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HAMPTON INSTITUTE/AMERICAN SOCIETY
FOR ENGINEERING EDUCATION/NASA
SUMMER FACULTY FELLOWSHIP PROGRAM 1984

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
NOT TO BE TAKEN FROM THIS ROOM

John H. Spencer (Compiler)

HAMPTON INSTITUTE
Hampton, Virginia

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665



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APPLICATIONS/ NUCLEAR PHYSICS/ STRUCTURAL ENGINEERING

ABA: Author

ABS: 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

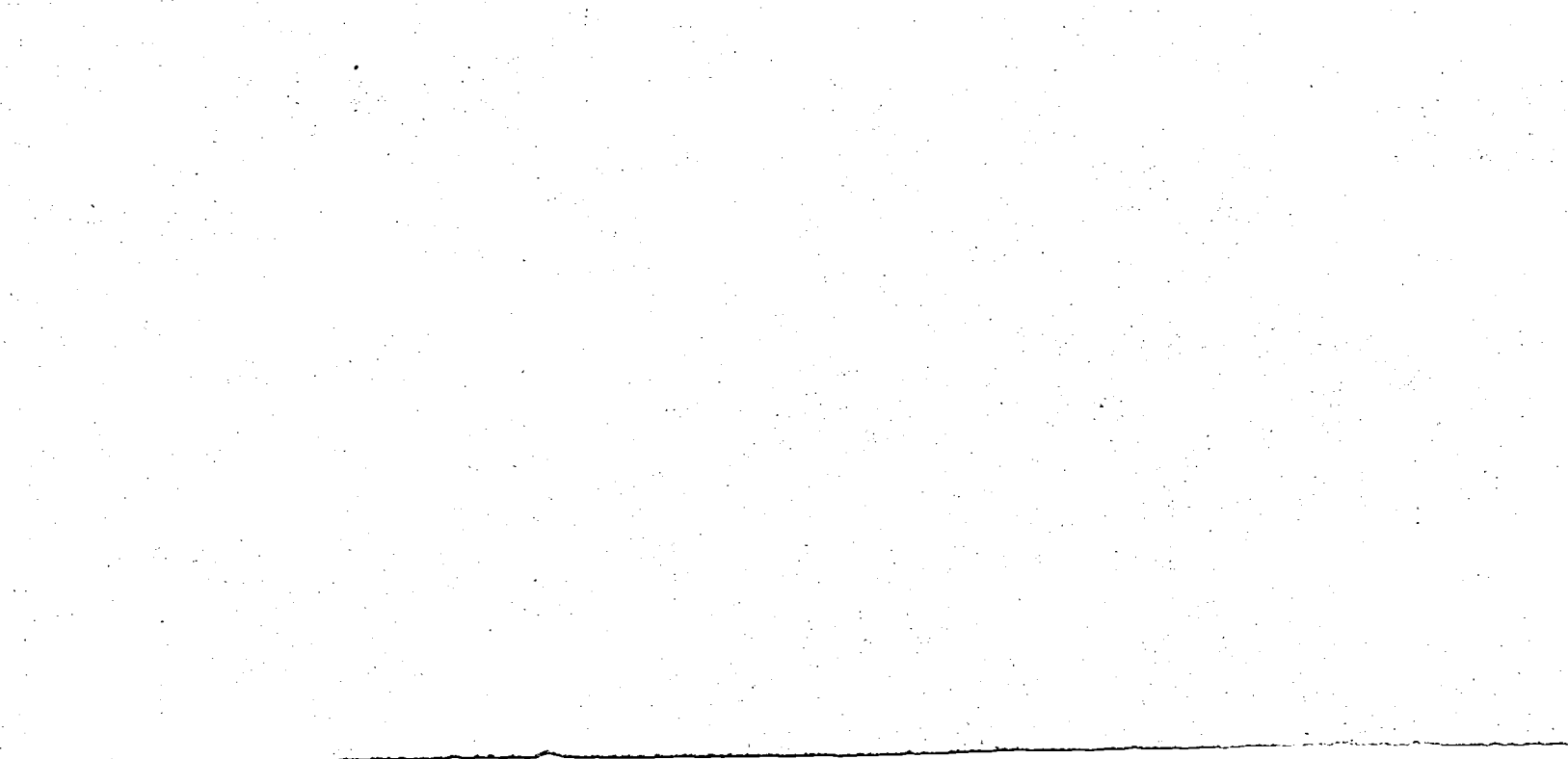


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ORGANIZATION AND MANAGEMENT

The 1984 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 twenty-first such institute to be held at Langley Research Center (LaRC). The 1984 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 Office of University Affairs.

Each individual applying for the program was provided a listing of research problems available to the Langley Fellows. Each individual was requested to indicate his or her research problem preference by letter to the University Co-Director. The desire to provide each Fellow with a research project to his/her liking was given serious consideration. An initial assessment of the applicants credentials was made by Dr. G. Goglia of Old Dominion University, ASEE codirector and consultant to the 1984 program, and the University Affairs Officer. The individual's credentials were then circulated to various divisions for further assessment. A committee consisting of staff members from the various Divisions, the University Affairs Officer and the University Co-Director then met to select the Fellows. A committee consisting of the Chief Scientist, Technical Assistants from the various Directorates, the University Affairs Officer and the University Co-Director reviewed the preliminary Selection of Fellows making the final selection.

The University Co-Director contacted each selected Fellow by phone extending the individual the appointment. The University Co-Director also forwarded each selected Fellow a formal letter of appointment confirming the phone call. Individuals were given 10 days to respond in writing to the appointment. After letters of acceptance were in hand, the NASA-Langley University Affairs Officer contacted the various Directorate Technical Assistants advising them who their Fellows were for the summer program.

Each Fellow accepting the appointment was provided material relevant to housing, travel, payroll distribution and a listing of all NASA-Langley Research Fellows as well as their Research Associates. Each Fellow, in advance of commencing the program, was contacted by his or her Research Associate or a representative of the branch.

The program opened with an assembly meeting on June 4, 1984. At this meeting the NASA-Langley University Affairs Officer introduced Mr. Robert Tolson, the Langley Research Center Chief Scientist, who formally welcomed the summer Fellows. Mrs. Jane Hess, Head, Technical Library Branch, briefed the Fellows on the use of the library. Mr. John LeDeaux, Administrative Operations Specialist, discussed the subject of security at LaRC.

Throughout the program Dr. Samuel E. Massenberg, the University Affairs Officer, served as the principal NASA Liaison person and had frequent contacts with the Fellows. Mr. John H. Spencer, the University Co-Director, served as the principal administrative officer.

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 the 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 the codirectors and with representatives from the Langley Research Center staff.

RECRUITMENT AND SELECTION OF RESEARCH FELLOWS

Returning Fellows -- An invitation to apply and participate in the Hampton Institute-Langley Research Center program was extended to those individuals who held previous Langley Fellow appointments. Forty-two individuals responded to the invitation, twenty-two were selected, twenty-one accepted the appointment.

New 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. Over 300 letters were sent and personal phone calls were made to minority schools throughout the South and the Southwest. The codirector made site visits to minority schools soliciting applicants.

There was a total of 159 applications. One hundred thirteen indicated the Hampton Institute-Langley Research Center Program as their first choice and forty-six indicated the HI-LaRC Program as their second choice.

Forty-five applicants formally accepted the invitation to participate in the program. Thirty positions were financed through the initial NASA-ASEE funding. Fifteen positions were funded by the Langley Research Center Divisions.

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

APPLICATIONS

Total Appl.	First Choice Langley	Second Choice Langley	Male	Female	Minorities Total	Blacks	Minority Schools
159	113	46	137	22	49	22	15*

*Twenty-eight applications from 15 minority institutions

PARTICIPANTS

Total	First Choice Langley	Second Choice Langley	Male	Female	Minorities Total	Blacks	Minority Schools
45	45	_____	38	7	10	7	3

Returning Fellows 18

New Fellows 27

Average Age of Fellows 41.4

STIPENDS AND TRAVEL

A 10-week stipend of \$6500 was awarded to all research fellows. Although an increase was provided again 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.

A portion of the funds that remained in the travel budget was used to pay stipends for extensions.

LECTURE SERIES

The lecture series for the 1984 Summer Faculty Fellowship Program was patterned after the programs from previous years. In order to give the research fellows a broader view of research at Langley, all speakers were chosen from among 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 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 the Office of University Affairs. These tours along with the lecture series were designed to add to the participants' knowledge of Langley Research Center.

TABLE 1. - LECTURE SPEAKERS AND TOPICS

Date	Speaker	Topic
June 5	Dr. Donald P. Hearth (NASA-LaRC) Director	Current Perspective of Langley Research Center
June 14	Brian E. Pritchard (NASA-LaRC) Office of Director for Space	Development of the Space Station
June 29	Dr. Joseph S. Heyman (NASA-LaRC) IRD-Matls Chctzatr Instrn Section	Non-Destructive Evaluation Research
July 13	Dr. Richard W. Barnwell (NASA-LaRC) NTF-Aerodynamics Branch	National Transonic Facility and Aeronautical Research
July 20	Anne K. St. Clair (NASA-LaRC) MD-Materials Division	High Performance Aerospace Polymers
July 27	Dr. Joel S. Levine (NASA-LaRC) ASD-Atmospheric Sciences Division	The Earth's Atmosphere: Past, Present, and Future
July 31	Presentation by Research Fellows Bldg. 1194A/Rms. 109, 110, 206 8:30 a.m. - 11:30 a.m.	
Aug. 2	Presentation by Research Fellows Bldg. 1194A/Rms. 109, 110, LCR 8:30 a.m. - 11:30 a.m.	

RESEARCH PARTICIPATION

The 1984 program, as in past years, placed greatest emphasis on the research aspects of the program. Mr. John H. Spencer, the codirector for the 1984 program, visited many of the research fellows and contacted the research associates for comments regarding the research being done by the research fellows. These comments from the Langley supervisors, together with the abstracts prepared by the fellows, provide convincing evidence of the continued success of this part of the program. The fellows' comments during the evaluation of the program indicated their satisfaction with their research projects as well as with the facilities available to them. The abstracts are included at the end of this report.

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

<u>Division</u>	<u>Number of Fellows Assigned</u>
.Analysis and Computation Division	2
.Instrument Research Division	5
.Flight Dynamics and Control Division	5
.Flight Electronics Division	-
.Flight Control Systems Division	4
.Low-Speed Aerodynamics Division	1
.Transonic Aerodynamics Division	1
.High-Speed Aerodynamics Division	1
.Atmospheric Sciences Division	3
.Space Systems Division	3
.Structures and Dynamics Division	4
.Loads and Aeroelasticity Division	1
.Materials Division	3
.Acoustics and Noise Reduction Division	1
.Financial Management Division	1
.Office of the Director	2
.Programs and Resources Division	1
.National Transonic Facility	3
.Personnel Division	1
.Office of External Affairs	1
.Systems Safety, Quality and Reliability Office	1
.Facilities Engineering Division	1

There was considerable variety in the LaRC program due to requests from many branches for a summer fellow. Specific mention should be made of research in the Financial Management Division; in the psychological factors dealing with stress in Space Flight; in success of aerospace technologists related to grade point average; a feasibility study of an automated time and attendance study; Data Base development for the Office of University Affairs and management of the 1984 NASA Governor's School. This is an indication of the great diversification of the Langley Research Program and the inter-relations of all the areas.

Background of Fellows

Accounting	1
Aerospace Engineering	3
Biochemistry	1
Business Administration	1
Chemistry	4
Chemical Engineering	1
Civil Engineering	1
Communications	1
Computer Science	3
Economics	1
Education	2
Electrical Engineering	2
Engineering Mechanics	2
Mathematics	3
Mechanical Engineering	6
Metallurgical Engineering	1
Meteorology	1
Physics	8
Psychology	2
Structural Engineering	1

<u>No. of Participants</u>	<u>Ph.D. Degree</u>	<u>Masters Degree</u>
45	39	6

PARTICIPATION INFORMATION

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Dr. Shaffiq Ahmed Professor Metallurgical Engr. & Materials Science Youngstown State Univ. Youngstown, OH 44505	50	Instrument Research Div.	A. Kantsios
Dr. Iris C. Anderson Professor & Dept. Head Biology Thomas Nelson Community College Hampton, VA 23607	44	Atmospheric Sciences Div.	J. Levine
Maj. Joseph L. Bergantz Assistant Professor Mechanics U.S. Military Academy West Point, NY 10996	35	Low-Speed Aerodynamics Div.	J. Thomas
Mrs. Angela M. Blayton Assistant Professor Accounting & Finance Hampton Institute Hampton, VA 23668	37	Financial Management Div.	J. Struhar
Dr. Charles E. Blount Professor Physics Texas Christian Univ. Fort Worth, TX 76129	53	Space Systems Div.	N. Jalufka
Mr. Freddie R. Bowen Assistant Professor Economics Norfolk State Univ. Norfolk, VA 23504	47	Office of Director	S. Massenberg
Dr. Daniel A. Brandt Professor Industrial Technology Western Wis. Tech. Inst. Lacrosse, WI 54601	52	Space Systems Div.	U. Lovelace

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Dr. Susan I. Brender Professor Information & Decision Science & Finance Boise State Univ. Boise, ID 83725	48	Programs & Resources Div.	B. Fowler
Dr. Kenneth G. Brown Associate Professor Chemistry Old Dominion Univ. Norfolk, VA 23508	39	Instrument Research Div.	G. Wood
Dr. William L. Bynum Professor Math & Computer Science College of William & Mary Williamsburg, VA 23185	48	Flight Dynamics & Control Div.	E. Foudriat
Dr. Randolph A. Coleman Associate Professor Chemistry College of William & Mary Williamsburg, VA 23185	40	Atmospheric Sciences Div.	R. Harriss
Dr. Anthony T. Dalessio Assistant Professor Psychology Old Dominion Univ. Norfolk, VA 23508	31	Personnel Div.	C. Burcher
Dr. Kenneth R. Demarest Assistant Professor Electrical Engineering Lafayette College Easton, PA 18042	31	Flight Control Systems Div.	F. Pitts
Dr. Michael L. Doria Associate Professor Mechanical Engineering Valparaiso Univ. Valparaiso, IN 46383	45	Transonic Aerodynamics Div.	J. South

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Dr. Stefan Feyock Associate Professor Math & Computer Science College of William & Mary Williamsburg, VA 23185	42	Flight Dynamics & Control Div.	N. Orlando
Dr. Glenda F. Hodges Chairperson Speech Communication & Theatre Arts Hampton Institute Hampton, VA 23668	33	Office of External Affairs	H. VanNess
Dr. Antoni Jakubowski Associate Professor Aerospace & Ocean Engr. VPI & SU Blacksburg, VA 24061	63	High-Speed Aerodynamics Div.	H. Beach
Dr. Yogendra P. Kakad Associate Professor Electrical Engr. Univ. of NC at Charlotte Charlotte, NC 28223	40	Flight Dynamics & Control Div.	E. Armstrong
Dr. Jeffrey J. Kelly Assistant Professor Mech. Engr. & Mech. Old Dominion Univ. Norfolk, VA 23508	37	Acoustics & Noise Reduction Div.	D. Chestnutt
Dr. Ali Kyrala Professor Physics Arizona State Univ. Tempe, AZ 85287	62	Flight Control Systems Div.	F. Pitts
Dr. Arlene S. Levine Instructor Psychology Hampton Institute Langley AFB Educ. Ctr. Hampton, VA 23665	39	Space Station Office	R. Muraca

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Dr. John H. Lilly Assistant Professor Electrical Engr. Univ. of Kentucky Lexington, KY 40502	34	Flight Dynamics & Control Div.	S. Joshi
Dr. Alfred C. Loos Assistant Professor Engr. Sci. & Mech. VPI & SU Blacksburg, VA 24061	34	Materials Div.	W. Freeman
Dr. William E. Maddox Professor Physics Murray State Univ. Murray, KY 42071	47	Facilities Engr. Div.	W. Kelliher
Dr. Larrv Mattix Associate Professor Physics Norfolk State Univ. Norfolk, VA 23504	37	Instrument Research Div.	W. Winfree
Dr. Keith W. Miller Assistant Professor Computer Science College of William & Mary Williamsburg, VA 23185	32	Instrument Research Div.	J. Monteith
Mr. Brett A. Newman Teaching Assistant Aerospace Engr. Oklahoma State Univ. Stillwater, OK 74077	23	Flight Dynamics & Control Div.	J. Elliott
Dr. Duc T. Nguyen Assistant Professor Civil Engineering Northeastern Univ. Boston, MA 02115	32	Loads & Aeroelasticity Div.	J. Sobieski
Dr. Paul S. Nichols Assistant Professor Aerospace Engineering Auburn Univ. Auburn, AL 36830	48	Systems Safety, Quality & Reliability Office	W. Hoggard

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Mr. Dean E. Nold Professor Electrical Engr. Indiana Univ.-Purdue Univ. at Fort Wayne Fort Wayne, IN 46805	52	Flight Control Systems Div.	J. Hatfield
Dr. William J. Rasdorf Assistant Professor Civil Engineering N C State Univ. Raleigh, NC 27650	32	Structures & Dynamics Div.	G. Salley
Dr. John E. Reissner Associate Professor Physical Science Pembroke State Univ. Pembroke, NC 28372	42	Structures & Dynamics Div.	G. Thurston
Dr. Harry Robertshaw Associate Professor Mechanical Engr. VPI & SU Blacksburg, VA 24061	41	Structures & Dynamics Div.	G. Horner
Dr. Moti L. Rustgi Professor Physics State Univ. of NY Buffalo, NY 14260	54	Materials Div.	S. Long
Dr. Jagdish C. Sanwal Associate Professor Mathematics College of William & Mary Williamsburg, VA 23185	49	Flight Dynamics & Control Div.	N. Orlando
Dr. Gregory V. Selby Assistant Professor Mechanical Engr. & Mech. Old Dominion Univ. Norfolk, VA 23508	35	National Transonic Facility Project Office	R. Hall
Dr. Y. Janet Shiu Assistant Professor Computer Science Old Dominion Univ. Norfolk, VA 23508	35	Analysis & Computation Div.	W. Kahlbaum

<u>FELLOW</u>	<u>AGE</u>	<u>ASSIGNED TO</u>	<u>RESEARCH ASSOC.</u>
Dr. Joan E. Sprigle Adjunct Professor School of Education College of William & Mary Williamsburg, VA 23185	51	Office of Director	E. Prior
Mr. John J. Stith Assistant Professor Physics Virginia State Univ. Petersburg, VA 23803	39	Space Systems Div.	J. Wilson
Dr. Michael H. Theil Professor Textile Chemicals N C State Univ. Raleigh, NC 27695	50	Materials Div.	N. Johnston
Dr. Ronald M. Welch Associate Professor Geophysical Sciences S. Dakota Sch. of Mines Rapid City, SD 57701	40	Atmospheric Sciences Div.	B. Wielicki
Dr. Donald A. Whitney Associate Professor Physics & Engineering Hampton Institute Hampton, VA 23668	37	Instrument Research Div.	J. Hoppe
Dr. David C. Wilson Associate Professor Mathematics Univ. of Florida Gainesville, FL 32611	41	Analysis & Computation Div.	R. Smith
Dr. Dennis E. Wilson Assistant Professor Mechanical Engr. Univ. of Texas at Austin Austin, TX 78712	36	National Transonic Facility Project Office	D. Barnwell
Dr. Charlie L. Yates Professor & Coordinator Physics & Engr. Hampton Institute Hampton, VA 23668	48	National Transonic Facility Project Office	D. Barnwell

PROGRAM EVALUATION SUMMARY

Program evaluation forms were sent to 45 research fellows. Thirty-four responses were received (a 75.55 percent return).

Seventy percent of the returns (Yes 24 - No 9 - N/A 1) indicated that the ASEE/NASA program was widely known in the academic community and at their institution. The fellows indicated that they were able to obtain sufficient information about the program.

All of the respondents indicated an early contact with the research associate and stated it to be of great value in preparing them for the 10 week period.

Twenty-eight (82.35 percent) stated they participated in the selection of their research topics. This was stated to be quite beneficial especially towards generating enthusiasm for the summer project.

One hundred percent of the returns indicated satisfaction with their research topics. There was statement that some compromise had been made and a request for more applied work.

The research fellows (97 percent) generally agreed that the research associates were helpful and supportive.

Sixty-eight percent of the returns stated they will continue research on the summer research project after returning to the home institution. Seven persons (21 percent) answered no and three persons (9 percent) were undecided.

Reasons for not continuing were:

- .Heavy teaching load
- .Facilities not available at home institution
- .Topic and research concluded
- .Program officially ended

Twenty-five fellows (73.5 percent) intend to submit an unsolicited proposal for a research grant.

When asked of the LaRC summer experience would benefit their students the response was an overwhelming yes (97.0 percent). The single negative answer was because the person was not returning to the university this year.

Thirty-two of the thirty-four responses were very supportive of the lecture series. The responses ranged from moderate to outstanding with some requests for more speakers. It is understood that it is difficult to choose speakers and topics that would be of interest to all of the fellows. The lectures were well attended and usually generated some discussion during the question and answer period.

Eighty-two percent of the respondents considered the stipend to be adequate, especially if it is tax exempt. There were suggestions for an additional weekly living allowance, inexpensive housing and a stated policy on reimbursement for travel expenses to include hotel and meal costs while traveling.

There was 100 percent agreement that the ASEE director and staff were very helpful and that all minor and major questions were answered.

The respondents also agreed that the University Affairs Officer and LaRC staff were very responsive to their needs.

Success of and interest in the summer program can be determined to some degree by the desire of the first year fellow to return for a second summer. A majority of those responding indicated their plan to apply for the second year. The program is considered to be an important step in their career development and an opportunity to become involved in research.

The research fellows cited the following benefits from the program: (1) career development and enhancement of professional abilities, (2) contact with professionals in a chosen area of research, (3) introduction to new areas of research, (4) development of new research techniques, and (5) developing relationships between NASA and the University.

While many of the research fellows would like to see more social contact with other fellows, more seminars and more lectures, the research associates seemed to favor a 90 percent commitment to research and 10 percent for outside activities.

In addition to the usual summer evaluation the ASEE-NASA Langley Program was visited by an evaluation team from ASEE. This is the first visit of this type in 10 years. The team arrived on Sunday 15 July and the visit took place on 16 and 17 July.

While on site the visitors participated in the following:

- .Overview of LaRC and the ASEE/NASA 1984 Summer Program
- .Visit to ASEE Directors Office
- .Interviews with individual Faculty Fellows
- .Interviews with Research Associates
- .Exit Briefing

The visiting team members were:

Dr. Eddie Hildreth
Professor and Director
Division of Technology
Southern University
Baton Rouge, LA 70813

Mr. Ernest R. Brown
Senior Recruiting Consultant
Lendman Associates
Knoxville, Tennessee 37917

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

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

The overall quality of the participants continues to be excellent and response from the research associate on the quality of the individuals and on the work produced was positive.

Early contact with the research associate was considered to be essential. This contact was instrumental in achieving an early understanding of the research project.

Participation by the research fellows in the selection of the research topic is also considered to be important.

The stipend and travel allowance were both considered to be adequate especially when considering the benefits associated with this program.

Only 70 percent of the fellows indicated that the ASEE-NASA Summer Program is well known in their academic community. In addition, a large number of the fellows learned of the program through their colleagues and not from the program announcements.

Recommendations

The following recommendations were given by the fellows.

Funds should be available for a pre-program visit to meet with the research associate. This visit can also be used to find housing.

The summer fellow should be included in the decision regarding the choice of a research topic.

The opening session should be utilized to give a further orientation to the LaRC facilities, especially on programs and ongoing research. The overview by the chief scientist could be given at this meeting.

Ten weeks is considered a very short time to conduct research. Extend the program to 12 or 14 weeks.

Develop a policy on travel expenses to include motel and meals for those who must drive a long distance.

More assistance on finding housing. Arrange for use of dormitory space at Hampton Institute. Arrange for more social activities so the fellows can mix and get to know each other.

Develop a definitive statement on the income tax situation so the summer fellow can have some idea of whether the stipend is deductible or not.

Ask some member of the university faculty to take on the responsibility of advertising the ASEE Summer Program. This should result in increased applications.

Get permission for ASEE Fellows to continue working after regular work hours.

Arrange for night operating hours for the library.

Small group colloquia for ASEE Fellows with similar research interests.

RESEARCH ABSTRACTS



STABILIZATION OF THE THERMAL EMF CHARACTERISTICS OF THE Ir-Rh THERMOCOUPLE
TEMPERATURE SENSOR IN THE RANGE OF 200 TO 3800°F

by

Shaffiq Ahmed

Professor
Department of Chemical and Metallurgical Engineering
Youngstown State University
Youngstown, Ohio

NASA presently needs a thermocouple temperature sensor with a stable thermal EMF in the above range for its use in many high temperature applications in an oxidizing atmosphere - e.g., 8 ft High Temperature Structures Tunnel, supersonic air breathing engine systems. Obviously no such material exists today. The IRD Thermal Instrumentation Section (Mr. E. F. Germain and S. F. Edwards under the direction of Mr. A. G. Kantsios) devoted a considerable amount of effort and investigated many materials. The most promising one appears to be Ir-(Ir 40 Rh) thermocouple. However, this material presented many problems - the high degree of brittleness, the low ductility, the unpredictability of the thermal EMF and questionable emissivity ("black smoke" and "bright spots").

The first phase of this summer's research was directed to define the problem by analyzing the past experiences and results and also its experimental studies (i.e., macroscopic, metallographic x-ray studies) conducted this summer on the old samples: the as-received and one from service conditions. It was concluded that all problems are related to the metallurgical internal structure. It is this structure that dictates the thermal EMF and other characteristics of the material. The basic consideration implies that the internal structure determines the Seebeck coefficient which, in turn, is directly responsible for the thermal EMF at a given temperature. The internal structure includes the chemical and physical characteristics of the grains and the grain-boundary, the internal stress system, the chemical homogeneity, the segregations and others.

The second phase of the effort is to obtain some scientific and metallurgical data on this alloy, simply because none exists in literature. The areas of investigations will include the macroscopic, the metallographic, the resistivity and the x-ray studies. There will be also some annealing studies to describe the structural characteristics.

The third phase consists of defining an annealing process to obtain the internal structure that will give us a stable thermal EMF characteristic. A considerable amount of effort has been devoted to these aspects. The first and second phase has been completed. A careful analysis of the results will establish the annealing process and the material characteristics. All results indicate success. A final report will be presented after the work is completed.



BIOGENIC PRODUCTION OF NITRIC OXIDE AND NITROUS OXIDE
UNDER LABORATORY AND FIELD CONDITIONS

by

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Man's activities especially since the industrial revolution have had a strong impact on the chemistry of the Earth's atmosphere. In order to assess the magnitude of this impact it is necessary first to take into account the contributions of nature with respect to emissions of chemically reactive substances into the atmosphere. Nitric oxide (NO) and nitrous oxide (N₂O) are particularly important trace constituents of the atmosphere. NO regulates concentrations of ozone in the troposphere and stratosphere. Tropospheric ozone increases at high NO concentrations, while stratospheric ozone is depleted. In the troposphere N₂O, which is stable, behaves as a greenhouse gas. In addition, N₂O may ascend to the stratosphere where it can initiate a series of photochemical reactions which result in destruction of ozone, thereby allowing increased penetration of biologically lethal ultraviolet light to the Earth's surface. NASA presently has a photochemical model, which can be used to predict long term changes in the chemistry of the troposphere. In order for such a model to be effective, it requires reasonably accurate input data on source strengths of chemically reactive species. Primary sources of nitric oxide include biomass burning, industry, lightning, biogenic activity, and ammonia oxidation. One of the most uncertain of these sources is biogenic activity. The project described in this report was an attempt to assess the importance of soil as a source of both nitric and nitrous oxides. Studies were performed both in the laboratory and under field conditions.

In the soil production of nitric and nitrous oxides is performed by nitrifying and denitrifying bacteria. Nitrification, a biochemical process, which occurs aerobically, involves oxidation of ammonium ion through intermediates including NO and N₂O to nitrite or nitrate ion. During denitrification, an anaerobic process, nitrite or nitrate ions are reduced through NO and N₂O to molecular nitrogen. In our laboratory study six types of bacteria were grown under controlled conditions in either a batch culture device or in a chemostat. Variables included oxygen partial pressure (pO₂), temperature, substrate concentration, and concentrations of various products. Of the six bacteria studied Nitrosomonas europaea and Pseudomonas fluorescens produced far more NO and/or N₂O than did any of the others. Nitrosomonas europaea, a nitrifier, proved to be tolerant of a wide variety of oxygen partial pressures. It produced both NO and N₂O at pO₂'s varying from 0.5 to 10 percent. Its production of NO in parts per billion volume per cell exceeded by at least

an order of magnitude that of any of the other organisms tested. The ratio of nitric oxide to nitrous oxide emitted under all partial pressures of oxygen was greater than two. Pseudomonas fluorescens, a denitrifier, produced primarily N_2O . The ratio of nitric to nitrous oxide produced was 0.01 ± 0.002 . Pseudomonas emitted more N_2O per cell than did any other bacterium tested, but this production was very sensitive to pO_2 . At pO_2 's greater than 2 percent neither NO nor N_2O was observed.

As a result of our laboratory studies, we predicted that biogenic production of nitric and nitrous oxides should vary as a function of percent moisture in soil. In aerobic soils we expect to see higher fluxes of NO than of N_2O . In flooded soils, where conditions rapidly become anaerobic, the flux of N_2O should exceed that of NO. In order to test these predictions we have performed a series of field measurements. Soil sites were chosen with the help of the Soil Conservation Service (U.S. Department of Agriculture). The experimental sites included a farm in Jamestown, within which we chose subplots in a corn field, fertilized one day prior to start of the study, in a soy field, fertilized 3 months prior to start of tests, and in an unfertilized area. Other sites were located in a freshwater marsh on Jamestown Island and in a hardwood forest behind Big Bethel reservoir in Hampton. Collars were inserted 1 inch into the soil at each site and were left in place for the duration of the study. Flux chambers were set into a v-shaped groove at the top of the collar. Water in the groove provided a seal. Care was taken to insure that no pressure differential developed while performing flux measurements. During a 15 minute period air from the box was pumped at 500 ml per minute into a chemiluminescence detector for determination of NO. Gas sampling bottles in a recirculating loop were returned to the laboratory for analysis of N_2O using a gas chromatograph with electron capture detector. Results of field measurements have thus far supported our predictions based upon laboratory studies. NO fluxes measured in the cornfield 1 week after fertilization averaged $91 \text{ ng(N)/m}^2\text{s}$. From week 2 to week 5 the flux leveled off and averaged $56 - 11 \text{ ng(N)/m}^2\text{s}$. At week 5 the flux dropped off sharply to a value averaging $20 \text{ ng(N)/m}^2\text{s}$. We suspect that the decrease in flux observed in the cornfield resulted either from maturation of the corn, causing fertilizer to become limiting or from increased soil moisture. Flux measurements in the soy field were initiated 1 week after soy was planted. Measurements over 3 weeks averaged $6 \pm 2 \text{ ng(N)/m}^2\text{s}$. The unfertilized site served as a control. As expected fluxes were low, averaging $4 \pm 2 \text{ ng(N)/m}^2\text{s}$. At the marsh and woodland sites no fluxes of NO were observed. Since the marsh site was flooded during all flux measurements, and since the woodland site was also very moist, these results suggest that soils with high percent moisture do not produce NO. On the other hand, preliminary results indicate that flooded soils do emit N_2O .

Recently a diurnal study was performed over a 19 hour period in the two subplots within the cornfield. Initially both subplots showed strong fluxes. Rain intervened over a 3 hour period. During this period one of the subplots was protected from rainfall; the second was not. Results indicated that the

NO flux disappeared in the wetted soil, while N₂O production increased. In the plot protected from rain, emission of NO was directly proportional to the soil temperature.

Our field studies thus far support predictions based on laboratory observations. These field measurements suggest that: (1) fertilizer is an important source of both NO and N₂O; (2) NO and N₂O fluxes are proportional to soil temperature; (3) NO is produced primarily by nitrification in aerobic soils; and (4) N₂O is formed mainly by denitrification in anaerobic soils.



A NUMERICAL STUDY OF THE INTERACTION OF A SHOCK WAVE
AND A TURBULENT BOUNDARY LAYER

by

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The purpose of my research was to make a numerical study of a shock-wave/boundary-layer interaction experiment performed in 1960 by J. Seddon. This was done employing an Euler code in the inviscid region (essentially all that portion of the flow field above the displacement thickness curve), and an inverse integral boundary layer code in the region next to the wall. The ultimate objective is to patch together the two analysis methods to obtain the entire interacting solution for the problem.

Probably one of the most important tasks to be done was to stipulate properly the boundary conditions on the computational domain. The computational domain selected was a grid which measured $18.75\delta_u$ vertically and $40\delta_u$ horizontally where δ_u represents the undisturbed boundary layer thickness upstream of the interaction. A normal shock wave was located at a distance of $15\delta_u$ from the left boundary and impinged on a turbulent boundary layer. The boundary conditions along the inflow boundary, the supersonic free stream, and the wall were treated in a straightforward manner. Boundary conditions along the subsonic free-stream boundary and the outflow boundary had to be developed.

The outflow condition was specified by prescribing either the pressure or the density at the exit based on the pressure or the density derived from classical, one-dimensional, isentropic and shock relations. All other parameters at the exit were then extrapolated. The subsonic free-stream boundary conditions were derived in two ways. First, the standard Rankine-Hugoniot expressions were used to determine the jump properties across the shock wave, and then at each subsequent station downstream new values of pressure, density, etc. were computed based on the area contraction due to the growth of the displacement thickness. This method was suggested by Shea in an earlier study where he concluded that this area contraction was a significant factor. The second method of specifying the subsonic free-stream boundary conditions was to use the Rankine-Hugoniot relations at the shock, and then to employ boundary symmetry conditions thereafter downstream.

Some important conclusions can be drawn at this point regarding boundary conditions. Although both methods for specifying the subsonic free-stream boundary conditions worked, the second method is preferred since the first method proved quite sensitive to displacement thickness variations, which can also be noted in the previous results of Shea. A second point worth noting is

that the Euler solutions were essentially independent of whether the outflow is based on a pressure-fixed or a density-fixed outflow boundary condition.

Another important task was that of grid generation. Two different grids were generated. One was rather coarse and one was fine. The coarse grid contained 31 columns and 16 rows while the fine grid contained 61 columns and 31 rows. The columns were clustered about the shock wave and their size grew as distance from the shock wave increased. The rows were of two sizes. From a vertical distance of $10\delta_u$ down to the bottom of the grid the size was half as large as the size of the rows above the $10\delta_u$ point. Thus, additional grid points were located close to the shock wave and in and near the boundary layer region where the gradients are quite large. Computations were initially done on the coarse grid to save time and money and then switched to the fine grid, once computations were running smoothly. Also, by changing to the fine grid much more detail was realized. Accuracy was greatly enhanced, particularly in the vicinity of the shock wave. Just after the shock, solutions from the fine grid predicted a slight expansion followed by a compression which was not noticeable in the coarse grid solution.

After successfully running the Euler code with Seddon's data in the inviscid region, the inverse boundary layer dissipation code was applied to the viscous region. The inverse boundary layer code predicts quite accurately the presence and proper location of a separated region within the boundary layer. However, pressure ratio comparisons at the interface of the two solutions are quite different. The Euler code contains an expansion and compression downstream of the shock not present in the inverse boundary layer computations or the experimental data of Seddon. Shea's pressure ratio curves, based on a Navier-Stokes solution to the same experiment, also show no such expansion. There are possibly two reasons for the expansion present with the Euler code. First, I am assuming the pressure to be constant throughout the boundary layer which is not entirely accurate. Secondly, the pressure measurements of Seddon may be somewhat inaccurate due to equipment available at the time and due to the separated region which is present. In addition, I believe that by running the two codes interactively the expansion will smooth out. In comparing Shea's Navier-Stokes solution to my Euler and inverse boundary layer solutions, one can see from the figure below that the Mach contours both look quite similar since they both exhibit a supersonic tongue (described by Seddon) near the edge of the boundary layer.

In order to investigate the discrepancies noted above more closely, additional systematic data from a 1982 report by the Royal Aircraft Establishment was used for further Euler and inverse boundary layer computation. These data are believed to be somewhat more accurate than Seddon's because laser velocimeters were used to obtain it. Thus far, only the case of Mach number equaling 1.27 has been tried. The results of this run agree almost identically between the inverse boundary layer code and the experimental data; while the Euler code still contains a slight expansion, although not nearly as large as before.

By investigating further the Royal Aircraft Establishment data, perhaps better results can be achieved as Mach numbers increase up to 1.5. Also, by realizing the final goal of patching the two analysis methods together and obtaining an interacting solution, it is likely that the discrepancies noted can be resolved.

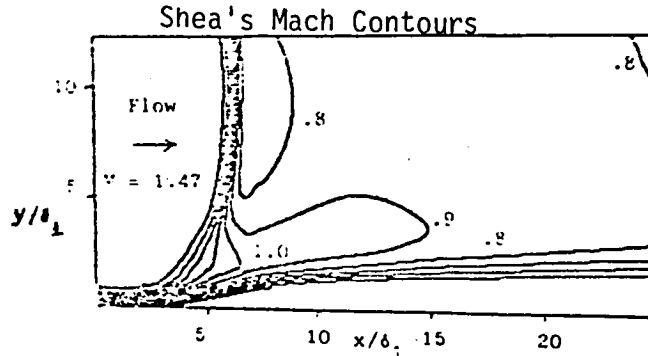
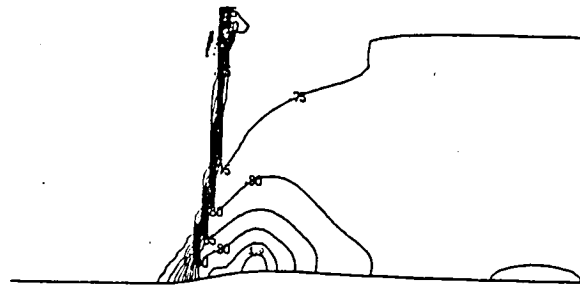


Figure 5A. Contours of constant Mach number (.5 to 1.5 in .1 increments) over the computational grid area for computation A

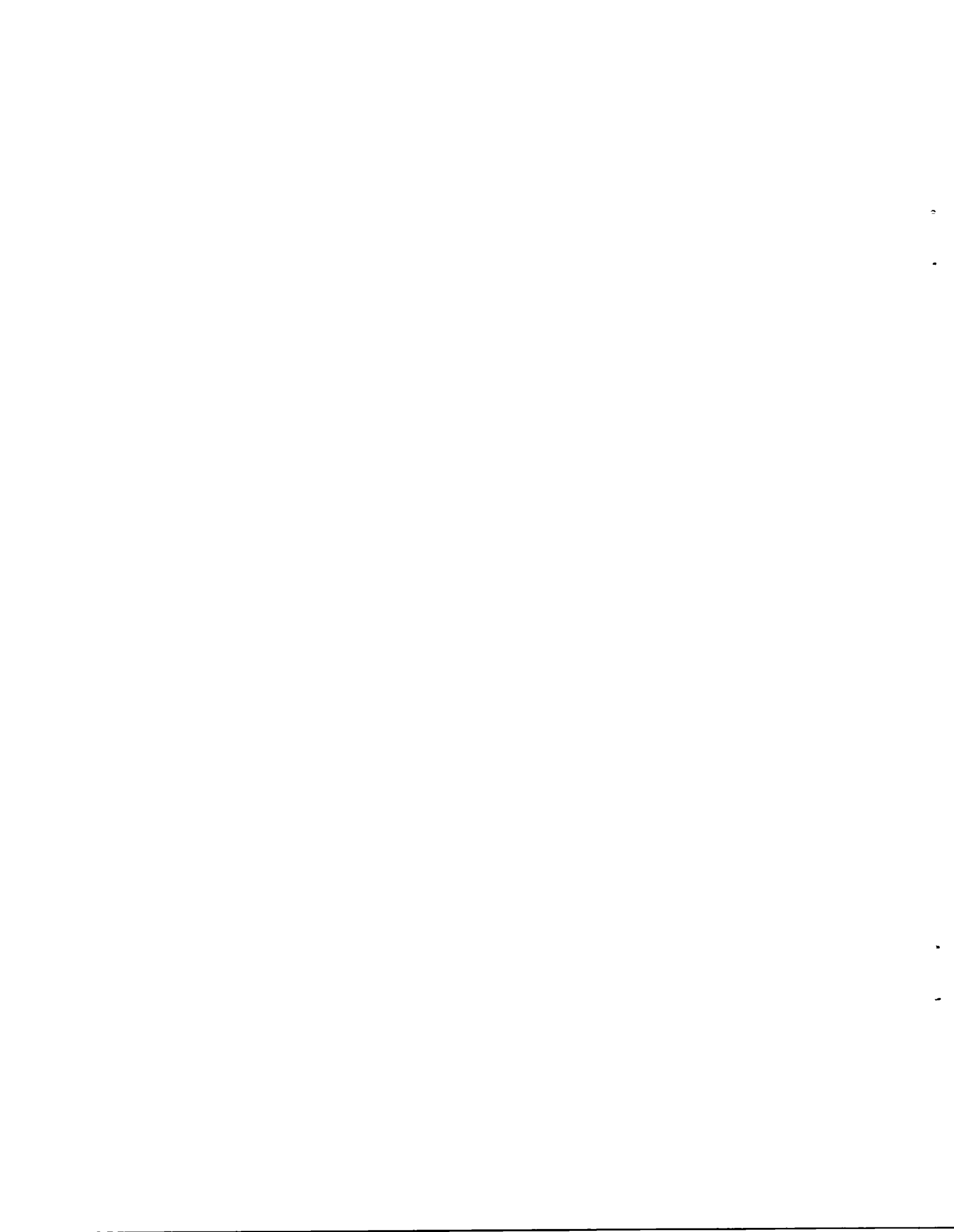
Euler Code Mach Contours



MACH CONTOURS MIN VALUE = .6922 MAX = 1.4711
 NEW BUMP IN A CHANNEL T/H=0.000 M=1.470 60X32
 61 X 33 GRID M = 1.470 ALPHA = 0.000 CD, CL = .08034 -38.271

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SUMMARY OF SUMMER WORK EXPERIENCE IN THE
FINANCIAL MANAGEMENT DIVISION
NASA-LANGLEY RESEARCH CENTER

by

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As a faculty fellow assigned to the Financial Management Division (FMD) of NASA-Langley Research Center (LaRC), I was given the following three assignments:

1. To obtain an understanding of Governmental Accounting and the practices and procedures of FMD, in particular.
2. To assist in a cost-benefit analysis of an automated time and attendance system proposed by FMD at NASA-LaRC.
3. To complete a study which compares the first pay period in May 1984, with the first pay periods in May 1983, 1982, and 1981. This study gives FMD information on how NASA-LaRC is maintaining its time and attendance records, as well as, trends in leave use, tardies, first-forty shifts, etc.

During my first week at NASA, I was briefed on the responsibilities and practices of the two branches and six sections of FMD (Fig. A). I spent my second and third weeks completing financial assignments in the Fund Accounting, Cost Accounting, and Payroll Sections of FMD.

Three weeks into the program, I developed and distributed a questionnaire designed to determine the procedures being followed by the Time and Attendance Clerks at NASA-LaRC. The questionnaire was also designed to determine the average time and average cost of preparing time and attendance data per pay period (bi-weekly).

One hundred and ninety questionnaires were distributed and one hundred and seventy-seven (93 percent) were returned. At present, I am still in the process of completing my analysis of the data; however, I have determined that the average time needed to complete the T&A procedures at NASA-LaRC is 2 hours and that the average cost of completing T&A procedures is \$15.58 per pay period (bi-weekly). The average time and cost of completing cost time cards is 0.6 hour and \$4.67, respectively, and the estimated total cost of completing T&A and Cost Time Cards each pay period is \$3,584.25.

My third assignment, which involved a study of the first pay period in May, showed no significant changes in trends with the exception of decreases in Irregular and Other Shift Change Categories which were offset, in part, by increases in First-Forty and Shift Change by Memo Categories. Also, Compensatory Leave increased by 56.23 percent (Fig. B).

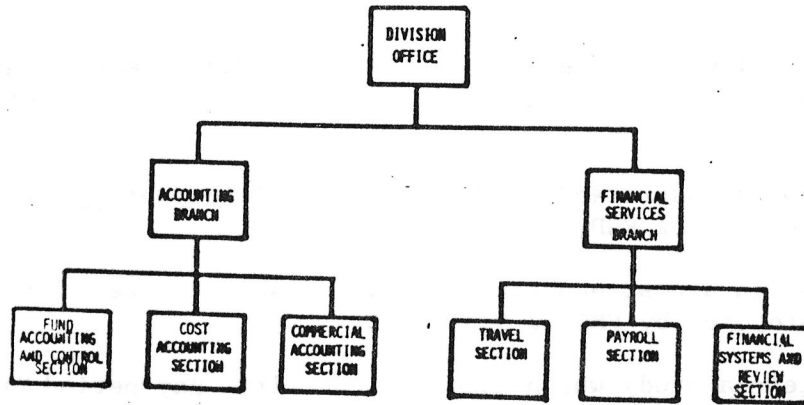


Figure A.- Financial Management Division.

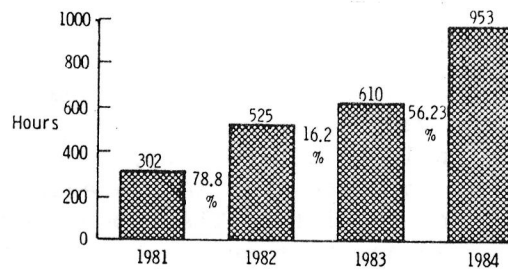


Figure B.- Compensatory leave - first pay period in May.

SODIUM VAPOR CANDIDATE FOR A SOLAR POWERED LASER

by

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The relative figure of merit for an orbiting laser system is the cost per delivered megawatt. Thus, weight will have as great an impact on cost effectiveness as laser efficiency. Comparisons indicate that a directly solar pumped laser with about 1 percent overall efficiency can compete with an indirectly solar pumped laser with an overall efficiency of 10 percent. Most of the weight in the closed cycle laser systems presently under consideration is the thermal radiators and other waste heat management equipment. Maximum output of alkali solar laser will occur at about 900 K--hot enough so that heavy heat elimination equipment is not necessary. A large number of alkali dimer laser lines have been achieved by pumping with argon and krypton ion lasers (refs. 1, 2, and 3). However, there has not appeared any reference to an alkali dimer laser having been pumped by a broadband excitation source, but broadband pumping of a laser is possible in this low threshold, high gain media.

The object of this summer's research was to investigate the fluorescence spectra of sodium vapor using a broadband excitation source. These investigations were conducted using a PEK model 401A 75-watt xenon and a 100-watt mercury flashlamp as the broadband source. The fluorescence spectra were recorded on a Honeywell Electronik 19 stripchart recorder using an RCA 7265 photomultiplier tube at the exit slit of a McPherson 0.5 meter spectrometer.

Initially, fluorescence spectra of the B-X transition of the sodium dimer and the 3P-3S transition of atomic sodium were obtained at selected temperatures from 675 to 890 K to determine the self-absorption properties of the sodium vapor. In addition to observing the B-X transition of the sodium dimer at all temperatures in this range the A-X transition was observed for temperatures from 790 to 890 K. However, ultraviolet bands at 430 and 450 nm⁴ were not observed.

Investigations of the effects of the trapped radiation (D-line of the atomic sodium and B-band of the sodium dimer) were conducted at 825 K by filtering the broadband source using narrow band filters. The experimental results indicate that the following interactions, $\text{Na}^* + \text{Na}_2 \rightarrow \text{Na} + \text{Na}^*_2$ and $\text{Na} + \text{Na}^*_2 \rightarrow \text{Na}^* + \text{Na}_2$ are occurring in the sodium vapor. Additional experiments will be necessary to determine the actual mechanisms involved in these energy transfer processes. Future experiments should include the effects of buffer gases, higher temperatures, and most definitely a more intense broadband source on the fluorescence spectra of sodium vapor.

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STATISTICAL ANALYSIS
OF
UNIVERSITY AWARDS 1979 - 1984
NASA LANGLEY RESEARCH CENTER

by

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INTRODUCTION

Under the auspices of the Center Director and the Chief Scientist, the Office of University Affairs is the major focal point for university personnel contact with Langley Research Center. As such, one of the primary functions of this office is to collect data and maintain statistical information relative to NASA-LaRC funded University Awards. The information provided by this office is used in monitoring current awards, management information and planning.

This project involved the development of a historical data base system which will facilitate the extraction and summarization of statistical information using the IBM PC-XT as the hardware support system.

PURPOSE

Although NASA Headquarters provides summarized listings of university awards by centers and various other categories from the NASA University Program Management Information System, this information is of limited statistical usefulness in its present form. Therefore, the specific purpose of this project was to develop a format for present and anticipated future data collection with emphasis on collection, tabulation, manipulation, analyzation and extraction of information, i.e., awards by institution, directorate, division, principal investigator, technical monitor, funding source, etc. - refer to chart 1 for a complete listing.

PROCEDURE

This project involved:

1. The identification of key variables and development of a data element matrix (chart 1).
2. Collection of historical data from NASA Headquarters Management Information System Listings and other primary and secondary sources.

3. Data entry - approximately 30,000 data elements were entered into the IBM PC-XT.
4. Statistical analysis and presentation
 - a. Listings and computations
 - b. Charts and graphs

SUMMARY

The main goals of this study are twofold: (1) development and creation of a computerized, management information system using historical data (1979 - 1983); (2) Statistical analysis of data and illustrations - graphs/charts. TIM (Total Information Management), a relational data base system was used in this project. Consequently, the data summarization and manipulation is limited only by the fields listed in the data element matrix.

The Office of University Affairs has immediate access to all of the information in the data base which should greatly enhance its ability to provide an array of statistical information.

NASA LARC UNIVERSITY AFFAIRS

Statistical Information System Data Element Matrix

	C\$ Grants		Cooperative Agreements		Contracts		Space Act Agreements		Purchase Orders		Totals	
	C\$	S\$	C\$	S\$	C\$	S\$	C\$	S\$	C\$	S\$	C\$	S\$
University Name	○	○	○	○	○	○	○	○	○	○	○	○
Spons Directorate	○	○	○	○	○	○	○	○	○	○	○	○
Proposal ID #												
Agreement #	○	○	○	○	○	○	○	○	○	○	○	○
Main Objective												
Field Sci/Eng	○	○	○	○	○	○	○	○	○	○	○	○
Number of mods												
Orig Amt (\$)												
Cum Amt (\$)	○	○	○	○	○	○	○	○	○	○	○	○
FY Oblig (\$)	○	○	○	○	○	○	○	○	○	○	○	○
Cost Share %(\$)												
Title												
Start Date												
End Date												
Mod End Date												
# Grad Students												
Prin Inves (PI)	○	○	○	○	○	○	○	○	○	○	○	○
2nd PI												
3rd PI												
NASA Officer 1												
Directorate	○	○	○	○	○	○	○	○	○	○	○	○
Division	○	○	○	○	○	○	○	○	○	○	○	○
HQ Code												
NASA Officer 2												
Directorate												
Division												
HQ Code												
Special Program	○	○	○	○	○	○	○	○	○	○	○	○
Special Data												
Pub/Pri Univ												
Univ Department												
City												
Street												
State	○	○	○	○	○	○	○	○	○	○	○	○
Zip Code												
Area Code, Phone												

C\$ - current FY obligations 1,000's

S\$ - cumulative obligations 1,000's



KINEMATIC AND KINETIC ANALYSIS OF THE DEPLOYMENT OF THE BOX TRUSS ANTENNA

by

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The space shuttle will carry large space antennas into the atmosphere and deploy them. It will leave them there to be selfsustaining.

The large space antennas will be several hundred feet in width. Each will carry its own power source, electronics, sensors, thruster motors, and telemetry. They will receive radio-frequency signals from the Earth on a massive antenna-dish that will digest information from these signals and will transmit signals back to Earth.

This project involves the deployment of one of these antennas, "The Box Truss Antenna." It has an elliptical dish approximately 60 x 120 meters, and an attached rectangular mast which is approximately 30 x 135 meters. It deploys in 22 stages.

In this project, we are primarily concerned with the accelerations, velocities, displacements, and torque and force values, with respect to time, that develop as the antenna opens up.

Phase 1 of this project involved setting up a coordinate system of 349 point locations. These were the key juncture and location points in the antenna system. All points were identified and programmed into the computer.

Phase 2 summarized all the subsystems that had regardable mass and broke them into 69 concentrated masses. Each mass was located on the coordinate system of phase 1, and programmed into the computer. Each of the 69 masses could now be located at any of the 22 stages of deployment.

Phase 3 summarized all the structural components in the system that had regardable mass and broke them into 891 concentrated masses. Each mass was located on the coordinate system of phase 1, and programmed into the computer. Each of the 891 masses could now be located at any of the 22 stages of deployment.

In phase 4, the weights of all 960 subsystems and structural components were calculated and tabulated. Each weight was located on the coordinate system of phase 1, and programmed into the computer. Each of the 960 masses could now be located at any of the 22 stages of deployment. Where two or more weights were located at the same place, they were combined.

Phase 5 established the relationship between Actuation Torque and Angular Displacement of the mechanism that creates the torque. Indirectly, this was the first step in setting up the relationship between actuation torque, acceleration, velocity, and displacement, with respect to time, for the entire antenna.

In phase 6, a method was analytically determined, whereby the actuation torque, acceleration, velocity, and displacement could each be determined with respect to time, whenever a nonlinear actuating torque was applied.

By means of the principle of dynamic equilibrium, the relationship between acceleration and torque was derived to be:

$$\alpha = \phi'' = \frac{T}{L^2} \left(\frac{1}{m_1 + 0.83m_3} + \frac{1}{m_2 + 0.83m_3} \right) \quad (1)$$

From basic principles of kinematics, the relationship between displacement and velocity is:

$$\omega = \phi' = \frac{d\phi}{dt} \quad (2)$$

From basic principles of kinematics, the relationship between acceleration and velocity is:

$$\alpha = \phi'' = \frac{d\omega}{dt} \quad (3)$$

From equations (1), (2), and (3), and the displacement-torque relationship given by the curve of phase 5, we now had a full relationship between all five parameters at any time. From displacement, we could find torque. From torque, we could find acceleration. From acceleration, we could find velocity. From velocity, we could find the next value of displacement, etc. Thus, once the initial starting value of torque, velocity, and displacement were established (the latter two were 0), an endless chart could be tabulated relating the five key parameters.

Phase 7 then took the results of phase 6 (which were for one of the 22 deployment stages), and applied similar equations and principles to all 22 stages. All of this was then programmed into the computer.

The computer can thus respond with the values of actuation torque, acceleration, velocity, displacement or time, when any of the other four parameters is designated as an input. It can tabulate and printout any combination of the five parameters over a given time period or stage sequence. It can determine maximum values of any of the five key parameters. It can display the structure graphically, showing locations of all components. It can display graphically a plot of any two parameters plotted against each other.

ANALYSIS AND DOCUMENTATION OF BUDGET DATA/INFORMATION PROCESSES:
LANGLEY RESEARCH CENTER
PROGRAMS AND RESOURCES DIVISION

by

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INTRODUCTION

This project involved a study of the budget data/information system which allows NASA Langley Research Center, Programs and Resources Division, to collect data to develop a budget planning system computer data base describing the research programs conducted by LaRC. The reports generated from this system are used to plan for, obtain funding for, and monitor the progress of research programs at the Center.

This study was a procedures analysis beginning with the source documents and continuing through computer data base creation, update, maintenance, and use.

PURPOSE

The purpose of this project was to document the procedures used, evaluate those procedures, and make appropriate recommendations for change. The study included the activities related to the above process of two organizations in PRD--the Research & Development Programs Branch (R&DPB) and the Information Systems Support Office (ISSO), plus how those activities require some data generated by the Institutional Programs Branch (IPB) and the Project Support Branch (PSB).

PROCEDURE

The analysis was made by conducting personal interviews with all employees in ISSO, R&DPB, and IPB, and with the head of PSB; observing ISSO and R&DPB activities; collecting and evaluating existing documentation; and researching literature related to documentation of procedures and computer programs.

Data were collected in the following areas: (1) methods of processing paper documents representing funding requests and approvals for station funds, reimbursables, and suballotments; (2) procedures for creating the planning system data base from funding documents; (3) procedures for data base maintenance; (4) procedures for generating planning system management reports at all levels; i.e., Branch, Division, Center, and Headquarters; and (5) procedures for generating management reports for PRD from the Resources Management System maintained by the Business Data Systems Division.

The activities of PRD analysts and ISSO personnel were included. Documents generated and reports used by the entire Center are involved in the process. However, the focus of this study was the activities which occur in PRD. Additionally, PRD has many responsibilities beyond the procedures studied.

SUMMARY OF ANALYSIS

In PRD, ISSO is a staff organization designed to support the entire division in their efforts to collect, organize, and maintain data, and use information to support managing the funds request, receipt, and expenditure process.

Research project funding is based on the planning and budgeting process in the preceding year. Funding reaches LaRC in three ways: (1) station funds which are appropriations to LaRC, (2) suballotments which are funds from other NASA Centers, and (3) reimbursables which are funds from other government and non-government agencies.

PRD involvement actually begins with the budgeting process which results in a Program Status Report showing Research and Technology Objectives and Plans (RTOP's). This report illustrates for what research projects the Center is requesting funding. Spending authority comes from Headquarters through Form 506, Resources Authority Warrant, in its several versions. As RTOP's are approved and subdivided into RTR's (specific research work plans), PRD analysts determine the portion of each which will be allotted to program support, a portion of research and development funding used for computer and other support costs. These data are recorded on the 506 form and records are added to the planning system data file. As funds are expended through a purchase request/purchase order and job order process, mostly handled by the researcher and the Financial Management Division (FMD), monthly updates of actual commitments, obligations, and costs are moved into the planning system. Regular reports are generated to provide information to: (1) PRD analysts to monitor contract progress so funds will be committed, obligated, and expended within the planned time frames; and (2) PRD branch and division, Center management, and Headquarters for monitoring and analyzing program progress and future funding planning.

DOCUMENTATION

The major purpose of this project was to document the activities described above. This has been done with a combination of brief narrative and chart formats. Copies of the complete documentation are located in PRD. The specific objective of the project was to provide a document which would: (1) describe the process studied, (2) provide an up-to-date and updatable set of documentation, (3) provide a training document for newly hired PRD personnel, and (4) provide an information vehicle to Center personnel outside PRD.

DEVELOPMENT OF AN EFFUSIVE INLET FOR DIRECT INTRODUCTION
OF GASES INTO A MASS SPECTROMETER ION SOURCE

by

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In order to better understand and analyze the aerothermodynamic properties of the boundary layer on either a reentry vehicle or a low altitude tethered satellite, it is important to know the chemical composition of the gases in the boundary layer. It will then be possible to include the effect of surface induced reactions in the overall energy calculation for the gas flow. In addition reactions induced at the shock wave produced by the vehicle may be more accurately determined and incorporated into the overall energy balance.

The best experimental technique to completely characterize the chemical composition of the flow is by mass spectrometry. However, it is quite critical that any mass spectrometric analysis does not perturb the flow and be as non-invasive of the boundary layer as possible. Therefore the interface between the surface and the mass spectrometer becomes a critical design criteria. The interface which is the inlet to the mass spectrometer must then meet the following: (1) it must allow sufficient sample into the mass spectrometer for a successful analysis, (2) the flow through the inlet must not disturb the boundary layer, and (3) the material of construction for the inlet must be as noncatalytic as possible so that reaction products of the stream and the vehicle will be the only constituents detected. The present research is addressed towards providing information concerning points one and two above with the materials question being addressed elsewhere.

We have previously shown that if the radius of an opening in the surface is small enough (of the order of 10-20 microns) the flow through the opening will be molecular between altitudes of 55-125 km at the temperatures of the proposed flights. In addition, the distance from the surface that material will be removed, for the above sized opening, is of the order of nanometers. Such an opening will remove material from the knudsen layer, well within the boundary layer an essentially noninvasive removal. However, one opening of this size will not remove enough material for a successful mass spectrometric analysis. It is possible to assemble a large number of these openings in a surface to try to combine the ability to remain in free molecular flow with enhanced removal of material without perturbing the boundary layer. One such device is a multi-channel plate which has a surface density of holes of approximately 15,000 per square centimeter with a hole radius of 5 microns.

A laboratory apparatus was assembled which enabled the determination of the pressure drop across the plate at a particular applied pressure and measured

mass flow rate. In addition a quadrupole mass spectrometer was utilized to determine the effect of the plate upon the composition of the gas mixture under investigation. In all cases a mixture of carbon dioxide in air was used. The discharge coefficient C_D could then be determined:

$$C_D = \frac{\dot{m}}{\pi r^2} \frac{\sqrt{RT}}{P_1 \left[\gamma \left(\frac{2}{\gamma + 1} \right)^{\frac{\gamma+1}{\gamma-1}} \right]^{1/2}}$$

as well as the ratio of the measured mass flow \dot{m} to the mass flow calculated for free molecular flow \dot{m}_{fm} :

$$\dot{m}_{fm} = k \pi r^2 P_1 \left(1 - \frac{P_2}{P_1} \right) \sqrt{\frac{M}{2\pi RT}}$$

where P_2 is the downstream pressure and P_1 is the upstream pressure. The other variables in the equations are r = radius, M = molecular weight and T is the temperature.

With the determination of C_D it can be determined if choked flow will be attained at these pressure differentials. At this point in the experiment it would seem that the flow remains unchoked with the device sensing the environment. The ratio \dot{m}/\dot{m}_{fm} becomes nearly equal to one at pressures below 10 torr indicating the onset of molecular flow. At the temperature at the surface of the vehicles under consideration this pressure will become considerably higher.

At this point in the investigation it appears that the particular device has too high a mass flow to be considered for the application. However, it does appear that the individual holes influence the flow separately simplifying the problem of analysis and ensuring that the total number of holes will not significantly perturb the boundary layer any more than one hole. We are currently extending the experiments to a lower pressure regime and are beginning to examine temperature effects.

A LOADER FOR A DISTRIBUTED NETWORK

by

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My task for the summer fellowship period has been to implement the initial version of the system loader for the network operating system research project under the direction of Edwin C. Foudriat. The system design is described in detail in references 1 and 2. The language in which the system is being written is Path Pascal, a dialect of Pascal which supports concurrent execution and separate compilation. For the design of the loader, the host processor at a node is assumed to be a Motorola 68000 processor.

The primary responsibility of the loader is, when requested, to bring a specified code file into main memory from secondary storage, do what is required to initiate its execution, and perform whatever cleanup is needed when the execution of the code file is complete. An additional responsibility of a loader in a distributed environment is the communication necessary with other loaders at remote nodes. If a program at a node needs to use code located at a remote node, the local loader must check with the loader at the remote node to ensure that the desired code is in place. Viewing this transaction in reverse, the loader at node must also respond to this sort of inquiry from a loader at a remote node.

Each program on the system needs both code space, the space for the executable statement of the program, and data space, the space required for the program's process descriptor and activation record, its global variables, and its runtime stack. Multiple invocations of a program can be executing simultaneously. Each invocation of a program would be allotted separate data space, but all invocations would use the same code space.

Because the system is currently under development and the other parts of the system necessary to implement the full functionality of the loader as described in references 1 and 2 are not yet available, it was necessary to limit the initial version of the loader to handling programs stored on a floppy disk at the local node.

For each program to be loaded, the loader must:

1. Check the loader tables to see if the code for the program is already in memory.

2. If not, then the loader must locate the object file for the program on the floppy disk, allocate space for the code in memory, and bring the code into memory, modifying any absolute jump addresses in the code file. This address modification is necessary because the location that the code will occupy at runtime is not known when the object file is being linked.
3. Once the code has been located in memory, then the loader must allocate data space to this invocation of the program and initiate execution.
4. When this invocation of the program terminates, the loader frees the data space, and if this is the last active instantiation of the program, the loader also frees the code space.

The program structure of the loader consists of a short main program (642 bytes) supported by the following nine Path Pascal modules:

1. Global types (0 byte), used at compilation time to supply the constants and type declarations needed by modules 2 and 3 below.
2. Driver routines for the DSD880 floppy disk (2781 bytes).
3. File handling utilities (4626 bytes) for opening, closing, reading from, and writing to files on the floppy disk.
4. Procedure (1757 bytes) to write a message to the terminal based on the return type of a file operation.
5. Input/output drivers for communication between the loader and the display terminal (1407 bytes).
6. Procedures to manage allocation of main memory to processes that are being loaded (2807 bytes). The memory map is represented as a doubly linked list of memory blocks. This facilitates coalescing space that is freed when a process terminates with adjacent free space. The code space for a process is placed in high memory, and the data space is placed in low memory (64K is reserved at the bottom of memory for the loader and operating system).
7. Procedures for searching for, adding, and deleting tasks in the task table (1107 bytes). The task table is represented as a hash table with chained overflow.
8. String handling procedure for comparing filenames (332 bytes).
9. Top level procedures used by the loader to load a program into memory, initiate its execution, and remove it on termination (3807 bytes). These procedures use the previous seven modules extensively.

The first three modules were written by E. C. Foudriat and I wrote the rest. The loader is currently being tested and debugged, and should be completed by the end of the summer.

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A GENERAL, CRYOGENICALLY-BASED ANALYTICAL TECHNIQUE FOR THE DETERMINATION
OF TRACE QUANTITIES OF VOLATILE ORGANIC COMPOUNDS
IN THE ATMOSPHERE

by

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Techniques for the sampling and analysis of volatile organic compounds in the atmosphere have been reported for over a decade. Much of the work on identifying organic compounds has been narrowly defined in terms of the class or classes of compounds capable of being determined by a particular method. This is due not only to the complex matrix of compounds present in the atmosphere, but also to shortcomings in the analytical techniques being utilized. In addition, the amount of material being determined is frequently below the detection limit (typically 1 ppm - 1 ppb) of the analytical device, thus requiring a concentration step in the procedure. The end result of these factors is that an analytical protocol will frequently detect only a small fraction of the volatile organic compounds present in a particular sample.

Investigations of volatile organic compounds in the atmosphere have generally relied on concentration steps involving (a) absorption on a finely-divided surface, or (b) condensation on a cold surface. Adsorption techniques require a thermal desorption phase. This thermal desorption, combined with the nature of the porous polymer support itself, precludes the possibility of analyzing oxygenated, or thermally labile compounds. There have also been reports of serious artifact problems using adsorption techniques. Concentration on a cold surface will normally involve the use of liquid oxygen, liquid nitrogen, or dry ice/methanol as the cryogens. Of these, liquid nitrogen offers the coldest convenient temperature, but suffers from slight liquefaction of atmospheric oxygen during the concentration step. In addition, cryogenic trapping suffers from the need to remove water vapor prior to sample flow through the cold trap. Conventional desiccants are not practical, since compounds having high molecular weight or oxygenated functionality will be adsorbed by the desiccant.

The NASA/ASEE Summer Fellowship Program has allowed development of a technique for the analysis of trace volatile organic compounds in the atmosphere which utilizes a permaselective membrane (Dupont Nafion) for water removal, a low-pressure liquid nitrogen cryogenic trap in the concentration step, and flame ionization gas chromatography for the analysis. The system is capable of analyzing compounds as polar as alcohols at concentrations in the sub-ppbv range. The cryogenic trapping loop uses readily-available liquid nitrogen, but operates at reduced pressure, thus avoiding problems due to oxygen liquefaction.

In developing this system, our first efforts were directed toward optimizing the cold trap design for efficiency, peak sharpness, and speed. The final design utilizes a 12 x 1/16 in. section of stainless steel tubing for the cold trap, with sample flows of 25 mL/min. This loop generates a baseline peak width of less than 5 sec for methane under the analytical conditions currently in use, and collection efficiencies (based on area counts for untrapped high-level standards) that increase from ca. 20 percent for ethane up to essentially 100 percent for heptane. The lower collection efficiencies for the most volatile alkanes is offset by peak sharpness, thus allowing the detectable levels to be comparable to the less volatile compounds. The cold trap also offers excellent linearity over a wide range of trapping volumes and concentrations. In addition, the present system configuration shows a day-to-day precision of greater than 95 percent. The generality of the system was tested by trapping a variety of organic compounds containing such functional groups as halogen, aldehyde, ketone, ester, ether, and alcohol. In each case the compounds showed excellent collection efficiencies, and produced symmetrical peaks comparable to the normal alkane hydrocarbons.

SUCCESS OF AST's AT LANGLEY RESEARCH CENTER
RELATED TO UNDERGRADUATE GRADE POINT AVERAGE

by

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A very major factor influencing whether or not an individual is hired into a scientific and engineering aerospace technologist (AST) position at NASA Langley is their undergraduate grade point average (GPA). A recent concern has been whether in the future Langley should strive to hire only those applicants with exceptionally high GPA's, i.e., well above the 3.00 level. The main thrust of this project was to collect data relevant to this issue. Specifically, the project examines whether there is a relationship between GPA and success as an AST at Langley. Two studies were conducted in this regard.

Study I

Subjects: This sample of subjects consisted of 113 AST's hired between June 1968 and December 1981. Undergraduate GPA's were obtained for this group from their personnel folders.

Measures of Success at Langley

1. Promotion Rate: This measure consists of the time taken to reach a certain GS level. The following promotion rates were considered: GS-9 to GS-11, GS-11 to GS-12, and GS-12 to GS-13.
2. Supervisory Ratings: Each of the 113 AST's was rated by their supervisor on four items. Two items dealt with the employee's research and technical skills, and two items dealt with the employee's potential as a researcher. For each employee, averages of the first two items, the second two items, and all four items were obtained.
3. Continuation of Education: Data were obtained concerning whether or not the employee had completed a Master's Degree. Although not a direct measure of job performance, continuation of education can be thought of as relevant to possible improvements in performance.

GPA was correlated with the three promotion rates, the three averages derived from the supervisors' ratings, and the continuation of education variable. The results of these analyses are presented below in Table 1. Only two of the seven correlations were large enough to reach statistical significance. The relative size of these two correlations, however, suggests very weak relationships at best. Overall, the resulting correlations suggest very little to no relationship between GPA and the success measures.

Table I: Correlations between GPA and Success Measures

		GPA
Promotion Rate: GS-9 to GS-11	-0.26*	(N = 93)
Promotion Rate: GS-11 to GS-12	-.19	(N = 40)
Promotion Rate: GS-12 to GS-13	-.15	(N = 21)
Average of Research and Technical Skills Ratings	.23*	(N = 101)
Average of Two Research Potential Ratings	.06	(N = 97)
Average of All Four Supervisor Ratings	.16	(N = 101)
Continuation of Education	.04	(N = 102)

Note: N = number of employees on which correlation is based.

* = means statistically significant probability <0.05.

Study II

In Study II groups of employees who were considered successful at Langley were first defined. If undergraduate GPA was related to success, the expectation would be that the successful group should have a higher mean GPA than a comparison group considered to be less successful.

Subjects

1. Sample I: One group of Langley employees who can be considered successful are researchers who have been promoted to the GS-15 level. GPA's for 23 GS-15 researchers were obtained from their personnel folders. A group of 23 Langley researchers, all below the GS-15 level, was selected for comparison against the GS-15 group. The two groups were similar in divisions represented, the highest degrees held, and date of hire. The mean GPA's of the two groups were not significantly different. (Mean GPA of GS-15's = 2.84; Mean GPA of Comparison Group = 2.91).
2. Sample II: A second group of Langley employees who can be considered successful are those who have reached high supervisory positions such as Division Chiefs and Branch Heads. GPA's for 47 of these supervisors were obtained from personnel folders, and GPA's for a comparison group of 47 nonsupervisors were also obtained from personnel folders. The two groups again were similar on: divisions represented, highest degrees held, and date of hire. Again a comparison of GPA's between these two groups yielded no significant differences. (Mean GPA of supervisors = 2.93; mean GPA of comparison group = 2.90).

Overall the data suggested that GPA showed very little or no relationship with the success measures. Based on these data, raising the GPA requirements above present standards does not appear to be an efficient way to improve the work force. Considering other factors besides GPA may be a more promising approach.

MODELING OF AIRCRAFT INTERIOR RESPONSES
DUE TO LIGHTNING STRIKES

by

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The protection of aircraft from lightning and static electricity has received renewed interest in recent years as a result of two trends in aircraft technology. First is the increasing use of graphite composite materials in place of metals in aircraft frames. This results in increased electromagnetic field levels inside these aircraft. Second is the increasing use of digital avionic systems and their high susceptibility to upset as a result of electrical transients.

The Fault-Tolerant Systems Branch of the Flight Control Systems Division has been developing a computer code capable of predicting the exterior electrical response of an aircraft to a lightning event. This is accomplished by solving Maxwell's equations directly in the time domain.

The present study has been to augment this code in order to calculate the fields interior to the aircraft due to coupling through apertures, such as doors, windows and seams. The technique being utilized is Babinet's principle, which allows one to model a hole in a conducting plane by considering its complementary geometry: a magnetic conductor in place of the hole and free space in place of the plane.

Preliminary results from this augmented code indicate that this technique will accurately predict the interior fields of aircraft when it is illuminated by an exterior lightning strike. When completed, this capability will greatly enhance the characterization of the lightning threat to aircraft.



TRANSONIC POTENTIAL FLOW AND GRID GENERATION
FOR BODIES IN A WIND TUNNEL

by

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The goal of this work is to develop an accurate robust computational tool for obtaining numerical solutions to the transonic full potential equation for very general shapes in a channel. The development involved two steps. First, a coordinate system suitable for bodies in a tunnel was generated. Second, the full potential equation was solved on the computational grid.

The work on grid generation was completed during the summer of 1983. A series of two Schwarz-Christoffel transformations and two shearing transformations maps the region between the body and the tunnel walls into a rectangular computational domain. This procedure leads to an "O type" mesh which is nearly orthogonal everywhere. The mesh is called O type because one set of coordinate lines wraps around the body. The other set originates on the body surface and terminates at the tunnel walls. The mapping can be used for arbitrary two-dimensional lifting bodies or for axisymmetric bodies of revolution with or without stings.

To generate a difference approximation to the transonic full potential equation, the mass conservation equation is written in integral form and applied to a control volume consisting of a basic computational cell. This leads to a difference approximation which is conservative. A unique feature of the differencing scheme is that the velocity potential is defined at cell centers, not at node points as in most potential flow schemes. This facilitates the treatment of Neumann boundary conditions.

The resulting finite difference equation is suitable for subsonic points. At supersonic points, an artificial viscosity term is added to stabilize the scheme and capture shocks. In this work artificial viscosity is introduced by means of the retarded density method. In this procedure the isentropic density is replaced by an artificial density which is retarded in the upwind direction. This leads to a finite difference equation which is second order accurate at subsonic points and first order accurate at supersonic points.

The set of finite difference equations is solved iteratively. Three different interaction schemes were tried and are presently incorporated in the code. These include vertical line overrelaxation (VLOR), approximate factorization (AF2), and an alternating horizontal line iteration scheme called ZEBRA. Each method exhibited advantages and disadvantages. VLOR is the most robust but is the slowest of the three. AF2 proved to be the fastest in most cases but

requires tuning of three iteration parameters. ZEBRA is of intermediate speed but requires tuning of only one iteration parameter.

The code has been run successfully for a wide variety of cases involving transonic flow with embedded shocks and large regions of supersonic flow. Supersonic free stream flows are also solved with captured bow shocks and embedded subsonic regions. The code has been compared with existing transonic potential codes and the agreement has been excellent. This summer the code was extended to handle cases where the tunnel exit area may be different from the inlet area and cases where the body is on a sting. Furthermore, the code has been given free air capability by taking the tunnel walls far away and applying a Dirichlet boundary condition at the outer ring.

The grid generation technique and finite difference approximation lead to an accurate and efficient computational tool for solving the transonic full potential equations for 2-D and axisymmetric bodies in a tunnel or free air.

SYNTAX PROGRAMMING

by

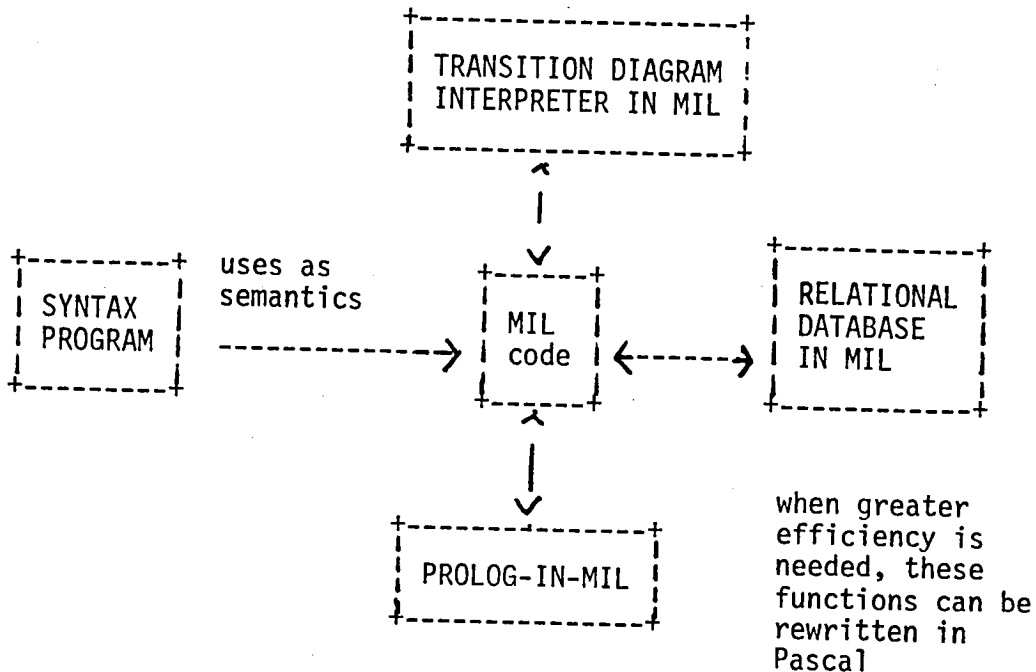
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Syntax programming is an innovative programming technology developed by the author while on leave at the Automation Technology Branch during the 1983-84 academic year. This development continued during the term of the author's ASEE fellowship.

Syntax programming is to parser construction technology as logic programming is to formal logic. Both programming techniques can be used for general programming applications, but are rule-based and thus particularly appropriate for artificial intelligence programming: Syntax programs offer a clarity and theoretical power frequently lacking in logic programs.

A major result of this research has proven to be the implementation and use, in connection with syntax programming, of the functional programming language MIL. The role of MIL in this project is depicted in the diagram below.



MIL is implemented in Pascal. One of the most significant features of the implementation is the fact that MIL is based on the classical secd machine, a simple yet extremely powerful LISP abstract machine. All MIL operations are specified in terms of transforms on a small number of registers in a highly disciplined fashion. These transforms are implemented by Pascal routines; it thus becomes easy to shift smoothly from Pascal to MIL and back as required. This ability to interface functional and algorithmic languages smoothly has important implications.

Suppose, for example, that we want to write a robot controller in terms of transition diagrams, syntax programming, or Prolog-in-MIL. As indicated by the diagram, such a program may be written in the form desired, and can interface easily with the Pascal-based low-level robot control routines. This prospect is made doubly attractive by the fact that the power of Prolog can be used effectively only if control structures such as those offered by MIL are available to the user.

The MIL system is close to completion. The transition diagram interpreter and the data base facility are in place. The Prolog implementation is at the halfway point: unification is implemented, whereas backtracking remains to be completed. Once finished, the MIL system will combine the advantages of a number of AI support tools: Prolog, relational data base systems, transition diagrams, syntax programming, and a LISP-like functional programming capability.

To increase NASA personnel's awareness of existing AI systems and languages, the author taught a Prolog short course during the term of the fellowship.

1984 NASA GOVERNOR'S SCHOOL

by

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The Governor's School for the Gifted, sponsored by the Virginia Department of Education, is designed to provide intellectually challenging and enriching experiences for a limited number of academically talented rising junior and senior high school students. NASA Langley Research Center has, for the past three summers, served as one of the host sites for the Governor's School program.

During the summer of 1984, NASA along with three other sites, hosted the program. The other sites included Virginia Polytechnic Institute, Mary Washington College and Longwood College. Each site was assigned a local Coordinator to effectively manage its Governor's School. One of the purposes of the Summer Faculty Fellowship Program was to coordinate this summer's NASA Governor's School program.

The 14 males and 10 females in the NASA Langley Governor's School were composed of 4 Black Americans, 4 Asian/Pacific Islanders, and 16 White Americans. The 24 students shared the following common profile:

- o rising high school juniors or seniors with a high degree of maturity,
- o firm career objectives in science, engineering, mathematics or related technical fields,
- o outstanding academic records which included advanced placement in math and science, and
- o unconditional recommendations by their teachers, guidance counselors, principals and superintendents.

Students were nominated to participate in the Governor's School program at particular sites based on their defined career objectives. Nominations were made by high school principals and guidance counselors. NASA Langley hosted students interested in math, science and engineering. Twenty-four high school students from several cities in the state of Virginia spent 6 weeks (June 18 through July 27) under the direction and supervision of a NASA engineer, researcher or scientist. These NASA "mentors" were charged with the responsibility of providing realistic work assignments for the 24 students.

The specific objectives of this summer's program were:

- o to expose and involve students in a scientific and technical work environment,

- to allow students the opportunity to interact with engineers, scientists, mathematicians and engineering technicians,
- to provide opportunities to gather information regarding related career objectives,
- to provide students with the opportunity to view the applications of many concepts studied in the classroom, and
- to provide a real work experience in the students' interest area.

Housed at Hampton Institute, the Governor's School students began their work day at 8:00 a.m. and ended it at 4:30 p.m. The students functioned as full-fledged researchers, making contributions to several branches and divisions, in particular, and to NASA Langley, in general. Overall, 13 divisions felt the impact of at least one student. Five divisions hosted one student each, six divisions hosted two students each, one division hosted three students and one division hosted four students. The following divisions were involved in this summer's program:

- Acoustics and Noise Reduction,
- Office of the Director for Systems Engineering and Operations,
- Systems Engineering,
- Aeronautical Systems Office,
- Structures and Dynamics,
- Analysis and Computation,
- Facilities Engineering,
- Flight Control Systems,
- Instrument Research,
- High-Speed Aerodynamics,
- Low-Speed Aerodynamics,
- Materials, and
- Atmospheric Sciences.

Within the aforementioned divisions, 20 branches were involved in hosting students.

Collectively, NASA Langley Governor's School students contributed significantly to the on-going research being conducted at the Center. The following research areas represent the nature of some of the contributions made by the students during their tenure:

- computer animation,
- analysis of infrared spectra from the atmosphere,
- magnetic permeability of metals,
- fundamentals of aircraft design and construction,
- use of microphones in the detection of infrasonic signals,
- direct lightning strikes on aircrafts,
- various stresses on socket type joints,
- structural maintenance of aircrafts,
- points of visual concentration for pilots,
- heat shield materials, and
- remote atmospheric measurements.

As part of the closing ceremony for the NASA Governor's School, the students filmed and edited a video-taped presentation highlighting each of their assignments and contributions at their various work sites. Upon program completion, each student was presented a Certificate of Commendation from the Commonwealth of Virginia, signed by Governor Charles S. Robb.



PHYSICS OF FLAMEHOLDING AND BLOWOFF MECHANISM
IN THE HYDROGEN FUELED SCRAMJET COMBUSTOR

by

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One of the key issues in the development of a supersonic combustor is the problem of flame stability. Experiments conducted during the past decade have indicated that certain configurations such as backward-facing steps and transverse fuel injectors may offer good flameholding capability. However, effects of various flow and geometrical parameters are not fully understood and there is no generally accepted physical or analytical model of the blowoff mechanism at supersonic speeds.

The objective of this investigation is to improve understanding of the flame stability and blowoff mechanisms by: (a) further analysis of the flameholding data collected at the NASA Langley and (b) visualization of the flame development and blowoff in a scramjet combustor using a single, large-size fuel injector. The following visualization techniques will be tried:

- (1) Short sequences of schlieren and shadowgraph pictures obtained with multiple spark source and camera system. Light pulse duration is 300 nanoseconds and the pictures will be taken at three closely spaced times (1 to 100 microseconds).
- (2) Visualization by using a narrow, planar laser-light sheet and scattering from submicron particles fed into the mainstream gas.
- (3) Direct side and top-view photographs relying on the flame generated light.

It is expected that a combination of relatively large-scale fuel injector (0.25 in.) and a short exposure will result in pictures having good resolution and, thus, allowing an insight into the flowfield structure and flame development.



DYNAMICS AND CONTROL OF FLEXIBLE SPACECRAFT
DURING SLEWING MANEUVERS

by

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Many NASA future missions will utilize significantly large and flexible spacecrafts and will require very stringent pointing and vibration suppression requirements. The active controller that can achieve these objectives will have to be designed with very accurate knowledge of the dynamic behavior of the spacecraft to ensure performance robustness to a variety of disturbances and model uncertainties. Also, the control law will have to be developed under limited control authority.

The Spacecraft Control Branch of the Flight Dynamics and Control Division at the NASA Langley Research Center, with the advice and counsel of the IEEE Subcommittee on Large Space Structures, has initiated a program to make direct comparisons of various control laws based on an analytical problem and subsequently implementing them on an experimental test article.

The summer project dealt with the dynamics and control during the slewing maneuver of this flexible spacecraft which consists of an orbiter with a large flexible antenna to which a reflector grill is attached. The important objective of the study was to develop an optimal control law for performing arbitrary slewing maneuvers (up to 20° angles), and at the same time minimize vibrations under limited control authority.

The flexible spacecraft system was modeled as a free-free uniformly distributed parameter beam with two end masses and was analyzed for uncoupled motions (pitch, roll, and torsion) using their corresponding partial differential equations to provide modal frequencies and mode shapes. These modal frequencies and the associated mode shapes were utilized in obtaining a finite dimensional model of the system which was used in obtaining feedback control laws for performing single-axis maneuvers.

The single-axis slew maneuver control problem was treated first as a rigid-body slew maneuver under limited control authority (the net moment applied to shuttle was limited to $\pm 10,000$ ft-lb) by formulating it as a finite-time regulator problem and was solved by existing NASA software package ORACLS (a system for Linear-Quadratic-Gaussian Control Law Design) to yield time-varying optimal control law. It was found that a slew maneuver of 20° in either pitch plane or roll plane can be performed within 20 seconds. The single-axis maneuver problem was further studied by considering two flexible modes in the rigid body model for vibration suppression and was formulated as

an infinite-time regulator problem in obtaining an optimal constant feedback gain matrix for state feedback control law. Two external control inputs were used on the spacecraft, namely torque on the rigid orbiter and force at the reflector end of the flexible antenna. Under the constraints imposed on the control inputs, it was found that a 20° slew maneuver can be performed in about 52 seconds in either plane.

Finally, an arbitrary slew maneuver was treated as a nonlinear rigid-body slew maneuver in terms of four Euler parameters, and slew angle was specified about an arbitrary axis of rotation. Using the method of nonlinear decoupling, this nonlinear slew maneuver control was reduced to calculating a pair of gain constants for each of the first three Euler parameters in implementing output feedback. Time-history of this type of slew maneuver was obtained using computer simulations.

ANALYTICAL INVESTIGATION OF TIP-CLEARANCE EFFECTS
IN ATP AIRCRAFT

by

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Due to the present demand for efficient aircraft, there has been increased interest in propeller engines. This has led to research into turboprop engines operating with supersonic tip speeds. A negative aspect of these advanced turboprop (ATP) engines is their high sound levels.

Synchrophasing, which is the term used when the relative rotational phase of each propeller is controlled, has been one method considered to reduce these noise levels (refs. 1 and 2). In this study, the effect of tip clearance on the acoustic levels is addressed. The approach developed by Fuller (ref. 3) is adopted where the fuselage is simulated using a cylindrical shell and the propeller is modeled as a dipole source. Due to the elasticity of the shell, it responds to the radiated acoustic field and thus transmits energy to the interior of the shell.

Tip clearance is simulated by varying the horizontal location of the source. No synchrophasing is considered since only one source is used. The aim of this approach is to determine the optimum source location for reduced noise levels. Identifying the radiation pattern (i.e., near field, far field) of this simplified case will give some insight into the proper placement of the engines with synchrophasing implemented. Also, since the source is a dipole, the change in directivity pattern with source location can be investigated.

In conjunction with the above analysis, the dipole source structure is investigated for both its free-field pattern and its scattered pattern (due to the cylinder). This will show some of the physical aspects of the acoustic field and complement the numerical study.

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MATHEMATICAL PHYSICS OF LIGHTNING DISCHARGES

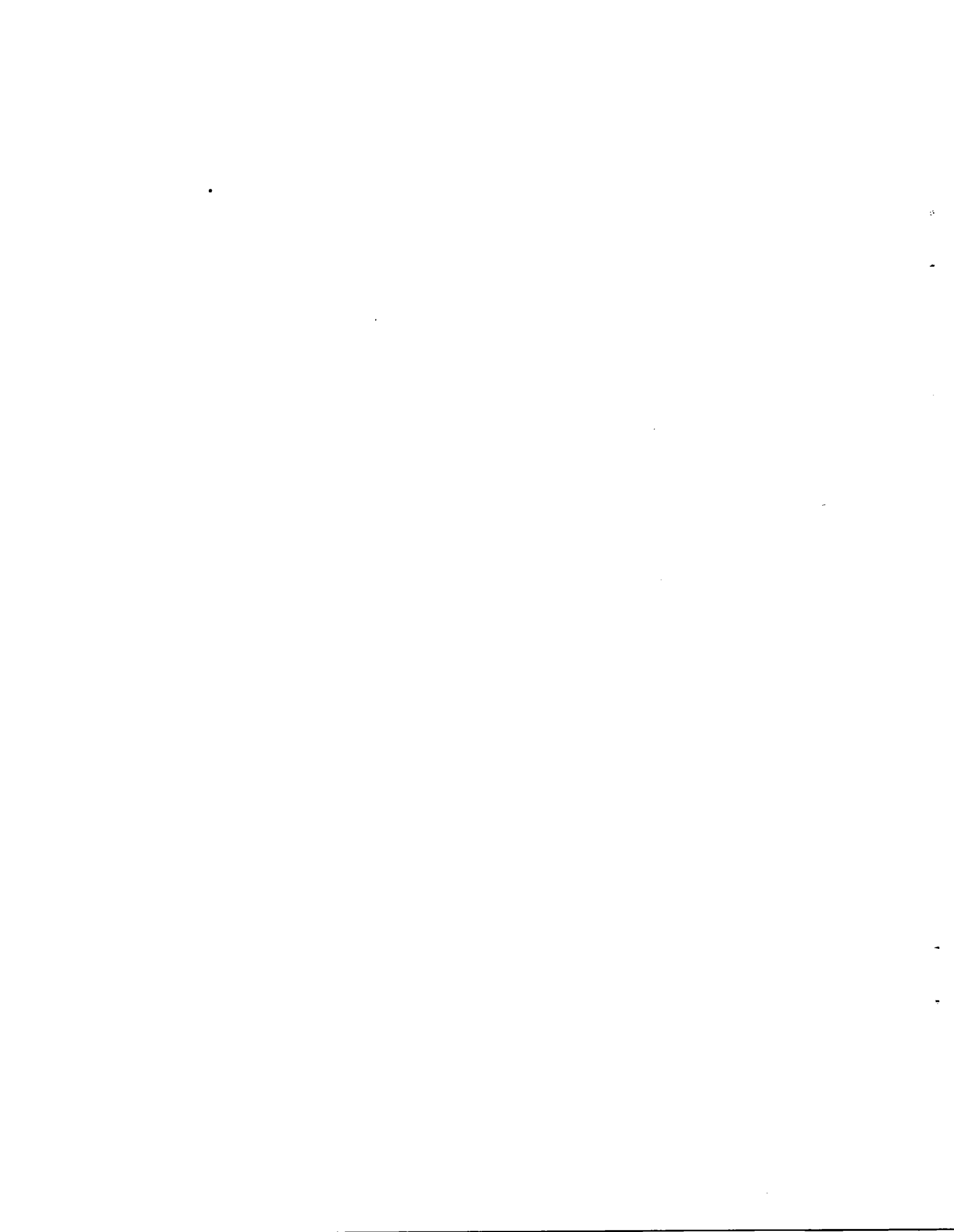
by

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Research work on Mathematical Physics of Lightning Phenomena was completed in four categories.

1. Soliton ansatz for the calculation of electromagnetic fields, currents and charge densities including charge generation term to describe the electrical process occurring during a lightning stroke.
2. Lightning discharge initiation solution for exponentially increasing current for which the generation term is a sine qua non. The discharge is found to occur because of relative saturation of convective current compared to displacement current so the field is able to rise to breakdown level.
3. Statistical distributions of positive and negative charges in a thundercloud.
4. Physical interpretation of the distribution and strike processes.



SPACE STATION HABITATION: A PLAN FOR STRESS AMELIORATION

by

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There are numerous reports in the United States and Soviet literature concerning the stresses associated with manned space missions. These psychological factors appear to increase as the duration of the flight increases.

NASA's recent commitment to develop the Space Station and extend human habitation in space on a permanent basis will greatly extend the duration of manned orbital missions. In addition, future manned exploration of Mars, the other planets, and their satellites, as proposed by various NASA studies, e.g., Outlook for Space (Report to the NASA Administrator by the Outlook for Space Study Group, D. P. Hearsh, Study Director) will require very long duration manned missions (of several years).* With this increase in duration of manned missions should come an increase in concern for these stress factors which may impede both well being and productivity in space. These stress factors may be chronic or episodic, physical or psychological. The bodily stress reaction is the same. Some of these stress factors include: isolation, confinement, weightlessness, space adaptation syndrome, noise, vibration, extremes in temperature, toxic agents, changes in atmospheric gas composition and pressure, radiation, reduced sensory input, sensory excess (occasionally), disruption of the circadian cycle, separation reaction, boredom, and fear of equipment failure.

* U.S. Manned Missions: Increasing Duration

<u>Mission</u>	<u>No. Flights</u>	<u>Flight Duration</u>
Mercury	6 Flights (5/5/61-5/15/63)	15 min - 34 hr 20 min
Gemini	10 Flights (3/23/65-11/11/66)	4 hr 53 min - 330 hr 35 min
Apollo	11 Flights (10/11/68-12/7/72)	147 hrs - 295 hrs 12 min
Skylab	3 Flights (5/25/73-11/16/73)	28 - 84 days
Apollo-Soyuz	1 Flight (7/15/75)	217 hr 28 min
Space Shuttle	7 Flights (4/12/81-6/18/83)	54 hr - 8 days
Space Station		appr. 3 - 6 months (?)
Mars Mission		3 - 5 years (?)

Once operational, the Space Station will provide unique opportunities for scientific, technological, and industrial exploitation of the space environment. This will open space to the "man on the street" (i.e., the nonprofessional astronaut who may not have the "right stuff" for space travel). Longer duration manned missions and the use of "nonprofessional" astronauts may increase the importance of stress reduction training for astronauts.

Some effects of stress include:

1. Lowered energy and decreased capacity for intellectual pursuits
2. Impairment of memory
3. Lowered productivity
4. Lowered problem solving ability
5. Lowered efficiency (both group and individual)
6. Increased hostility toward other crew members
7. Increased hostility toward ground control
8. Lowered attentiveness
9. Fatigue
10. Anxiety
11. Sleep disorder
12. Boredom
13. Withdrawal and increased need for privacy
14. Miscommunications
15. Overconcentration with health concerns
16. Impulsive behavior

For these reasons and many others too numerous to identify here, it is apparent that psychological stresses may surface as a major problem for future long duration manned missions, e.g., Space Station habitation and manned missions to the planets. The elimination or prevention of these psychological stresses may become an important aspect of future long duration manned missions. Various psychological stress amelioration techniques were considered as part of my research assignment. Some of these identified include:

1. Meditation, transcendental meditation, and yoga
2. Progressive muscle relaxation
3. Self-hypnosis and autosuggestion
4. Biofeedback
5. Rythmic breathing
6. Autogenic training

Preliminary assessment of these psychological stress amelioration techniques suggests that meditation in its various forms would be a good candidate for astronaut training. Meditation involves achieving a state of deep relaxation. Meditation takes only 15-20 minutes a day to practice and involves a temporary shutdown of information processing in the brain. It is interesting to note that yoga was practiced by the Indian cosmonaut, Rakesh Sharma, on the recent Soviet Soyuz T-11 flight.

In summary, it is important to recognize that psychological stress may emerge as an important problem on future long duration manned missions. Psychological stress amelioration should become an important component of astronaut training. It appears that meditation may be a good candidate technique for stress amelioration.



PROBLEMS IN ADAPTIVE IDENTIFICATION AND
CONTROL OF FLEXIBLE STRUCTURES

by

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It is expected that some form of adaptive control will be necessary for the control of flexible spacecraft (large antennae space station, etc.) due to unknown or poorly known states and parameters. One approach is to employ an adaptive observer (ref. 1) to adaptively identify the states and parameters, and use these estimates to design a feedback control law. The following three problems related to adaptive identification have been studied:

1. Reduced-Order Behavior of a General Adaptive Law Structure for Parameter Identification

The adaptive observer scheme of reference 1 is given by:

$$\dot{M} = FM + [I_y, I_u], M_0 \text{ arbitrary} \quad (1)$$

$$\hat{x} = Mp \quad (2)$$

$$\hat{y} = c^T \hat{x} \quad (3)$$

$$\dot{\hat{p}} = -G \frac{\partial L(\hat{p}, t)}{\partial \hat{p}}, \hat{p}_0 \text{ arbitrary} \quad (4)$$

where y and u are the plant output and input, respectively, c and F are chosen arbitrarily such that F is strictly stable and (c^T, F) is observable. The matrix G is positive definite and chosen arbitrarily. In the above adaptive observer, \hat{x} is the estimate of the plant states, \hat{y} is the estimate of the plant output, and \hat{p} is the estimate of the plant parameters. The function $L(\hat{p}, t)$ is an arbitrary nonnegative error criterion which rates the output error between the observer and the plant, and satisfies certain properties of a norm, i.e., convexity, etc. In reference 1, this scheme was proven asymptotically stable (i.e., \hat{x} , \hat{y} , \hat{p} approach the true values as $\tau \rightarrow \infty$) when the observer order is the same as that of the plant.

If the observer order is reduced, however, asymptotic stability is no longer assured. Our objective has been to show that such a general adaptive law produces ultimately bounded state and parameter errors in the presence of unmodeled dynamics. This result can be shown to hold under certain restrictions on the error criterion L . It is hoped that the analysis will provide insight into how best to choose L in order to minimize reduced-order errors in the estimates.

2. Adaptive Identification of Multiple Input-Output Flexible Structures

An ideal flexible structure can be modeled as

$$\ddot{q} + D\dot{q} + \Lambda q = \Phi u \quad (5)$$

$$y = \Phi^T q \quad (6)$$

where q is the modal amplitude, D and Λ are diagonal damping and stiffness matrices, and Φ is called the "mode shape matrix." The inputs u and outputs y are measurable, but q , D , Λ , and Φ are unknown. The objective is to employ an adaptive identifier (e.g., ref. 2) to identify the system. The scheme in reference 2 can be applied directly in this case, and D , Λ , and Φ (up to a sign) can be identified. However, the computational demands can be severe if the dimension of the system is high. We wish to utilize the simple second-order structure of equations (5) and (6) to simplify the computational demands. It is expected that some form of simplification will result, since this system is essentially a number of second-order systems in parallel. The significance of this investigation is that the performance of an adaptive controller based on the parameter estimates can be enhanced if the estimates are obtained quicker. This problem is currently being studied.

3. Stability Regions for a Discrete-Time Adaptive Controller

In reference 3, the adaptive control of a flexible structure is undertaken by modeling each mode to be controlled as a second-order discrete system given by

$$q(k) = A_1 q(k-1) + A_2 q(k-2) + B_1 u(k-1) + B_2 u(k-2) \quad (7)$$

If A_1 , A_2 , B_1 , B_2 are known, a feedback control law

$$u(k) = C_1 q(k-1) + C_2 q(k-2) + D_1 u(k-1) + D_2 u(k-2)$$

can be designed to provide arbitrary placement of the closed-loop poles. However, since A_1 , A_2 , B_1 , B_2 are unknown, a lattice identification scheme is

employed to estimate them. The estimates $\hat{A}_1, \hat{A}_2, \hat{B}_1, \hat{B}_2$ are then used to calculate the control variables C_1, C_2, D_1, D_2 .

The problem under investigation is to determine regions for the parameter errors which insure closed-loop stability. An approach to the problem is to consider the matrix

$$A + bk = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ B_1 & B_2 & A_1 & A_2 \\ 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} [D_1, D_2, C_1, C_2] \quad (8)$$

where $A + bk$ has the same eigenvalues as the closed-loop system. If only k is in error (by Δk), conditions sufficient for stability can be obtained via the Bellman-Gronwall lemma. The result is that stability is retained if

$$\|\Delta k\| < \frac{1 - \alpha}{M_0} \quad (9)$$

where $\|(A + bk)^i\| < M_0 \alpha^i$, $M_0 > 1$, $0 < \alpha < 1$. Note that M_0 and α are known quantities which represent the desired degree of stability of the plant. It remains to find bounds on the identification errors $\|\Delta A_1\|$, $\|\Delta A_2\|$, $\|\Delta B_1\|$, $\|\Delta B_2\|$ which insure (9). The relationship is quite complex even in the second-order case, but it has been found that the answer depends in part on the "degree of controllability" of the estimated plant, i.e., $\det W$, where W is the controllability matrix of the estimated plant. If $\det W$ is small, then stability is endangered. Thus, it appears essential to consider this point, although it has not been stressed in existing work on the subject.

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MODELING THE CURING PROCESS OF RESIN MATRIX COMPOSITES

by

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Composite structures constructed from continuous fiber-reinforced, organic resin matrix prepreg materials are fabricated by laminating multiple plies into the desired shape and then curing the material in an autoclave by simultaneous application of heat and pressure. Elevated temperature applied during cure provides the heat required for initiating and maintaining the chemical reactions in the resin which cause the desired changes in the molecular structure while the applied pressure consolidates the individual prepreg plies by squeezing out excess resin. A composite that is processed using an optimum cure cycle will result in a void free structure that is uniformly cured to the desired resin content in the shortest amount of time. Therefore, the cure cycle must be carefully selected for each application considering the composition of the prepreg material and the geometry of the structure.

Due to the large number of material properties and processing parameters that must be specified and controlled during cure of composite parts, the cure cycle can best be selected with the aid of analytical models. A mathematical model has been developed by Loos and Springer (ref. 1) to simulate the curing process of composites fabricated from continuous fiber-reinforced prepreg materials. Based on the model, a computer code was developed which can be used to predict the following information for press molded graphite-epoxy flat plate composites cured by a specified cure cycle:

- (a) the temperature distribution inside the composite;
- (b) the degree of cure of the resin as a function of position and time;
- (c) the resin viscosity as a function of position and time, and the gel time of the resin;
- (d) the resin flow as a function of time and the resin distribution;
- (e) the void sizes, and temperatures and pressures inside the voids as functions of void location and time; and
- (f) the residual stress distribution inside the composite after cure.

A major goal of the 1983 NASA/ASEE Summer Faculty Research Program was to modify the model and computer code of Loos and Springer to simulate the curing process of autoclave cured composites and to obtain test data which can be used to assess the validity of the model. Results of this program (ref. 2) indicate that the model describes adequately the temperature distribution and resin flow process of graphite-epoxy composites fabricated with different ply stacking sequences, length-to-width dimensions, and thicknesses during autoclave cure.

The overall objective of the 1984 NASA/ASEE Summer Faculty Fellowship Program will be to continue the cure modeling research initiated during the 1983 summer program. This research will be focused on two areas of current interest; (1) modeling the curing process of thick-section autoclave cured composites and (2) cure process modeling of graphite-polyimide composites.

Previous investigations have shown that temperature gradients are significant during cure of large area, thick-section composites. Such temperature gradients result in nonuniformly cured parts with high void contents, poor ply compaction, and variations in the fiber/resin distribution. Thus, it would be expected that the mechanical properties of thick composite structures will vary through the thickness of the structure.

The goal is to develop a mathematical model to simulate the curing process of thick-section autoclave cured composites. Work is currently underway to modify and extend the Loos-Springer model to consider the added complexities of autoclave cure. Modifications include consideration of forced convective heat transfer at the boundaries of the composite and modeling the thermal resistance and heat capacitance of the bleeders, release fabrics, and tooling.

An experimental program will be performed to obtain data which can be used to verify the model. Thick-section (1 in. to 3 in. thick) laminates will be autoclave cured. During cure the temperature distribution in the laminate will be measured by thermocouples embedded in the structure. Upon completion of cure, small samples cut from the laminate will be sectioned through-the-thickness to measure the degree of resin cure, glass transition temperature, density, fiber/resin content, and void content.

In recent years, considerable attention has been focused on the use of graphite-polyimide composites as a structural material for high temperature aerospace applications. During this phase of the program the cure model of Loos and Springer will be modified and extended to describe the curing process of graphite-polyimide composites. An AS4/PMR-15, graphite-polyimide prepreg system will be characterized to obtain input data required for the solution of the model.

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X-RAY FLUORESCENCE ANALYSIS OF WEAR METALS IN LUBRICATING OILS
FROM NASA/LaRC AIRCRAFT

by

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Analysis of wear metals in oil samples from engines, gear boxes, and other lubricated mechanisms has been routinely performed for years. The purpose of the analysis is to predict and prevent failures and complete breakdowns in the equipment using the oil. The methods most often used for this type of analysis have been atomic emission (AE) and atomic absorption (AA) spectroscopy. Some problems associated with AE and AA have led to the recent use of other methods, such as ferrography and x-ray fluorescence (XRF) spectroscopy, to supplement or even replace these conventional methods. The work of this project, which was begun in the summer 1983, dealt with the design, assembly, calibration and subsequent use of an XRF system for analyzing wear metals in lubricating oils from NASA/LaRC aircraft.

The XRF spectrometer assembled for this purpose utilizes three different radioactive sources for the excitation of the elements in the oil samples. The lighter elements Al, Si and Ti are analyzed using 5.89 keV x-rays from a ^{55}Fe source while the elements Cr, Fe, Cu, Ni, Mo, and Pb are analyzed using 22.16 keV x-rays from a ^{109}Cd source. Ag and Sn are analyzed using ^{241}Am to produce 45.4 keV x-rays from a dysprosium foil.

Oil samples are analyzed by first filtering 1 to 2 ml of the used oil through 0.45 μ filter paper and using the x-ray spectrometer to determine the concentrations of the wear metals on the paper. The calibration of the system indicated minimum detectable limits (MDL) ranging from a high of 20 μg for Al to a low of 0.03 μg for Mo. Most elements analyzed had MDL's less than 1 μg .

For the oil analysis program to be of use, data from the oil of each mechanism must be routinely collected over long periods of time and the concentrations of the wear metals correlated with known problems in the aircraft. A computer program was written to store and maintain disk files of the data from each mechanism. In the future, these data will be analyzed for the purpose of doing preventive maintenance on the aircraft.

The results from the XRF analysis of oil collected from several aircrafts over a period of 1 year agree quite well with the AE analysis of the same oil. In the case of the concentration of Fe, the differences between the AE and XRF measurements have averaged somewhat less than 10 percent.

The results of this work indicate XRF can be used reliably to do routine wearmetal analysis of lubricating oils. Since XRF instruments can be miniaturized, this opens the door for the design and construction of man-portable devices and even for real time devices that may be installed on the aircraft for in-flight monitoring of oil.

ULTRASONIC DETECTION OF BROKEN FIBERS IN GRAPHITE COMPOSITES

by

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During the last decade, there has been much interest in fiber-reinforced polymeric matrix composites. The use of these composite materials in aerospace applications is increasing because of the large strength to weight ratios of these materials and their great versatility (ref. 1). The versatility of composite materials stems from the wide choice of constituent materials available, and from the variety of ways in which these composites can be fabricated to provide the desired combination of properties. These tailor-made properties are frequently not available or simply cannot be achieved in conventional isotropic materials.

The versatility of composite materials is also accompanied by a complexity in their chemical and mechanical properties that is inherent in the multi-phase nature of these materials (ref. 2). This was in many cases caused the basic principles, which underly the much desired properties, to be obscured in that complexity. A good example of this effect occurs in the attempts at characterizing and evaluating composite materials with ultrasound. The propagation of sound through anisotropic material is very complex indeed.

One of the problems associated with composite evaluation is the detection of broken fibers. In order to image areas as small as the size of the fibers in a composite, very high frequencies must be used. Wave attenuation is a function of frequency and is very high for high frequencies. One simply cannot get high frequency waves into the composite.

An alternative approach would be to use low frequency waves, and instead of imaging directly, look for the intensity of waves that propagate down the fibers. Broken fibers would then show up as a drop in the received ultrasonic signal.

The goals of our study were: (1) to excite and observe ultrasonic waves in the fibers of a monolayered composite; (2) to look for a drop in the ultrasound intensity when a region which contains cut fibers is scanned; and, time permitting, (3) to try the experiment on a real structural composite.

Consider one medium where the velocity of sound is u and a second medium with velocity v . If sound propagates from the first medium to the second refraction occurs according to Snell's Law: $v \sin a = u \sin b$, where a is the angle in medium u and b is the angle in medium v . The condition for propagating a wave parallel to the fiber surface (where $b = 90^\circ$) is: $a = \arcsin (u/v)$. For our polysulphone/graphite composite measured under

water, $\alpha = 10.5^\circ$. This angle is measured from the normal to the surface of the interface between the fibers and the polysulphone (or the polysulphone and the water). It is called the critical angle. To excite the so-called "creeping waves" in the fibers, the transmitting transducer is mounted at this angle. To receive the small signal which we expect to radiate from the fibers at all points along their lengths, we set the receiving transducer to the same angle but on the other side of the normal (ref. 3).

A sample was made up from two 1/4 inch layers of polysulphone sandwiching one layer of fibers. This is the monolayered composite. A "pitch and catch" setup was used, where one transducer was used to excite the wave, while a second one was used to observe it. The transmitted signal was amplified from 0.7 volt to about 50 dB. The received signal was amplified by 60 dB, filter to remove high frequency noise, and either observed on a scope or averaged with a Nicolet 12/70 signal averager. The scanning of the probe was done manually with a hand cranked scanning unit.

A very weak signal was observed with a signal to noise ratio of 2. This signal was observed to disappear as the cut-fiber region was scanned.

Attempts to observe the creeping waves in a uniaxial composite were unsuccessful.

In conclusion, the effect is small but observable, too small for the attenuation experiment. The potential for using this technique to find broken fibers shows promise. More work is needed to get the signal to noise ratio to higher levels, before this technique is practical for composite characterization.

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ABSTRACTION, DOCUMENTATION, AND IMAGE PROCESSING

by

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Two important principles of software engineering are abstraction and documentation. My work at NASA-Langley this summer revolved around these principles and around the image processing work done at two NASA labs, one at ACD, and the other at IRD. The work at the ACD lab was a continuation of a project begun prior to the summer, and is similar to the work at IRD; therefore, this report focusses on the work at the IRD lab.

The image processing equipment at the IRD lab consists of a COMTAL image processing workstation linked with the lab's HP-1000 minicomputer. The COMTAL machine has special high speed memory and pipeline processors for image manipulations. The COMTAL also has its own keyboard, a trackball, a digitizing tablet, a color monitor, and a television camera as peripherals. Although the COMTAL includes a command language for image processing tasks, its programming facilities are limited. In contrast, the HP-1000 has a mature operating system, numerous editors and programming tools, and high level language compilers. The HP also has a disk drive and a tape drive.

The COMTAL machine is linked to the HP with a hardware interface supplied by COMTAL. COMTAL also supplied assembler language routines for accessing this interface from HP programs. However, the assembler routines proved to be unreliable, and IRD staff had obtained a new, largely undocumented driver from another COMTAL customer. An IRD programmer has written a users manual that includes a number of programs that call both the unreliable assembler code and the new driver; each of these programs utilizes one of the two interface software routines.

The goal of my summer project was to expand and improve the software available on the HP-COMTAL system. I divided the project into three separate stages: first, establishing a reliable software interface between the two machines; next, building a collection of generally useful, single purpose subprograms that would afford convenient, low level control of the COMTAL from HP programs; finally, developing image processing programs based on the single purpose for IRD projects.

The driver from the COMTAL customer was selected as the basis of a reliable interface. The code for that driver was examined and is being more thoroughly documented. Various tests were executed to establish the behavior of certain sections of the driver code.

The major work this summer was designing, coding, and testing a collection of subprograms for COMTAL control via the HP driver interface. Software engineering techniques were used in producing modular procedures and adequate documentation. Internal cohesion was enhanced by strictly limiting the scope of each subprogram; for example, no parameters were allowed which would act simply as control flags. Coupling between modules was kept to a minimum; for example, no function includes a side effect, and no global variables were allowed. A standard form for documentation was enforced for all subprograms written. At this writing, 55 subprograms have been coded, documented, and unit tested.

Several complications arose in the development of the subprogram collection. The imprecision of COMTAL documentation made it necessary to experiment extensively to discover the actual behavior of the COMTAL hardware. Some anomalies in the error detection and the timing constraints in the COMTAL were particularly vexing. On a more theoretical level, the principle of information hiding was occasionally abandoned because of efficiency considerations; for example, reading a vertical line of pixels is an order of magnitude more expensive than reading a horizontal pixels in the COMTAL system, and it was decided not to hide this implementation detail.

The third stage of the project, the integration of subprograms into full scale image processing programs, has yet to be completed. Work will continue on this phase in the coming week.

The major research issue that arose this summer was the inadequacy of English in specifying the behavior of image processing software. I have submitted a grant application so that I can explore the use of algebraic abstract data types to specify collections of image processing software.

IMPROVING THE HANDLING CHARACTERISTICS OF AIRCRAFT
EMPLOYING FLIGHT CONTROL SYSTEMS DURING THE LANDING FLIGHT PHASE

by

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Aircraft of today and tomorrow are being designed and built with flight control systems to attain higher performance levels in the basic areas of aerodynamics, propulsion, structures, and stability/control. An operational flight control system which provides excellent longitudinal handling characteristics during nonlanding flight phases is the pitch rate command control system. However, this control system is known to introduce a significant longitudinal handling difficulty, floating, during the landing flare maneuver. Floating is a tendency of the aircraft to glide above the runway with a zero sink rate.

The National Aeronautics and Space Administration's (NASA) Dryden Flight Research Facility and Langley Research Center along with Arvin/Calspan Advanced Technology Center have conducted an inflight investigation of the pitch rate command control system for the purpose of improving the handling qualities during the landing flight phase. During the investigation, it became clear that two factors directly influence the handling qualities. First, larger initial cockpit vertical accelerations improve the handling qualities. The improvement is due to the quicker and stronger indications the pilot feels as the aircraft responds to his commands. Apparently, the pitch rate command control system is lacking in this area. Second, monotonic stick forces improve the handling qualities. The stick force indicates to the pilot the current state of the flare maneuver. Most pilot experience is with conventional aircraft which require a monotonic pull force during the flare maneuver. The pitch rate command control system inherently requires stick force reversal during the flare maneuver. Pilots simply do not like to push the stick during the flare maneuver.

Major results of the investigation include: (1) the addition of a lead/lag filter can increase the initial angle of attack and cockpit vertical acceleration; (2) the addition of a washout filter can introduce monotonic pull stick forces; and (3) the addition of an angle of attack limiter can introduce monotonic pull stick forces. Due to money and time constraints, results (2) and (3) were not extensively investigated. My fellowship program project is to further investigate the effectiveness of the washout filter and angle of attack limiter so that when NASA decides to further investigate this area with another flight test program, a small data base will already exist.

The analysis technique consists of developing the Laplace transformed control law relating the pilot command to the elevator deflection. This control law and the configuration aerodynamics are then supplied to the NASA computer program ACMOTAN. This program calculates the characteristic equation roots, transfer functions, and time solutions for the perturbed forward speed, angle of attack, pitch rate, pitch angle, elevator deflection, and any combination of the above variables, such as cockpit vertical acceleration. The time histories are then evaluated as the filter and limiter parameters are numerically changed.

Early results indicate that the washout filter does indeed introduce monotonic stick forces since the time responses approach steady state values after an elevator step command much like a conventional aircraft does. Also, the combination of a washout filter and a lead/lag filter can both introduce monotonic stick forces and increase the initial responses. The filter parameters can be varied to shape the time responses for improved handling qualities. The prefilters and limiters are still under investigation at this time.

DISTRIBUTED STRUCTURAL OPTIMIZATION PROGRAMS
OVER A NETWORK OF MICROCOMPUTERS

by

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SUMMARY

In the past years, numerous efforts have been concentrated in the development of structural analysis code (refs. 1 and 2). Some preliminary results in the development of structural synthesis code, however, have been recently presented in the literature (ref. 3).

In an attempt to speed up the solution process, efforts are undertaken to use substructuring formulation for both the analysis (to obtain nodal displacements and element stresses of the finite element model) and design sensitivity analysis on a network of microcomputers.

The problem treated here is to choose a design variable vector $b \in R^k$ to minimize the objective function

$$J = J(b, Z_B, Z_I) \quad (1)$$

where $Z \in R^n$ is a nodal displacement vector, subscripts B and I indicate boundary and interior quantities, respectively, and subjected to the following constraints:

Equilibrium equations from the finite element model

$$\begin{bmatrix} K_{BB} & K_{BI} \\ K_{IB} & K_{II} \end{bmatrix} \begin{bmatrix} Z_B \\ Z_I \end{bmatrix} = \begin{bmatrix} S_B \\ S_I \end{bmatrix} \quad (2)$$

where K is the structural stiffness matrix and S is the equivalent nodal loads.

Stress and displacement constraints

$$\phi^s(b, Z_B, Z_I) < 0 \quad (3)$$

Lower and upper bounds on design variables

$$\phi^d(b) < 0 \quad (4)$$

STATIC ANALYSIS: Very briefly, the interior displacements are eliminated from the second half of equation (2), the results are substituted back into the first half of equation (2), thus

$$Z_I = K_{II}^{-1}(S_I - K_{IB}Z_B) \quad (5)$$

$$K_B Z_B = F_B \quad (6)$$

where

$$K_B = K_{BB} - K_{BI}K_{II}^{-1}K_{IB} \quad (7)$$

$$F_B = S_B - K_{BI}K_{II}^{-1}S_I$$

It should be noted that the effective boundary stiffness matrix K_B and the effective boundary force can be obtained from the contribution of all substructures. Interior displacements for each substructure can be found from equation (5) and element stress can be obtained by a familiar finite element procedure.

DESIGN SENSITIVITY ANALYSIS: Very briefly, let $\psi(b, Z_B, Z_I)$ be a general function that may represent the cost or any constraint function. The first order change in the function ψ due to small changes in the design variable vector δb is given as

$$\delta_\psi = \frac{\partial \psi}{\partial b} \delta b + \frac{\partial \psi}{\partial Z_B} \delta Z_B + \frac{\partial \psi}{\partial Z_I} \delta Z_I \quad (8)$$

By taking the first variation of the equilibrium equation (2), equation (8) can be transformed into the form (refs. 4 and 5)

$$\delta_{\psi} = G^T \delta b \quad (9)$$

where G is called the sensitivity vector and is given as (ref. 5)

$$G = \frac{\partial \psi^T}{\partial b} + C_2^T \lambda_I + C^T \lambda_B \quad (10)$$

and

$$\lambda_I = K_{II}^{-1} \frac{\partial \psi^T}{\partial Z_I} \quad (11)$$

$$C_1 = \frac{-\partial}{\partial b} (K_{BB} Z_B) - \frac{\partial}{\partial b} (K_{BI} Z_I) \quad (12)$$

$$C_2 = \frac{-\partial}{\partial b} (K_{IB} Z_B) - \frac{\partial}{\partial b} (K_{II} Z_I) \quad (13)$$

$$C = C_1 + Q^T C_2 \quad (14)$$

$$Q = -K_{II}^{-1} K_{IB} \quad (15)$$

$$\lambda_B = K_B^{-1} \left(\frac{\partial \psi^T}{\partial Z_B} + Q^T \frac{\partial \psi^T}{\partial Z_I} \right) \quad (16)$$

Once the cost, constraint functions and their gradients are known, any gradient based optimization method (such as the GRadient Projection algorithm, GRP) can be used to obtain the improved design.

DISTRIBUTED STRUCTURAL SYNTHESIS PROGRAMS: Data are passed between the control program and the substructure programs using a 20 MB hard disk. Three files on the hard disk (AVAIL1, AVAIL2, AVAIL3) are used to determine when the substructure programs have finished executing and the controller should take over and vice-versa. When a program is not doing analysis, it performs a multiplication in a DO loop to act as a pause. When the DO loop terminates, the AVAIL files are read to see if analysis should begin, if not, the multiplication DO loop begins again.

In the first phase of the study, we'll concentrate in having a distributed finite element analysis and sensitivity analysis, with centralized optimization. A flowchart of the proposed scheme is shown in Figure 1. If we are successful in completing this phase, we can look at adding the optimization back at the substructure level.

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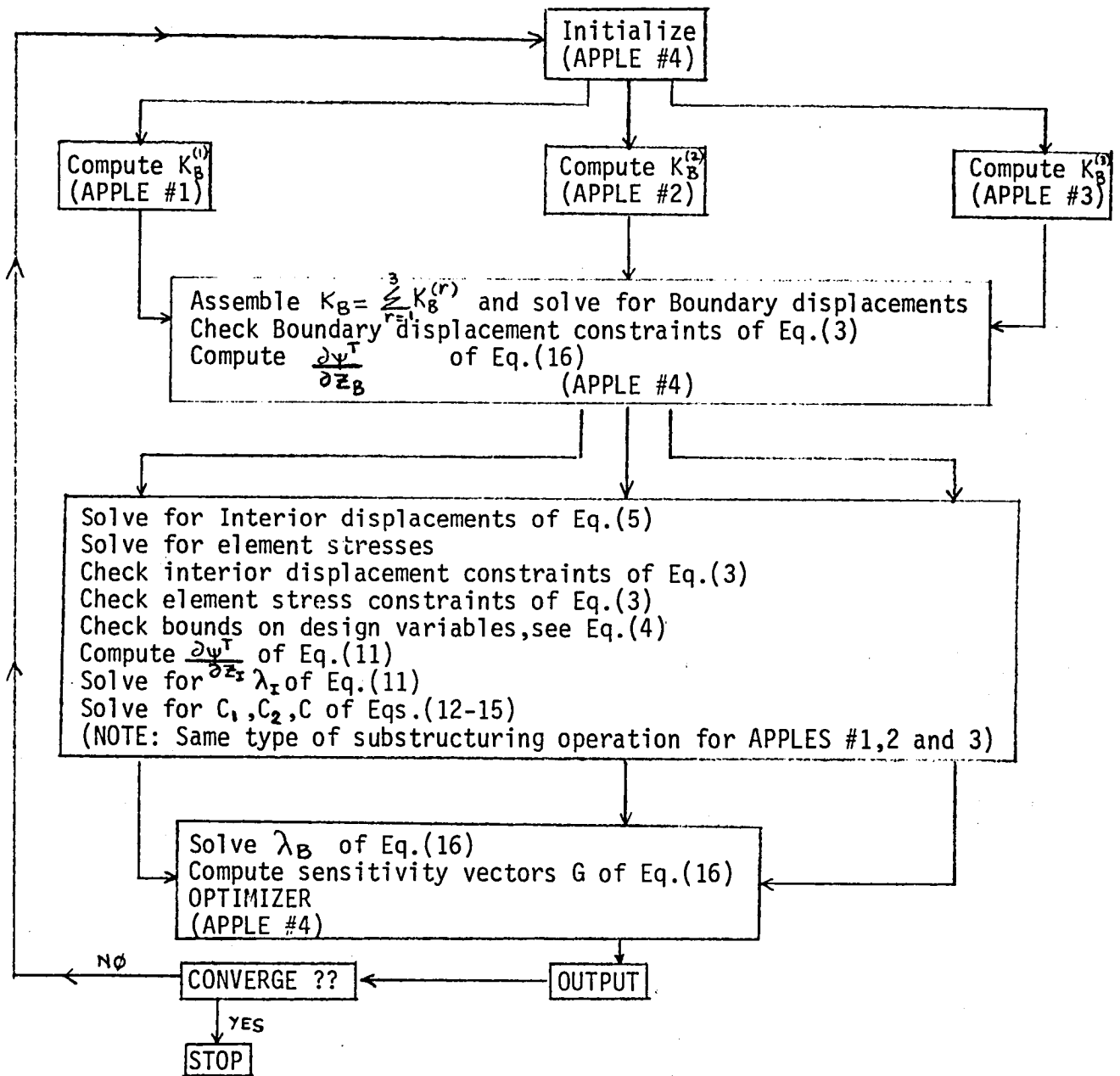


Figure 1. Flowchart of distributed structural synthesis programs.



SYSTEM SAFETY AT NASA

by

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As the 1970's were approaching, industry and government perceived that even more money could be saved by building safety into any "SYSTEM" from the very beginning. Instead of making the "SYSTEM" go faster, further, or higher and then modifying it IF safety problems developed, a "SYSTEM SAFETY" concept would force the research engineer, contractor, manufacturer, or user to consider safety at each step along the way; correction "before the fact" is better economically than "after the fact." "System Safety Hazard Analyses and Risk Assessments" should be applied from the conceptual phase, through development and testing, to system retirement; in other words, throughout the life cycle of a system.

This led NASA, in March 1970, to adopt a new Basic Safety Manual (NASA Handbook 1700.1) which incorporated "SYSTEM SAFETY" concepts into their established safety program.

"Each NASA program and project is required to ensure that its hazards are identified, and that adequate measures are taken to eliminate or control these hazards."

Objectively, NASA wants to ensure that reasonable safety measures will be designed into all systems and subsystems; this approach also incorporates cost factors which may influence management's decision to halt the project or seek other alternatives.

The 1970 Basic Safety Manual was a bold, new approach. As time passed, NASA became aware the manual, although excellent in theory, was not so easy to use by project engineers. This eventually led to Boeing Services International, Inc. being selected (bidding) to update the basic manual, but most important was the task to provide adequate guidance (i.e., checklists) for project engineers on HOW, WHERE, WHAT methods and techniques should be used.

In the interim, until the new manual is completed (est. 1985), the LaRC Flight Research Section wanted to adopt interim procedures for use by project engineers they worked with; this was one of the projects this ASEE Fellow worked on. A "qualitative" System Safety Hazard Analysis and Risk Assessment checklist, with descriptive explanation, was developed. It incorporated a Preliminary Hazard Analysis, and a multiple-use form for Subsystem, System, plus Operating and Support Analyses. An integral part of each analysis is a section on "risk assessment;" by considering "hazard severity" in conjunction

with "probability of occurrence," a "risk priority code" can be reasonably determined which will assist management to:

1. Suppress the risk to a lower level prior to using the system.
2. Operate the system on a restricted basis, i.e., on a waiver by special permission of an authoritative source.
3. Operate without restriction.

Without going into a lot of detail, the reader should be aware that the several analyses have applicability at different places in the life cycle of a system. For example, the Preliminary Hazard Analysis is done very early, often during conceptual planning; the purpose is to recognize major hazards and the accompanying system applications in a "gross sense," and to facilitate use of the safety evaluations in future trade-off studies and/or as a basis in establishing framework for later analyses. The Subsystem Hazard Analysis is done after the Preliminary and prior to, in conjunction with, the System Hazard Analysis; this analysis should closely examine the "components" of each subsystem to determine which hazards might occur IF the component fails. The System Hazard Analysis is performed during "system definition" and the early part of "engineering design development;" it is important to identify "interface" considerations between system elements (that might create hazards), plus the result of failure or improper operation, in respect to the "system function" being examined. The Operation and Support Hazard Analysis has more to do with hazards resulting from how the system might be used and not necessarily as a result of possible component failure or human error.

Although the checklist proposed was qualitative in nature, the reader should be cognizant that there are many other qualitative and quantitative techniques which might be utilized in Hazard Analysis and Risk Assessment; a few examples are Fault Tree Analysis, Sneak Circuit Analysis, plus Failure Mode and Effects Analysis. Which approach is taken depends on the complexity of the system, the experience of the individual, funds available, etc. With most projects/ systems, once hazards are reasonably identified, management must correct the hazard or decide how much risk will be acceptable to take, and as a last resort, abort the project IF it is not economically feasible to continue. It should be noted this decision can be made at ANY POINT in the life cycle of the system. Likewise, in keeping with this philosophy, when the new NHB 1700.1 is adopted, the Flight Research Section should review the checklist for currency and possible revision.

THE DESIGN OF A PILOT INTERFACE FOR TRANSPORT AIRCRAFT SUBSYSTEMS

by

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This project was conducted under the sponsorship of the Cockpit Systems Branch at the NASA Langley Research Center. One of the research objectives of this branch is to provide advanced enabling technologies and design methodologies to such areas as display components/subsystems and pilot input/output interfaces. These research systems are usually implemented on the branch's Advanced Display Evaluation Cockpit (ADEC) and are evaluated by NASA research pilots. The ADEC utilizes the VAX-11/780 as a host computer, and the Fortran supported Adage 3000 as a color graphics raster scan generator. The present configuration of the ADEC system only displays the Electronic Attitude Direction Indicator (EADI) and an Electronic Horizontal Situation Indicator (EHSI).

The ADEC system lacks displays indicating throttle position, engine power (EPR) and subsystems. Current literature suggests that the number of controls/switches in future transport aircraft will rapidly increase while the number of displays/meters will remain constant. The first phase of this project had the objective of establishing a baseline for transport aircraft subsystems. The baseline was established by reviewing the Lockheed's advanced concepts flight station, the on-line Boeing 767 aircraft and the newly proposed Gulfstream IV Jet Transport by Gulfstream Aerospace Corporation. The finished project consisted of the implementation of an advanced interactive control/display interface for monitoring engine/subsystems through the development of a debugged Fortran program that displays throttle position, EPR color indicators, automated advisory caution and warning system, automatic subsystems scanning mode, etc. In order to reverse the trend of increasing number of controls/switches in future aircraft, the project was designed around a programmable display push-button device to be used as a multifunction display/switch. The software program also reflects two displays modifications suggested by a NASA research pilot.

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ENGINEERING DATA MANAGEMENT TECHNOLOGY

by

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Introduction

This summary describes a broad plan designed to respond to the need for an established program of research in engineering and scientific data acquisition, representation, management, use, and generation. Research in this area is currently being conducted at only a few engineering schools nationwide. However, engineering and scientific data management, combining concepts of artificial intelligence with data representation, requires increasing attention as the amount and complexity of information necessary for performing engineering operations increases and the need to coordinate its acquisition and use increases. This area of research promises advantages for a wide variety of engineering application, particularly those which seek to use data in new and innovative ways in the engineering process. Such areas include graphics and computer-aided design which depend on the underlying data base representation of geometric data and extend to expert systems which depend on the representation of data in the form of "expert" design knowledge.

The Representation of Analytical Data - Data Base Management System Research

The decade of the 80's will see a major trend towards the integration of individual, stand-alone engineering analysis and design application programs into comprehensive, user-friendly, multi-component design systems. Engineering design data bases are viewed as the primary integration mechanism between the various design and manufacturing processes. These, in combination with data base management systems (DBMS) and executive controllers, are essential for achieving truly integrated, generative computer-aided design systems. A multi-faceted DBMS research program of the highest scientific quality can result in the developments necessary to enable these systems to emerge.

Although data bases originated as passive repositories of data, recent research efforts enhanced their capabilities by enabling them to rigorously perform integrity and consistency checking in accordance with defined constraints. Subsequent research extended the role of the data base further by utilizing constraints to enable the data base to automatically generate limited amounts of data. The research program suggested here seeks further extensions to obtain a DBMS environment that accurately represents an entity, design, or process, permits intelligent external interaction, ensures

integrity and consistency through the evaluation and satisfaction of engineering constraints, and actively contributes to its own evolution by generatively increasing its data content. Specific research objectives of immediate concern involve communication between an internal data representation scheme and the external environment. Such communication must occur through the use of application program interfaces, graphic and alphanumeric problem-oriented query languages, and automated data acquisition mechanisms to obtain data from both designers and sensors. The influences of developments in this area are expected to far-reaching; borrowing from and contributing to research efforts in constraint formulation, geometric modeling, codes and specifications, applications program interfacing, and DBMS technology. Yet significant progress toward the achievement of these objectives is a realistic goal and one that is necessary to solve the current problems that are inhibiting industrial organizations from developing and most effectively using large-scale, broad-scope design systems.

The Representation of Heuristic Data - Expert System Research

Knowledge-based expert systems (KBES), providing program problem-solving capabilities comparable to that of a human expert in a particular problem domain, have emerged. A number of successful applications have been developed that demonstrate their feasibility and utility. The range of expert system applications extends from interpretive problems where reasoning about the problem is required in light of the knowledge available in that problem's domain to generative problems where potential solutions are generated and tested against candidate solution defined by sets of constraints. KBES's use expert knowledge and expert methods to conceptualize and reason for the purpose of deriving decisions and inferences from which problem solutions are obtained.

Knowledge-based expert systems are presently moving from the research environment where they were developed to production environments. One potential scenario for the transition is that they act as new stand-alone tools for engineering use. Another is that engineering capabilities be built into them. A more desirable transition, however, dictates that they possess the extensions necessary to enable them to successfully fit within the traditional engineering design and manufacturing environment. In particular, they must be incorporated as an integral component into a comprehensive engineering design and manufacturing computer-based system.

To achieve the greatest utility from KBES's, through their use as components of a larger system, requires research on system component configurations and the problems inherent in building and using such a configured environment as an automated engineering assistant. KBES interfaces are of particular concern. The interfaces must tie KBES's to existing engineering software, data base management systems graphical displays and graphics software, and sensors. They must also tie KBES's to designers through user interfaces and knowledge and data acquisition modules. Although research is proceeding to build these capabilities into expert systems, such efforts have limited

utility from the perspective of an integrated engineering computing environment. This study seeks to investigate external KBES interfaces to determine ways to successfully integrate KBES's into an environment supporting engineering design, manufacturing, control, and production.

The flow of engineering and scientific analytical data among CAD system components has been investigated and is well understood. But to achieve the objectives proposed here will require a new form of flow analysis. It will require an investigation of the analytical problem solving process as a collection of subprocesses at a "quanta" level for common use in data bases, expert systems, and multicomputer architectures. In addition, the use of myriad of engineering constraints on analytical data and constraint handling capabilities is also of concern. On the other hand the form, content, and characteristics of heuristic and logical data also mandate new thinking with regard to information flow. In both cases the information flow, the interface pipeline through which it will pass, and the configuration on an engineering system supporting KBES's is proposed here.

Summary

The developments outlined in these two areas of investigation make a significant contribution to the formulation of a program of research in the representation, management, and use of data in an expert context in engineering processes; a program which addresses issues of concern to industry and which has strong potential for success. The results of these research programs will directly contribute to our understanding of the use of information analysis methodology, decision logic theory, and data base theory for representing engineering data and to the development of an environment of communication among a linkage of diverse CAD system components. The results are expected to lead to the development of expert systems that enhance monitoring and control of the engineering process and improve data management efficiency while providing up-to-date information in a variety of forms to those who need it, allowing them to respond quickly to changes in anticipated patterns. As a result, these research programs will be of particular interest to those individuals and organizations who develop comprehensive integrated application software and data bases.

The research proposed herein will require a dedicated effort that utilizes many resources. It is expected to be formally proposed as a joint effort. The results of the research will be disseminated through conference presentations, publication of articles in scientific and engineering journals, and by incorporation into data base, expert system, and computer-aided design courses at North Carolina State University. The use of state-of-the-art DBMS and KBES software in these courses is also anticipated to stem directly from the research, thereby enhancing the foundations of NCSU's educational as well as research program in these areas.



TOWARDS IDENTIFICATION OF ERROR IN NONLINEAR FINITE ELEMENT ANALYSES

by

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The Finite Element Method has provided a versatile and effective technique for the solution of problems in applied solid mechanics. A limitation of the technique, especially for nonlinear problems such as those of particular concern in this project, is the difficulty of estimating the error in any specified calculation. While it is possible to extrapolate results for increasing refinements of grid and basis functions, alternative approaches seek to provide either greater generality, enhanced computational efficiency, or both.

For substructures that correspond to plates and shells in the circumstances of substantial deformation that concern us, there exist coupled systems of nonlinear partial differential equations that can be solved iteratively by "Newton's method." The work of this summer's project has been to continue development of a post-processor that would transform finite element data available at discrete points to continuous functions that were sufficiently faithful to the underlying data and its derivatives to allow solution by Newton's method.

Specifically, such a treatment of the equilibrium equations for the in-plane displacements was required. We consider these equations in the form

$$A_{11}u_{,xx} + A_{66}u_{,yy} + (A_{12} + A_{66})v_{,xy} = N_1(w,w)$$

$$(A_{12} + A_{66})u_{,xy} + A_{66}v_{,xx} + A_{22}v_{,yy} = N_2(w,w)$$

where u and v are displacements along the x and y axes, respectively, literal subscripts denote partial differentiations, and the coefficients A_{ij} are usual symbols for various extensional and shear stiffnesses. The functions N_1 and N_2 are sums of products of these stiffnesses and third-order products of derivatives of the transverse deflections w , that arise from consideration of geometric nonlinearity.

The particular solution of these equations corresponding to a Fourier expansion of the transverse deflection terms was found. It was verified that back-substitution of the solution led to calculations of N_1 and N_2 that were accurate to within an additive constant. A calculation was provided to

determine the translations and rotation of a rigid body that best fit edge values for finite element data, and the uniform extensional and shear strains that best fit finite element data for stress resultants.

Displacements corresponding to such translations, rotations, and strains correspond to solutions of the homogeneous parts of the equation displayed above, and these solutions as well as the particular solutions were subtracted from the finite element data before collocating the residual data on the boundaries with linear combinations of sine and cosine product solutions of the homogeneous system. The sums of these linear combinations, the solutions describing uniform strains and rigid-body displacements, and the particular solutions, for each of u and v respectively, correspond to a solution of the system of equations above that is identical to the available finite element data for u and v on the boundary.

The analysis and coding of the solutions to the homogeneous system has provided a solution to the linear problem of in-plane deflections in the displacement formulation. Furthermore, as these solutions were being developed, it was discovered that the two types of laminate systems of orthotropic materials, distinguished by real and complex forms of a certain function of the extensional stiffnesses that appears in those solutions, were not the same two classes as distinguished by the corresponding behavior of the function of the bending stiffnesses that applies to the transverse equation that had been treated earlier. In the case of the in-plane equations, the behavior is distinguished by the magnitude of

$$\frac{A_{11}A_{22} = A_{12}(A_{12} + 2A_{66})}{2A_{66}(A_{11}A_{22})^{1/2}}$$

relative to the value corresponding to isotropic systems, of 1, and in the case of bending stiffnesses, of the magnitude of

$$\frac{D_{12} + 2D_{66}}{(D_{11}D_{22})^{1/2}}$$

relative to 1 as well. These quantities have proven helpful in correlations of nonlinear effects in orthotropic systems previously. Further investigation as to whether there may be any significance to this observation outside the context of the coding of these solutions is proceeding.

Work on the problem has generated over 1500 lines of FORTRAN code, written in a modular and structured way. Included are output routines that may prove more generally useful for displaying large arrays of various kinds in convenient forms for inspection.

POSITION CONTROL OF FLEXIBLE BEAM USING STATE FEEDBACK

by

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The ability to control flexible structures in space is fast becoming a skill needed by NASA engineers. Slewing maneuvers for a wide variety of appendages of the space station are but one of the applications of this needed control. The work I performed this summer in the Structural Dynamics Branch (NASA-LaRC) has been directed toward this class of applications. I have attempted to solve a generic problem in the control of flexible structures: the position control of a beam cantilevered on the end of a rotary actuator.

I have taken the approach of: developing mathematical models for the components involved (beams, actuators, and sensors); deriving the needed state feedback coefficients (assuming the sensors do not measure any rate-dependant variables); simulating the controlled and uncontrolled system response using the SDB EAI 2000 analog-hybrid computer; and, finally, testing the control state feedback scheme in the laboratory using an available actuator and two beams made of thin sheet metal. The beams used have first (cantilever) mode frequencies of 1.3 Hz and 0.56 Hz.

I derived a mathematical model for the beams by applying Lagrange's equation to the potential energy and kinetic energy of the beam continuum which were derived from a three-term Ritz approximation of the beam displacement field. The spatial functions chosen for the Ritz approximation are the first three natural mode shapes of a clamped-free beam. The electric motor used to apply torque to the beam root was modeled as a torque source with significant back emf and significant inertia (the inertia was significant once the effect of the motor's 941:1 gear ratio was included). The time constant of the armature circuit (with a break frequency of approximately 400 r/s) was neglected. The amplifier used to drive the motor was modeled as having a fast response with saturation (at plus and minus 27 vdc).

I used the EAI 2000 to perform the state feedback control in real time on the beams in the laboratory. The initial tests (performed as of this writing with 2 weeks left in my fellowship period) show good control of the beam. With measurements of the root strain (the beams have instrumentation for measuring strain at two other places) and motor angular position, the step responses of the beam-motor system have been slightly underdamped with a slewing time for approximately 90° of motion being close to 2 seconds. With the addition of an estimate of the motor velocity in the feedback the beam root strain and the motor position have an overdamped response to step inputs in the reference position input with only a small increase in the slewing time.

I have demonstrated that the state feedback approach can be successfully applied to a flexible beam positioning problem. Further work to be carried out will be using other actuators and more stringent constraints on the system.

INTERACTION OF NEUTRINOS AND ANTINEUTRINOS WITH STRUCTURAL POLYMERS

by

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For the last few years NASA has been interested in large space structures and long duration missions in future Earth-orbital space flights. The choice of the materials for these space structures is dependent on the structural properties, radiation durability, and minimum weight penalty. From the radiation durability point of view it is desirable to study the interaction of selected structural materials with the charged and neutral particles encountered in space. Though the interaction of charged particles with structural materials continues to be the subject of numerous investigations, the interaction with the neutral particles like the neutrinos and antineutrinos has never been investigated. We have undertaken such a study.

Following the Weinberg-Salam model, a formula for the $\bar{\nu}_e$ -e scattering is worked out and is used to calculate the stopping power ($-dE/ds$) of $\bar{\nu}_e$ in matter. It is found that for electron antineutrinos

$$\begin{aligned}
 -\frac{dE_{\nu}}{ds} = N \frac{G^2 m_e}{2\pi} & \left(\frac{8P_e(t) \sin^2 \theta_w + \cos^2 2\theta_w}{E_{\nu}^2} \left(\frac{Q_m^4 - \eta^4}{4} \right) \right. \\
 & + \left\{ \frac{m_e \sin^2 \theta_w}{E_{\nu}} [4 \cos^2 \theta_w - P_e(t)] - 16P_e(t) \sin^2 \theta_w \right. \\
 & \left. \left. - 2 \cos^2 \theta_w \right\} \left(\frac{Q_m^3 - \eta^3}{3E_{\nu}} \right) + [4 \sin^4 \theta_w + 8P_e(t) \sin^2 \theta_w \right. \\
 & \left. \left. + \cos^2 \theta_w \right] \left(\frac{Q_m^2 - \eta^2}{2} \right) \right),
 \end{aligned}$$

where Q is the recoil energy of the electron, N is the electron density, E_{ν} is the antineutrino energy, $\sin^2 \theta_w = 0.224$, $(G^2 m_e / 2\pi) = 4.1 \times 10^{-45}$ cm²/MeV, η is the average ionization energy, $P_e(t)$ is the probability of the electron/antineutrino to preserve its identity at a time t , and Q_m is the maximum energy transferred to the electron.

A similar formula has been worked out for the electron neutrinos. These formulas are now being applied to calculate the energy losses in polymers and the results will be soon published.

COMMANDS FOR COOPERATING ROBOT ARMS

by

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The Automation Technology Branch of NASA Langley Research Center has designed a Distributed Artificial Intelligent System for Interacting with the Environment (DAISIE) (see ref. 1 for details). One component of this system consists of two PUMA 600 manipulators with their individual LSI 11/2 controllers which can be interfaced with a VAX/750 via a communication network (RTNET). The servo-mechanism for moving each joint of the PUMA is controlled by a micro-processor and all six of the joint controlling microprocessors are supervised by the LSI 11/2 controller. Currently, one arm is equipped with a surface adapting vacuum gripping end effector (SAVG) and the other with a parallel jaw gripping end effector (PJG).

Most of the current robot arms perform their work using only the position control commands without any feedback sensor information. The vacuum gripping end effector provides two sensory signals: (1) when the end effector has made physical contact with a desired object; and (2) when the vacuum has succeeded in holding an object. These two sensory inputs can be used to initiate and terminate motions. The parallel jaw end effector is equipped with various feedback sensors, but I did not have any opportunity to work with it at this time.

I investigated, without modifying any commands, the existing implementation of the basic commands for the arm on DAISIE with the vacuum end effector. This set of commands for the arm was cleverly designed for the sequential control of the arm manipulator. I successfully implemented various task level commands, e.g., PICKUP (object) and PLACE (position), for the "white" PUMA equipped with the vacuum end effector. Moreover, the program can choose alternate actions on the basis of its sensor data. Two desirable features were found missing. The commands were designed to be given one after another. If more than one command is pending to the same arm, it is hard to determine which command was completed and when. If two commands are simultaneously given to the two arms and one command has been carried out, there does not exist any mechanism for the program to determine which arm is still carrying out its order. If one arm is given a move command and repeated inquiry is made about its position and then depending on this information either the speed is changed or an end effector command is given, the situation becomes hopeless. Thus it will be necessary to modify the current commands so that the user can find out which commands have been carried out. A record has to be made available so that the program can find out the status of all pending commands. That is, a means for tagging each command has to be implemented. If at all possible, a delay command based on a clock would be useful.

Background Information For The Next Phase:

Robot level programming can be done on DAISIE by means of a package written in LISP which can issue basic commands to the manipulators. In robot level programming the user writes a computer program specifying in complete detail the basic commands for motion and sensing. In task level programming the user merely specifies the final target for the positions of objects, rather than a sequence of basic commands for the motion of the manipulator required to achieve the goals.

Task Level Programming:

Consider the task of inserting a cylindrical rod into a round hole. We would like to give a task level command "insert rod into the hole." To be able to carry out this task conveniently we need a world model. The world model must have the position and the shape of the hole, the size of the hole, the position, shape and the size of the rod, and how the end effector must hold the rod, i.e., it must not hold it across the flat ends and that either end is allowed. Since the rod has circular cross section any rotation along the axis should not make any difference. The world model has to be able to specify the approach and insertion strategy for successful insertion.

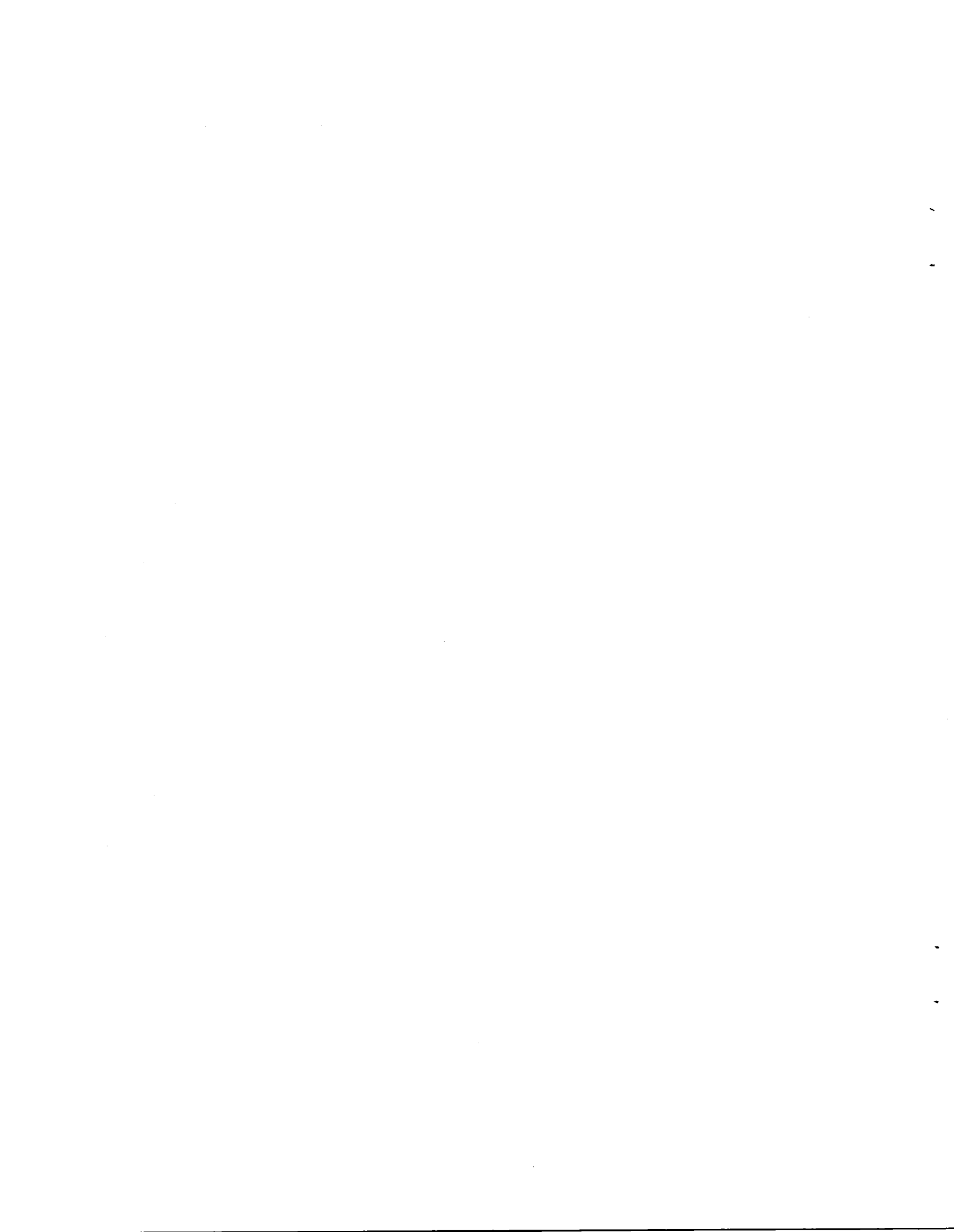
Next consider the simple task of stacking blocks one on top of the other in certain order and orientation knowing their present location and orientation. Two arms would be required for this task in those cases when not all the blocks could be reached by a single arm. Only one arm can be in the work area to avoid collision. The arms must be able to tell each other when they have completed a subtask or when the other arm should start its work. A more complicated task requiring two arms is threading a wire through the eye of a needle. Notice that in this case, both arms must be in the work area and further information is required so that the two arms can coordinate their moves. I have started implementing a world modelling system based on the concept of frames (see ref. 2). Frames are essentially three level trees with uniform structure at each level. They provide a powerful and versatile tool for managing information about the world model.

The plan is to implement all the default actions normally needed to be invoked when the data base is updated or accessed. Most of the error recovery would be invoked by the data base and task itself will be directed by it. Thus for the PICKUP (object) command all the information about the object will be stored in the frames and suitable error recovery functions will automatically be invoked when the move subcommand of the PICKUP command is issued. This approach is made attractive because we can exploit the concept of "demons" in frames.

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VAPOR SCREEN FLOW VISUALIZATION EXPERIMENT IN THE 0.3-METER
TRANSONIC CRYOGENIC TUNNEL

by

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The National Transonic Facility will presumably be given operational status within a few months. At that time, experimenters are expected to routinely list among their test requirements the capability of visualizing surface and free-stream flow fields. In order to satisfy such requirements, a timely, intensive and comprehensive experimental study of candidate flow visualization techniques is appropriate. One such technique, vapor screening, has been examined in the present experiment.

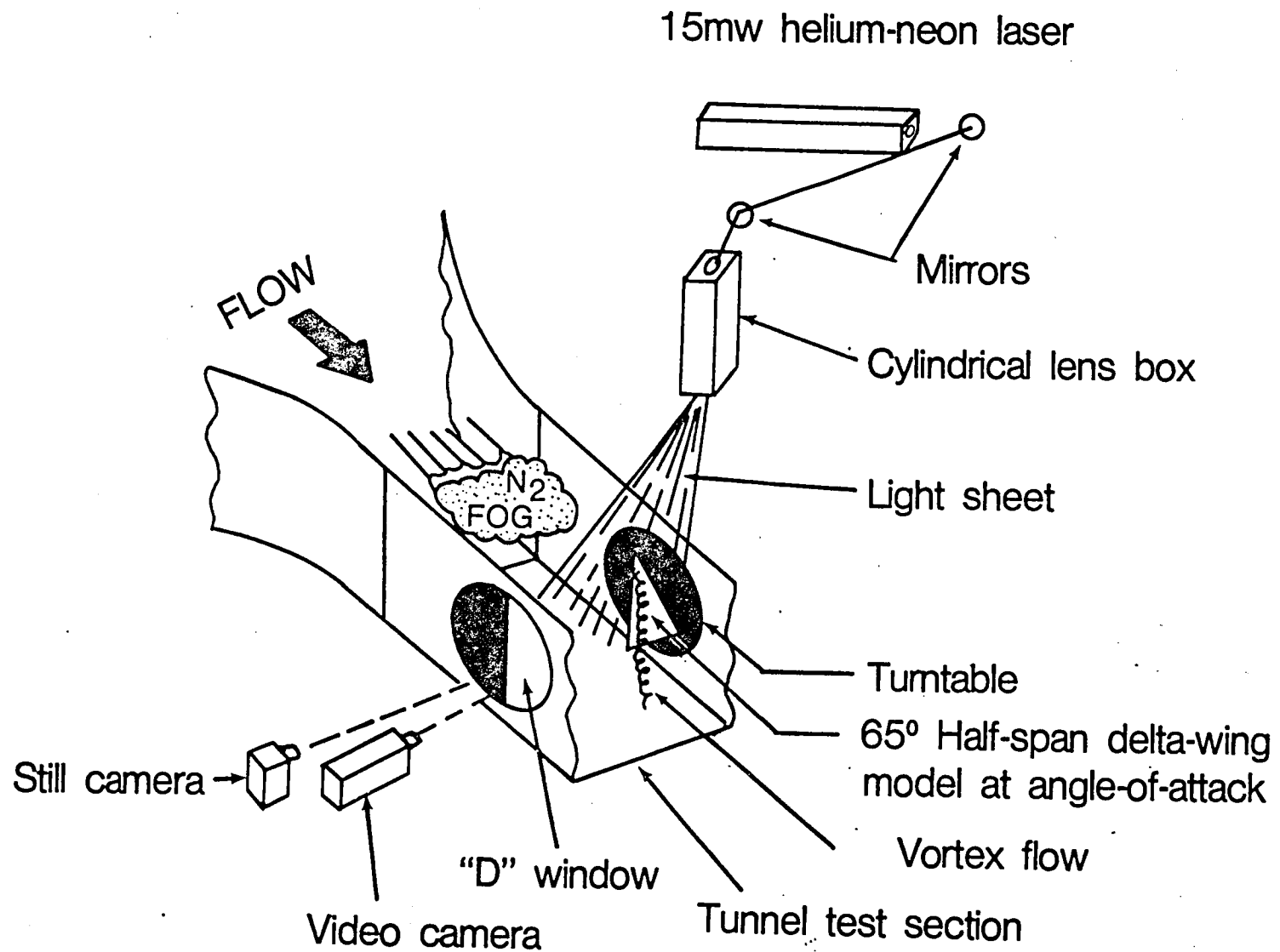
Understandably, only a few formal flow visualization studies have been performed in a cryogenic environment. Various experimenters have examined liquid and gaseous surface indicators and have used optical methods to visualize cryogenic flow fields. To the present author's knowledge, cryogenic flow visualization has not previously been attempted using the vapor screen technique.

The vapor screen technique was used to visualize the flow over a 65° half-span delta-wing model which was tested at several angles of attack. The delta-wing model was mounted on a turntable in the test section in order to accomplish variations in the angle of attack. Fog was generated in the test section by running the tunnel near the free-stream saturation temperature. The density of the fog was varied (by varying free-stream temperature) in an effort to produce an optimum density. The flow was illuminated by an intense sheet of light from a 15-mW helium-neon laser provided by the Instrument Research Division. Personnel from the Instrument Research Division designed the illumination system shown in the figure. Video and still cameras, used to record the visualized flow field, were mounted inside a pod which was attached to one side of the test section. The swept (with respect to the tunnel walls) vertical light sheet (light source mounted on top tunnel wall) facilitated visualization of the three-dimensional vortical flow structure on the leeward side of the model.

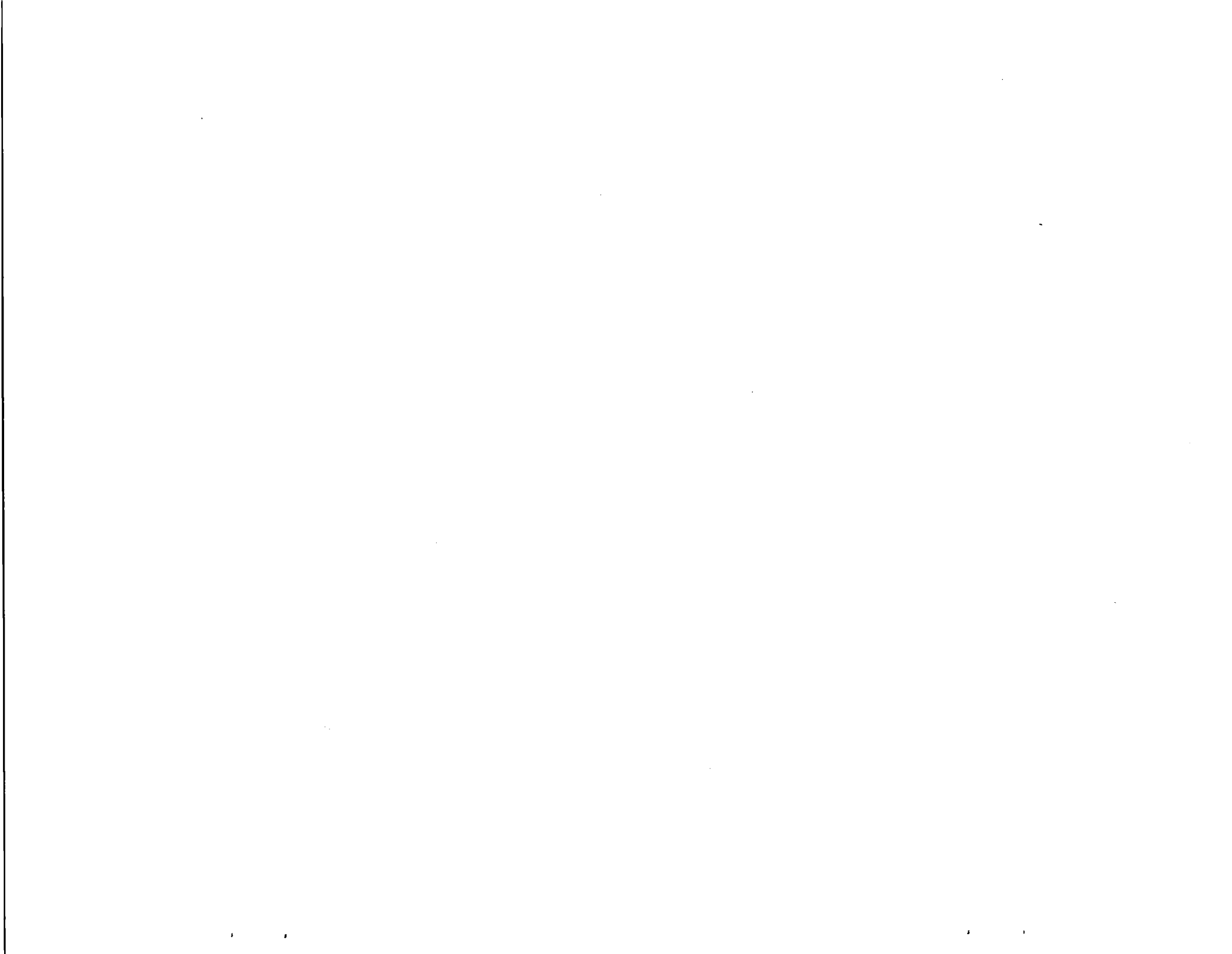
The vortical flow on the leeward side of the delta-wing model was visualized at several different tunnel conditions. Mach number was varied from 0.4 to 0.8; total pressure was varied from 1.3 to 5.0 atmospheres; total temperature was varied from 83 to 101 K and angle of attack was varied from 13° to 30°. Flow conditions for photographically suitable vapor screens were defined at a Mach number of 0.6 and total pressure of 1.3 atmospheres in terms of total temperature and angle of attack. Excellent photographs of the visualized flow

were presumably obtained at Mach numbers of 0.5 and greater. (Photographs are presently being printed.) It was not possible to visualize the flow at a Mach number of 0.4 because optimum thermal conditions were not reached before the operating safety limit was approached.

It has been demonstrated that the vapor screen technique can be used to visualize flow in a cryogenic tunnel.



Schematic of Illumination System Used in Vapor Screen Experiments



APPLICATIONS OF MICROPROGRAMMING CONCEPT
TO THE IKONAS GRAPHICS SYSTEM

by

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Microprogramming was first proposed as an alternative method for implementing machine language instructions. However, with development of hardware technology namely the writable control stores and user programmable machines, applications of microprogramming are becoming more popular in the computing society, especially for those demand speed and flexibility for special applications. These include: (1) machine emulation, (2) program enhancement, (3) high level language direct execution, (4) operating system implementation, (5) fault tolerant system, and (6) graphics applications.

In a graphics system, pictures are transformed, rotated, projected, clipped, etc. These graphics operations are quite different from those of a general purpose machine. For a complex display, these manipulations often require significant computation time which is critical in real time applications such as flight simulation of cockpit display where fast response and high updating rate are essential to the viability of the program. Therefore, microprogramming has been utilized to facilitate the realization of graphics system in the aspect of developing graphics primitives, and fine tuning the machine to this special application in addition to the reducing of overhead involved in graphics processing.

The IKONAS RDS-3000 is a microprocessor based graphics display system. The heart of the system is a BPS32 microprocessor which is implemented by an AM2903 bipolar bit slice processor, and an AM2911 bit slice microprogram sequencer. The microcode word length is 64 bits and is a horizontal type microinstruction which allows parallel execution of more than one operation. The system supports more than 20 IDL instructions which are microcode implemented graphics primitives. One of the current needs is to implement a polygon clipping routine to use with the "polygon fill" operation for displaying runway in flight simulation. The IDL2 clipping routine (VCLIP) is a perspective clipping routine where clipping is done against a 3-D canonical viewing volume. This routine was implemented by clipping each line segment against six planes of a canonical volume. Trivial acceptance and trivial reject are employed when the line was completely inside or outside the boundary, and intersection was computed if the line crossed boundary. This algorithm works well except when the object defined by these line segments are partially lying outside and one (or more) line segment is completely outside boundary. To implement a different clipping routine which is called PCLIP, a polygon is defined in terms of its vertices and an algorithm developed by

Sutherland and Hodgman is used to clip the entire polygon against "each" clipping boundary in sequence. The similar approach was implemented in IDL2 language by Kahlbaum and was working well except that the routine required more computation time which slowed down the updating rate substantially. The approach here is to develop a fast, efficient microprogram implemented polygon clipping routine for real time flight simulation display system. At this stage, code implementation is completed and efforts are in progress to integrate this new instruction into the system. The improvement of performance over the IDL2 language implemented routine is expected to be at least 2 to 1, while typical improvement of a ratio of 5 to 1 is possible depending upon optimization.

Since NASA's application focuses on the speed of execution, there are several points to be mentioned about optimizing a microprogram. It is in general not an easy task, however the following can be seen as directions for the first step toward optimization: (1) identify the most critical and time consuming part of the algorithm, and try to optimize these parts as best as you can; (2) allocate the most frequently used variables and constants to registers or fast memory to minimize memory access; (3) detect all possible parallelism and overlapped operations to minimize the number of microinstructions; and (4) use good algorithm--under no circumstance, simply transforming a poor algorithm into microcode is not optimizing. A complete different algorithm may be needed for optimizing, since microprogramming provides degrees of parallelism and range of control which are not possible with most of the machine instructions and high level languages.

Microprogramming requires more efforts than either machine language or high level language programming; with microprogramming ability, one has the full control of the machine. However, a thorough knowledge of the architecture and resources of the system are essential in order to fully use this capability.

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DATA BASE DEVELOPMENT FOR FISCAL YEAR 1984

by

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The purpose of this task was twofold: (1) to extend the Business Data Systems Division (BDS) information to the University Affairs computer system, and (2) to develop an information and retrieval system which would serve the University Affairs Office.

BDS system runs on an IBM 4341 Model 2 computer and was fully compatible for downloading with the IBM PC-XT system in the University Affairs Office. Programs have been written which allow the routine downloading to information from the mainframe.

The nature of the queries to the University Affairs Office during the last 2-year period demonstrated a need for information which was not being captured and stored on the mainframe. Therefore, a system that anticipated projected data retrieval needs for all university programs managed at LaRC was developed. Total Information Management (TIM IV) software was used to create the data base into which the downloaded data was entered. Additional data was then loaded to satisfy the defined information needs.

Access to the data in the local (IBM PC-XT) data base is through the Selection and Report generation functions of TIM. Routine search programs were written and report formats defined. An instructional guide (specific how-to-directions) was prepared for the end users who may not be fully skilled in the total use of the software.

The following are examples of the kinds of data now available and retrievable for fiscal year 1984:

1. Number, type, objective and field of awards.
2. Principal investigators, NASA technical monitors and sponsoring directorate of each award.
3. Addresses and phone numbers of each institution.
4. Special programs such as HBCUs, JIAFS, graduate aeronautics programs and graduate researchers programs.
5. Number of graduate students sponsored by each award.
6. Start date, end date and modified end date.
7. Original dollar amount, cumulative amount and current FY obligation.

Summary of Findings

FY 84 Obligations by Directorate

<u>Directorate</u>	<u>Number of active awards</u>	<u>Number of FY 84 obligations</u>	<u>Amount obligated FY 84</u>
Structures	127	80	4,589 K
Electronics	109	62	3,790 K
Aeronautics	85	51	2,854 K
Space	74	39	2,476 K
Projects	25	12	766 K
Management Operations	12	5	138 K
Systems Engineering	3	2	84 K
Chief Scientist	<u>2</u>	<u>2</u>	<u>352 K</u>
Grand totals	436	252	15,049 K

COMPUTER SIMULATION OF RADIATION DAMAGE IN GaAs

by

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The theoretical understanding of radiation damage effects in solids requires a detailed analysis of the dependence of the number of point defects produced and their spatial distribution on the energy of the primary recoil atoms. These atoms, originally set into motion by interactions with incident electrons, protons, neutrons, or ions, dissipate their kinetic energies in a series of inelastic encounters with other atoms of the solid, displacing some of the atoms which will slow down by a similar series of collisions. The resulting cascade of displaced atoms and their accompanying vacancies are responsible for the changes which occur in the irradiated solid.

The object of this work was to simulate radiation damage in GaAs through the use of a computer radiation-damage simulation program called MARLOWE. This program was written by Mark T. Robinson of ORNL and Ian M. Torrens of The Center for Nuclear Studies in Saclay, France. The program required some modification in order to run on the computer system here at NASA LaRC and, due to the necessity of extra-large common blocks, it could only be run on the STAR.

To simulate radiation damage one must include as many aspects of the physical situation as possible in order to produce a fairly realistic picture of the displacement cascade production in the crystal. Atomic scattering is governed by the Molière atomic interaction potential. The Molière potential is given by

$$V(r) = \frac{z_1 z_2 e^2}{r} \times 0.35 \exp(0.30 \times r/b) + 0.55 \exp(-1.2 r/b) + F,$$
$$F = 0.1 \times \exp(-6.0 \times r/b),$$

where r is the interatomic separation and b is the screening length. Binary-collision approximation was used to construct the projectile trajectories. The Monte Carlo technique was used to generate the initial directions of the primary recoil atoms. Figure 1 is an illustration of a collision between a primary recoil atom and a target atom. The necessary calculations are performed by the computer to determine the energy transfer between the projectile and target and if energy obtained by the target is greater than the threshold displacement energy, the trajectories of projectile and target are determined. If the atoms involved in the collision process energies greater than some minimum value set by the programmer, the faster atom is followed and a search is performed to determine the location of the next target atom or atoms (simultaneous collisions) in the crystal.

The calculations are then repeated for this encounter. This process is repeated until the energies of the atoms in the cascade have decreased to the minimum value that has been set by the programmer. Figure 2 is an illustration of radiation-induced defects in a binary crystal such as GaAs.

Some preliminary results have been obtained with the simulation program. Several primary energies were picked between the values of 15 and 100 eV. One hundred cascades were generated for each energy picked. Figure 3 is a graph of the average number of defects produced per cascade versus the primary recoil energy. These results have been compared to results generated by a model developed here at NASA using a different approach and there is very good agreement.

Future plans will include generating a larger data base and modifying the program to use protons and electrons as the initial projectiles.

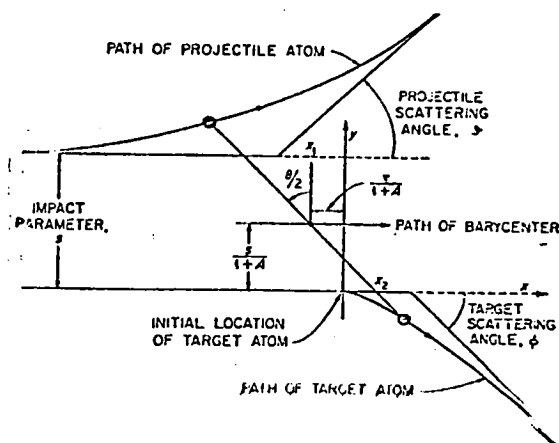


Figure 1.- L trajectories of two particles interacting according to a conservative central repulsive force. The positions of the particles and of the barycenter are shown at the apsis of the collision.

RADIATION INDUCED DEFECTS IN BINARY CRYSTALS

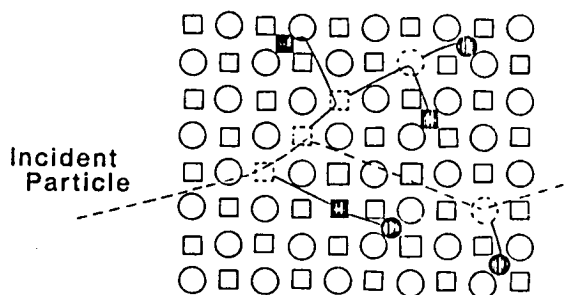


Figure 2

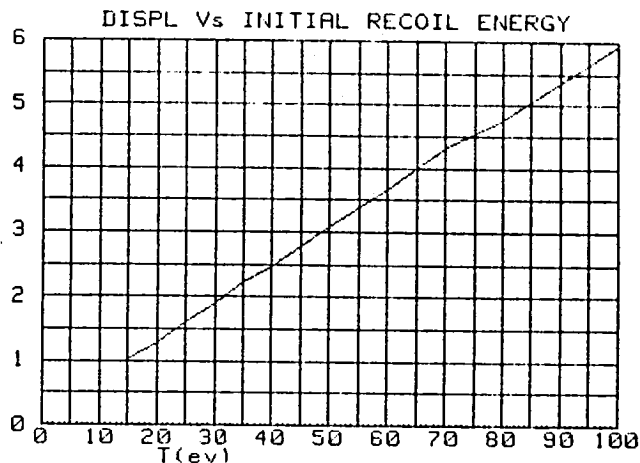


Figure 3

THE CRYSTALLIZATION OF POLY(ARYL-ETHER-ETHER-KETONE)
IN THE PRESENCE OF CARBON FIBERS

by

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Thermoplastic, crystallizable polymers, when applied in fiber reinforced composite materials, offer the potential of greater toughness and greater ease of fabrication and repair than do the currently used thermosetting epoxy resins.

The polymer known as poly(aryl-ether-ether-ketone) (PEEK) is a prime candidate for use as a matrix component for composite materials in the aerospace industries. PEEK owes its toughness, to a great extent, to its partially crystalline state. At the same time, the presence of crystallinity makes the matrix component of the composite material a heterogeneous system in itself.

A study of this system was begun in order to develop understanding and eventual control of the way PEEK crystallizes in the presence of reinforcing carbon fibers. Differential scanning calorimetry is being used to compare the crystallization of the neat polymer with the crystallizations of PEEK in its commercially available composites as developed by Imperial Chemical Industries.

Preliminary results indicate that the melting temperature and the heat of fusion of the composite designated as APC-2 is less sensitive to the thermal history of the sample than is the somewhat different material designated as APC-1. APC-1, as received in the prepreg form, is more crystalline and its crystallites are more thermally stable than are the cases with the neat resin as received. More meaningful statements about comparisons among materials can be made when more thermal analysis data are obtained and when the relative molecular weights of the PEEK polymers in question are determined. Preliminary but reproducible results of x-ray diffraction measurements appear to show smaller spacings between planes in PEEK with 110 indices when the x-ray beam is directed so that at one point it will graze the sample parallel to the fiber direction rather than perpendicular to it. Work continues in an effort to explain the meaning of this observation.

*The author gratefully acknowledges the collaboration of Dr. Norman J. Johnston and of Dr. N. T. Wakelyn in the undertaking of this project.



STRATOCUMULUS CLOUD FIELD RADIATIVE PARAMETERIZATIONS

by

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Reflected fluxes have been computed for stratocumulus cloud fields as a fraction of sky cover, cloud aspect ratio and cloud shape. Cloud liquid water volume was held invariant as cloud shape was varied so that the results can be utilized more effectively by climate and general circulation models.

A number of broken-cloud models have been developed for the three-dimensional geometry. However, present efforts now have shifted to the modeling of the radiative properties of cloud fields. Studies reported in the literature have made at least one of the following assumptions: (1) the radiation exiting cloud sides is isotropic, (2) multiple scattering between clouds is neglected, and (3) shading is neglected between clouds. In contrast, the present study eliminates these approximations.

Most cloud radiative parameterizations used in general circulation and climate models are based upon plane-parallel, horizontally homogeneous cloud assumptions. The present study demonstrates that such assumptions lead to very large errors in radiative fluxes at the top of the atmosphere, indicating that plane-parallel calculations are not satisfactory at most values of cloud cover.

The present results also showed that cloud shape as well as the size of the gaps between clouds are important variables. Clouds scatter radiation out their cloud sides anisotropically, and elongated cusp-like regions between clouds are efficient at allowing photons to propagate to the ground without further interaction with neighboring clouds. Therefore, the presence of holes between clouds has a large impact upon cloud albedo.

An empirical relationship for effective cloud fraction was found to decrease differences between plane-parallel and broken cloudiness from 40-50 W/m^2 to less than 10 W/m^2 . This procedure allows for the relatively accurate computation of broken cloud field reflected fluxes from the much less expensive plane-parallel computations. The relationship is based upon Monte Carlo simulations of the radiation scattering patterns out the cloud sides and is appropriate for optical depths ranging from 10 to 100 and for solar zenith angles ranging from $\theta = 0^\circ$ to about 83° . Additional work is required to extend these parameterizations to clouds of small optical depth in the range of 0.1 to 10. Work also is not complete in extending the results to a complete range of cloud aspect ratios.

A paper entitled "Stratocumulus Cloud Field Reflected Fluxes: The Effect of Cloud Shape" has been submitted to the Journal of Atmospheric Sciences. A second paper to be entitled "Stratocumulus Cloud Field Radiative Parameterizations" will be submitted once these final parameterizations are completed.

SPECIFICATION OF A RAYLEIGH SCATTERING SYSTEM FOR
PROBING THE FLOW FIELD OF A REENTRY VEHICLE

by

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Laser Rayleigh scattering has recently been identified as a promising technique for probing the flow field on the windward side of a hypersonic test vehicle (ref. 1). A high power laser is required in order to scatter a measurable signal into a detector for the expected range in particle density at altitudes between 55 km and 85 km. The proposed measurements would be used to improve the reliability of current aerothermodynamic models of the flow field around aircraft, such as those in the Space Transportation System, moving at high Mach numbers ($M > 10$) and encountering high heating rates.

Before specifications of the laser system can be completed, a careful analysis of the expected experimental conditions and constraints must be conducted. These include: (1) background light signals; (2) the size, weight, and power requirements of the laser and of the light detection system; and (3) the availability of the specified laser and measurement system within the next 2 years. The significance of background light is related to detector sensitivity, dynamic range, and noise characteristics and depends strongly upon the wavelength range observed, just as the Rayleigh signal does. The expected sources of background signals and noise are: (1) thermal radiant emission from the hot gases in the very high temperature shock layer ($6,000 \text{ K} < T < 15,000 \text{ K}$) and in the region between the shock and the boundary layer ($2,500 \text{ K} < T < 10,000 \text{ K}$); (2) Rayleigh scattered sunlight; (3) stray laser light; and (4) instrumental noise.

Selection of an optimum wavelength range will limit the choice of the laser system, related optics, and detection system. A decrease in the background signal (related to black body radiation) and increase in the Rayleigh signal (proportional to $1/\lambda^4$) can be accomplished by selection of the shortest practical wavelength laser system. Lasers with high output energy in the ultraviolet or blue-green spectrum are available in such systems as the excimer lasers, gas dynamic lasers, dye lasers, and solid state lasers. Additional restrictions upon the physical size and weight, pulse characteristics (repetition rate, width, and peak power), and power requirements point to the excimer and gas dynamic lasers as being the best candidates for the proposed reentry vehicle experiment.

Results are provided below for several candidate laser systems to investigate the Rayleigh, thermal and solar signals expected for the proposed flight

conditions. The shock layer temperature and density and the sample region densities were extracted from data provided by Don Eide, Vehicle Analysis Branch, SSD. The layer thickness and representative distance for the shock layer and Rayleigh volume were estimated from data presented in reference 1 and provided by Shinn, Moss, and Simmonds, Aerothermodynamics Branch, SSD. Various sources of absorption coefficients (ref. 2) for hot air were used to cover the range of temperature and density expected for the shock layer. Emission from the region in front of the shock layer was calculated and found negligible compared to that of the much hotter shock layer. Sunlight, Rayleigh scattered (refs. 3 and 4) into the sensor, was estimated assuming that the sensor was directed downward with the Sun at zenith and with an Earth ground albedo of 0.25. The optics and sensor were assumed to be characterized by an aperture area of 1 cm^2 , viewing angle of 0.01 steradian, 1 nm bandpass, sensor located at the image of the Rayleigh volume, about 1 percent of the thermal emission entering the lens actually received by the sensor (out-of-focus), and noise characterized by random "shot" noise in the photomultiplier tube for each pulse.

<u>Laser system</u>	<u>Altitude (km)</u>	<u>Expected Rayleigh</u>	<u>Maximum thermal</u>	<u>Signals (W) solar</u>	<u>Signal to back- ground</u>	<u>Signal to noise</u>
Lambda Physik EMG 203:	84	3×10^{-4}	1×10^{-5}	2×10^{-10}	10^1	150
ArF excimer at 193 nm	73	1×10^{-3}	9×10^{-8}	2×10^{-10}	10^4	250
250 Hz rep. rate	65	3×10^{-3}	1×10^{-9}	2×10^{-10}	10^6	500
10 ns width, 24 MW peak	55	6×10^{-3}	4×10^{-9}	2×10^{-10}	10^6	750
Lambda Physik EMG 203:	84	1×10^{-4}	8×10^{-6}	3×10^{-11}	10^1	150
KrF excimer at 249 nm	73	4×10^{-4}	2×10^{-7}	3×10^{-11}	10^3	200
250 Hz rep. rate	65	1×10^{-3}	5×10^{-9}	3×10^{-11}	10^5	350
20 ns width, 20 MW peak	55	2×10^{-3}	6×10^{-8}	3×10^{-11}	10^4	500
PRA L 1000:	84	3×10^{-6}	4×10^{-6}	2×10^{-7}	10^0	5
N ₂ gas at 337.1 nm	73	1×10^{-5}	1×10^{-7}	2×10^{-7}	10^2	10
20 Hz rep. rate	65	3×10^{-5}	4×10^{-8}	2×10^{-7}	10^2	15
0.6 ns width, 2 MW peak	55	6×10^{-5}	1×10^{-8}	2×10^{-7}	10^2	25
Plasma Kinetic Model 751:	84	2×10^{-9}	2×10^{-6}	4×10^{-7}	10^{-2}	1
Copper Vapor at 514 nm	73	1×10^{-7}	6×10^{-8}	4×10^{-7}	10^{-1}	5
5000 Hz rep. rate	65	3×10^{-7}	3×10^{-9}	4×10^{-7}	10^0	10
50 ns width, 0.1 MW peak	55	5×10^{-7}	1×10^{-9}	4×10^{-7}	10^0	20

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GRID GENERATION

by

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With the advent of modern high-speed computers, numerical simulation has come to play a prominent role in the study of aircraft design. At the moment, certain parts of the aircraft, such as the fuselage and airfoil, have been investigated successfully; however, the ultimate goal is to be able to analyze the configuration in its entirety.

Since air is a fluid, any mathematical study of an aircraft will necessarily involve the classical Navier-Stokes equations. Grid generation is an essential aspect of the mathematical simulation of fluid flow because it provides the link between the computational domain (where algorithms exist to solve the Navier-Stokes equations numerically) and the physical domain. In particular, a grid is a nonoverlapping transformation from rectilinear to curvilinear coordinates.

The focus of the author's research has been to investigate how smoothing techniques can be utilized in the area of grid generation. The author developed the smoothing ideas while attempting to construct a grid for an aircraft. A plane can be divided in a natural way into components such as the forebody, the airfoil, the tail, etc. The regions surrounding these components can usually be subdivided in a natural way so that suitable local grids can be found for each subregion; however, the frustration of trying to splice together these various pieces into one smooth global grid drove the author to search for a technique which would blend one patch into the next while still preserving the essential structure of each local grid. The principal smoothing technique investigated involved a convolution of the grid transformation with a "bump" function to obtain a new smoother grid which approximates the old one. The Laplace operator which merely averages the four immediate neighbors was also considered.

The author showed that it is possible to patch a grid together from local grids. Desirable properties such as orthogonality and clustering of grid points were almost retained. Numerous examples were run using both the Laplace and convolution technique. While both worked well, the Laplace method was easier to program, faster in terms of CPU time, and seemed to generate grids that were somewhat smoother; however, in some cases, the convolution operator was better at preventing overlapping near the boundary.



A NEW SINGULAR INTEGRAL FORMULATION FOR COMPRESSIBLE FLOW

by

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A new singular integral technique has been developed for solving the full nonlinear potential flow equations describing the outer flow field about an arbitrary two-dimensional body. The only approximations employed are the usual potential flow/boundary layer restrictions which exclude large scale flow separation. No other approximations, such as small disturbances or linearized boundary conditions, are made. At present, the method is limited to local Mach numbers less than one and two-dimensional flows, although the latter restriction can be relaxed, at least theoretically. The method bears some resemblance to conventional singular integral methods in its final form. However, the development is inherently different, in that it does not rely on the mathematical artifice of using sources or vortices to model the body. Instead, the surface geometry is contained explicitly in the resulting integral equation. In this sense, the formulation is more fundamental. In addition, several classical analytical results can be exploited before resorting to the numerical solution for a specific flow condition. The most important result is that the two-dimensional surface integral is reduced to a one-dimensional line integral equation. This equation is a Fredholm integral equation which contains $\partial\phi/\partial x$, $s(x)$, and ds/dx , where $s(x)$ is the surface geometry. For the incompressible flow, the equation is a linear singular integral equation, whereas, for the compressible case, it becomes nonlinear.

Results for surface velocity and pressure have been calculated for several airfoil shapes at various free-stream Mach numbers, and compared with existing codes at NASA Langley.

Finally, it should be noted that this present formulation should provide a method for obtaining surface geometry given a desired pressure distribution. This can be accomplished by either inverting the integral equation or indirectly by solving the original equation iteratively for the surface shape.



AN ANALYSIS OF THE NATIONAL TRANSONIC FACILITY
PURGE AND COOL-DOWN PROCESSES

by

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Operation of the National Transonic Facility (NTF) in the cryogenic mode requires extensive purging prior to the initiation of tunnel cool down. The objective is to decrease the water vapor and oxygen concentrations of the tunnel medium to levels at which condensation of those elements would be inconsequential. The purpose of this study was to analyze the established purge procedures with a view toward identifying alternatives which might lead to economy of liquid nitrogen, electrical energy, and manpower. During the course of the study it became appropriate to consider the closely-related question of how similar savings could be effected in the tunnel cool-down procedure.

The current procedure for purging the NTF consists of three volume changes of its gaseous contents using dry air, followed by five volume changes using vaporized liquid nitrogen. Each volume change is of 30-minute duration and is conducted at an elevated temperature of about 60°C. The motive for the adopted procedure is largely based on the existence in the tunnel's interior space of an exposed liquid nitrogen supply pipe whose temperature approaches that of the contained fluid. Of particular concern is the possible formation at that location of both ice, which could lead to damage of the antiturbulence screens, and of a condensed, oxygen-rich mixture of nitrogen and oxygen, the latter of which can produce serious corrosion problems. The aim of the purge procedure is, therefore, to reduce substantially the concentration of the potentially troublesome species while the tunnel is at a moderate temperature.

In approaching this study, it was immediately concluded that the need to avoid condensation due to the exposed supply line represented a severe limitation on the prospects of identifying improvements to the established purge procedure. Therefore, the viewpoint was adopted that progress depended on the practical possibility of insulating the exposed pipe, so that only temperatures at the level of the gaseous medium needed to be of concern. Consequently, the problem was reduced to one of calculating the gas phase temperature-composition relationship for various purge and cool-down procedures, and determining which procedures satisfied the established criteria: a water vapor dewpoint temperature of less than -20°C, and an oxygen concentration of less than 1.0 mole percent at the temperature of tunnel operation.

The analytical methods required to calculate temperature-composition histories for the purge process were readily drawn from well-established techniques.

However, a unique requirement for this study was the development of a method for making similar calculations for the unsteady situation when the tunnel gas is cooled and diluted by the injection of liquid nitrogen while gas is simultaneously exhausted to maintain a constant pressure. Such an analytical method was developed, and it includes all of the essential ingredients of the NTF thermodynamics, except for heat transfer from the walls and internal structures. Inclusion of the heat transfer element requires an extensive effort; however, its omission from the present study results in conservative estimates for instantaneous compositions.

Calculations that were made with the analytical model show, for extreme initial tunnel conditions of 40°C and 100-percent relative humidity, that the aforementioned criteria for water vapor and oxygen concentration can be satisfied with as few as one dry air volume change and two nitrogen volume changes, followed by a tunnel cool down. For the less severe initial conditions of 20°C and 100-percent relative humidity, the dry air purge may be eliminated. In making these calculations, which simulated the actual NTF cool-down procedure, it was possible to identify several procedural modifications, some of which are alluded to below, that offer across-the-board savings in that phase of tunnel operation.

The study resulted in the following recommendations, most of which are directed toward more economic purge and cool-down procedures: (1) insulate the liquid nitrogen supply line; (2) develop and incorporate an NTF heat transfer model in the cool-down analysis; (3) purge at or near ambient temperature, with little loss in the ability to vaporize liquid water which may be initially present in the tunnel; (4) base the purge procedure on the existing, initial tunnel conditions, as opposed to the use of a fixed procedure; and (5) consider modifying the Mach number schedule used during tunnel cool down.



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16. Abstract <p>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. <u>Objectives:</u> (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. <u>Program Description:</u> 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.</p>					
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