducted to evaluate the current state of the art of acoustic mode measurement in cylindrical ducts and to define the existing problem areas. Several ideas for improving existing techniques have been identified for further study. The ultimate goal is to design a system that can accurately measure the modal spectrum of an actual engine in operation.

The majority of techniques for this type of measurement have been developed for experiments designed to study basic noise generation mechanisms in axial fans and sound propagation through various duct geometries. In these cases, the modal spectrum generated in the duct has been carefully controlled so that only a few dominant modes exist. In general, the complex acoustic pressure is measured at a number of known locations in the duct and used to compute the modal spectrum. Currently used procedures for this include Fourier and Bessel expansions, least-squares fit techniques, cross-spectral analysis, and other time-space correlation methods. A number of supplementary signal enhancement techniques have been developed which improve measurement accuracy. Each of these methods has certain advantages depending on the specific application. When properly applied, they will all yield reasonable results, provided an adequate number of measurement locations are used and only a few dominant modes exist.

All of the techniques currently in use are subject to similar basic problems. Most experiments have been designed to measure a specified band of modes. If significant modes exist in the duct outside of this band, a form of aliasing occurs and spurious modes are generated in the measured spectrum. Spurious modes may also be created due to the fact that the acoustic field may not be uniquely determined by the finite number of pressure measurements available.

Additional problems occur when trying to make measurements on an operating engine. The acoustic field contains a significant amount of random-flow noise, and is nonstationary due to engine speed variations and modulating noise sources within the engine. The inlet ducts on modern engines are relatively short, which eliminates using large arrays of microphones. Duct extensions and probe microphones can alter both the inlet flow and acoustic fields of the engine.

Several techniques developed in the fields of underwater acoustics and antennae theory appear to offer means of improving the state of the art of acoustic mode measurement in ducts. The use of irregularly spaced microphone arrays should improve the sensitivity of the measuring system with respect to individual modes. This technique has been tried in the past, but has never been fully developed. The development of an adaptive array for this type of measurement offers numerous possibilities. In such an array the microphone signals would be individually phased and weighted by optimization algorithms to filter the signals, improve signal-to-noise ratio, correct for certain nonstationary effects, and suppress spurious modes. These techniques have been applied to numerous applications in the design of radar and sonar systems and should be given further study with regard to the measurement of acoustic modes.

DYNAMICS AND CONTROL OF FLEXIBLE APPENDAGE OF A SPACECRAFT

by

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The Structural Dynamics Branch of the Structures and Dynamics Division at NASA-Langley Research Center is actively engaged in research on dynamics and control of large space structures (LSS). The problem of deploying a very long and flexible structure like an antenna mast from a spacecraft, such as the Shuttle Orbiter, is of current interest to the Branch and is being studied under the Mast Project.

The summer research project dealt with the dynamics and control of such a flexible appendage of a relatively rigid spacecraft during the deployment phase and after its full deployment. The interaction between the flexible appendage and the rigid spacecraft during both phases was also of interest. One of the important objectives of the study was to develop a theoretical model for transverse vibrations of the flexible appendage due to spacecraft motion (both rotational and translational) so that an optimal control strategy could be obtained.

The fully deployed flexible-appendage vibration problem due to spacecraft motion was formulated with variable geometry as a continuous-mass cantilever beam with a tip mass at the free end. The flexible appendage was subjected to root motion due to spacecraft manuevering. The governing partial differential equation was solved using the Rayleigh-Ritz-Galerkin method in conjunction with state-variable techniques. Some numerical example problems were solved which showed this approach to be satisfactory.

In order to study appendage dynamics during deployment when subjected to root motions, an original method of analysis was developed by modifying the procedure of analysis for a fully deployed appendage and using the concept of convolution to incorporate time-varying appendage parameters and time-varying initial conditions. Computer simulations were carried out using this method. It was found that during the deployment, the amplitudes of vibrations of the appendage increased and the frequency of vibrations decreased. The rate of increase in vibration amplitudes and the corresponding decrease in frequency were found to be highly dependent on the rate of appendage deployment with a high deployment rate having a destabilizing effect. The vibration amplitudes and frequency were also dependent upon other parameters such as the time instant of application of root motion, the magnitude of tip mass relative to appendage mass, and the appendage geometry.

The basic equations for obtaining spacecraft dynamics due to vibrations of the appendage during and after deployment were obtained by using three coordinate systems: the fixed inertial system on the Earth, the spacecraft system with origin at center gravity, and the appendage system with origin at its base. By means of energy relationships and coordinate transformations, equations of spacecraft motion were derived.

It is anticipated that methodology and the results of this research will be used in developing an optimal deployment scheme for the deployment of the appendage and in computing an optimum set of control system parameters to minimize amplitudes of appendage vibrations and the effect on the spacecraft.

USING THE FORTRAN-77 ANALYZER

by

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The FORTRAN-77 Analyzer was developed for the National Bureau of Standards by TRW Defense and Space Systems Group as a method for ensuring the quality of FORTRAN programs. The Analyzer consists of three phases: the preprocessor, the instrumented source program, and the postprocessor.

The preprocessor accepts as input the user's original source program and options indicating special requests. The preprocessor separates the source program into segments and numbers each segment for use in subsequent phases. An annotated listing is produced identifying these segments. Code is inserted into the source program, and special subprograms are added to create the instrumented source program. Files are created for use in other phases of the Analyzer. Actual reports produced by the preprocessor include the Program Call Tree listing, indicating the subprograms referenced, and the Statement-Type Summary, indicating the number of occurrences of each type of FORTRAN statement.

The instrumented source program produces the output generated by the original source program along with a report indicating the frequency of execution of each segment. If the trace option is specified by the user, program segment numbers are listed in the order of their execution. The annotated listing produced by the preprocessor is used in interpreting these reports.

The postprocessor uses files produced by both the preprocessor and the instrumented program to produce summary reports. If requested, the postprocessor can also provide cumulative statistics from several runs instead of just the current run.

Reports produced by the FORTRAN-77 Analyzer can be extremely useful in the verification of FORTRAN programs. For example, the report on segment execution frequencies can assist in the selection of appropriate test data, and the trace output can be very valuable in debugging. However, the problems encountered in trying to use the Analyzer as it currently exists at the Langley Research Center will certainly discourage widespread use. Files created by the preprocessor for use in subsequent phases must be copied to different units for use as input to the instrumented program, and then be recopied for use as input to the postprocessor. Any files created by the instrumented program must also be copied to other units to correspond to the postprocessor's input units. Since this involves numerous files, this task is rather tedious and can be somewhat confusing. Reports are not normally sent to the printer, necessitating the use of several options to redirect the output or further copying of files to receive printed output.

Some of the options caused the preprocessor to insert code that could not be reached during execution. This produced several warnings from the compiler and concern about the validity of some of the output. In one case the original source program had to be modified slightly in order to accommodate the code inserted by the preprocessor. The need for this modification was discovered when correctly specified options did not produce the promised output.

Some modifications facilitating the use of the Analyzer are necessary. Initially, a procedure file could be set up for immediate use while program changes to correct the problems previously mentioned are being made. The procedure file would contain the options producing only the reports thought to be of greatest value in aiding in program verification.

TRACE ELEMENT ANALYSIS OF ASH FROM THE NASA REFUSE-FIRED STEAM GENERATING FACILITY

by

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The Refuse-Fired Steam Generating Facility (RFSGF) funded jointly by NASA, the Air Force, and the City of Hampton is presently in operation at NASA, Langley Research Center in Hampton, Virginia. The facility burns approximately 200 tons/day of refuse and supplies approximately 170×10^3 tons/year of steam at 350 psig to the Langley Research Center. This steam results in a savings of 2.2×10^6 gal/year of No. 6 fuel oil. As part of an overall study of this facility, NASA has been monitoring the trace elements present in the ash from the furnace bottom and from the electron static precipitators. This summer project dealt with the design, construction, and subsequent use of an X-ray florescence spectrometer (XFS) to do this trace element analysis.

The XFS used AG K X-rays from a ^{109}Cd source and Mn K X-rays from a ^{55}Fe source to excite K levels in elements P to Mo and L levels in Hg and Pb. X-rays emitted from the elements in the samples were detected with a Si(Li) detector with a resolution of 200 eV at 5.89 keV. Data were collected and stored using a Tracor-Northern 1710 MCA equipped with dual floppy disks. Samples were prepared for analysis by first grinding the ash in a mill then pressing the resulting powder into a briquette. The system achieved minimum detectable limits ranging from a low of approximately 50 ppm for Mo to a high of 1100 ppm for Mn.

This system was used to make quantitative measurements on the concentration of elements in the ash from the electrostatic precipators and the bottom ash from the furnaces. The elements detected were Cl, K, Ca, Ti, Fe, Cu, Zn, Br, Sr, Zr, and Pb. Of these elements, all except Br, Sr, and Zr were present in concentrations of a few mg/g or higher. The elements Br, Sr, and Zr were present in concentrations of a few hundred ppm or less.

These measurements will be repeated at the X-ray lab at Murray State University as a check on the accuracy of the newly constructed XFS. Similar measurements will be made at MSU on the water used to quench the ash at the botton of the furnace.

GRAPHICS DISPLAY PROGRAM FOR THE FINITE ELEMENT MACHINE

by

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In the conventional finite element method, a structure is considered to be composed of a number of subdivisions called finite elements. These elements are interconnected at joints called nodes. Solutions are obtained for each node for displacements, stresses, or a combination of both. These solutions provide the basis for analyzing the whole structure. With this scheme, a body can be likened to a network of interconnected springs, their points of connection being the nodes, and the springs themselves being the elements. Although conventional computer architecture performs adequately, it considers each nodal solution sequentially. Parallel processing offers a real advantage here. Using this method, a microprocessor with its own memory and floating-point arithmetic is allocated to provide solutions for a single node or a small number of nodes. The interconnections between the microprocessors correspond to the elements. This is a more efficient and, therefore, faster method. Although the Finite Element Machine (FEM) is a prototype parallel processor designed to perform structural analysis by the finite element method, its versatility extends far beyond the solution of structural design problems.

A Texas Instruments minicomputer (TI-990) controller communicates with each microprocessor via a time-multiplexed "global bus." PASCAL was chosen as the high-level language for the controller. In order to input and display three-dimensional data graphically, the system required an appropriate graphics software package. The bulk of this summer's effort was directed toward developing such a package. Implicit in the task was the need for a working knowledge of PASCAL. This had to be developed along with a familiarity with the VAX-11/780 and TI-990 minicomputer systems, as well as the AD-2000 CAD/CAM software.

A graphics display program was completed which rotates an object about the X-, Y-, and Z-axes in either a clockwise or counterclockwise direction. It also translates left, right, up or down, and scales larger or smaller - all at the touch of a key. Selected views may also be chosen. The program is structured to access two sequential files, one containing elements, and the other containing nodes. Since the node file is not randomly accessed, it is written into a scratch array. Sequential reading of the element file indicates which node address is to be read randomly from the scratch array. In this way, a graphics array is created. Determining the maximum and minimum X, Y, and Z values permits computation of the largest vector which exists in the object envelope. This is used to calculate a factor which will pleasingly fit the object to the screen regardless of its actual dimensions.

An object is rotated to form an axonometric projection by assuming a zero X-coordinate and transforming the Y- and Z-coordinates. This rotates the projection of the object in the Y-Z plane about the X-axis. The new coordinate values thus obtained are substituted, and the object is rotated in the X-Z plane about the Y-axis. The horizontal direction of the screen is the direction of the X-axis, while the vertical direction is that of the Y-axis. The Z-axis is perpendicular to the screen so that the observer sees the object's projection onto the X-Y plane. Rotation about the Z-axis does not change the aspect, but only the orientation. The point about which an object is rotated is established by subtracting that point's coordinates from the coordinates of the object. Adding a constant term and multiplying by a factor accomplish translation and scaling, respectively.

The graphics options appear in a menu printed in the upper left corner of the screen. The menu is reprinted each time it is needed.

The display program interfaces with a library compatible with the Tektronix-4014 graphics terminal. Further effort, if supported, will involve the enlargement of this library with PASCAL procedures to draw various geometric shapes and splines analogous to PLOT-10 and Calcomp subroutines. More importantly, the display program will be extended to permit the graphical input of three-dimensional data. This is presently envisioned to be through conventional orthographic projection understood by most engineers. By apportioning the screen so that all values of X in excess of 641 pixels* and all values of Y in excess of 385 pixels* are interpreted as Z values, a three-view orthographic drawing of an object can be constructed using the terminal cursor. Any point located in two views will appear in the third. Should there be nodes which are hidden in all orthographic views, the principal views may be rotated to form auxiliary views which expose these nodes to aid in connectivity.

*A pixel is the smallest addressable point on the CRT face. There are 1024 addressable points in the X direction and 768 in the Y direction.

TORQUE DEVICE FOR CONTROL OF

LARGE SPACE STRUCTURES

by

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The control of large space structures is an area of research currently receiving considerable attention. This interest comes from the fact that space missions such as communications, surveillance, astronomy, and power generation will require the use of extremely large space structures. These structures, due to their light weight, sparse construction, and extensive size, will not be rigid. To counteract the tendency of the structure to bend, vibrate, or possibly even buckle, active control devices will be installed to exert forces at appropriate times and locations on the structures. In some cases these actuators might also be employed to maneuver the structure.

One such actuator to undergo testing is a device which will exert torque by using an electric motor to accelerate a flywheel. The design of the device and its accompanying control system began in June 1982 and a prototype model will be completed probably in September 1982.

One of the objectives of the design was to utilize available motors. The chosen motor was originally designed to be a tachometer generator operating up to 8500 rpm. This small d.c. motor is rated for about 2 oz-in of torque at 27.5 volts. It is hoped that by driving the motor with higher than rated voltage, it will allow a momentary torque output of up to 4 oz-in. Torque will be applied to the structure through the motor mount. It will be in the form of a damped sinusoid with a frequency matching one of the structure's natural frequencies of vibration.

Applied torque is given by this formula:

$$T(t) = I\,\alpha(t)$$

where $T(t)$ is the applied torque, I is the moment of inertia of the flywheel and motor armature, and $\alpha(t)$ is the angular acceleration of the flywheel. Controlled torque will be generated by the device by controlling the angular velocity of the flywheel. The angular velocity will be

$$\omega(t) = \omega_o + \omega_m \sin \gamma t$$

where $\omega(t)$ is the angular velocity, ω_o is the bias velocity, ω_m is the amplitude of the modulation velocity, and γ is the frequency of the structure vibration. Now

$$\alpha(t) = \omega_m \gamma \cos \gamma t$$

and

$$T(t) = I \omega_m \gamma \cos \gamma t$$

ω_o is selected so that $\omega(t)$ is always positive. This avoids the difficulty of dealing with the nonlinear friction associated with zero velocity. In order to minimize the gyroscopic effécts of spin-axis precession, the torque devices will be used in pairs with their spin axes concentric and their velocities in opposite directions.

The velocity control system relies on an electro-optical device to sense the flywheel spin rate by observing the rate at which radial lines fixed on the wheel pass. This sensing device produces a train of pulses, $P_\omega(\tau)$, with frequency proportional to the velocity of the wheel. Another train of pulses, $P_c(\tau)$, has a frequency that matches the desired motor velocity. A voltage, $v_e(t)$, is formed according to this formula:

$$v_e(t) = K_e \int P_c(\tau) - P_\omega(\tau) \, d\tau$$

In order to eliminate any steady-state error, another integration is performed and the final voltage which drives the motor is given by:

$$v_m(t) = v_o(t) + v_c(t)$$

where

$$v_c(t) = K_c \int v_e(\tau) \, d\tau$$

and $v_o(t)$ is the voltage necessary to maintain a steady-state motor velocity of $\omega_o(t)$.

While the actual prototype system is being constructed and parts are being ordered, a simulation of the system is being tested on an analog computer.

COMPARISON OF TWO METHODS OF SOLUTION OF THE PROBLEM OF MULTIPLE-STATION ANALYTICAL PHOTOGRAMMETRY

by

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Photogrammetry is the determination of the position of points in three-dimensional space given the position of their images on two or more photographic plates taken by separate cameras. The positions and orientations of the cameras are accurately known, or they can be determined from the images of points whose coordinates are accurately known, called control points. The present application is to the accurate measurement of the deformation of a model aircraft in a transonic wind tunnel. Photogrammetry represents a viable technique because remote measurements do not perturb the flow in any way.

The actual equations relating the camera coordinates and the object space coordinates are

$$x + \Delta x - x_p = -c_x \frac{m_{11}(X - X_0) + m_{12}(Y - Y_0) + m_{13}(Z - Z_0)}{m_{31}(X - X_0) + m_{32}(Y - Y_0) + m_{33}(Z - Z_0)}$$

$$y + \Delta y - y_p = -c_y \frac{m_{21}(X - X_0) + m_{22}(Y - Y_0) + m_{23}(Z - Z_0)}{m_{31}(X - X_0) + m_{32}(Y - Y_0) + m_{33}(Z - Z_0)}$$

where x and y are the photo coordinates of a point, Δx and Δy are systematic errors in these coordinates, x_p and y_p are the photo coordinates of the principal point of the camera, $c = (c_x + c_y)/2$ is the camera principal distance, $[m_{ij}]$ is the orthogonal rotation-reflection matrix from object space coordinates to camera coordinates, X, Y, and Z are the object space coordinates of the point, and X_0, Y_0, and Z_0 are the object space coordinates of the camera perspective center.

Given that the nine camera parameters are known (three angles determining $[m_{ij}]$, plus x_p, y_p, c, X_0, Y_0, and Z_0), and that the systematic errors (due to lens distortion, film deformation, comparator errors, etc.) are known, it is clear that X, Y, and Z can be determined if the image of the point appears on at least two photographs. However, there are more equations than unknowns, so they must be solved in a least-squares sense for the "best" values.

The so-called bundle method of D. C. Brown (1) is the most general way of solving the photogrammetry problem. Not all camera parameters or control point coordinates need be known; if necessary, the program iterates from initial guesses until satisfactory values have been obtained.

The DLT (direct linear transform) method, on the other hand, casts the projection equations in the form

$$x + \Delta x = \frac{L_1 X + L_2 Y + L_3 Z + L_4}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

$$y + \Delta y = \frac{L_5 X + L_6 Y + L_7 Z + L_8}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

where the L's are called the DLT parameters. These 11 parameters are not independent since they are determined by the 9 camera parameters. The L's (and hence, the camera parameters) can be determined from known control point coordinates, and then these values can be used to determine unknown coordinates from the corresponding plate coordinates of camera points.

The author's assignement this summer has been to study and contrast the two techniques. This study has consisted of working with and improving an existing DLT code, and producing a simplified bundle-method code (since no such program is currently available at LaRC). Improvements in the DLT program include adding pivoting to its matrix inversion routine (especially crucial since least-squares matrices tend to be badly behaved), and adding a capability to output the matrix $[m_{ij}]$ rather than the three camera angles, since it was discovered that $[m_{ij}]$ involves a reflection as well as a rotation. This might have escaped notice for a long time if inconsistent results had not been obtained by feeding the camera angles given by the former version of DLT to the simplified bundle-method code.

The DLT method is quite fast and accurate. The bundle method, as programmed by the author, being based on an iterative technique, is quite slow and appears not to be so accurate. The iteration process is not particularly stable; the relative error does not converge to zero. Good initial guesses are required for convergence to occur at all. The value of the three-dimensional coordinates is inordinately sensitive to small angular perturbations of the camera, somewhat less so to perturbations of its position, and least so to changes in the inner parameters.

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[1]Brown, Duane C. Application of Close-Range Photogrammetry to Measurements of Structures in Orbit. GSI Report No. 80-012, Geodetic Services, Inc., Melbourne, Florida, September 15, 1980. (Two Volumes)

INVESTIGATION OF THE USE OF COMPUTER GRAPHICS AND COMPUTER-AIDED DESIGN TECHNIQUES IN SPACECRAFT DESIGN

by

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This research effort focused upon the investigation and evaluation of computer graphics as an aid to the spacecraft design and analysis activities of the Systems and Experiments Branch of the Space Systems Division at NASA's Langley Research Center. The Branch is actively involved in the development and evaluation of alternate configurations for large space structures, including large antennas and space stations. The research evaluated the abilities of two graphics software programs, MOVIE.BYU and the IDEAS (Interactive Design and Evaluation of Advanced Spacecraft) solid modeler to aid the design process.

Since the Systems and Experiments Branch is active in the early phases of the design process, examination of a large number of alternate configurations and identification of the most promising of these for more detailed study are required. In this dynamic design environment, any graphics software that is used must be able to respond rapidly as design parameters change. This creates a problem with maintaining up-to-date visualizations of the competing designs and reduction of the geometric definition of the configurations into a data format that is compatible with the analysis software available at Langley. Both the IDEAS solid modeler and MOVIE.BYU aid in the solution of the visualization and geometric data generation problems by facilitating the development of graphics models and outputting data formats compatible with analysis programs. The IDEAS system was developed at Langley to complement the capabilities of MOVIE.BYU which was developed at Brigham Young University.

The research problem focused upon the capability of the software packages to handle two tasks: A) development of a series of configurations for space station concepts, and B) illustration of the deployment of a large antenna in space. The geometric data developed during completion of these tasks is to be further evaluated by existing structures programs. The first task required programs that would allow ease of geometric definition and modification, and the second required the ability to manipulate geometric models to simulate actual spacecraft maneuvers/movement.

The investigation focused upon the ease with which a relatively naive user could learn the two systems and use them to accomplish the above tasks. Since the two programs were complementary, the ability of the user to use the two sets of software as a unified graphics system was also investigated. This investigation revealed that the two sets of software could each accomplish both tasks but that the unified system was faster and easier to use.

In completion of both tasks, the user found that the IDEAS system was easier to use to define basic geometry. However, in task B, only very simple structural subsets were developed using IDEAS and then combined into structural shapes using the capabilities of MOVIE.BYU (symmetry, merge, etc.). In task B, complex model manipulation was required and the animation capabilities of MOVIE.BYU were used and enhanced to generate a short film depicting the deployment. Geometric definitions generated as a by-product of developing the visual output were used by other researchers in the Branch for structural analysis.

COMPARISON OF SINGLE-ENGINE AND TWIN-ENGINE FIXED-WING AIRCRAFT IN THE AREAS OF ENGINE FAILURE AND STALL

by

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Aircraft accidents are a major concern to all facets of the aviation community. The majority of aircraft accidents occur in general aviation, which consists mostly of single- and twin-engine aircraft. This researcher feels aircraft accidents related to engine failures and stalls are very significant areas for research due to the serious nature of these incidents, particularly the high fatality rates associated with spins and spirals. Many people, aviators included, think twin-engine aircraft are safer than single-engine aircraft. This may be true in some circumstances, but in analyzing National Transportation Safety Board (NTSB) accidents, twin-engine aircraft accidents were found to be more severe than single-engine aircraft accidents.

The research covers NTSB accident data from 1976 through 1979 on fixed-wing, single- and twin-engine aircraft, in the accident categories of engine failure and/or stall; stall has four subcategories of spin, spiral, stall, and mush. All single-engine fatalities and all but 2 percent of twins were in general aviation.

Engine Failures

In comparing engine failures, single-engine aircraft had a fatality rate (percentage of fatal in total accident experience) of 5.8 percent, whereas twins were almost five times higher at 28.1 percent. The data also showed 48.9 percent of single-engine failures (1979) and 34.4 percent of the twins (1976-79) were involved with some type of fuel problem; fuel problems include improper management of fuel, water in the fuel, and fuel selectors improperly set. Most fuel problems are correctable; the underlying cause is that someone was careless, perhaps several persons. Therefore it will take a concentrated effort by instructors, flying clubs, manufacturers, publishers etc. to keep reminding pilots and fixed-base operators (FBO) of this problem so that complacency or forgetfullness will not lead to more accidents.

Engine Failure or Stall

When comparing accident data where engine failure or stall was considered by NTSB to be the type of accident, the fatality rate for twins was 2.3 times greater than the single-engine rate (33.7 percent vs 14.4 percent). The accident briefs did not clearly show why twins had a higher percentage of fatalities versus single engines, but a logical suggestion might be to compare flight profiles when seeking answers to this complex question.

Engine Failure and Stall

When comparing data where engine failure and stall were listed as the first and second type of accident (both in the same accident), single-engine aircraft had a fatality rate of 41.7 percent and twins had 72.7 percent. The combination of an engine failure with a stall appears to be disastrous! It obviously behooves the pilot to avoid any stall subsequent to an engine failure; success in this area depends on a strong background in training, awareness that emergencies can/do happen, and keeping a cool head when they do. Low flying time in the (accident) aircraft and/or poor judgment came up all too often in the data as contributing factors.

Spin or Spiral

The final comparison of various single-engine and twin-engine data was spin or spiral as a first or second type of accident. Singles had a fatality rate of 70.9 percent, whereas twins were 93.9 percent fatal; the few twins that did not become a fatal statistic broke out of the clouds at a high enough altitude to make a safe recovery.

Pilot flying time was an area of concern. Flight hours were categorized as low, medium, and high; medium hours ranged from 101 to 1500 hours. Single-engine pilots had total flying hours mainly in the medium category (66 percent) and flying hours in (accident) type aircraft in the low category (51 percent). Twin pilots had total flying hours mostly in the high category (65 percent) and flying hours in (accident) type aircraft as follows: low - 22 percent, medium - 37 percent, high - 10 percent, unknown - 31 percent. The data indicates that twin pilots generally have more experience (hours) than do single-engine pilots, but both have relatively low hours in the specific accident-type aircraft. This is further substantiated by looking at the median flight hours: singles had 699 total hours and 153 hours in accident-type aircraft, whereas twins had 2,704 total hours and 200 in accident-type aircraft. Also, only 34.2 percent of the singles had an instrument rating, but 75.5 percent of the twins were instrument qualified.

Other spin/spiral data showed little significance as to where the incident happened; slightly over 50 percent occurred in the traffic pattern environment, while most of the remainder occurred during cruise or climb to cruise altitude. Eighteen percent of the singles had possible cause factors related to low-altitude operations, including agriculture spraying operations, hunting and buzzing, plus 22 percent were identified as having lack of familiarity with the aircraft and/or with low experience in general. Twins had problems with the following factors: ice, weather, winds - 20.4 percent; engine/material failure, poor maintenance, weight/balance - 30.6 percent; judgment, aircraft control - 42.9 percent.

Summary

The NTSB data had shown that twins had a much higher fatality rate than did single-engine aircraft when comparing accidents related to engine failure and stalls. Even though twin-engine pilots generally were more experienced than single-engine pilots, both had low flight time in the accident-type aircraft; this and other data point toward pilot unfamiliarily with the aircraft, such that they were unable to handle the emergency situations.

Conclusions

It may be impossible to fully answer the question, "Why do twins have a higher fatality rate in some areas than do singles?" This researcher feels the flight profile may have a partial answer. Twins fly higher, faster, and are usually more sophisticated/complex; they fly in a generally more hazardous environment, such as higher altitudes, and are more often in instrument weather conditions. Also, twins have more of a control problem (vs singles) when an engine is lost. Manufacturers have made several attempts to make aircraft stall spin resistant, but usually in doing so, much is lost in other areas such as responsiveness and fuel efficiency. Some interesting efforts are being made with pitch-control limitors, canard wings, parachutes (spin recovery), and drooped-wing leading edges; results are encouraging both in stall prevention and recovery.

This researcher firmly believes that training plays a major role in pilot survivability. If the pilot has really prepared himself for all emergencies, then he can have a better chance to remain calm and in control of the aircraft; once control or flying speed or both are lost and a stall is subsequently entered, it is a highly fatal situation. More emphasis must be palced on engine failure and stall recovery during initial flight training and follow-on training. Also, a pilot must receive <u>adequate</u> indoctrination in the new aircraft; accident data points to unfamiliarity with the aircraft as a possible cause of many of the accidents.

REAL-TIME NETWORK COMPUTING SYSTEM

by

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Future spaceborne computer systems will consist of networks of computers that must execute special purpose programs in real time resulting in requirements that are not actively addressed by conventional approaches to computer networks. The Automation Technology Branch of the Flight Dynamics and Control Division is engaged in investigating ways that would make networks more usable for spaceborne applications such as robotic systems for space construction and satellite repairs. Some of the characteristics of these systems are:

1) Real-time interprocessor communications (30 milliseconds round trip)

2) Small to moderate numbers (12 - 20) of nodes

3) Fault tolerance

4) Dedication to a class of applications but not one single application

5) Special equipment at specified nodes

6) Dynamic load-time resource allocation

A real-time network computing system was developed which is tailored to the robotic environment characterized above. The design assumed Path Pascal as the applications language. In particular, it was assumed that all nodes of the system had a Path Pascal capability (compiler and executive). With this assumption, a real-time network computer system with the desired characteristics could be achieved by implementing the following three additional network functions: first, a network executive function, the primary purpose of which is to assure that requested network programs are executed; second, a network resource management function to assure effective utilization of system resources; and third, a network linking capability that will allow the final module/node mapping to be resolved at load time.

These three functions are performed by three processes: NETLOAD, LOCALOAD, and NETPLAN. NETLOAD acts as a passive network executive and network loader. LOCALOAD performs run-time resource management and local link/load functions at each node by determining which modules can be loaded, where in local memory to load them, and then linking them into the system. NETPLAN performs the static resource usage planning and module distribution.

Copies of all three processes reside at all network nodes and communicate via NETLOAD interfaces to the network's message system.

There are several advantages to this design. First, since the same set of programs is loaded in every node, the executive function is distributed so that if any piece of equipment is out of service any other node with similar equipment can be used in its place. This feature provides a great deal of fault tolerance capability in the Real-Time Network Computing system (RTNC). Moreover, if one system software node copy is lost, it can be easily imported from another node. The only modifications required are that the internal record of the name of the node and the addresses of the local drivers be updated. Second, the only outside interface needed to implement this approach is to the local executive and the network message system. An instantiate and an abort routine are needed to interface with the local executive. The network message interface requires only a message send and a message receive capability. Another advantage of this design is the potential for incorporating different hardware with different Pascal implementations. The only communications between nodes are via the network. Therefore, if the hardware can be integrated into a network, the only additional requirement is that the system software can be compiled, loaded, and executed under the individual Pascal systems in all of the nodes.

In summary, the RTNC system is an easy to implement network executive capable of supporting real-time applications programmed in Path Pascal on small networks with selected nodes containing special purpose equipment.

MICROCOMPUTER-BASED CONTROLLER FOR A ROBOTIC END EFFECTOR

by

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As part of its Automation Research and Technology Program, NASA's Office of Space Technology is supporting research into teleoperator and robotics systems capable of remote space operations. A near-term focus of this program is the implementation of the Remote Orbital Servicing System (ROSS) concept which would permit satellites to be serviced by an orbiting vehicle under remote control from a ground station. The ROSS concept is to incorporate state-of-the-art technology into a system intended to service a variety of existing and planned spacecraft in a manner comparable to that provided by man during extravehicular activity. Although the ultimate goal is to develop a completely autonomous system capable of task and trajectory planning, this is currently beyond present technology. Even with man in the loop to provide remote interactive control, application of available and emerging technology requires extensive research. Because of communication channel limitations, the high volume of information to be transmitted, and the relatively long time delays inherent in even simple remotely initiated commands, a system of distributed control is necessary. This is implemented by having aboard a network of computers arranged in a control hierarchy to supervise the motions of the robotic mechanism's joints and links.

The Automation Technology Branch of the Flight Dynamics and Control Division, as part of its involvement in the development of ROSS, has established an Intelligent Systems Research Laboratory to provide a facility for the development, integration, and physical testing of hardware and software for teleoperator and robotics systems. To provide access to and develop familiarity with state-of-the-art robotic technology, the laboratory includes two Unimate PUMA 600 six-degree-of-freedom manipulators and their associated University of Rhode Island-designed parallel jaw end effectors. The standard control system for the PUMA comprises an LSI-11 minicomputer with individual 6503 microprocessors assigned to each joint (degree of freedom). The research project supported by the ASEE summer fellowship continued an ongoing program to develop microcomputer-based local control of the end effector so that it could be integrated into the PUMA control system and become part of a teleoperator demonstration system.

The computational hardware for the end effector controller was chosen from the recently available Intel 8051 family of integrated circuit, single-chip microcomputers. The 8051 is indeed a microcomputer since it combines, on a single chip, a CPU; nonvolatile 4K bytes of read-only program memory; 128 bytes of volatile read/write data memory; 32 input/output (I/O) lines; two 16-bit timer/event counters; a five-source two-priority level nested-interrupt structure; serial I/O port for either multiprocessor communications, I/O expansion, or full duplex universal asynchronous read/transmit (UART); and on-chip oscillator and clock circuits.

Program development is performed using an 8031 microprocessor and a Microtec relocatable macroassembler, linking loader and simulator accessed through LaRC's central computer system.

Prior to the start of the summer research project, a breadboard hardware system had been developed. This included the 8031 microprocessor; a 2716 chip having 2K bytes of ultraviolet light-erasable/electrically programmable read-only external code memory; an 8155 chip with 256 bytes of external random-access memory, 22 parallel I/O lines and a timer aboard; and a digital-to-analog converter interfaced to the servoamplifier driving the end effector's torque motor. Analog rate feedback to the servoamplifier from a tachometer stabilizes the motor; jaw position feedback to the 8031 arises from an incremental shaft encoder driven by the motor. Also, a rudimentary operating system had been developed enabling the 8031 to communicate with the teletype and the end effector. In response to teletype command, the microprocessor moves the effector jaws to a desired position and holds them there in the face of disturbances.

The summer research project involved the optimization and modification of the existing program and the planning for an implementation of sensory modalities into the end effector to develop it into a "smart" hand. Thus far, the program has been revised so that position feedback and control input signal traffic is interrupt driven. A number of utility macros have been included, and the output from a limit position sensor is employed in an initialization routine. Currently being mounted on the effector are a collision (overload force) sensor, a between-jaws object loacting sensor, and proximity sensors. The software to service these transducers is also being developed as a parallel effort. In the planning stages are force (touch) and slip sensors. Incorporation of the information from these sensors into an optimal, local, real-time feedback control scheme for the effector would represent a major achievement and cannot be considered a straightforward task. The software written and debugged so far has demonstrated that the 8051 microcomputer family can provide the computing power and I/O facilities necessary to experiment with the utilization of this information in a system housed in a physically compact package. This is a key step in a practical realization of the ROSS concept.

DYNAMIC RESPONSE OF PARTIALLY RESTRAINED SLENDER COLUMNS FOR USE IN SPACE STRUCTURES

by

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Very slender columns may be used to form large space structures for use in a number of NASA's future space missions. Serious consideration is being given by the Structures Concepts Branch, Structures and Dynamics Division, to the possible use of tubular columns with a slenderness ratio of the order of a thousand due to the optimization constraints imposed by efficient deployment requirements. The connections and the adjoining members that frame in at the ends of a typical column in a space structure provide partial rotational restraints that are expected to affect the behavior of the column itself. The influence of such partial restraints on the dynamic response of a column has not been studied in the past. The main thrust of the summer research project has been toward the development of procedures for determining the natural frequencies and the associated lateral deflection versus time relationships for partially restrained columns, and verifying the theoretical analyses by conducting full-scale tests on a tubular steel column.

Three different analysis procedures are developed each of which originates from the partial differential equation of motion governing the dynamic response of the column in the presence of a constant axial load. The partial end restraints are modelled as rotational springs with linear moment versus flexural rotation characteristics. The first method is based on an exact solution of the governing equation and results in a cumbersome transcendental equation that is solved iteratively. The second method relies on an approximate mode shape taken in the form of a trigonometric expression that satisfies the boundary conditions a priori, and uses Galerkin's orthogonality criterion. This procedure leads to an explicit formula for evaluating the natural frequency of the column in the presence of rotational end springs. In addition, an explicit elastic-column static-buckling-load formula is obtained from the natural frequency expression. The third method is based on tracing the entire deflection-time history using a second-order central finite-difference solution of the partial differential equation including the presence of initial imperfections. An extensive numerical study of over a hundred different columns using specially developed computer programs shows that the three methods are in excellent agreement. Although the second method seems to be the most convenient one for use in the particular problem studied, the third method is more suited if imperfections are present or when time dependent loads are applied. Several natural vibration tests on a steel tube of length 12 ft., and outer and inner diameters of 0.5 and 0.37 in., respectively, are conducted in the laboratory. The ends are partially restrained by specially designed connections, and no axial load is applied.

The spring constant for the end restraint is 1974.3 lb-in/rad. found from static testing and is similar to that obtained from basic stiffness calculations. The damping coefficient is determined from the experimental deflection-time relation. The dynamic response of the column found from each of the three theoretical procedures is in excellent agreement with the experiments. It should be noted that the actual columns in a space structure will be made of graphite/epoxy. The steel tube is used since very slender graphite/epoxy tubes are not yet available, and the procedures developed are good for both materials. Additional research is being conducted to study the effects of various types of damping devices.

In conclusion, it is found that the columns studied possess low natural frequency. For example, the one tested has a frequency of about 3.4 Hz. Interestingly, it is also found that what may appear to be a small or nominal end restraint may actually provide a considerable degree of end fixity rather than a nearly pinned condition. Furthermore, a 'moderate' amount of end restraint provides near complete end fixity.

Three major problems that need to be investigated in the future are: (1) the three-dimensional dynamic response of partially restrained columns with spatial imperfections; (2) the three-dimensional dynamic behavior of a space structure with semirigid connections; and (3) a procedure for sizing the members of a space structure such that the energy due to an overall structural perturbation can be transferred to the individual members where it may be dissipated passively.

THE ROLE OF ADA* AT NASA

BY

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Ada is a new computer programming language. It was developed under the sponsorship of the U. S. Department of Defense (DoD) in an effort to halt the proliferation of languages used in embedded systems. (An embedded system is one in which a computer is physically a part of an object, usually for the purpose of monitoring or controlling it.)

At a recent (July 1982) meeting at NASA Headquarters in Washington, DC, a decision was made to form an Ada committee with representatives from the various NASA centers. This committee will serve as a liaison between NASA and DoD, will be a source of information on Ada-related matters, and will possibly make recommendations on NASA policy.

There are good reasons for NASA to embrace the new language. Ada is an excellent product. It is a powerful, general-purpose language that not only embodies the best principles of modern language design (modularity, separate compilation, top-down design, exception, and interrupt handling, etc.) but also has the capability to accomplish virtually any programming task, including parallel processing, real-time processing, very large programs, data manipulation, and scientific computation.

But perhaps of even greater importance than the outstanding qualities of Ada is the extensive support that DoD is likely to give the

* Ada is a trademark of the U. S. Department of Defense.

language. DoD will almost certainly spend a great deal of time and money in the development of Ada tools and software libraries, in Ada research, in compiler validation, etc., and NASA can reap the benefits at minimal cost.

The main languages currently used at NASA are COBOL for administrative work, HAL for flight software, and FORTRAN for scientific computation. It is by no means suggested that these now be abandoned in favor of Ada. They are all well-developed, familiar languages which have been used successfully for years; whereas there does not even exist a validated Ada compiler yet. NASA should slowly climb aboard, not jump on, the bandwagon.

A first step is to gain some experience writing Ada programs and working with the language. After a sufficient amount of time, NASA can begin to do some of its projects in both Ada and another language in order to gain additional experience and to make comparisons. Assuming satisfactory progress in these two phases, as well as in the general development and acceptance of Ada, NASA can begin to use Ada for selected programming projects.

The armed services will probably phase in Ada for their embedded systems programming along the lines indicated above, except that there will be an additional step: mandatory use of Ada unless sufficient justification can be given for using another language.

NASA may or may not wish to go this far, but it cannot afford to ignore Ada.

CHEMICAL KINETIC DATA FOR ATMOSPHERIC REACTIONS FOR

USE IN NONEQUILIBRIUM CHEMISTRY FOR INVISCID

HYPERSONIC FLOWS IN EARTH ATMOSPHERE

by

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The Aerothermodynamics Branch, Space Systems Division, is engaged in a program of research into the entry of both slender and blunt-nosed vehicles in Earth or non-Earth atmospheres. For the extreme velocities encountered, the gas flow in the shock layer can experience a severe departure from thermodynamic equilibrium. Exact analyses of the effects entail simultaneous solution of the basic fluid dynamic equations plus a set of coupled phenomenologic rate equations governing the nonequilibrium chemistry involved. In such analyses what is required is the specification of the appropriate system of rate equations describing the high temperature kinetics for the atmosphere being considered.

Thus for Earth atmosphere a set of rate equations could be used which would correspond to the kinetic scheme:

$$O_2 + M \rightleftharpoons 2O + M$$

$$N_2 + M \rightleftharpoons 2N + M$$

$$NO + M \rightleftharpoons N + O + M$$

$$O_2 + N \rightleftharpoons NO + O$$

$$N_2 + O \rightleftharpoons NO + N$$

$$NO^+ + e^- \rightleftharpoons N + O$$

The present project calls for a program to test various inputs of changing kinetic schemes for the purpose of evaluating the importance of both species and processes. The computer program to be used is one written by Dr. William L. Grose (NASA TN D-6529, 1971). The program must first be made compatible with the present system and then test run. This has been done, and we are now in a position to examine and evaluate both species and processes.

EXPERIMENTAL TESTING OF MODIFICATIONS IN THE ILS-DME NAVIGATION MODE

by

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In the C-4000 navigation computer unit aboard the NASA B-737 research aircraft, the instrument landing system (ILS) localizer and the distance measurement equipment (DME) radio signals smoothed with inertial velocity information are used to calculate a position estimate while flying with the ILS-DME environment. The original software was designed by Boeing to provide a more accurate position estimate for approach guidance than could be obtained with other available radio modes. Improvements were obtained; however, this method of position estimating was not accurate enough to provide the precision guidance required for an approach to landing. Hence, an alternate method of using these signals was proposed.

This work reports the progress and test results of three changes in the ILS-DME update mode: improved algorithms for computing the differences between measured and estimated position; faster filter gains; and a dissipation factor.

In NASA TM-80167, improved ILS-DME update algorithms are derived. These algorithms compute the position differences directly, whereas the original algorithms compute individual components of position error due to the ILS and DME signals, and a portion of these components are then summed and used in the position estimate calculations.

Filter gains used in the original ILS-DME algorithms are the same as those used in the other position estimate modes in the navigation computer unit. Due to the more accurate radio signals of the ILS localizer, faster filter gains can be used to improve performance.

A dissipation factor that exponentially dissipates, with respect to time, the effect of computed position differences on the filter equations has been designed. This factor reduces the error of the position estimate due to errors accumulated from previous estimates.

Thirty ILS-DME approaches were simulated on the NASA B-737 Fixed-Base Simulator with variable items including navigation equations, filter gains, radio noise, dissipation factor, initial estimated position, approach path, and runway heading. Responses to initial 1000-foot position estimate offsets and flight maneuvers were measured and analyzed. Substantial improvements in positional accuracy were measured using the improved equations, faster filter gains, and a dissipation factor of 0.997.

Flight tests were run with the NASA B-737 at NASA Wallops Flight Center and Atlantic City, New Jersey. Positional offset errors of 1000 feet were injected by the flight test engineer at various points along the approach path. Measurements gave an initial recovery rate of 62.1 fps for the improved equations with the 30-second filters versus 21.7 fps for the original equations with the 50-second filters. The 80-percent recovery time for the 1000-foot displacement was reduced from 44 seconds to 22.25 seconds. The positional accuracy of the computer drawn runway as measured by superimposing on the television image of the real runway was also substantially improved. Detailed test results are being written at the time of this report.

ORIENTATION PROGRAM FOR NEW EMPLOYEES

AT NASA-LANGLEY RESEARCH CENTER

by

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The Personnel Division of the NASA-Langley Research Center has initiated a project to develop a comprehensive orientation program for new employees. To date, no such program exists.

The criteria for this program requires that it be appropriate for all new employees regardless of grade or type of duty assignment. The orientation material must be readily available for presentation to any number of new employees without the need for additional staff in the Personnel Division. Also, the program must maintain a "personal" approach in dealing with the new employees.

In order to determine the content of this program, interviews were conducted with recently hired employees. Based on these interviews, an examination of orientation programs at other NASA installations, and observation of orientation programs in industry, it was concluded that this project should consist of a general overview of the Center and a series of specific subject modules:

Safety
Occupational Health
Security
Insurance
Library/Technical Report Process
Langley Activities Association

Because the overview module is to be general and motivational in nature, it was decided that videotape should be the production and display medium. This medium will permit the use of color visuals, motion, and realistic sound in presenting the people and facilities of NASA-Langley.

The specific subject modules are informational in nature; therefore, it was determined that slide/sound would be the appropriate presentation medium. This medium permits the presentation of numerous facts in an orderly and logical manner, and it allows the viewer time to comprehend and study the material being presented.

In order to retain a "personal" touch in this orientation program, each new employee will be assigned to a regular NASA-Langley employee who will help the new person in adjusting to the new environment. This personal contact will help offset the impersonal nature of the media-based orientation modules.

I was asked to begin developing the narrative for the specific subject modules during the 1982 summer fellowship work period. A Hampton Institute student majoring in mass media arts was made available to help me in this effort. I gave him the task of developing the narrative for the occupational health module. I worked on the security, safety, and insurance modules. All of these modules were developed with the assistance of training specialists in the Personnel Division along with the full-time professionals working in each of the subject areas.

It was decided that the overview module should be the last to be developed because only a limited amount of research has been conducted in that area and the narrative has not been written. No work has been done on the library/technical report process module nor on the Langley Activities Association module.

It is felt that NASA-Langley possesses the "in-house" capability to complete the graphics and photographs needed to accompany the narratives for these orientation briefings.

MAN/COMPUTER INTERFACES FOR
COMPUTER-AIDED DESIGN SYSTEMS

by

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The objective of this project was to investigate various techniques and designs of user interfaces, to study the requirements of users of the computer-aided design system called Aerospace Vehicle Interactive Design (AVID), and to initiate the design of a user interface appropriate to AVID.

AVID can be summarized as a system used by the aerospace engineer to create, modify, and analyze a collection of specifications for a proposed vehicle and mission requirements. The hardware of the AVID system can be briefly described as consisting of graphics equipment, a microcomputer (Prime 750), and mainframe computers (CDC CYBERS). The graphics equipment consists of a graphics terminal, a graphics tablet for configuration of geometric input, and a hard-copy unit. AVID currently consists of many independent geometry, design, and analysis programs along with a preprocessing program that enters and retrieves design information from a data base and tailors data for the application programs. The user interface should provide the user with simple commands to carry out and monitor the design process.

It is assumed that use of AVID would occur with two levels of users: novice and experienced. It is further assumed that it is the user's responsibility to provide basic geometry, mission requirements, and vehicle parameters not provided by analysis programs. The task of the interface can be summarized as follows:

1. To provide simple commands that will invoke data entry, data management, and analysis programs existing in AVID

2. To provide a command building facility so that complicated and/or repetitive processes can be predefined and saved

3. To provide easy access to the computer's system utilities

4. To provide "user friendly" prompts, warnings, and errors for both levels of users

General software engineering techniques for development of major programs involve the following phases: definition of requirements, specification of requirements, design of the system, implementation of the system, testing and maintenance (see for example [1]). In addition, the design of a user interface breaks down into four areas: the user model, the command language, the feedback, and the information display (see [2]). This summer's project has progressed through the first three phases of design development. Work is currently being completed on the implementation of an interface demonstration package for a subset of the command language. For a summary of the hierarchial structure and the state interaction for the interface, see figures 1 and 2.

Summary of Interface Design

Since the objective of the user is to create, modify, and analyze vehicle specifications, the objects of main interest to the user will be collections of data containing vehicle specifications (e.g. geometry, weights, aerodynamic parameters) and any relevant mission requirements (e.g. payload capacity). Denote these objects as vehicle configuration data (VCD) files. In an effort to facilitate extended user-conceived design programs, two auxiliary objects are introduced: user-defined commands and user control variables. Denote these objects as process control aids (PCA's).

Consideration of a task analysis led to the following requirements for user action upon the VCD and PCA objects.

1. User actions on VCD objects:

   a) Copy from archive a VCD file for active analysis
   b) Save an active VCD in the archive
   c) Replace an archived VCD with a modified version
   d) Delete a VCD from archive
   e) Create a new VCD
   f) Invoke AVID geometric definition and modification
   g) Invoke AVID analysis and application programs
   h) Invoke AVID data base manager

2. User actions on PCA objects:

   a) Create PCA variables
   b) Define PCA variables
   c) Delete PCA variables
   d) Perform logic, arithmetic, and other operations or tests with PCA commands
   e) Define PCA commands
   f) Edit PCA commands
   g) Delete PCA commands

3. User actions with the computer system:

   a) Invoke any valid system command or utility.

4. General user actions with the interface:

   a) Ask for a directory of archived VCD's
   b) Ask for a menu of user-defined commands
   c) Ask for a menu of AVID commands
   d) Ask for a list of PCA variables
   e) Ask for help

5. Miscellaneous interface requirements:

   a) Warn user of consequences of a potentially time consuming or data destroying command
   b) Trap errors and restore a predefined reference point
   c) Keep a log of commands for later reference

Additional Summer Activities

NASA Computer Science Colloquium

"Visual Realism in Computer Graphics."

Consultation

1. John Heinbockel (SSD - Space Technology/ODU) - Graphical display for growth of solar-cell crystals.

2. Kenney Jones (SSD - Systems and Experiments/Kentron) - Methods of object identification in display representations.

3. Don Randall (SSD - Systems and Experiments/Kentron) - details of representation and presentation of realistic 3-D objects.

4. Ray Gates (SSD/Kentron) - MOVIE.BYU program.

5. Ned Gleason (HSAD - Performance Aerodynamics) - Adaptive scaling and zoom display techniques

References

1. Green, M., "A Methodology for the Specification of Graphical User Interface," Computer Graphics, V. 15, No. 3, Aug. 1981, pp. 99-108.

2. Newman, W. M.; and R. F. Sproull, Principles of Interactive Computer Graphics," Second edition, "Chapter 28: User Interface Design," McGraw-Hill, 1979.

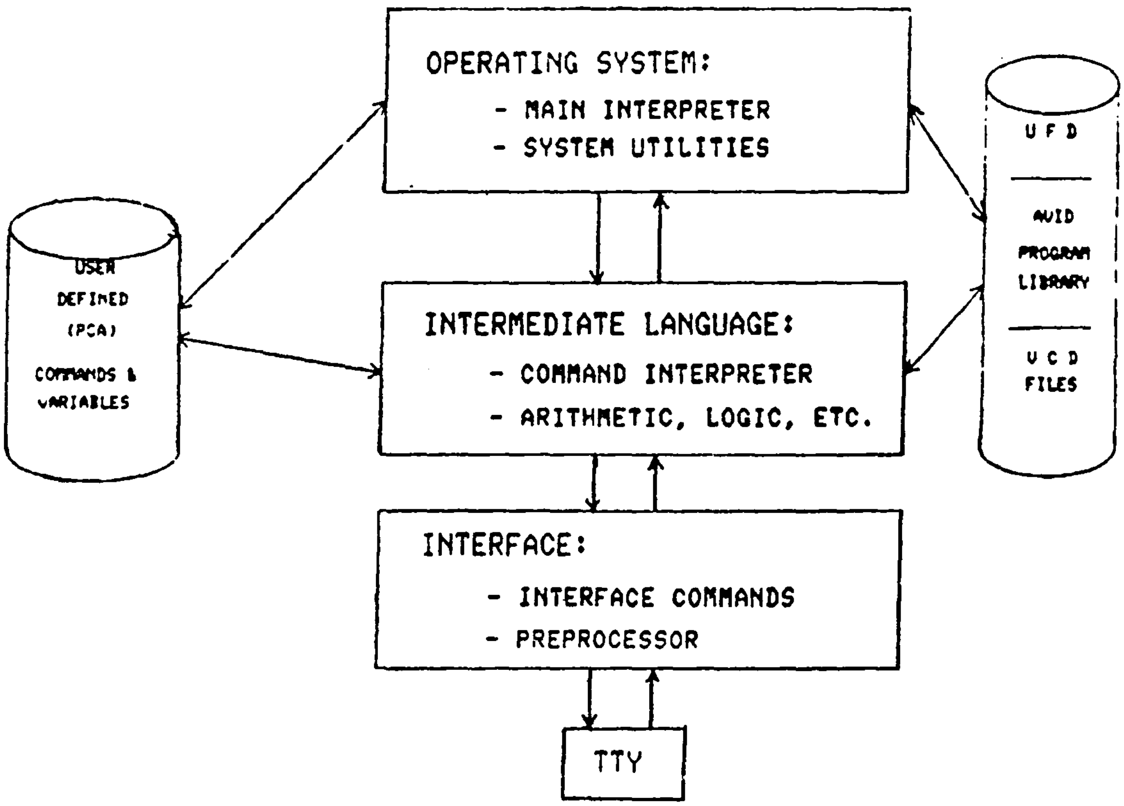

Figure 1.- Hierarchial structure.

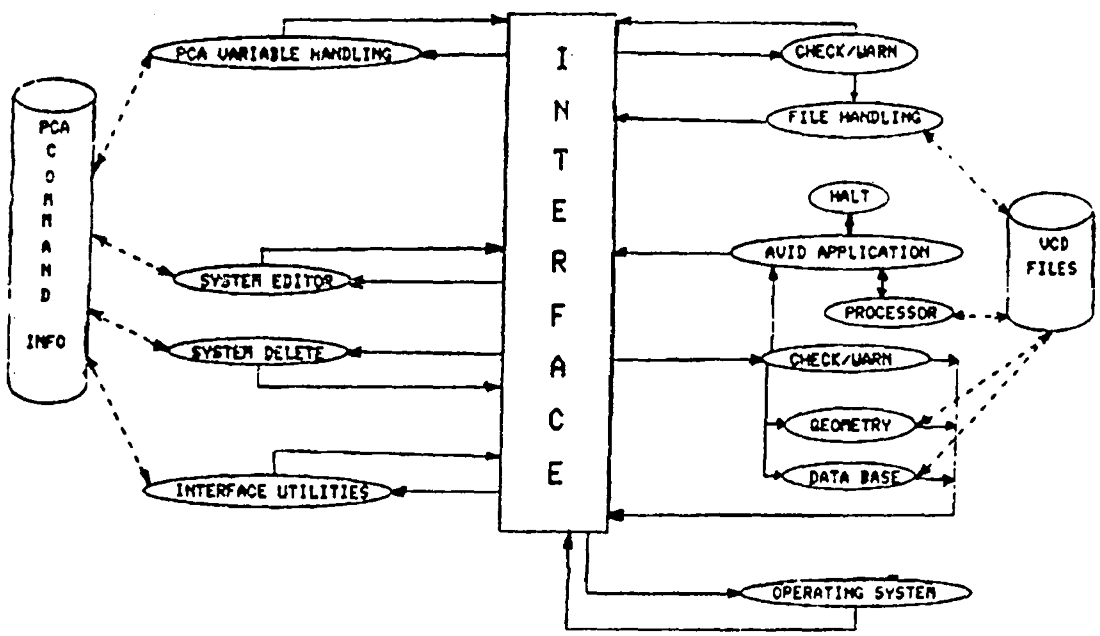

Figure 2.- State diagram.

DESIGN AND DEVELOPMENT OF

THE ALGORITHMS FOR ERBE RELEASE-3 SOFTWARE DEVELOPMENT

by

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NASA is scheduled to launch the first of the Earth Radiation Budget Experiment (ERBE) satellites in the spring of 1984. ERBE will measure reflected sunlight and the radiation emitted by different parts of the Earth at different times and under different conditions. The ERBE satellite consists of two major instruments: (1) scanner and (2) non-scanner. The scanner instrument has three different radiation measuring channels: (1) total channel, (2) longwave channel, and (3) shortwave channel. The nonscanner instrument has five different radiation measuring channels: (1) wide field-of-view (WFOV) total channel, (2) wide field-of-view shortwave channel, (3) medium field-of-view total channel, (4) medium field-of-view shortwave channel, and (5) solar monitor channel.

WFOV channels of the nonscanner instrument look at a 60^{o} subtended angle at the center of the Earth. MFOV channels of nonscanner instrument look at a 10^{0} subtended angle of the center of the Earth. The scanner instrument has a footprint of a diameter of 32 km. Each nonscanner channel makes 1.25 measurements per second or 5 measurements in 4 seconds. Each scanner channel makes 120 samples in 4 seconds, of which 74 are sent to Earth.

These data from the three ERBE satellites will be reduced at the Langley Research Center's computer complex. This is a massive computing job that has a large number of tasks. The software development is occurring in three stages known as releases. Each release is intended to begin with a set of requirements that are developed into a detailed design. The computer programs are coded from the design documentation and then tested. Release-2 software is near completion.

The work done this summer as part of the ASEE program is of the release-3 design work. It is expected that there will be nine major subsystems, one of which is intended to convert the satellite data into a useful form. This subsystem is named as the count conversion subsystem. This count conversion subsystem is designed (1) to convert the radiometric data from all the nonscanner and the scanner channels into engineering units, and (2) to generate an output product consisting of the averages of different radiometric data and housekeeping data for instrument quality control groups at NASA. The functional flowchart for the count conversion subsystem is in figure 1.

During the ASEE summer program, algorithms were developed (1) to edit raw data from the nonscanner instruments, (2) to edit raw data from the scanner instruments, (3) to process raw data from the nonscanner instruments, and (4) to compute voltage and temperature differences needed in the processing of raw data from the scanner instruments, and (5) to process raw data from scanner instruments using the Warnier-Orr diagrams. The details of these algorithms will be published in a release-3 design document.

Also, during the entire ASEE summer program, there were group discussions about release-3 algorithms for the count conversion subsystem for the nonscanner and the scanner instruments. As a result of these group discussions between people from the instrument group, the data management group, the science team, and the design team, a better understanding of (1) the instrument operation, (2) the data formats, and (3) the algorithms and constants to convert data from instruments to the engineering units was reached. As far as the nonscanner instruments are concerned, how to convert raw data to engineering units is agreed upon. For the scanner instruments, the algorithms to convert the raw data to engineering units is still under consideration and it will be some time before the final algorithm is accepted.

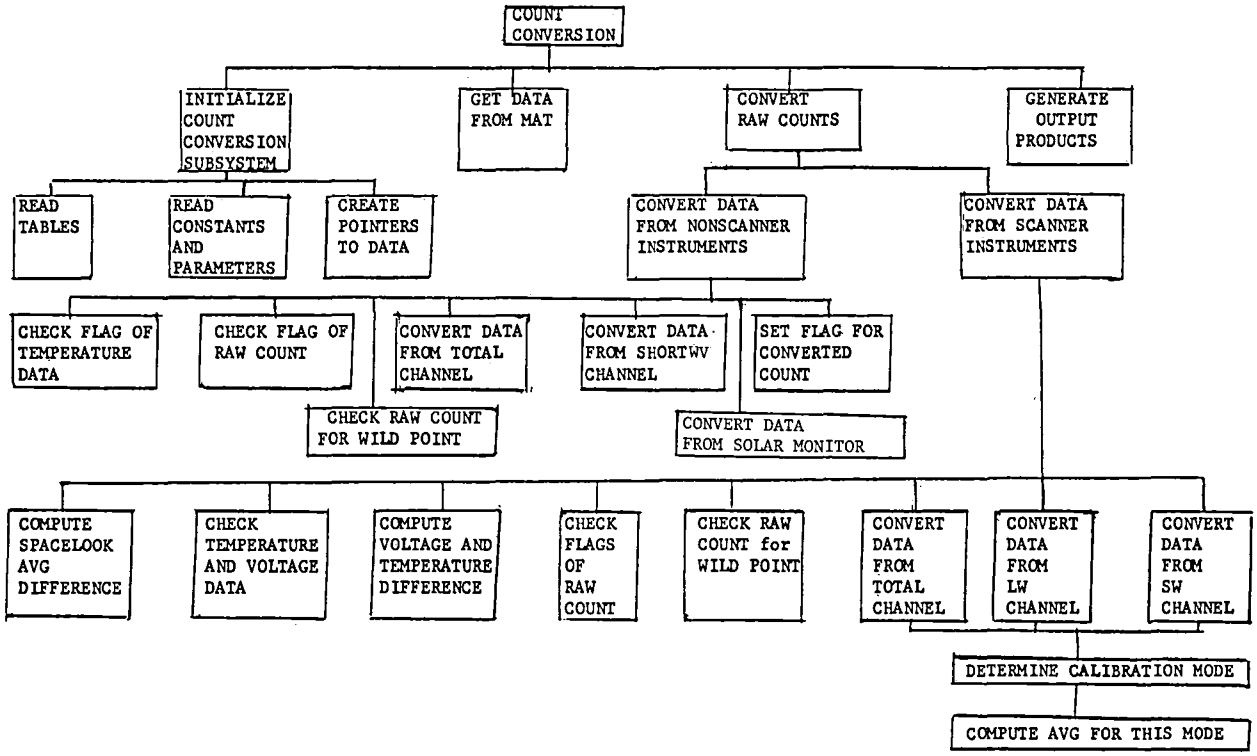

Figure 1.- Count conversion subsystem flowchart.

SLAM II AND SIMULATION OF FUTURE SPACE TRANSPORTATION SYSTEM OPERATIONS

by

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The Vehicle Analysis Branch, Space Systems Division, has begun to implement a simulation study of future space vehicle operations. The objectives were to find out the operational procedures and to determine the resource requirements to optimize the utilization of future space transportation systems (FSTS).

The first step was to select an appropriate tool for implementing the simulation study. Several simulation languages were considered. A decision was made to use SLAM II of the Pritsker and Associates, Inc. There were two major favorable factors that affected this choice. One was that several other NASA agencies had been using SLAM II for simulation and scheduling purposes. Compatibility within NASA would be useful in the future. Another factor was that this system allows network-oriented, process-oriented, and continuous simulations to be incorporated in one single model. Thus, very flexible simulation models could be conveniently built with savings in programming efforts.

This summer research project included a thorough study of the SLAM II system and the building of several pilot simulation models. SLAM II is a relatively young system. Its full capabilities were not well understood. Its weaknesses and pitfalls were not fully recognized. Certain users seemed to have some problems which were unsolved.

Careful studies were done and systematic tests were made on the system. A paper was written by the research associate, Doug Morris, and me to report on the capabilities as well as the pitfalls of the system. Some recommendations were made on the improvements of the system. These recommendations will appear as a NASA technical report and will also be submitted for possible journal publication.

Pilot models of the space vehicle operations simulation were built. The experiences gained through the pilot models will help in the implementation of full-scale simulation studies here at Langley.

It was found that the network modeling capability of SLAM II indeed provided very convenient means for building simulation models. A typical simulation model could be implemented with a small fraction of programming efforts that would be required if the same implementation were in, say, SIMSCRIPT or SIMULA. FORTRAN routines could be called from within the SLAM II network model, and entities could be created in a

FORTRAN routine and then entered into the network model. Some network status could be modified from FORTRAN routines. The capability of combining network modeling with FORTRAN routines allowed very flexible and elaborate models to be built in SLAM II with ease.

Many types of branching were provided. Conditional, unconditional, probablistic, delayed, and multiple branchings were all allowed. Combinations of these branchings were also possible.

Blocking, balking, and discarding of entities in the network were implemented. However, it was found that integrity enforcement in this area was lacking. Entities could be lost unintentionally. Entities could also be sent to wrong nodes when the file numbers were not appropriately declared for the resources. Inconsistent and erroneous results might be obtained by unwary users. Users would have to exert extra care in this area until further improvements were made by the software vendor.

The tracing feature was found to be very valuable to users in trying to visualize the dynamic phenomena in the network. Selective tracing was possible. One deficiency in tracing was that the SELECT node and the service activities were not given in the trace report; thus, a user might not be able to see the complete picture in certain situations.

Intermediate summary reports might be requested for any clock time. However, the reports were generated prior to the specified clock time, and entities in activities not ended would not be counted in the intermediate reports. A user unaware of this characteristic could be faced with confusing results. The terminology "utilization" in the summary reports was used with a meaning different from what was commonly understood in engineering and business.

The system limitations on the number of entities, the number of files, and so on might turn out to be a little too restrictive for some large models. However, the users could change such limitations in the SLAM II source codes.

In conclusion, SLAM II was found to be a very good language to use for the FSTS simulation project, but it should be used with care.

FROZEN ORBITAL METHOD FOR MATERIALS RESEARCH (FOMMAR)

by

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Recent discovery of organic crystals that become superconductors via vibrational-electronic (vibronic) stabilization of Cooper electron-pairs, lithium-doped polyenes which are good conductors, and increased sophistication in four-component III-V semiconductors argue strongly for high accuracy when applying quantum mechanics to study subtle effects of chemical fine-tuning. The computer programs developed at NASA-LaRC by Dr. D. H. Phillips and his colleagues over the last 10 years to provide very accurate treatment of small molecules in atmospheric research are being modified and reorganized according to a model (FOMMAR) derived by Dr. Phillips to allow application of these techniques to solids.

The problems of interest include local effects of metal dopants in polymers, effects of site substitution in III-V semiconductors, and chemisorption of compounds on bulk surfaces. In these cases the region of interest is not periodic, but the host lattice structure is regular. By carrying out multiconfiguration self-consistent-field (MCSCF) treatment of the local cluster, the problem retains accuracy and manageable size provided the effect of the periodic host lattice is properly included. The FOMMAR treatment has been coded to include all coulomb and exchange interactions of local cluster electrons with the bulk lattice within the one-electron Hamiltonian of the local cluster, and uses localized orthogonal orbitals for the bulk/host lattice. Through the use of exchange-localization for orbitals in the bulk and the relative short range of specific components of the electronic interaction between the local cluster being studied with the exchange-localized bulk orbitals, we expect that convergence of the cluster results to experimental accuracy can be achieved within a bulk region of no more than 20 neighboring atoms in any given direction. Numerical experiments are planned to determine the effects of smaller bulk regions, larger local cluster size, and approximate treatment of long-range interactions.

It is important to note that the usual Bloch-orbital treatment of this class of problems fails because the region of interest is not periodic. Subtle electronic effects at local sites require highly accurate treatment at that region, but long-range effects of the host lattice can also be accurately included using only frozen exchange-localized orbitals. Even with this technique, it is necessary to design the computer programs and choose problems carefully to avoid overloading current computer hardware.

STATIC ANALYSIS OF REAL-TIME FLIGHT PROGRAMS

by

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The Computer Science and Applications Branch, Analysis and Computation Division, is engaged in a long-term program of development of methodologies and tools for testing and verification of real-time flight computer software. As a result of this effort, the HAL/S Integrated Verification and Testing System (IVTS) has been implemented. The system is developed by Boeing Computing Services and based on research conducted mostly by L. J. Osterweil[1] and other researchers at the University of Colorado. The purpose of this summer research project is to evaluate and further develop IVTS algorithms for data flow analysis. The algorithms detect three major data set-use anomalies in a HAL/S program: 1) a variable is referenced without being previously assigned a value, 2) a variable is assigned a value more than once without intervening reference, 3) a variable is assigned a value and then undefined without intervening reference.

The data flow analysis extends through procedure boundaries using the depth-first search algorithm due to Tarjan[2]. The anomalies are discovered by so-called LIVE and AVAIL algorithms due to Hecht and Ullman[3]. The algorithms use a program graph in which each mode represents a source program statement, each arc represents a possible transfer of control, and the nodes are annotated by bit vectors indicating for each variable whether this variable is defined or used at this node. The annotated graph does not contain information on which combinations of arcs are actually executable. Some combinations of arcs are not executable, and this results in spurious diagnostics and makes the data flow analysis messages more difficult to use.

The accuracy of data flow analysis cannot be improved further by algorithms based only on the program structure without using the program semantics. The algorithm due to Osterweil and Bollacker[4] finds unexecutable paths that use a program graph whose arcs are annotated with 1) a predicate representing the condition for traversing this arc, 2) a bit vector indicating for each program variable whether it participates in computing this arc predicate. In addition, the algorithm creates: A) bit vectors attached to each node and indicating for each graph arc whether the statement at this node assigns a value to variables affecting the predicate of this arc; B) bit vectors attached to each arc and indicating for each other arc whether 1) the two arc predicates are mutually exclusive, 2) there exists a path between these two arcs which does not affect the value of the predicate of the second arc, and 3) these two arcs are possibly mutually inconsistent in the sense that their predicates are mutually exclusive, and the second predicate is not affected while control passes from the first arc to the second.

Then a bit vector is attached to each arc indicating for arcs that are mutually inconsistent with the given arc whether the given arc is 1) the first arc of a possible path between inconsistent arcs, 2) the last arc of a possible path between inconsistent arcs. The pairs of possibly mutually inconsistent arcs are stored in a table, and five additional bit vectors are attached to each node indicating for each table entry whether 1) the statement at the node affects either of the predicates of the two arcs, 2) the statement at the node uses path predicates, 3) the second arc of the pair can be reached from this node, 4) the node cannot be bypassed by a path from the first arc, 5) the presence of the node does allow for the possibility that two arcs belong to an executable path. The conjunction of negations of the vectors of the fifth set of vectors indicates which pairs of arcs cannot be executed.

The algorithm uses heuristically modified LIVE and AVAIL algorithms with various combinations of initial conditions. The advantage of this approach is that a single execution of the algorithm is sufficient to determine nonexecutable paths. However, it significantly increases both time and space requirements, and it does not find all nonexecutable paths. Its resolution power is diluted by the fact that all predicates whose values may potentially change (but do not) are removed from further analysis. The predicates that may become mutually exclusive as a result of path traversal are not considered at all. The predicate analysis is limited to simplest relational forms; all other forms are treated as mutually consistent.

The solution developed in this research is based on our analysis of 1) existing coding patterns, 2) limitations that could be imposed on coding patterns to improve software reliability, and 3) requirements on the form and content of information available to the programmer during different phases of the software development life cycle.

It was found that existing code patterns involve numerous legal instances of definition-definition as well as definition-undefinition sequences; they do not impair software reliability; their usage improves code readability. Diagnosis of these sequences is crucial neither during unit testing nor at the time of regression testing. References to uninitialized variables are less frequent, much more dangerous, and more difficult to find by other methods. Their control is crucial for unit testing and for both the system integration testing and system maintenance.

We propose to concentrate on uninitialized variables and enumerate executable paths instead of nonexecutable ones (enumeration algorithm is due to Sloane[5]). The algorithm annotates each arc with its predicate and executes each path symbolically; at each node, the operations over variables that do not affect path predicates are skipped. This results in efficient accumulation of path predicates in the normal conjunctive form. The traversal of each path is terminated when: 1) the path predicate assumes the value FALSE, that is, any components of the conjunctive form become mutually exclusive, or 2) all monitored variables have been accessed (either assigned or referenced) along the path. To decrease the number of variables, only those variables are monitored which 1) are identified by the existing algorithm as potentially uninitialized, and 2) do not have the INITIAL attribute. To speed up the check for inconsistency, only those components of conjunctive forms are tested whose value is affected by common predicate variables.

The proposed approach has the following advantages: 1) the algorithm operates on executable paths only, thus suppressing information that cannot be efficiently used by designers and programmers, 2) the algorithm can control operations over array components as well as over scalar variables, and 3) the enumeration of executable paths can be used for dynamic testing.

The data flow analysis user interface can be further improved by providing the options 1) to monitor explicitly requested variables only, and 2) to pronounce the program to be too complex if the number of executable paths exceeds a predetermined limit. The approach is based on the assumption that the number of executable paths reflects the complexity of the underlying application and is significantly less than the total number of paths that reflects the complexity of the program graph only.

Little can be done to improve concurrency analysis as it stands now; HAL/S has very powerful real-time constructs, but they were not designed with verification in mind. Besides deadlocks, the programmer has to be concerned with the possibility of starvation (infinite delay). The first step can be development of coding patterns suitable for both flight software applications and for testing and verification. The next step is design of appropriate notation to represent HAL/S real-time statements, since neither diagraphs nor Petri nets are suitable for this purpose.

Other proposed enhancements of static analysis are aimed at comparison of the programmer's intent with A) actual code for module interfaces (procedure invocation structure, input-output parameters, and global variables) and access rights (task invocation structure, monitor and abstract date-type simulation), and B) with the set of design standards (GO TO statements, CASE statements without the ELSE clause, multiple RETURN statements, numeric literals in executable statements, assignment to input parameters, etc.). All of these items mentioned can improve readability and verifiability of flight software.

References

1. Osterweil, L. J.; Brown, J.; and Stucki, L.: ASSET: A Life Cycle Verification and Visibility System. J. of Systems and Software, vol. 1, 1979, pp. 77-86.
2. Tarjan, R. E.: Depth-First Surge and Linear Graph Algorithms. SIAM J. of Computing, September 1972, pp. 355-365.
3. Hecht, M. S.; and Ullman, J. D.: A Simple Algorithm for Global Data Flow Analysis Problems. SIAM J. of Computing, April 1975, pp. 519-532.
4. Osterweil, L. J.; and Bollacker, L.: An Algorithm for Detached Unexecutable Paths Through Program Flow Graphs. Technical Report CU-CS-112-78, University of Colorado, Boulder, Colorado, January 1978.
5. Sloane, N. J. A.: On Finding the Paths Through a Network. The Bell System Technical Journal, vol 51, no. 2, February 1972, pp. 371-390.

APPLICATION OF ARTIFICIAL INTELLIGENCE TO ROBOTICS

by

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There has been a recent surge of activity in investigations in robotics and in artificial intelligence (AI). For the most part these have been separate fields of investigation. Traditionally, robotic research has been concerned with manipulators and the appropriate applications of mechanical engineering and control theory to those manipulators. AI has investigated intelligent behavior and the modeling of such behavior on computers. The recent surge of activity in robotics can be attributed largely to the advent of inexpensive microcomputers which greatly decrease the cost and size of the computer necessary for the controlling algorithms. The application of techniques from AI to allow manipulators to exhibit more intelligent behavior is an intriguing possibility and has received surprisingly little investigation.

The Automation Technology Branch (ATB) of the Flight Dynamics and Control Division, NASA-Langley, has an ongoing research effort on applications of robotics to space activities. The combination of robotic manipulators and computers capable of supporting AI activities makes ATB's Intelligent Systems Research Lab an excellent facility for applying AI to robotics. Within this context, I investigated the following questions during this summer.

1. Beginning with a teleoperator-based manipulator system, how can it evolve into a fully autonomous system without major backtracking? What will be required of present efforts at ATB to facilitate such an evolution? What directions for future work are suggested? What does the current state of AI have to offer?

2. What techniques from expert systems are applicable to space station and remote manipulator technology? What new techniques are needed?

3. What additions to and interconnections with the current environment at ATB can be made to allow for control of real-world robots under programs that use AI techniques?

4. Can teleoperator control, interactive keyboard control, and autonomous program control be integrated into the current ATB environment?

5. In an incompletely controlled environment, or in a system with more than one manipulator, how does one avoid destructive collisions?

6. How do we interface model-based planning systems with real-time monitoring and rule-based expert systems in order to create an intelligent system capable of directing robotic manipulators?

I developed a high-level functional design for a suitable autonomous system and investigated how this autonomous system would smoothly degrade into teleoperator operation. This and other investigations of items 1 and 2 will be included in part in a forthcoming joint paper with ASEE fellows Dr. Jerry Potter and Dr. Stefan Feyock. Items 3 and 4 led to the implementation of programs that established protocols and that will allow LISP control of the manipulator arms. Items 5 and 6 are still in the early stages of investigation. Work completed on item 5 has led to the first stages of development of a system to protect the arms and any collided objects from damage. Hardware is presently being prepared to test real-time sensing and prevention of collisions.

A METHOD FOR PREDICTING THE COST

OF PRECISION METAL WIND TUNNEL MODELS

by

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A project was undertaken within the Systems Engineering Division (SED) of the Langley Research Center (LaRC) to develop a cost algorithm for all metal precision wind tunnel models. This requires the development of a mathematical model for determining the cost of wind tunnel usage not only at LaRC but also for possible usage at similar installations. To arrive at an acceptable cost-estimating equation, the highest correlation and best fit between historic data and combinations of empirical data will be sought by using a statistical multiple-regression analysis. Historic data from 32 wind tunnel model projects is being used as a statistical data base for the mathematical model (Table 1).

The initial phase of the data process was to determine the type and availability of data which was required. The type of data desired was that which showed actual man-hours for a particular task related to given wind tunnel model projects. The second phase was to complete a preliminary review of past and present studies of man-hour cost factors which should be considered as a part of the model base.

In general, the particular form of the equation is $y = AoX_1^{A_1} . X_2^{A_2} \ldots . X_n^{A_n}$ where Ao is a constant, the An's are the independent parameters, and the X_n's represent the independent variables. A logarithmic transformation had to be made in order to be able to use the statistical package for the social sciences (SPSS) program for multiple regression.

In addition to the use of the multiplicative model in our evaluation, the additive model $y = Ao + A_1X_1 + A_2X_2 + \ldots A_nX_n$ where Ao is a constant, the An's are the coefficients of the Xi's to be estimated, and the X_n's represent the independent variables that were also employed.

A method of least squares affords us a procedure to determine the "best" functional relationship that exists between the variables. Hopefully, the relationship between the selected variables is linear in nature, and all of the regression assumptions hold.

Since the cost-estimating model depends very strongly on historical data, an accurate data base is required to determine the constants and best unbiased estimates of population parameters. Accurate records from Micro Craft, Inc., were used to create the initial data base. The information obtained from Micro Craft, Inc., represents 32 projects of different types of precision models. One additional case was obtained later to be used as a test case for the proposed alogarithms. These 33 cases represent the population; therefore, the calculated values are based on N-1 sample points, where N = 33. We had eight independent variables and one dependent variable (Table 1) (man-hours) to be considered. The mathematical model will be expanded to include data from other subcontractors once the technique has been thoroughly tested.

An analysis of the more than 36 comparisons resulted in a decision that no one model (additive or multiplicative) would satisfy the requirement of the cost estimating function (Table 2). An evaluation of the plots led to the acceptance of the additive model for values of $y > 2500$. For $y < 2500$, the program indicated that the number of outliers outside the two-standard deviation range represented only 6.25 percent of the total. Plots were constructed with a ± 20 percent band, i.e., differences were calculated between the actual man-hours and the calculated man-hours, and the appropriate equations were selected with the minimum delta. A case that had not been used in the derivation of the cost equations was used to test the calculated equations. This resulted in an acceptable cost function.

Based on the analysis of the various plots (man-hours actual versus man-hours estimated and actual cost versus estimated cost), it is believed that the following models "best" serve the needs for cost estimating. With more cases added from other subcontractors, it is possible to obtain a better fit.

Direct Model Costs

Manufacturing cost:

m-h > 2500

$$\text{Mm-h} = 353X_1^{-1.665}X_2^{.573}X_3^{-.558}X_5^{2.111}X_6^{1.050}X_7^{.312}X_8^{.111}$$

m-h < 2500

$$\text{Mm-h} = -1537.8 + 715.7X_1 + 203.1X_2 + 307.9X_3 - 24.6X_4 - 75.2X_5 + 121.4X_6 + 20.8X_7 + .6X_8$$

Engineering cost:

Based on least-squares approach

$$\text{Em-h} = 98.5 + .2\text{Mm-h}$$

Material cost: 7.8 percent of manufacturing cost

Other efforts within SED were concerned with testing the model and the use of multiple-regression analysis to deal with the composite model which is quite complicated.

The original form of the data fits the matrix in Table 1.

Table 1

Manufacturing Estimating Matrix

X_i	Item	Count 1	2	3	4
1.	Basic machine processes	lathe	mill	N.C.	Edm.
2.	Model size	0 → 1	1 → 10	10 → 30	30 →
3.	Material	AL	SH, f.m.	SH, other	Miscel.
4.	Surface finish	32	16	8	4
5.	Precision	.01	.005	.001	.0005
6.	Aux. processes	0	1	2,3	4
7.	No. of pieces	1 → 5	6 → 15	16 → 25	26 →
8.	Amt. of instrumentation	0	1 → 10	11 → 100	101→

9. Y = Actual man-hours reported (the dependent variable)

Table 2

Breakdown of Computer Trials

Trials	No. of cases in trial	Range of Y	Comments
A		All cases	
B	30 2	y < 5000	outliers out
C	26	y < 3000	not enough
	6	y > 3000	cases for n = 6
D	23*	y < 2500	best fit
	9	y > 2500	best fit
E	21	y < 2000	
	11	y > 2000	
F	20	y > 1000	
	12	y < 1000	

Criteria for the selection for a particular proposed model was based on a cutoff value of the actual value of the man-hours M-H (=y).

VALIDITY OF EQUIVALENT ELECTRON FLUENCE FOR GaAs SOLAR CELLS

by

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Gallium arsenide solar cells have received considerable attention due to their potential usefulness in high-power space energy systems as well as special space probe applications where high operating temperature is a factor. However, space radiation damage to the cell may be a limiting factor. Consequently, radiation damage experimental studies have been conducted to determine the effect of radiation on the performance of the cells.

A major problem is encountered when attempting to duplicate the radiation of the space environment for experimental studies because of the different qualities of radiation that exist in space. A possible solution to this problem is the concept of equivalent electron fluence.

A simple model for particulate radiation damage in shallow junction (0.5 and 0.8 micron) heteroface GaAs solar cells is used to evaluate the equivalent electron fluence concept, particularly in the sense of additivity of electron and proton exposure. The equivalent electron fluence is defined as that fluence of electrons of fixed energy (usually 1 MeV) which produces the same effects on the performance of the cell as a particular fluence of protons of energy E_p. Therefore, the fluence of electrons ϕ_e equivalent to a fluence of protons ϕ_p is given by

$$R_p \; [\phi_p \; (E_p)] = R_e \; [\phi_e] \tag{1}$$

where R_p and R_e are the device response functions for proton and electron damage, respectively. If the relation (1) is satisfied, the equivalent fluence ratio may be defined as

$$r \; (E_p) = \phi_e / \phi_p \; (E_p) \tag{2}$$

The validity of the concept of equivalent fluence requires that $r \; (E_p)$ be independent of the magnitude of $\phi_p(E_p)$. The combined effects of electron and proton exposure are then taken as

$$R_{tot} \; [\phi_p \; (E_p), \; \phi_E] = R_e \; [\phi_e + r \; (E_p) \; \phi_p \; (E_p)] \tag{3}$$

Simple models for proton and electron damage in GaAs solar cells were used to calculate the efficiency changes of the cell. Efficiency changes caused by protons of different fluence and energy were compared with efficiency changes caused by electrons of 1-MeV energy and different fluency. It was found that spatial-dependent factors for low-energy protons (less than 1 MeV) exposure result in a dependence of the equivalent fluence ratio on the proton fluence. Therefore, the equivalent fluence concept cannot be applied for low-energy protons. Above 1 MeV, the equivalent fluence ratio appears to be independent of proton fluence and would allow application of the equivalent fluence concept for protons with energy above 1 MeV.

AEROELASTIC CONSIDERATIONS FOR CONTINUOUS PATROL/HIGH-ALTITUDE SURVEILLANCE PLATFORMS

by

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For the last several years, Langley Research Center, Naval Air Development Center, and others have investigated the feasibility of unmanned, airborne, high-altitude powered platforms (HAPP), and high-attitude surveillance platforms for over-the-horizon targeting (HI-SPOT). These airborne platforms have been proposed as a means of achieving a continuous regional communication relay or for continuous regional surveillance for use in agricultural research or military applications, i.e., fleet support. These platforms would offer improvements over existing orbiting satellites, i.e., better resolution and more mission flexibility. The required mission endurance would be obtained through the use of either solar or microwave power. Solar power would allow for more flexibility in the mission, but would require a much larger platform in order to produce sufficient energy for continuous day and night operations. To demonstrate proof of the concept, three solar-powered aircraft have been developed and flown, two piloted, and one remotely piloted, but in each of these aircraft no attempt was made to store energy for nighttime use.

In order for the solar-powered aircraft to function continuously and to maintain cruise altitude, it must generate sufficient power during the day to maintain both day and night operational capabilities and thus maintain a daily energy balance. A daily energy balance can be determined once the mission, energy storage system, and motor/propeller characteristics are defined. By using wing-loading data from the gliders and solar-powered aircraft, daily energy balance, required payload weight, load factor, and aerodynamic data, the airborne platform can be sized. Because the platforms that are now being sized are so much larger than the gliders and solar-powered aircraft that compose the data base, the airborne platforms may have aeroelastic instabilities, i.e., wing divergence, flutter. The research just completed dealt with the flutter characteristics of two airborne platforms designed in this manner and an additional concept, the joined-wing, which may be considered in the future. The joined-wing platform that was used in the study did not attempt to maintain similar performance as normally would have been done, but was designed to have the same structural weight and wing area/solar panel area as the baseline configuration.

The research project was subdivided into three separate tasks: (1) structural definition, (2) structural and aerodynamic modeling, and (3) modal and flutter analysis. Available structural information was very limited since the airborne platform concept was still in the early development phase. The basic concept was to use graphite/epoxy skin, Kevlar leading and trailing edges, Nomex honeycomb for upper skin support, and a graphite/epoxy truss configuration for internal support of the wing. Three different weight/strength concepts (structural weight of 0.66 lb/f^2, 0.33 lb/ft^2, and 0.15 lb/ft^2) were utilized for each of the three airborne platforms and yielded a total of nine structural models for analysis.

The unsteady aerodynamic modeling was done using the Doublet-Lattic method for half the platform with a total of 80 aerodynamic panels on the wings. The modal, unsteady aerodynamics, and flutter analyses were done using NASTRAN. The flutter analyses were done using either the "K" or the "KE" flutter analysis technique.

Results of the flutter analyses indicate that as the structural weight and associated strength are decreased, there is a marked decrease in the critical flutter speed. There are potential flutter problems associated with the conventional design concepts which require a large platform with light structure. In addition to the potential flutter problems, there may be control problems due to interaction of the low-frequency elastic modes and the rigid body motion of the platforms. The joined-wing platform indicated similar trends, but the critical flutter speed was well beyond its operational requirements. Based on the flutter study, the joined-wing concept should be considered as a possible design concept for the high-altitude surveillance platform, but the study should be expanded to include both gust response and control response before a final recommendation can be made.

TELEPHONE SEMINARS ON ADVANCED TECHNOLOGY:

AN EXTENSION OF THE LANGLEY RESEARCH CENTER TELELECTURE PROGRAM

by

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In establishing NASA in 1958, the Congress charged the organization with a broad range of responsibilities. These included that the results of technical work be given "the widest possible dissemination." This charge, in addition to their natural interests in the exchange of scientific and technical information, has presented the various centers with a continuing challenge.

The Langley Research Center (LaRC) has approached its informational activities in a variety of ways including, as a matter of course, technical publications, attendance at conferences, contacts with public media-relations experts, joint meetings with industrial and educational organizations, and visits to schools and colleges. Budgeting constraints have caused LaRC to continually investigate new methods and media for carrying out these tasks. The Telelecture Program is one of these that has proven to be quite cost effective.

The origins of the Telelecture Program are somewhat obscure. As early as 1975, organized presentations on the Viking Program were offered by individual scientists and engineers at LaRC. The list of offerings for school and other lay audiences was expanded by the Visitor Center. More recently, responsibility for the development and coordination of the program has been assigned to the Educational Services Branch. In their current format, telelectures are live presentations made with the use of the telephone and color slides. Duplicate carousel trays are prepared. One tray is mailed for projection to the audience; the other is displayed on a viewer on the lecturer's desk. There is no physical connection between the slide projection system and the telephone. A speaker telephone is used at the audience end of the telephone line. Since the presentation is made live over a duplex line, either the speaker or members of the audience may ask or answer questions.

The author's project for the summer of 1982 has been to extend the Telelecture Program to graduate students and faculty in colleges of engineering. This has involved work on developing a profile of the audience, identifying topics and speakers, and preparing an information package for mailing.

A survey of about 30 engineering professors was conducted at the 1982 Annual Conference of the American Society for Engineering Education. The results confirmed initial assumptions that there is university interest in telelectures on a broad range of LaRC activity. It was also established that an overview of research activity for a departmental seminar is the generally perferred format.

Approximately 50 possible seminar topics were identified. Dicusssions of the program were conducted with various technical staff members of the LaRC research directorates. It is expected that about 30 topics will be developed into telelectures.

An information package entitled Telephone Seminars on Advanced Technology is in preparation. This will be sent to university aerospace, mechanical, and electrical engineering departments.

SPECIATION OF HIGHER MOLECULAR WEIGHT ATMOSPHERIC HYDROCARBONS

by

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The Atmospheric Sciences Division of NASA-Langley Research Center is involved with determining processes that control the composition of the troposphere and assessing the extent to which man's activities may be perturbating its composition. Hydrocarbons are important organic components of the atmosphere because they react with oxidizing air constituents (e.g., ozone), and some are known or suspected carcinogens. Information on the concentration and speciation of atmospheric hydrocarbons is necessary in order to determine their residence time, reactivity, distribution toxicity, and ultimate fate.

Sample collection and analytical procedures were developed which would provide information on speciation of higher molecular weight hydrocarbons. Atmospheric aerosols were size fractioned using an Anderson cascade impactor. The sampler was modified to include polyurethane foam plugs which were placed behind the cascade impactors back-up filter. The polyurethane foam was used to retain gaseous atmospheric hydrocarbons. Hydrocarbons isolated from the filters and plugs were quantitated by high-resolution gas capillary chromatography.

Samples analyzed to date reveal hydrocarbons associated with aerosols are below the detection limit (0.1 $\mu g/m^3$) where there was a total concentration of gaseous hydrocarbons of 8.2 $\mu g/m^3$. The hydrocarbons found were predominately anthropogenic. Eight EPA priority pollutant polynuclear aromatic hydrocarbons (acenapthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, and benz(a) anthracene) were detected. The mixing ratio for higher molecular weight atmospheric hydrocarbons was calculated to be on the order of 10^{-9}. This mixing ratio is similar to other atmospheric gaseous constituents (NO_2, NO, etc.) that have major roles in atmospheric chemistry. This may also be true for these hydrocarbons.

This research is continuing. Larger volumes of air will be sampled in order to provide detectable concentrations of aerosol associated hydrocarbons.

INTERACTIVE CONSISTENCY ON THE SIFT COMPUTER

by

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The Software Implemented Fault Tolerance (SIFT) system and its comtemporary, the Fault Multiprocessor (FTMP) are experimental computer systems. They will be tested at the NASA-Langley Research Center in the AIRLAB Operation of the Fault Tolerant Systems Branch of the Flight Control Systems Division. Simulative models, emulative models, and statistical models are being developed to predict the reliability of ultrareliable computer systems. Experiments will be run with SIFT and FTMP to test and calibrate the models. Eventually the models will be used to predict the reliability of potential computer systems from their design specifications.

SIFT uses redundant hardware, replicated tasks, voting of output, fault location through error analysis, and the removal of faults by reconfiguration to achieve reliability. The SIFT system consists of up to eight BDX 930 minicomputers which are connected by a broadcast bus. Each processor has a 1553a terminal for communication with the outside environment.

The operating system for SIFT was coded by SRI International. In this operating system the SIFT processors operate in loose synchronization with a maximum clock skew of 100μs, and each processor is required to respond to a clock interrupt every 3.2 ms. Critical tasks of the operating system are replicated and their results are voted. A processor that fails to be in the majority is flagged, and processors with excessive errors are dropped from the pool of working processors during reconfiguration. In order not to deplete the processor pool, the system must ensure that all processors receive the same input data for all replicated tasks.

The process that guarantees identical input from the external environment is called the interactive consistency (IC) task. It has been shown that four processors can provide interactive consistency if at most one of them is faulty. My project was to make improvements in the part of the SRI code that implements interactive consistency.

Processors executing the SRI code for IC remain in a busy wait loop whenever new input is not available. This wait complicates synchronization with processors not assigned to this task. Further, this wait could introduce a skew of about 90μs between two processors that are both executing IC.

The new version of the IC code supplies the processors with random input and prevents output whenever the real data is not ready. This allows the processors to make a dummy run through their application tasks. During this run, errors are flagged and faulty processors are removed from the system. The changes will also avoid the synchronization problems introduced by the busy wait.

Each processor uses a 128-word storage area for broadcasting data to the other processors. The SRI code requires that 84 works of this area be used to handle the interactive consistency task. The improved code requires only 63 words of this area to handle the same input. This makes space available for diagnostic monitoring of the system.

LIQUID INJECTION INTO A SUPERSONIC AIRSTREAM

BY

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The Hypersonic Propulsion Branch, High-Speed Aerodynamics Division, is involved in the exploratory development of supersonic combustion ramjet (scramjet) propulsion engines. The design of efficient combustors for these engines requires a thorough knowledge of the spatial features of the fuel-air mixture that is attendant to a particular fuel-injection scheme.

Early in the NASA scramjet program, hypersonic transport vehicles were identified as an area of application. The use of gaseous fuels was chosen for these vehicles. Accordingly, extensive analytical and experimental expertise has been developed in conjunction with gaseous injection. Recently, however, some attention has been given to the use of a liquid hydrocarbon-fueled scramjet to propel a cruise missile. Therefore, the need has arisen to assess the state of liquid injection technology with a view toward identifying those areas in which further investigation is needed.

The major efforts during the summer research project were in three areas: (1) a study of the liquid injection literature published since 1971 when the author was last actively engaged in that area of research; (2) the completion of a simplified analysis of liquid injection which had been initiated by Dr. G. B. Northam, Hypersonic Propulsion Branch and which produced some useful rough estimates of injector sizing and spacing for realistic flight conditions; and (3) an assessment of using the laser-induced fluorescence technique to measure composition in an injectant plume.

<u>Literature Review</u> - Most past investigators of liquid injection have used photographic records of light scattered from an injectant plume to derive empirical correlations for the height and width of the boundary extremities. By illuminating a thin, transverse section of the plume, the scattered-light technique has also been used to study boundary shape. These approaches, however, provide little information about the spatial distributions of the injectant mass fraction and mass flux which are important to successful fuel ignition and uniform heat release.

In a 1971[1] study the author used in-stream mass-sampling, cone-static-pressure, and pitot-pressure probes to deduce the flow field structure of a highly volatile liquid injectant. The results revealed significant gradients in the static-pressure and velocity profiles which had to be accounted for in computing the mass-flux distributions. Furthermore, the data showed that 50 percent of the injectant was contained within a region approximately defined by 35 percent of the plume height and 25 percent of its width.

A limited attempt to generalize the mass-flux distribution for different injectant and free-stream conditions was only partially successful.

A review of the more recent liquid injection literature revealed only one study[2] that produced detailed information about flow field structure. In that study a calibrated thermocouple was used along to deduce mass composition profiles by measuring essentially convective heat transfer rates. Although the results suffer from the improper neglect of mass-flux variations, they agree qualitatively with those mentioned above. Here too, limited success in generalizing the profiles was experienced; however, the attempt to account for injectant vapor pressure variations met with minimal success.

Injection Study - A simple analysis of liquid injection was performed by approximating the near-field (within 50 jet diameters downstream) plume as a rectangle whose height and width were calculated with existing empirical correlations. The calculations were done for combustor inlet conditions that were determined with an engine performance computer code for a realistic flight schedule. A major goal was to establish whether a reasonably sized orifice (a diameter greater than 0.5mm which is judged necessary to avoid blockage by foreign matter) could be used without overly sacrificing injection efficiency, here defined as the plume area divided by the combustor area to be fueled. The results showed that only at the cruise condition of Mach 6, 30.5km did the orifice size restriction noticeably degrade injector performance, but that the amount was acceptable. In addition, the use of liquid injection showed an improvement over gaseous injection; this might be accomplished by use of a gas generator at all conditions except the cruise condition. This study also pointed up the need to obtain better prediction capability for the effective back pressure of a liquid jet.

Laser-Induced Fluorescence - Dr. G. B. Northam has suggested a diagnostic technique for investigating liquid injection which involves seeding the injectant with a fluorescent dye and illuminating a thin section of the plume with a laser of the resonant wavelength. Recording the emitted radiation with a calibrated optical setup could then be used to infer local mass composition. A literature review revealed that the combination of iodine dissolved in benzyl alcohol together with an argon-ion laser has been used to study evaporating flows. It has been noted, however, that radiation quenching, which is pressure and composition dependent, can influence the results. It is concluded that the technique is viable but that it will need to be supplemented with other means of determining pressure and velocity fields.

Recommendation - Based on the summer research project it is recommended that a series of tests of varying injectant and free-stream conditions be conducted with emphasis on determining: (1) the effective jet back pressure; (2) the influence of injectant vapor pressure; and (3) a generalized description of injectant mass fraction and mass flux.

References

1. C. L. Yates, "Liquid Injection Into a Supersonic Stream," Air Force Aeropropulsion Laboratory, Wright Patterson Air Force Base, Ohio, AFAPL-TR-71-97, vol. 1, March 1972

2. A. G. Shaikhutdinou; and V. M. Klevanskii, "Penetration and Mixing of Liquid Injected Into Supersonic Transverse Gas Stream," Soviet Aeronautics, vol. 19, no. 1, 1976, pp. 74-80.

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15. Supplementary Notes

Langley Technical Monitor: Mr. Robert H. Tolson

16. Abstract

Since 1964, the National Aeronautics and Space Administration (NASA) has supported a program of summer faculty fellowships for engineering and science educators. In a series of collaborations between NASA research and development centers and nearby universities, engineering faculty members spend 10 or 11 weeks working with professional peers on research. The Summer Faculty Program Committee of the American Society for Engineering Education supervises the programs. Objectives: (1) To further the professional knowledge of qualified engineering and science faculty members; (2) To simulate and exchange ideas between participants and NASA; (3) To enrich and refresh the research and teaching activities of participants' institutions; (4) To contribute to the research objectives of the NASA center. Program Description: College or university faculty members will be appointed as research fellows to spend 10 weeks in cooperative research and study at the NASA-Langley Research Center. The fellow will devote approximately 90 percent of the time to a research problem and the remaining time to a study program. The study program will consist of lectures and seminars on topics of general interest or that are directly relevant to the fellow's research project. The lecturers and seminar leaders will be distinguished scientists and engineers from NASA, education, or industry.

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