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NASA/AMERICAN SOCIETY FOR ENGINEERING
EDUCATION (ASEE) SUMMER FACULTY
FELLOWSHIP PROGRAM - 1985

G. Goglia (Compiler)

OLD DOMINION UNIVERSITY
Norfolk, Virginia

Grant NGT 47-003-029
September 1985

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665

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16 Abstract

Since 1964, the National Aeronautics and Space Administration (NASA) has supported a program of summer faculty fellowships for engineering and science educators. In a series of collaborations between NASA research and development centers and nearby universities, engineering faculty members spend 10 weeks working with professional peers on research. The Summer Faculty Program Committee of the American Society for Engineering Education supervises the programs. The objectives of this program are: (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; and (4) to contribute to the research objectives of the NASA center. 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, the educational community, or industry.

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Section I

ORGANIZATION AND MANAGEMENT

The 1985 Old Dominion University-NASA-Langley Research Center Summer Faculty Research Program, the twenty-second such institute to be held at the Langley Research Center, was planned by a committee consisting of the Co-Directors and Langley 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 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 applicant's credentials was made by the University Co-Director. The purpose of this assessment was to ascertain to which Divisions the applicant's credentials should be circulated for review. Each application was then annotated reflecting the Division to which the applications should be circulated. On February 27 after the applications had been reviewed by the various divisions, a committee consisting of staff members from the various Divisions, the University Affairs Officer and the University Co-Director met. At this meeting the representatives from the various Divisions indicated those individuals selected by the Divisions.

The University Co-Director then 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 ten 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 of their Fellows 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. Each Fellow, in advance of commencing the program, was contacted by his or her Research Associate or a representative of the branch.

At the assembly meeting, the host, the NASA-Langley University Affairs Officer, introduced the Langley Research Center Chief Scientist, who formally welcomed the Summer Fellows. Mrs. Jane Hess, Head, Technical Library Branch, then briefed the Fellows on the use of the library. Mr. John Banks, Manager, Langley Research Cafeteria, briefed the Fellows relevant to the cafeteria policies, hours etc. Mr. Roger Butler of the Computer Management Branch briefed the Fellows on the Computational Facilities. The subject of security at the Langley Research Center was discussed by O. J. Cole, Chief, Security Branch.

Throughout the program the University Co-Director served as the principal liaison person and had frequent contacts with the Fellows. The University Co-Director also served as the principal administrative officer. At the conclusion of the program, each Fellow submitted an abstract describing his/her accomplishments.

Each Fellow was also required to conduct a fifteen minute oral presentation of his/her accomplishments as part of the lecture series. Each Fellow was requested to complete a questionnaire provided him/her for purposes of evaluation of the Summer Program.

Section II

RECRUITMENT AND SELECTION OF FELLOWS

Returning Fellows

An invitation to apply and participate in the Old Dominion University-Langley Research Center Program was extended those individuals who held previous Langley Fellow appointments. Twenty-four individuals responded to the invitation; however, only eighteen were selected. Although eighteen previous Langley Fellows participated, seven individuals, who were participants in other similar programs, also participated in the program bringing the total number of returnees to twenty-five.

New Fellows

Although ASEE distributed a combined brochure of the Summer Programs, more than two hundred personal letters were mailed to Deans and Department Heads of various engineering schools in the East, South and Midwest requesting their assistance in bringing to the attention of their faculties the Old Dominion University-Langley Research Center Program. In addition to the above, a number of departments of chemistry, physics, computer science and mathematics at colleges (including community colleges) and universities in the State of Virginia as well as neighboring states were contacted regarding this program. Although minority schools in Virginia and neighboring states were included in the mailing, the alternating Co-Director from Hampton University made site visits to minority schools soliciting applicants. These efforts resulted in a total of one hundred eighteen formal applications, all indicating the Old Dominion University-Langley Research Center Program was their first choice and a total of fifty indicating ODU-LaRC Program was their second choice. The total number of applications received came to one hundred sixty-eight (Table 1).

Forty-five applicants formally accepted the invitation to participate in the program. The average age of the participants was 41.3. On June 1, 1985, the University Co-Director received a letter from one of the appointees informing us that he was withdrawing from participating in the program. A replacement was available and the appointment made maintaining the total of forty-five participants in the program.

TABLE I

First Choice Applications

Total	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
118	3	4	15	96	12

Second Choice Applications

Total	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
50	0	5	3	42	6

NASA-LaRC FELLOWS

TOTAL	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
45	2	2	5	36	4
	First Year Fellows		Returnees		
	20		25		

Section III

STIPENDS AND TRAVEL

A ten-week stipend of $6,500 was awarded to each Fellow. Although this stipend was a considerable improvement over previous years, it still fell short (for the majority of Fellows) of matching what they could have earned based on their university academic salaries. This decision on their part does, however, clearly reflect the willingness of the Fellow to make some financial sacrifice in order to participate in the Summer Program.

Travel expenses incurred by the Fellows from their homes to Hampton, Virginia, and return were reimbursed in accordance with current State regulations.

Section IV

LECTURE SERIES, TOURS, AND PICNIC

Lecture Series

Two lecture series were arranged for the NASA-ASEE Langley Fellows. The first series arranged consisted of general interest and specifically centered about research activities at the Langley Research Center. The second lecture series consisted of a number of lectures in Numerical Aerodynamics, specifically in Transition and Turbulence Modeling. These same lectures were part of a short course in Numerical Aerodynamics conducted by Old Dominion University's Mechanical Engineering Departments' Institute of Computational and Applied Mechanics. Although the Fellows were invited to all lectures, the following three lectures were for their benefit: Two lectures on Basic Statistical Mechanics of Turbulence and Statistical Theories of Turbulence and one lecture on Turbulent Shear Flows-Physics, Phenomenology and Control. The intent behind the Numerical Aerodynamics lecture series was to provide the Fellows with an exposure to Computational Fluid Dynamics and how valuable a tool it is in research at Langley.

A complete listing of both lecture series is included in appendix III of this report.

Tours and Picnic

A briefing and tour of the NASA Langley Research Center was arranged for June 4, 1985. A briefing and tour of the NASA Computational Facilities was arranged for June 5, 1985. A tour of the Acoustics Laboratory was arranged for July 23, 1985, and a tour of the Full-Scale Wind Tunnel was arranged for July 26, 1985. A picnic for the Fellows, their families, and guests was held on June 14, 1985.

Section V

RESEARCH PARTICIPATION

The 1985 Old Dominion University-Langley Research Program, as in the past years, placed greatest emphasis on the research aspects of the program. Included in this report are abstracts from the Fellows showing their accomplishments during the summer. These abstracts, together with the comments of the Langley Research Associates with whom the Fellows worked, 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 research projects undertaken by the Fellows were greatly diversified as is reflected in their Summer Research Assignments. Their assignments were as follows:

Number of Fellows Assigned	Division
2	Analysis and Computational Division
4	Instrument Research Division
6	Flight Dynamics and Control Division
2	Flight Electronics Division
5	Flight Control Systems Division
1	Materials Division
1	Acoustics Division
4	Structures and Dynamics Division
2	Loads and Aeroelasticity Division
4	Transonic Aerodynamics Division
1	High-Speed Aerodynamics Division
3	Atmospheric Sciences Division
4	Space Systems Division
1	Systems Engineering Division
1	Facilities Engineering Division
1	Personnel Division
1	Management Support Division
1	Financial Management Division
1	Low-Speed Aerodynamics Division

All but six of the participants were holders of the doctorate degree. The group was a highly diversified one with respect to background. In terms of their last degree, the breakdown revealed:

Number	Last Degree
4	Aeronautical Engineering
1	Aerospace Engineering
4	Chemistry
1	Civil Engineering
1	Computer Science
1	Education
1	Accounting
1	Nuclear Chemistry
1	Language and Literature

1	Mathematics/Computer Science
1	Psychology
1	Pharmaceutical Chemistry
1	History
3	Electrical Engineering
2	Engineering Mechanics
1	Astronomy
6	Mathematics
7	Mechanical Engineering
1	Business Administration
1	Systems Engineering/Computer Sciences
3	Physics
1	Operations Research
1	Economics

Extensions

A portion of the funds that remained in the travel budget was used to grant a one week extension to fourteen Fellows in the program. For an extension to be granted approval by both the Research Associate and the University Co-Director was necessary. The following individuals were granted a one week extension:

A. Blayton
K. Brown
R. Causey
R. Coleman
A. Dalessio
M. Doria
M. Ferguson
R. Kapania
J. Liburdy
D. Lindner
H. Robertshaw
G. Rublein
L. Silverberg
P. Skoner

Attendance of Short Courses, Seminars and Conferences

During the course of the summer there were a number of short courses, seminars and conferences, the subject matter of which had relevance to Fellows' research projects. A number of Fellows requested approval to attend one or more of these conferences as it was their considered opinion that the knowledge gained by their attendance would be of value to their research projects. Those Fellows who did attend had the approval of both the Research Associate and the University Co-Director. The following is a listing of those Fellows attending either a short course, seminar or conference.

C. Cox attended a SIAM meeting in Pittsburg on June 24-26. He also presented a paper entitled, "On the Accuracy of Least-Squares Methods in the Presence of Corner Singularities."

M. Maughmer attended a workshop held at the University of Notre Dame on June 17-19.

G. Selby attended a short course on Fluid Mechanics Measurements held at the University of Minnesota on June 17-21. G. Selby's employer, Old Dominion University, provided all funds necessary for the trip and course.

F. Gross attended an IEEE/APS and URSI Symposium held in Vancouver on June 17-21. F. Gross represented the Antenna and Microwave Research Branch, FED at this symposium. His Research Associate requested that the ASEE program provide reimbursement for certain of his expenses. F. Gross was reimbursed for $115 in accordance with his request.

E. Lawrence attended Texas Instruments Industrial and Development Center in Johnston City, Tennessee, on July 8-19 and he also attended the Allen-Bradley Company's Training Center in Philadelphia, Pennsylvania, on July 22-27. In both cases the purpose of the visit was to allow the Fellow to attend short courses on Programmable Controllers (PC's) Programming. Both companies provided tuition-free enrollment for the Fellow.

R. Longman and H. Robertshaw both attended the VPI and SU/AIAA Symposium on Control of Large Structures held in Blacksburg, Virginia, on June 12-14.

Anticipated Publications Resulting from Fellows Research Efforts

Turbulence for Flight - to be submitted to Journal of Aircraft - G. Trevino.

System Indentification Using a Recursive Form of the ERA Method - R. Longman.

Vapor Screening in a Cryogenic Environment - to be submitted to AIAA Journal - G. Selby.

Design of a Variable Coefficient Viscous Inertial Damper Using the Dual-Generalized Hessenberg Representation - to be submitted to Alberton Conference - D. Lindner.

Phase of Gain Margins in Grassman Manifolds - to be submitted to IEEE Transactions - G. Rublein.

Effects of Radiation on a Polyarylene Ether - R. Kiefer.

Aspects of Resolution Concerning Multi-particle Dectection Using Far-Field Holography - to be submitted to Applied Optics - J. Liburdy.

A Control System Design Approach for Flexible Spacecraft - to be submitted to AIAA Journal of Spacecraft and Rockets - L. Silverberg.

Putting Offline Documentation Online: A Staged Approach - to be submitted to AMC - SIGDOC - P. Carlson.

An Annotated Bibliography of Online Documentation - to be submitted to AMC - SIGDOC - P. Carlson.

Equivalent Continuum Analysis of Lattice Structures - J. Dow.

OPTIMAL: A Parse Tree Manipulation Language - to be submitted to IEEE Transactions or ACM Transactions - L. Morell.

Atmospheric Profiles in Atmospheric Environments - R. Coleman.

In addition to the above, six additional Fellows will be publishing their results.

Anticipated Research Proposals

Flow Visualization Studies in a Cryogenic Environment - to be submitted to NASA-Langley - G. Selby.

An Automated, Open Air, Absorber Measurement System - to be submitted to NASA-Langley - F. Gross.

Design Application of Factored Representations of Linear Systems - to be submitted to NASA-Langley - G. Rublein.

Radiation Effects on High-Performance Polymers - to be submitted to NASA-Langley - R. Kiefer.

Particle Detection Using Far-Field Holography in Turbulent Gas Flows - to be submitted to NASA-Langley - J. Liburdy.

Characterization of the Interaction Between the Non-Linear Lift-body Motion and the Linear Elastic Motion of Rotating Flexible Spacecraft - to be submitted to NASA-Langley - L. Silverberg.

Experimental Determination of the Stiffness Matrices for Symmetric Laminates - to be submitted to NASA-Langley - H. Patrick.

Self-Generating Manuals: A Way of Incorporating User Comment in Online Documentation - to be submitted to NASA-Langley - P. Carlson, L. Morell.

Sodium Vapor Solar Powered Lasant - to be submitted to NASA-Langley - C. Blount.

OPTIMAL: A Parse Tree Manipulation Language - to be submitted to NASA-Langley - L. Morell.

Identification Techniques for MAST - to be submitted to NASA-Langley - J. Lilly.

Influence of Antennas Flexibility in the Design of COFS Experiment - to be submitted to NASA-Langley - R. Kapania.

In addition to the above, ten additional Fellows anticipated submitting proposals either to NASA, NSF or other agencies.

Section VI

SUMMARY OF PROGRAM EVALUATION

A program evaluation questionnaire was provided each Fellow and each Research Associate involved with the program. A sample of each questionnaire appears in Appendix V of the report. Forty-two of the forty-five Fellows responded. Twenty-four of the forty-five Research Associates responded. The results of the questionnaires are summarized below.

Fellows

Ninety-five percent of the Fellows indicated they had found adequate information relevant to the program.

Eighty-eight percent of the Fellows indicated that they had an early contact with the anticipated Research Associate. Without exception the Fellows considered the early contact as essential.

Eighty-eight percent of the Fellows indicated that they were given a choice of research projects.

Ninety-eight percent of the Fellows indicated that the research project was both challenging and in their field of interest.

Ninety percent of the Fellows indicated that they anticipate continuing with their research upon return to their institutions.

Ninety-one percent of the first year Fellows look forward to returning to Langley for a second year should they be extended that invitation.

Ninety-two percent of the Fellows indicated satisfaction with the lecture series.

All but six of the Fellows considered the stipend to be adequate. One recommended the stipend be increased by $1,000.

Eighty percent of the Fellows indicated that they had no difficulty finding housing. Two individuals indicated dissatisfaction with the accommodations at Hampton University.

All Fellows indicated satisfaction with the administration of the program.

Fourteen Fellows provided the titles of papers they anticipate publishing shortly. Six others have plans to also publish a paper.

Twelve Fellows indicated that they definitely will submit proposals to NASA Langley to continue their research. Ten other Fellows are contemplating doing so.

Fellows' Comments

The comments were as follows: excellent program for teachers who come from schools where there is little opportunity for research; very impressed with program; supremely valuable; very worthwhile and extremely well administered; very useful for exposing University professors to engineering problems of current interest; believe NASA benefits from program by the infusion of new people for a brief period; participants benefit by association with talented individuals; environment at NASA Langley very conducive to doing research; lovely program, it seems to benefit everyone; excellent program, excellent opportunity for a young professor; administrators served us well, very well administered, administration is especially to be commended; everything provided on time and with no administrative problems; everyone was courteous, helpful and friendly; very good management, couldn't be better.

Fellows' Recommendations

Recommendations included the following: a housing officer is needed to assist in locating housing for the Fellows; recommend some monies such as $1,500-$3,000 be set aside to aid Fellows in obtaining necessary supplies; monies should be provided for those research projects requiring travel; computer system shortcomings: (1) inadequate diagnostics, (2) inexperienced consulting staff, (3) 24-48 hour job turnaround time, (4) long waits for response at terminal coupled with a timed shutdown that doesn't permit one to go away and come back, (5) file editing can be impossible, (6) limited times of access to computer - evening and weekend use would help, (7) REWIND exists on no other system - get rid of it.

Research Associates

All Research Associates responding indicated that their Fellows were adequately prepared to undertake his/her research assignment.

All Research Associates responding were satisfied with the diligence, interest and enthusiasm that their Fellows exhibited. Research Associates responding were satisfied with the productivity and results of their Fellows' summer effort.

All Research Associates responding expressed an interest in serving in the program again.

Research Associates' Comments and Recommendations

Comments and recommendations are given below.

The interaction with highly capable people and a "new look" at some problems seems highly useful. This program is an excellent means to provide LaRC with access to skilled researchers with fresh viewpoints. The Fellows appear to benefit as well because it gives them access to current research problems. With the right pairing this program is beneficial to both parties. This program is a good experience for both the Fellow and his Associate, I personally have benefited greatly from this association. This program is a good idea. An increase in the number of fellowships would help. Also, it would help if the restriction to U.S. citizens could be dropped. This is an excellent program. When Fellows have been selected, notified and have accepted, then the NASA associate should be specifically contacted by the University Co-Director's office and asked to communicate with the researcher. This year it seemed a bit awkward. I wasn't sure if the offer was accepted etc., and wished to communicate in advance. Some directions to the NASA associate would be appreciated. What type of problems do the fellows want, how much interaction, and what direction?

Section VII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Comments advanced by the Research Fellows, as well as others associated with the program, indicated satisfaction with the program.

All Fellows considered contact with the anticipated research associate, prior to arrival, as essential and most desirable.

A majority of the Fellows considered the stipend as adequate; however, there were a few who would only agree to this after considering the peripheral benefits associated with the program.

The overall quality of the Fellows was considered outstanding to excellent by all those associated with the program.

All Fellows indicated the program should be continued.

Recommendations

The Fellows recommended the practice of contact by the research associate, prior to arrival, be continued. They further recommended a site visit to Langley, in advance of the commencement of the program, be favorably considered.

The Fellows recommended the stipend be increased, one suggested by as much as $1,000. They indicated that some very qualified individuals are discouraged from applying with the current stipend.

The Fellows considered the tenure of the program as too short and recommended it be lengthened to perhaps twelve weeks.

Some research associates recommended recruiting more candidates like the ones they had this year. One research associate recommended allowing anticipated returnees a short visit to Langley during winter academic break to plan second summers' work. One research associate indicated it desirable not to assign more than on Fellow to an associate.

All individuals associated with the program recommended that the program be continued.

APPENDIX I

Participants - ASEE-NASA Langley

Summer Faculty Program –

Returnees

1985

NASA-ASEE FELLOWS

ODU-NASA LANGLEY

RETURNEES

Fellow	Age	Assigned to	Research Associate
Mrs. Blayton, Angela Assistant Professor Business Department Hampton University Hampton, VA 23668	38	Financial Management Division	Joseph C. Struhar Building 1192 Tel. 865-2724
Dr. Blount, Charles E. Professor Physics Department Texas Christian University Fort Worth, TX 76129	54	Space Systems Division	Nelson W. Jalufka Building 1247A Tel. 865-3781
Dr. Brandt, Daniel A. Professor Industrial Technology Department Western Wisconsin Technical Institute Lacrosse, WI 54601	53	Flight Dynamics and Control Division	Marion A. Wise Building 1268A Tel. 865-3871
Dr. Brown, Kenneth G. Associate Professor Chemical Science Department Old Dominion University Norfolk, VA 23508	41	Instrument Research Division	George M. Wood Building 1230 Tel. 865-2466
Dr. Bynum, William L. Professor Computer Science Department College of William and Mary Williamsburg, VA 23185	49	Flight Dynamics and Control Division	Fenton W. Harrison Building 1268A Tel. 865-3871

Dr. Carlson, Patricia A. Associate Professor Humanities Department Rose-Hulman Institute of Technology Terre Haute, IN 47803	40	Analysis and Computation Division	Susan J. Voigt Building 1221 Tel. 865-2083
Dr. Causey, Robert L. Professor Computer Science Department Christopher Newport College Newport News, VA 23606	58	Flight Control Systems Division	Ricky W. Butler Building 1220 Tel. 865-3681
Dr. Coleman, Randolph A. Associate Professor Chemistry Department College of William and Mary Williamsburg, VA 23185	41	Atmospheric Sciences Division	W. Cofer/R. Harriss Building 1202 Tel. 865-4372/3237
Dr. Dalessio, Anthony T. Assistant Professor Psychology Department Old Dominion University Norfolk, VA 23508	33	Personnel Division	L. Cornell Burcher Building 1219 Tel. 865-2165
Dr. Doria, Michael L. Associate Professor Mechanical Engineering Department Valparaiso University Valparaiso, IN 46383	46	Transonic Aerodynamics Division	Manuel D. Salas Building 1244 Tel. 865-2627
Dr. Dow, John O. Assistant Professor Civil Engineering Department University of Colorado Boulder, CO 80309	44	Structures and Dynamics Division	Harold G. Bush Building 1148 Tel. 865-2498

Dr. Gosink, Thomas A. Research Associate Geochemistry Department Geophysical Institute University of Alaska Fairbanks, AK 99701	49	Atmospheric Sciences Division	Leonard McMaster Building 1250 Tel. 865-2065
Dr. Kandil, Osama A. Associate Professor Mechanical Engineering and Mechanics Department Old Dominion University Norfolk, VA 23508	41	Transonic Aerodynamics Division	Manuel D. Salas Building 1244 Tel. 865-2627
Dr. Kyrala, Ali Professor Physics Department Arizona State University Tempe, AZ 85282	64	Flight Control Systems Division	Felix L. Pitts Building 1220 Tel. 865-3681
Dr. Liburdy, James A. Associate Professor Mechanical Engineering Department Clemson University Clemson, SC 29631	36	High-Speed Aerodynamics Division	Dennis Bushnell Building 1247A Tel. 865-4546
Dr. Lilly, John H. Assistant Professor Electrical Engineering Department University of Kentucky Lexington, KY 40506	36	Flight Dynamics and Control Division	Suresh M. Joshi Building 1268A Tel. 865-4591
Dr. Longman, Richard W. Professor Mechanical Engineering Department Columbia University New York, NY 10027	42	Structures and Dynamics Division	Jer-Nan Juang Building 1293B Tel. 865-2881

Dr. Mattix, Larry Associate Professor Chemistry/Physics Department Norfolk State University Norfolk, VA 23504	38	Instrument Research Division	William Winfree Building 1230 Tel. 865-3036
Dr. Nebel, Henry Associate Professor Physics Department Alfred University Alfred, NY 14802	45	Atmospheric Sciences Division	James M. Russell Building 1250 Tel. 865-4789
Mr. Nold, Dean E. Professor Electrical Engineering Technology Department Purdue University Calumet Hammond, IN 46323	53	Flight Control Systems Division	Jack J. Hatfield Building 1298 Tel. 865-2171
Dr. Robertshaw, Harry H. Associate Professor Mechanical Engineering Department Virginia Polytechnic Institute and State University Blacksburg, VA 24061	43	Structures and Dynamics Division	Garnett C. Horner Building 1293B Tel. 865-2817
Dr. Sanwal, Jagdish C. Associate Professor Mathematics Department College of William and Mary Williamsburg, VA 23185	51	Flight Dynamics and Control Division	Nancy E. Orlando Building 1268A Tel. 865-3871
Dr. Scanlon, Charles H. Associate Professor Computer Science, Math and Physics Department Arkansas State University State University, AR 72401	48	Flight Control Systems Division	Charles E. Knox Building 1168 Tel. 865-3621

Dr. Selby, Gregory V. Assistant Professor Mechanical Engineering and Mechanics Department Old Dominion University Norfolk, VA 23508	36	Transonic Aerodynamics Division	Richard Barnwell Building 1229 Tel. 865-2601
Dr. Trevino, George Associate Professor Mechanical Engineering and Engineering Mechanics Department Michigan Technological University Houghton, MI 49931	43	Flight Control Systems Division	Roland Bowles Building 1168 Tel. 865-3621

APPENDIX II

Participants - ASEE-NASA Langley

Summer Faculty Program -

First Year Fellows

1985

NASA-ASEE FELLOWS

ODU-NASA LANGLEY

1st YEAR

Fellow	Age	Assigned To	Research Associate
Dr. Chachere, Bernadette P. Chairman Economics Department Hampton University Hampton, VA 23668	41	Flight Electronics Division	Glenn R. Taylor Building 1299 Tel. 865-3541
Dr. Chen, Kwan-Yu Professor Astronomy Department University of Florida Gainesville, FL 32611	55	Space Systems Division	Edmund J. Conway Building 1247A Tel. 865-3781
Dr. Cox, Christopher L. Assistant Professor Mathematics Department Clemson University Clemson, SC 29631	29	Loads and Aeroelasticity Division	John W. Edwards Building 648 Tel. 865-4236
Dr. Day, Henry P. Assistant Professor Virginia Polytechnic Institute and State University Blacksburg, VA 24061	37	Low-Speed Aerodynamics Division	Bruce J. Holmes Building 1212 Tel. 865-2877
Mr. Ferguson, Milton W. Assistant Professor Physics Department Norfolk State University Norfolk, VA 23504	47	Instrument Research Division	Sheila T. Long Building 1267 Tel. 865-3892

Dr. Gross, Frank B. Assistant Professor Electrical Engineering Department Florida State University Tallahassee, FL 32308	34	Flight Electronics Division	Marion C. Bailey Building 1299 Tel. 865-3631
Dr. Hansen, James R. Assistant Professor History Department University of Maine Orono, ME 04473	33	Management Support Division	Richard T. Layman Building 1151 Tel. 865-3511
Dr. Kapania, Rakesh K. Assistant Professor Aerospace and Ocean Engineering Department Virginia Polytechnic Institute and State University Blacksburg, VA 24061	29	Structures and Dynamics Division	Brantley R. Hanks Building 1293B Tel. 865-3055
Dr. Kiefer, Richard L. Professor and Chairman Chemistry Department College of William and Mary Williamsburg, VA 23185	48	Materials Division	George F. Sykes Building 1205 Tel. 865-4555
Dr. Lawrence, Ellis E. Associate Professor Industrial Technology Department Elizabeth City State University Elizabeth City, NC 27909	36	Facilities Engineering Division	John L. Gilbert Building 1209 Tel. 865-4534
Dr. Leemis, Lawrence M. Assistant Professor Industrial Engineering Department University of Oklahoma Norman, OK 73069	28	Space Systems Division	W. Douglas Morris Building 1232 Tel. 865-2768

Dr. Lindner, Douglas K. Assistant Professor Electrical Engineering Department Virginia Polytechnic Institute and State University Blacksburg, VA 24061	33	Flight Dynamics and Control Division	R. C. Montgomery Building 1268A Tel. 865-4591
Dr. Maughmer, Mark D. Assistant Professor Aerospace Engineering Department The Pennsylvania State University University Park, PA 16802	35	Transonic Aerodynamics Division	William D. Harvey Building 641 Tel. 865-2631
Dr. Morell, Larry J. Assistant Professor Computer Science Department College of William and Mary Williamsburg, VA 23185	33	Analysis and Computation Division	Edmond H. Senn Building 1268A Tel. 865-2558
Dr. Pacheco, Maria D. Visiting Assistant Professor Science and Math Division College of The Virgin Islands St. Thomas, U.S.V.I. 00802	28	Instrument Research Division	Jag J. Singh Building 1230 Tel. 865-3907
Mr. Patrick, Howard V. Assistant Professor Aeronautical Engineering Department Embry-Riddle Aeronautical University Regional Airport Daytona Beach, FL 32014	49	Acoustics Division	John S. Mixson Building 1208 Tel. 865-3561
Dr. Rublein, George T. Associate Professor Mathematics Department College of William and Mary Williamsburg, VA 23185	50	Flight Dynamics and Control Division	Douglas B. Price Building 1268A Tel. 865-4681

Dr. Silverberg, Larry M. Assistant Professor Mechanical & Aerospace Engineering Department North Carolina State University	28	Space Systems Division	L. Bernard Garrett Building 1232 Tel. 865-3666
Mr. Skoner, Peter R. Instructor of Physics and Management St. Francis College Loretto, PA 15940	28	Systems Engineering Division	Charles E. Cockrell Building 1209 Tel. 865-4666
Mr. Turner, James C. Graduate Teaching Assistant Mathematics Department Carnegie-Mellon University Pittsburg, PA 15213	38	Loads and Aeroelasticity Division	Allan R. Wieting Building 1265 Tel. 865-3423

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APPENDIX III

ASEE-NASA Langley Summer Faculty Program - Lecture Series

ASEE-NASA
Old Dominion University - Langley Research Center
Lecture Series
General

Location: Building 1219, Room 225
Time: 9:00 a.m. - 10:30 a.m.

Date	Speaker	Topic
June 7	Mr. Robert E. Bower Associate Director NASA/Langley Research Center	An Overview of the Langley Research Center
June 19	Dr. Douglas L. Dwoyer, Branch Head Computational Methods Branch High-Speed Aeronautics Division	Computational Fluid Dynamics
June 28	Dr. Roger A. Breckenridge LaRC Space Station Office	NASA's Space Station
July 2	Mr. Frederick O. Allamby Space Flight Experiment Definition and Integration Office	Commercialization of Space
July 11	Dr. James H. Starnes, Branch Head Structural Mechanics Branch Structures and Dynamics Division	Composites in Aeronautics and Space
July 25	Dr. William P. Winfree Instrument Research Division	Applications of Quantitative Physical Measurements
August 1	Dr. Samuel E. Massenberg University Affairs Office NASA/LaRC	Preparation and Submission of Unsolicited Proposals

August 7
8:15 a.m.

ASEE-NASA Fellows assigned to Aeronautics Directorate

Dr. Henry Day
Dr. Michael Doria
Dr. Mark Maughmer
Dr. James Liburdy

ASEE-NASA Fellows assigned to Electronics Directorate

Dr. Patricia Carlson
Dr. Larry Morell
Dr. Ali Kyrala
Dr. Robert Causey
Mr. Dean Nold
Dr. Charles Scanlon
Dr. John Lilly
Dr. Douglas Lindner
Dr. William Bynum
Dr. Jagdish Sanwal
Dr. George Rublein
Dr. Frank Gross
Dr. Bernadette Chachere
Dr. Kenneth Brown
Mr. Milton Ferguson
Dr. Larry Mattix
Dr. Maria Pacheco

August 8
8:15 a.m.

ASEE-NASA Fellows assigned to Space Directorate

Dr. Randolph Coleman
Dr. Henry Nebel
Dr. Lawrence Leemis
Dr. Larry Silverberg
Dr. Charles Blount
Dr. Kwan-Yu Chen
Dr. Thomas Gosink

ASEE-NASA Fellows assigned to Structures Directorate

Mr. Howard Patrick
Dr. Christopher Cox
Mr. James Turner
Dr. Richard Kiefer
Dr. Harry Robertshaw
Dr. John Dow
Dr. Richard Longman
Dr. Rakesh Kapania

ASEE-NASA Fellows assigned to Management and Operations Directorate

Mrs. Angela Blayton
Dr. Anthony Dalessio
Dr. James Hansen

ASEE-NASA Fellow assigned to Systems Engineering and Operations Directorate

Dr. Ellis Lawrence

ASEE-NASA
Old Dominion University - Langley Research Center
Lecture Series
Numerical Aerodynamics

Location: Building 1244, Room 223
Time: 10:00 A.M. - 12 Noon

Date	Speaker	Topic
June 24	Dr. T. A. Zang NASA Langley Research Center	Introduction to Spectral Methods
June 25-27	M. G. Worster Massachusetts Institute of Technology	Introduction to Hydrodynamic Stability, Inviscid Instability of a Vortex Sheet (Free Shear Layer), and Two-Dimensional Parallel Shear Flow (Inviscid Disturbances)
July 1	M. G. Worster Massachusetts Institute of Technology	Taylor-Couette Flow (Linear Theory)
July 2-3	Annick Pouquet Observatoire de Nice, France	Basic Statistical Mechanics of Turbulence and Statistical Theories of Turbulence
July 8	D. M. Bushnell NASA Langley Research Center	Turbulent Shear Flows-Physics, Phenomenology, and Control
July 9-11	M. G. Worster Massachusetts Institute of Technology	Two-Dimensional Parallel Shear Flows (Viscous Disturbances), Linear and Nonlinear Theories
July 15-18	Tom Eidson Georgia Institute of Technology	Inadequacies of Reynolds Averaging of Turbulence, Simulation of the Flow Equations and Subgrid Modeling Theory, and Advanced Topics and Problems in Large Eddy Simulation (LES)
July 22	Dr. T. A. Zang NASA Langley Research Center	Numerical Methods for Simulation of Transition and Turbulence
July 23-25	Tom Eidson Georgia Institute of Technology	Data Analysis of Large Eddy Simulation (LES), LES of Turbulent Convection, and LES of Channel Flow

APPENDIX IV

ASEE-NASA Langley Faculty Fellows-

Abstracts

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A STUDY OF THE FAB RATE

Angela Macklin Blayton
Assistant Professor
Accounting and Finance
Hampton University
Hampton, Virginia

The Fabrication Division (Fab) is responsible for providing and procuring the services required to manufacture and test aeronautical and aerospace research hardware, related ground support equipment, and research facilities test equipment. In supporting the engineering and research organizations at the Center, Fab also performs experimental and developmental work related to the use of new materials processing techniques.

Fab by itself cannot support all of the Center's fabrication requirements; therefore, one-half of the work is performed out-of-house by contractors. As a result, there was a lot of competition for Fab's resources which required that the researcher only pay for material costs. If the researcher had the same work performed out-of-house, he would have to pay the full cost of materials and labor; therefore, in light of the competition for in-house work, the Center developed a "Standard Rate" which made the hourly cost of the job the same irrespective to whether or not the job was performed in-house or out-of-house.

The Fab Rate System is an operational cost recovery system. All stock issued, PR/PO purchased supplies, materials, equipment replacement and repair costs plus small business tasks and other contract costs must be recovered via the Fab System. The Fab rate is determined by dividing Total Operational Cost by Hours of Research Support and the Fabrication Division has the objective of delivering the hours needed to match recorded costs in an effort to maintain the predetermined Fab rate.

The Program and Resources Division (PRD) is concerned with monitoring the Fab rate to insure its reasonableness through year-end. PRD is also concerned with controlling the dollar amount of uncosted obligations at year-end.

The Financial Management Division (FMD) is concerned with maintaining accurate records of actual costs along with assisting Fab and PRD with controlling the Fab rate, and as a representative of FMD, I have met with Jeannie Duncan (PRD) and Bob Magee (Fab) at various intervals throughout the summer to discuss the status of the Fab rate which was set at $15.25 for Fiscal Year, 1985.

At our last meeting, I presented an analysis of Fab Contracts and a year-end cost projection for FY '85. Bob Magee presented a year-end labor hour projection for FY '85 along with an estimate of new Fab dollars to be obligated before 9/30/85.

1. $9,672,743 - FMD Year-End Costs Projection (see Exhibit A)

2. $8,555,191 - Fiscal Year To Date Obligations as of 6/30/85

3. $649,000hr - Fab's Year-End Projection

4. $1,086,000 - Fab's estimated increase in Task Contract Obligations prior to Year-End 1985

5. $ 636,000 - The additional dollars which should be costed ($1,086,000-450,000).

6. $ 412,500 - Fab's estimated increase in obligations for support items.

7. $ 400,000 - Obligation for Equipment (not on the books)

Projections

	Obligations	
2.	$8,555,191	
4.	1,086,000	
6.	412,500	
7.	400,000	
	10,453,691	
	1,509,911	FYTD Carryover
	11,963,602	Total Obligations

	Costs	
1.	9,672,743	
5.	636,000	
	10,308,743	total costs

Hours
649,000

Obligations	Cost	Uncosted Obligations
$11,963,602	$10,308,743	$1,654,859

Projected Rate at Year-End - $\frac{\$10,308,743}{649,000} = \$15.89$

Projected Rate	-	$15.89
Predetermined Current Rate	-	15.25
Difference	-	.64

Recommendations:

1. Do not change the rate at this time.

2. Attempt to reduce the Fab hours put into AJO's and increase the RJO effort, cut back on stock issues, and put a lid on new obligations.

3. Continue discussions and analyses.

Exhibit A

An Analysis of FAB Contracts
For The Month Ending June 30, 1985

Contract #	Job Order #	PYTD Obligations	PYTD Accruals	PYTD Uncosted Obligations
NAS-1-15416	M1713, M1305, M1777	$6,696,169	$6,561,726	$134,443
NAS-1-15876	M1305, M1585, M1773	1,661,595	1,661,595	-0-
NAS-1-16369	M1305, M1711, M1775	5,456,474	5,456,454	20
NAS-1-16610	M1305, M1714, M1752, M1765, M1778	1,442,562	1,393,376	49,186
NAS-1-16613	M1712, M1776	1,144,619	950,253	194,366
NAS-1-17222	M1306, M1766	3,355,200	3,346,121	9,079
NAS-1-17514	M1820	4,250,000	2,940,794	1,309,206
NAS-1-17986	M1773	250,000	161,874	88,126
	Subtotal	$24,256,619	$22,472,193	$1,784,426
Other Direct Cost and Obligations Not Included Above:				
	M1305	$ 676,680	$ 676,680	-0-
	M1306	1,487,385	1,487,385	-0-
	M1585	1,392,377	1,392,377	-0-
	M1713	58	58	-0-
	M1800 (Adj.)	(1,807,237)	(1,807,237)	-0-
	Subtotal	1,749,263	1,749,263	-0-
	Total Direct	$26,005,882	$24,221,456	$1,784,426

Exhibit A (Concluded)

Indirect Costs.	PYTD Obligations	PYTD Accruals	PYTD Uncosted Obligations
Model and Fabrication Support (Small Business)-M1765, M1305	$3,633,072	$3,459,159	$173,913
Fabrication Supplies-M1753, M1304	2,788,457	2,788,457	-0-
Equipment Maintenance, Repair & Replacement-M1752, M1303, M1779	2,136,229	1,780,891	355,338
Supplies Purchase Request-M1774, M1586	2,147,645	2,011,948	135,697
Balance Call Agreement-M1769, M1581	240,917	193,117	47,800
RCA Contract Supplies-M1768, M1493	238,152	235,902	2.250
Machine Tool Rehabilitation-M1772, M1584	12,019	12,019	-0-
Naval Air Rework Facility-M1770, M1582	759	759	-0-
Total Indirect	11,197,250	10,482,252	714,998
Total	$37,203,132	$34,703,708	$2,499,424

FYTD Cost Accruals as of 6/30/85 -		$7,523,787
Potential Accruals at Year-End, 9/30/85:		
Uncosted Obligations	$2,499,424	
Less: Costs not to be Accrued in FY 1985 Dynamic Engineering/NAS-1-17514	(350,468)	2,148,956
Potential Year End Costs		$9,672,743

THE ULTRAVIOLET AND VISIBLE EMISSION OF SODIUM VAPOR PRODUCED BY LASER AND XENON CONTINUUM

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It has been proposed that the space station will have a solar pumped laser. Presently, all proposed solar pumped laser systems require additional waste heat management equipment. The development of a solar powered metal vapor laser would eliminate the need for the heat management equipment. The object of this research has been to obtain the fluorescence spectra of sodium vapor excited by light similar to that of the sun, seeking those bands in the fluorescence spectra that might produce laser emission.

Atomic alkali molecules have long been an object of considerable spectroscopic interest. Sodium molecules due to their well known spectrum, high absorption and emission cross section, and ease of production are of particular interest for laser systems. Presently, in the literature a large number of laser bands in the ultrviolet (1), visible (2) and infrared (3, 4) regions of the spectrum have been reported for sodium vapor. However, in all of these a laser was used for excitation.

Of the fluorescence bands of sodium vapor observed in the ultraviolet and visible region of the spectrum and their dependence on the vapor pressure, future research should be directed on the band at 436 nm for which gain measurements have been reported (5) and at 451 nm.

1) C. Y. R. Wu and J. K. Chen, Opt. Commun. 50, (1984) 317-319.

2) C. N. Man-Pichot and Alain Brillet, IEEE J. Quantum Electron, QE-16, (1980) 1103-1108.

3) B. Wellegehausen, W. Luhs, A. Topouzkhanian, and J. d'Incan, Appl. Phys. Lett. 43 (1983) 912-914.

4) W. Muller and I. V. Hertel, Opt. Commun. 45 (1983) 400-402.

5) J. T. Bahns and W. C. Stwalley, Appl. Phys. Lett. 44, (1984) 826-827.

MECHANICAL FEATURES OF SPACE ROBOTICS

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Industrial Technology Division
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and

Mechanical Engineering Department
Milwaukee School of Engineering
Milwaukee, Wisconsin

This project became a series of projects, each involving some aspect of the mechanical design and analysis, of robotic mechanisms and features which will be utilized in space.

Following is a brief summary of four of the these design analyses:

1. Design of Space Tools-For reasons of safety and convenience, it is desirable that tools that are utilized in the outer space environment be actuated by robots instead of by astronauts. A screwdriver (see Appendix A), pliers (see Appendix B), and forceps (see Appendix C), were designed, drafted and prototypes were manufactured and assembled. Each is powered and gripped by the end-effector gripper of the PUMA 600 robot at Langley Research Center.

2. End-Effector Force Analysis-A force analysis was made of the forces in the end-effector mechanism of the robot at Langley.

   This analysis related (a) the output torque of the end-effector motor, (b) the tangential output force of the worm, (c) the tangential force transmitted to the worm gear, and (d) the resulting gripper force at the actuation end of the mechanism (see Appendix D). These relations were found to be:

$$F_\omega = \frac{T_\omega}{\frac{1}{2} PD_\omega} = 22.5^{\#}$$

$$\frac{F_\omega}{F_G} = \frac{\cos \phi_n \sin \lambda + \mu \cos \lambda}{\mu \sin \lambda - \cos \phi_n \cos \lambda} = .167$$

$$\frac{G}{F_G} = \frac{g}{L \cos \theta} = \frac{.594}{\cos \theta}$$

where: G = the force of the gripper
F_G = the tangential gear force
F_W = the tangential worm force
T_ω = the actuating torque of the motor

The maximum gripper force was found to be 80.2 pounds, based on a maximum input torque of 60 ounce-inches.

3. Velocity Analysis of Epicyclic Gear Train in Robot Arm.-Joint #2 of the robotic mechanism employed an epicyclic gear train (see Appendix E). The velocity ratios of robot arm "A" to intermediate gears "C-D" and to the input motor shaft were found to be:

$$\frac{n_{motor}}{n_{arm}} = \frac{N_B N_D}{N_C N_E} = 108/1 \qquad \frac{n_{motor}}{n_{CD}} = \frac{N_B N_D}{N_E (N_C + N_B)} = 10.2/1$$

where n is the angular velocity of each respective component and "N" is the number of teeth of each respective gear.

4. Inertia Analysis of Robot Arm Mechanisms.-It was necessary to translate the inertia of two of the robot arms to an equivalent moment of inertia at the input motor shaft, (see Appendices F&G). Results included the following:

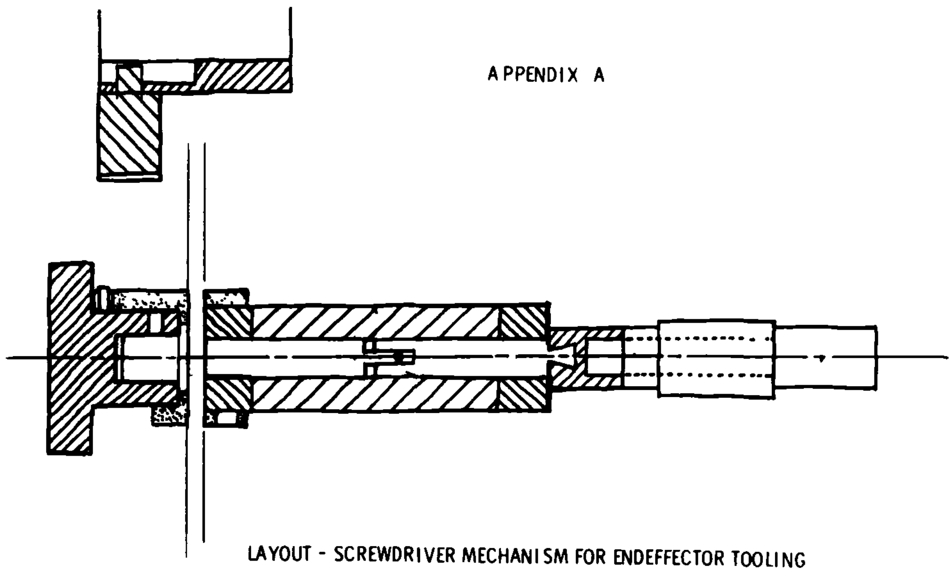
$$\frac{I_{motor\#1}}{I_{ARM\#1}} = \frac{N_B^2 N_D^2}{N_C^2 N_E^2} = 2.45 \times 10^{-4}$$

$$\frac{I_{motor\#2}}{I_{ARM\#2}} = \frac{N_E^2 N_C^2}{2 P_d N_B N_D^2 R_{ARM}} = 77.42 \times 10^{-6}$$

$$\frac{I_m}{I_A} = \frac{T_m \theta_A''}{T_A \theta_m} = \frac{F_m R_m \theta_A''}{F_A R_A \theta_m''}$$

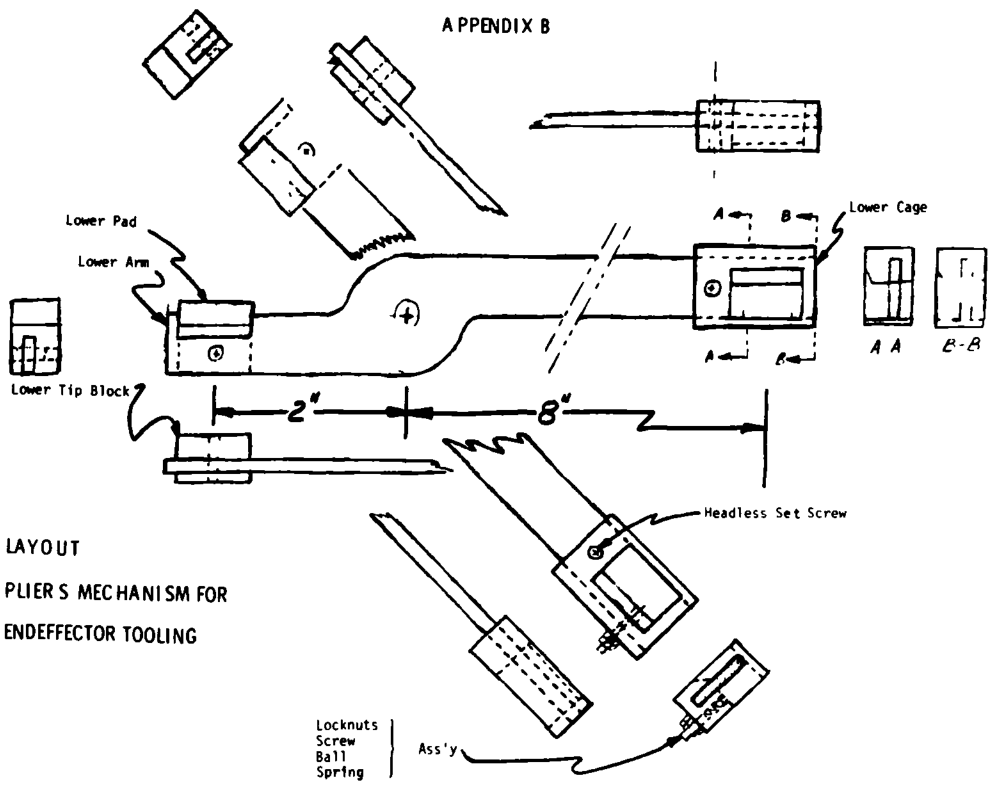
where: I = moment of inertia
θ'' = angular acceleration
T = torque
F = force
P_d = diameter pitch of gears
N = number of gear teeth
R = radius of member

APPENDIX A



LAYOUT - SCREWDRIVER MECHANISM FOR ENDEFFECTOR TOOLING

APPENDIX B

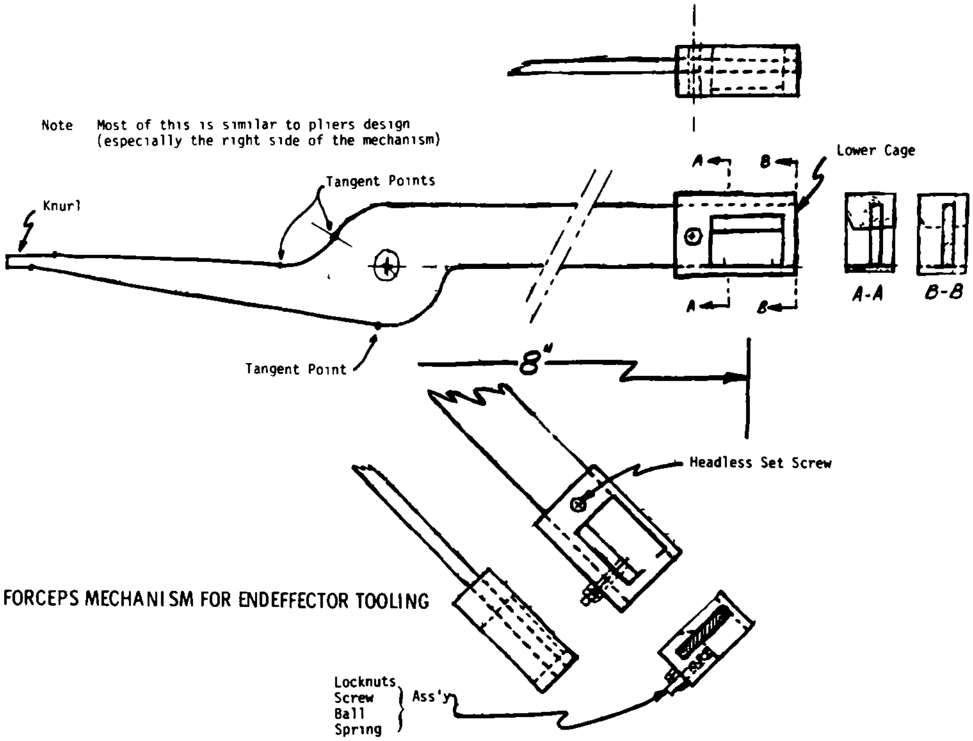


LAYOUT

PLIERS MECHANISM FOR

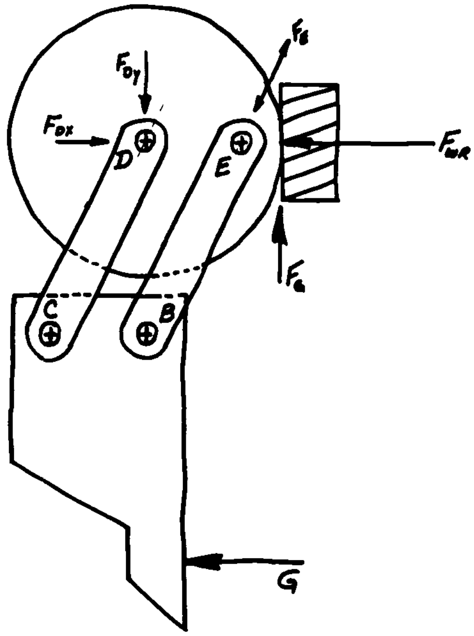
ENDEFFECTOR TOOLING

APPENDIX C

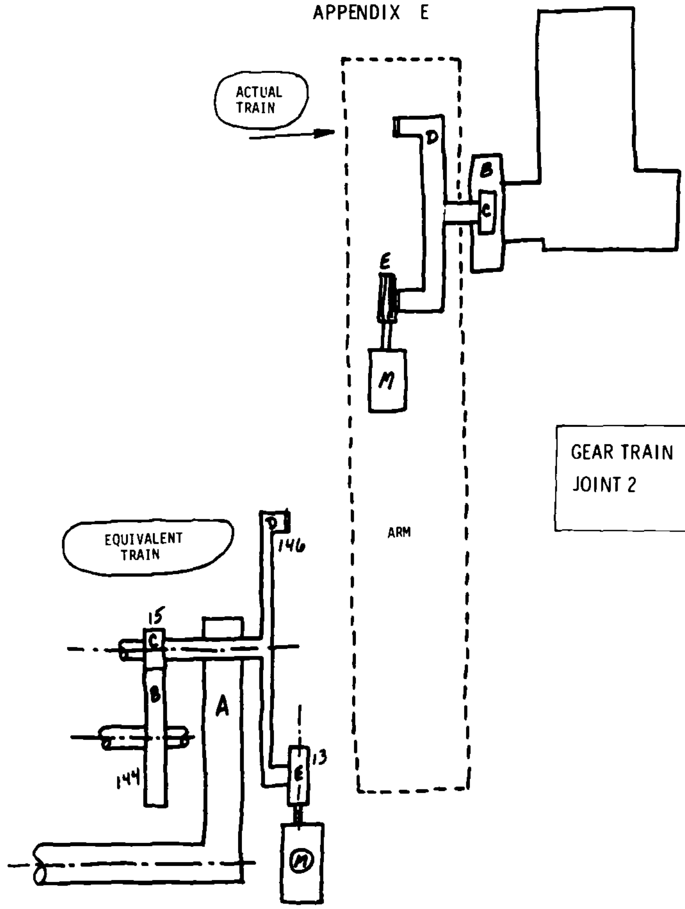


FORCEPS MECHANISM FOR ENDEFFECTOR TOOLING

APPENDIX D

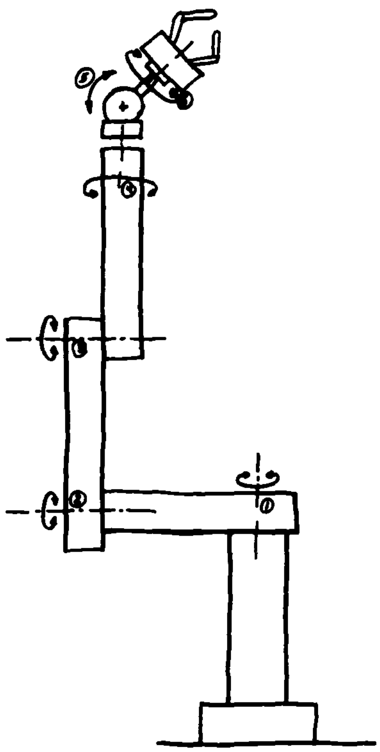


APPENDIX E



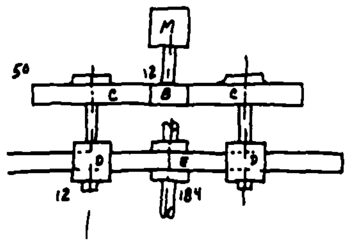
GEAR TRAIN
JOINT 2

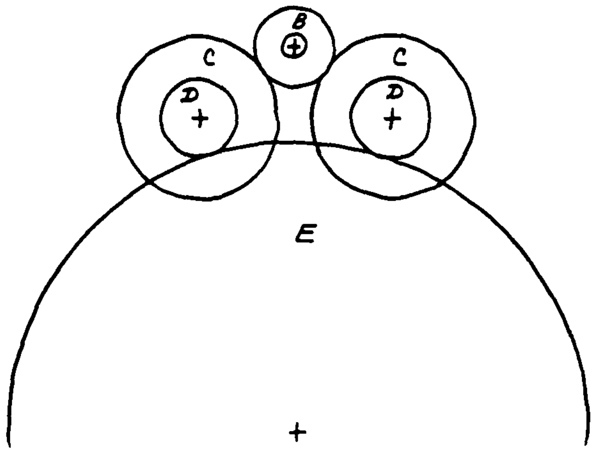
APPENDIX F



APPENDIX G

GEARING JOINT I





THE DESIGN OF A MASS SPECTROMETER FOR ATMOSPHERIC ANALYSIS ON A TETHERED SATELLITE AND ENTRY VEHICLE

Kenneth G Brown
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The use of mass spectrometry to sample the near surface environment of an entry test vehicle or low altitude tethered satellite is evaluated For successful operation in the higher pressure regions that exist at lower altitudes the mass spectrometer system must contain an inlet that 1) is capable of providing a sufficient pressure drop to protect the ion source, 2) can admit sample to the mass spectrometer that is representative of the external environment, and 3) the sample removal will not significantly perturb the flow at the surface of the vehicle In addition the remainder of the mass spectrometer must be located some distance from the inlet in order to be within the protective shielding As a result it is necessary to consider the design of the magnet in order to achieve a magnetic field that will allow the source and detection equipment to be situated apart fom the magnet and at the same time ensure that the total system is lightweight

The proposed inlet system consists of an array of capillary openings (approximately 10^5 /cm^2) The openings in the individual plates are uniform and range in diameter from 5 4 µm for a plate that is coated to 9 6µm for an uncoated plate The plates under study are either 400µm or 1000µm in thickness A plate is mounted in a holder with the surface of the plate flush with the surface of the holder The holder with the plate in place is mounted at the inlet of a quadrupole mass spectrometer The entire system is capable of being evacuated to 10^{-6} torr or lower The test gas is admitted to the system to obtain a flow which is parallel to the surface of the plate The pressure upstream and downstream of the plate is then measured as well as the pressure inside the mass spectrometer and the intensities of the individual peaks that are present in the particular sample

The test gas used in the initial evaluation of the inlet was a mixture of 7% CO_2 in air The upstream pressure ranged from 1 to 1000 micrometer of Hg which corresponds to a mean free path range at room temperature of from 1 to 1 cm at 298K The peak intensities due to N_2 , O_2 , and CO_2 were determined as a function of applied pressure To evaluate the flow the peak intensities for each molecule were plotted as a function of the ratio of the transparency, ε , of the plate to $\sqrt{\lambda L}$ where λ is the mean free path and L is the length of the capillary (1) A sample plot is shown in figure 1 with a break in the curve indicating the onset of molecular flow occurring at approximately 7 for all three species Future experiments will involve plates of different thicknesses, higher gas temperatures and gases with a greater disparity in molecular weight

The magnet in a mass spectrometer is usually designed to produce a homogeneous magnetic field As a result the object and image focus occur at the magnet face limiting the flexibility of the instrument An inhomogeneous magnetic field will allow the object and image points to be located away from the face of the magnet as shown in figure 2 The image plane, for different masses, will now be at an angle to the edge of the magnet instead of the parallel plane which exists for a homogeneous field We are currently investigating the effect of downsizing the magnet and changing the sector angle from the 180 degree case shown in figure 2 (2) to angles of 90 degrees or less Ray tracing, such as shown in figure 2, will enable the determination of the overall design for the system

1 Johnson, J C , Stair, A T and Pritchard, J L , J Appl Phys 37 1551-1558 (1966)

2 Whitehead, T W and White, F A , Nuclear Instruments and Methods 103 437-445 (1972)

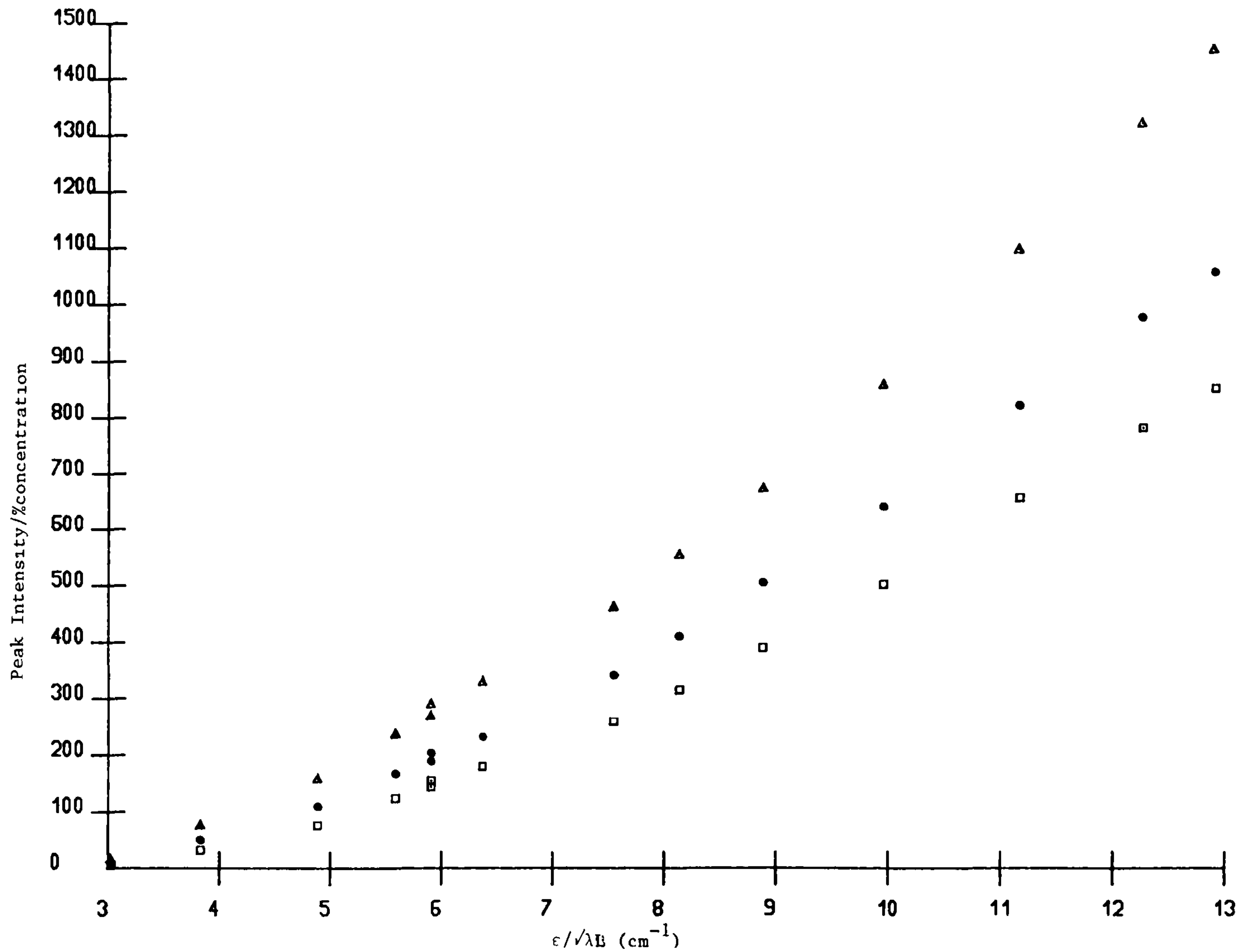

Figure 1. The dependence of the mass spectrometer peak intensity of N_2 ●, O_2 □, and CO_2 △ upon the characteristic parameter $\varepsilon/\sqrt{\lambda}L$

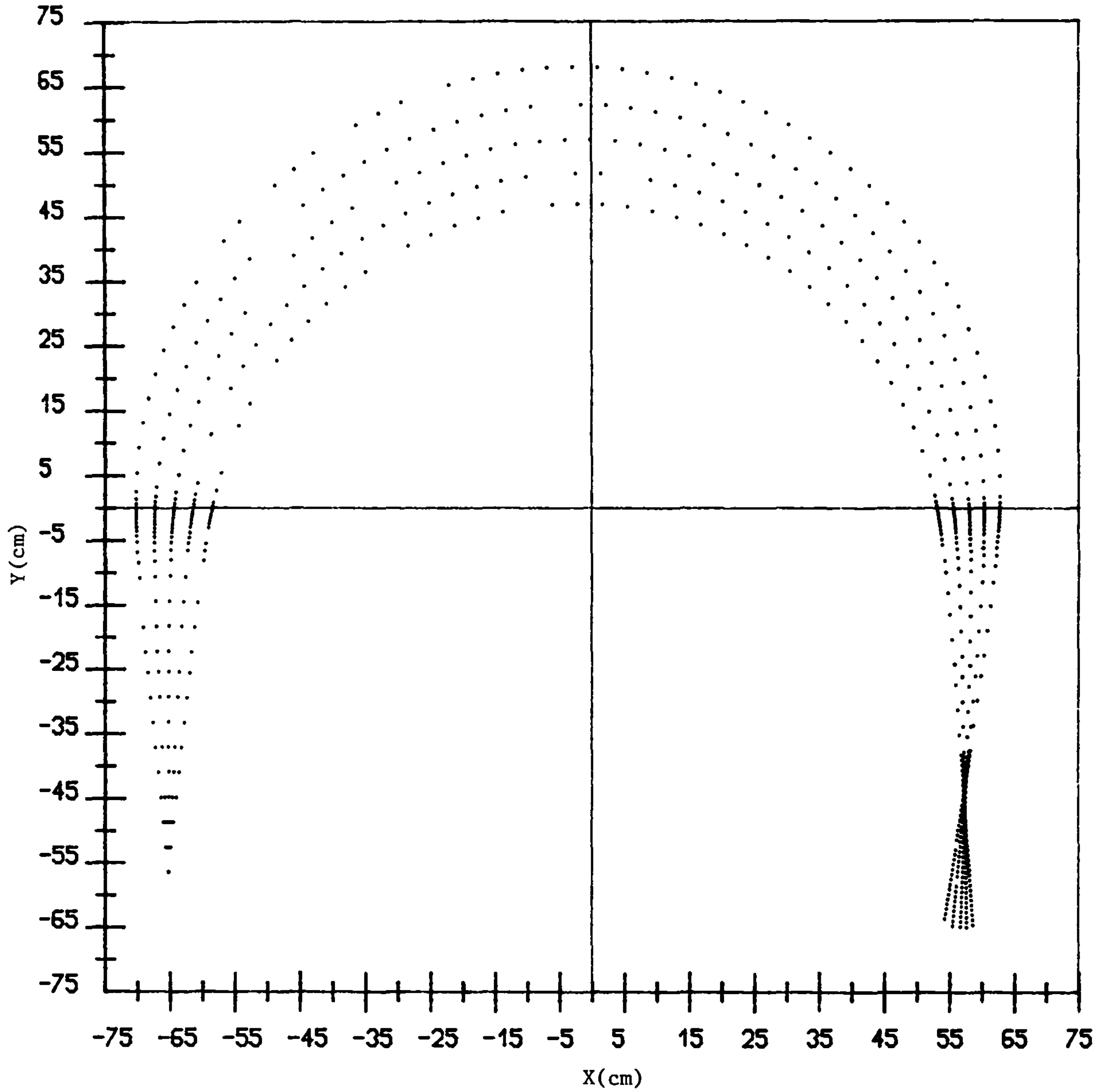

Figure 2. Calculated ion trajectories for an ion of mass 16 in a 24 inch magnet with an inhomogeneity of .5. Acceleration voltage of 2000keV and a B_0 of 500 gauss.

SIMULATION OF A PARALLEL JAW END EFFECTOR

Bill Bynum
Professor
Department of Computer Science
College of William and Mary
Williamsburg, VA 23185

One of the current research projects in the Automation and Technology Branch on remote teleoperator control of robotic manipulators is the Distributed Artificially Intelligent System for Interacting with the Environment (DAISIE) (cf [1,2,3]), a system developed by Nancy Orlando that combines artificially intelligent, goal-structured robot planning algorithms with traditional control methods for mechanical equipment In the DAISIE system, communication between the strategic planner and the various sensors and devices of the system is of paramount importance. When a new device is incorporated into the system, the set of commands that the device will accept and the responses that it will return must be specified; then this command protocol has to be encoded in a form usable by the processor that controls the device. In the case of an end effector, the specification of the command protocol is straightforward, but conveying the protocol to the processor controlling the end effector consists of burning the communciation protocol program into the ROM of the processor Unfortunately, it is impossible to forsee every eventuality when specifying a command protocol, which leads to iterating the previously described two-step process several times in developing a satisfactory command structure. The associated expense and effort of this process justify the use of software simulation to develop a command protocol for the end effector.

My project for the fellowship period has been to develop a collection of programs that will simulate the parallel jaw end effector used in the Intelligent Systems Research Lab [Wise, M.A., NASA Langley]. The design goal for this collection of programs is to provide a graphical display of the end effector that moves in approximately real time and executes concurrently with the contolling DAISIE program. The program is to execute on the VAX 11/750 in the Intelligent Systems Research Lab.

Graphics

The first step of the project was to develop a graphical representation of the end effector that moves in approximately real time A program was developed in FORTRAN77 using the DI3000 graphics package driving either a DEC VT240 graphics terminal or a DEC VT100 terminal fitted with a Retrograde Graphics board. Unfortunately, this hardware could not change the graphics display quickly enough to approximate real time movement of the end effector.

The program was rewritten for the VS11 graphics package driving the DEC VS11 terminal. The VS11 terminal has four separate memories, called "memory planes", in which images can be stored. This hardware obtains a higher display rate by overlapping the storage of the image in one of the planes while another of the planes is being displayed. For the sake of simplicity of program structure, only two of the memory planes are used in the graphical display of the end effector Movement of the end effector from one gap opening to another is portrayed by subdividing the total gap into smaller parts and showing the end effector in each of the intermediate positions. The speed of the movement is directly related to the number of subdivisions chosen and can be varied from barely perceptible to almost instantaneous.

Concurrency

Concurrency is simulated through the use of the VAX/VMS system subroutines, accessible from FORTRAN77. These routines provide concurrently executing processes the capabilty of communication through "mailboxes" and of synchronization through "event flags" Additionally, there are subroutines with which a process can "create," or initiate execution of a separate process

Program Structure

The strategic planner for the DAISIE system is written in the version of LISP on the ISRL VAX, Franz LISP. This LISP provides the facility to incorporate dynamically into the LISP environment separately compiled FORTRAN subroutines and functions, which allows the graphics and concurrency capabilites described above to be controlled by a LISP program.

An imported FORTRAN subroutine is called to start the simulation. This subroutine initializes the graphics display and the interprocess mailboxes and event flag clusters and initiates the subroutine that generates the graphics. The initialization subroutine executes to completion, but cannot terminate until the process that it created, the graphics process, terminates Control returns to the calling LISP program, allowing additional LISP functions to be invoked.

Each of the commands to the end effector is encoded as a LISP function . Each of these functions transforms its command into the format that the graphics process expects and invokes an imported FORTRAN subroutine to place the command message into the command mailbox and set an associated event flag. The graphics process is watching this event flag, waiting for it to be set. When the graphics process notices that a command has been given, it retrieves the command from the mailbox. The move or initialize-jaw commands are enqueued for subsequent action, whereas the quit, status request, and debug commands receive an immediate reply Move commands are enqueued because, in general, they require a longer time to complete than a status request. It is possible for the LISP driver program to transmit commands, particularly status requests, and receive replies during the execution of a move command

In the case of the request for status information, a reply consists of placing an appropriately formatted command in the reply mailbox and setting the associated event flag, the response to the move command is similar. The response to the debug command is to enable or disable the output to the user's terminal of various debugging information. The quit command causes the release of the system mailboxes and event flag cluster, as well as the termination of the LISP driver function, the graphics program, and the initialization process that created it.

Sketches of the end effector for several jaw openings are shown in Figure 1.

REFERENCES

1. Harrison, F.W. and Orlando, N.E., "A Systems-Level Approach to Automation Research", Proceedings of the 1984 Robotics Conference at the University of Alabama at Huntsville, April 1984

2 Orlando, N E., "A System for Intelligent Teleoperator Research", presented at the AIAA Computers in Aerospace IV Conference, October 1983

3. Orlando. N.E., "An Intelligent Robotics Control Scheme", presented at the American Controls Conference, June 1984.

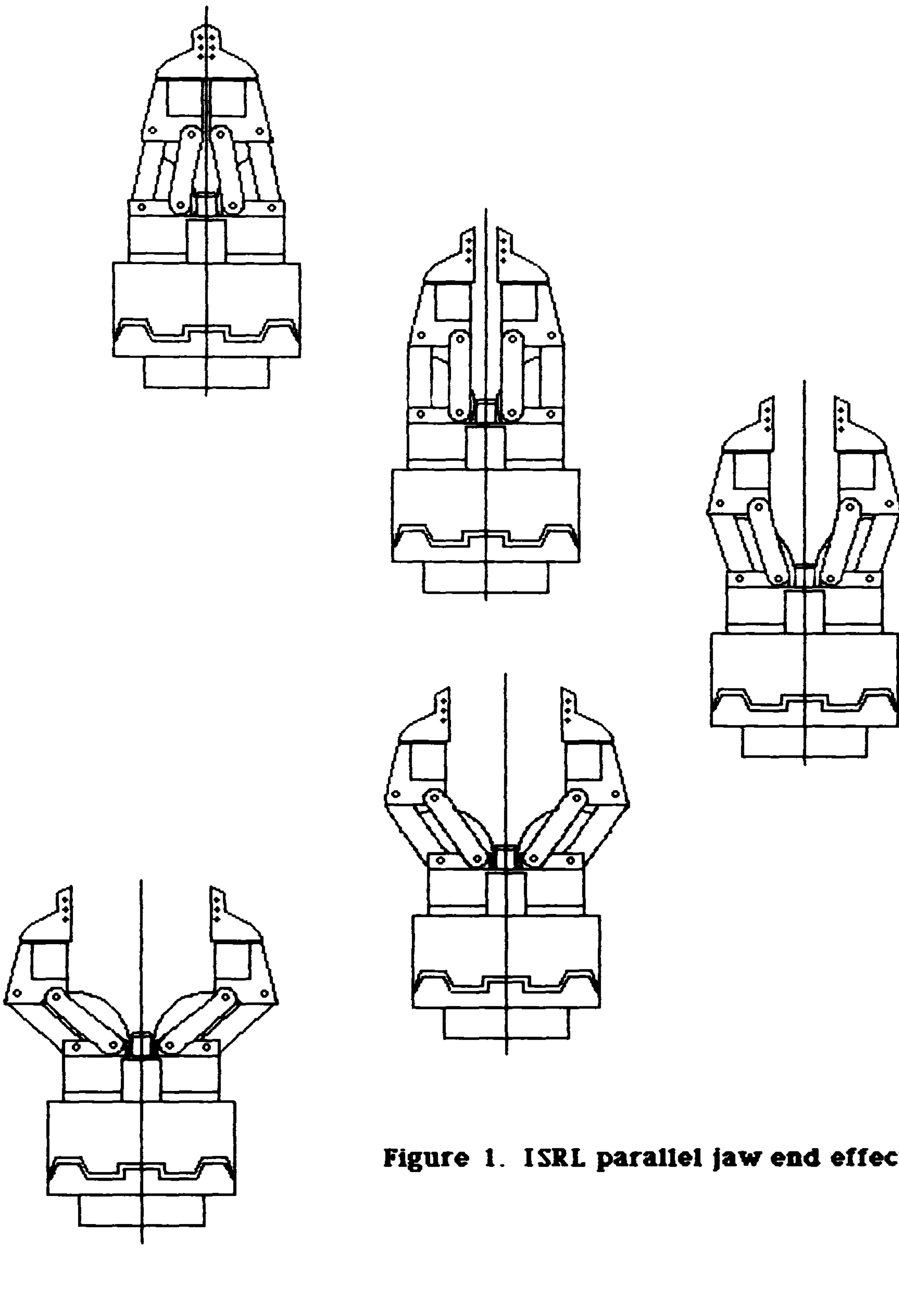

Figure 1. ISRL parallel jaw end effector

ELECTRONIC SOFTWARE SUPPORT:
ONLINE DOCUMENTATION, TUTORIALS, HELP AND ERROR MESSAGES

Patricia Ann Carlson
Professor
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Introduction

Electronic software support has matured from the early days where terse and often cryptic error messages constituted the only form of online assistance. Currently, specific categories of electronic user support include: command help and error assistance; prompting; online tutorials, and online documentation. Driven by the need to make systems usable by a diversified community and the awareness among hardware and software vendors that "user-friendliness" is a marketable concept, man/machine interfaces and online assistance are central issues in research and development today. This report deals specifically with online and offline documentation.

NASA/Langley Project

I was asked by my NASA colleagues -- Dr. John Shoosmith and Susan J. Voigt, of the Analysis and Computation Division -- to examine three issues -- with particular attention to the Control Data Corporation environment and the NOS operating system:

- the Langley users' documentation needs
- the current library of paper documentation
- the current capabilities of electronic computer support -- both at LaRC and state of the art

Specific recommendations for implementing online user support at LaRC follow from the investigation of these three items.

Overview of Findings

Except for an influx of summer people, LaRC has a large but relatively fixed user community. The majority of NOS users are computer professionals or scientists/engineers working on specific analytical problems. Because the users are "computer literate," training and support typically begin at a relatively high level. For the most part users refer to the documentation for task-related information -- either procedural instructions to perform a function or explanations/descriptions of particular features. This report elaborates on the need for (1) easy-to-use, (2) timely, (3) accurate, (4) accessible, and (5) readable documentation in the LaRC user community.

Paper documentation is the traditional method for handling user information needs. Even so, only recently has serious attention been given to techniques for producing good offline documentation. Within the past three years, LaRC has identified a set of manuals that fit together in a logical and sequential fashion without unnecessary overlap and has set up comprehensive policies and procedures for writing and distributing quality paper documentation. This report addresses both the strengths (e.g., rigorous editorial and review processes) and the weaknesses (e.g., insufficient field testing and lack of modern document design techniques) of this system.

The efficacy of online documentation is demonstrated by the growing number of systems that offer it in some form. Good online information offers convenience and timeliness to the end user and flexibility and ease of updating to the documenter. This study examines and evaluates current LaRC online documentation capabilities, with specific attention to:

- o NOS online Help (as part of the CDC system)
- o Information Tree (IT) -- a Langley generated program for allowing users to keep up with programs and capabilities developed by the LaRC community
- o KEYWORD -- a listing and description of utility programs available
- o CONTEXT -- a CDC "tool" for constructing online documentation

In addition, the study summarizes state of the art by reviewing online capabilities such as the Symbolics "Document Examiner," UNIX's "man" and "apropos" features, and the EMACS text editor's INFO system.

Summary of Recommendations

The industry trend is toward more online documentation. Furthermore, many installations have begun converting offline to online. However, simply putting existing texts online is not a satisfactory approach because accessibility and ease of use are seriously impaired. Two general approaches help to overcome these limitations: (1) design and rewrite the manuals so that substance, structure, style, and syntax meet the requisites of online presentation; (2) treat existing documentation as a database and develop sophisticated interfaces allowing the user access to appropriate information in a timely manner. This report adopts a hybrid of the two methods and suggests a scenario for online documentation at LaRC, phased in accordance with predicted hardware and software advances.

COMPUTING THE EXPONENTIAL FUNCTION OF A BI-DIAGONAL MATRIX WITH APPLICATIONS TO RELIABILITY ASSESSMENT OF FAULT-TOLERANT COMPUTER SYSTEMS

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ABSTRACT

The Semi-Markov Unreliability Range Evaluator (SURE) software package contains a module which estimates the probability E(T) of arriving at the death state of a pure Markov process by a given (mission) time T. The pure Markov chain is a subpath of the semi-Markov model which describes the behavior of fault-tolerant computer architectures.

The pure Markov model is characterized by a system of n first-order ordinary differential equations where n is the number of states leading from the intial state S_1 to the death state S_n. If $p_i(t)$ denotes the probability of being in state S_i at time t, the differential equations are of the form $p_1'(t) = \alpha_1 p_1(t)$, $p_n'(t) = \lambda_{n-1}p_{n-1}(t)$ and $p_i'(t) = \lambda_{i-1}p_{i-1}(t) + \alpha_i p_i(t)$ for $i = 2, \ldots, n-1$ where λ_i denotes the transition rate between state S_i and state S_{i+1}. The constant α_i is given by $-\lambda_i - \gamma_i$ where γ_i denotes a stransition rate from S_i to an intermediate state in the semi-Markov model. There are exactly n-1 αs and λs. We note also that $\alpha_i < 0$; $\lambda_i > 0$ for all i.

The system of differential equations may be expressed in the matricial form $P' = AP$ where $P = P(t)$ denotes the colum matrix $P(t) = [p_1(t), \ldots ,p_n(t)]^*$ (* denotes trabspose) and $A = (a_{ij})$ denotes the n by n bi-diagonal matrix with $a_{ii} = \alpha_i$, $a_{i+1,i} = \lambda_i$ $(i = 1, \ldots ,n-1)$ and $a_{ij} = 0$ elsewhere. The eigenvalues of A are 0, $\alpha_1, \ldots ,\alpha_{n-1}$. The probability function E(T) is calculated by solving the matricial system $P' = AP$ as an initial-value problem with $P(0) = [1, 0, \ldots ,0] = e_1^*$ and then setting $E(T) = p_n(T)$. The general solution is given by $P(t) = \exp(At)e_1$ where exp(M) denotes the matrix exponential of M. The value of E(T) is therefore the (n,1) component of exp(AT).

The primary objective of the summer research has been to develop and implement fast algorithms for computing E(T). The following results may be reported. Let exp(AT) $= [c_1, \ldots ,c_n]$ where c_i denotes the ith column of the exponential. We have proved that $c_n = e_n = [0, 0, \ldots ,1]^*$ and that

(1) $(A - \alpha_i I)c_i = \lambda_i c_{i+1}$ for $i = 1, 2, \ldots ,n-1$.

These relations hold regardless of the multiplicity of the eigenvalues of A or whether A is defective. The coefficient matrix in (1) is always singular of rank n-1. Consequently, the solution space is one-dimensional. If the eigenvalues of A are distinct, the equation (1) may be used to solve for the columns of exp(M) [here, M = AT] recursively in the order $c_{n-1}, c_{n-2}, \ldots ,c_1$ by noting that exp(M) is lower triangular with the scalar exponentials $\exp(\alpha_i T)$ along the main diagonal

in the first n-1 columns. Software is being developed to implement this algorithm.

If A has multiple eigenvalues, the algorithm requires modification. This problem is the subject of further investigations.

Another module for the fast calculation of E(T) is being developed. This has complete generality and is based on the rational approximation to exp(AT) found in the ninth diagonal entry of the Pade table for exp(x). The code takes full advantage of the sparse form of A. While it is essentially equivalent mathematically to the algorithm used in the NASA subroutine CONEXP, it will be far more efficient in its use of computing resources.

CONSIDERATIONS IN A COST/BENEFIT ANALYSIS OF THE COMMERCIALIZATION OF SPACE PROGRAM

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Abstract

In his state of the union message of January 1984, President Reagan announced the implementation of a number of executive initiatives designed to promote private sector investment in space. The executive initiatives have been termed the 'commercialization of space program.' A primary instigation of this commercialization of the space program can be traced to an Industry Commercial Space Group Report of December 1983 which concluded "commercial activities in space by private enterprise need to begin now if our nation is to retain its leadership in science and technology...and its advantages in international trade. With government as a partner, private enterprise can turn space into an arena of immense benefits for our nation." More specifically the macroeconomic goals of the space commercialization program as articulated by NASA Commercial Space Policy (unpublished data, NASA Commercialization Office, 1985) are to promote industry participation in accelerating the application of space technology to the civilian sector to "strengthen the nations economic vigor; retain our international technological preeminence; improve our balance of trade and maintain our high standard of living."

This study assumes that the significant and positive correlations found in previous studies[1] between technological advance, economic growth, trade advantages and improvements in general economic welfare will hold to a greater or lesser degree in the application of space technology to civilian goods and services. The study also assumes that technological progress can be influenced directly by the resources committed to research and development activities, i.e. technological progress/change is not a random event. What the study questions is whether or not there will be a greater amount of resources committed to R&D projects in the space arena under the 'commercialization' program initiatves than there would be in the absence of the initiatives.

Commercialization means to make profitable in a business way.[2] Thus the assertion of the commercialization of space program is that technological progress will be accelerated if the allocation of resources to R&D activities takes place in the private, for-profit sector, rather than the public, non-profit sector. Thus the national interest will be better served via the exploitation of space rather than the exploration of space[3].

Evaluating the potential public or social benefits of the commericalization of space program requires answers to the following questions:

1. What determines the level of a firm's research and development expenditures? While the term 'industry' is used repeatedly in discussions of the commercialization program, industry as such does not constitute a legal nor decision making entity. Allocation of resources takes place at the level of the individual firm.

2. What determines the allocation of a firm's expenditures among alternative R&D projects? Alternatively stated, what are the characteristics of the R&D projects that are undertaken? Social benefits are derived not only from the quantity of R&D expenditures but also from their quality and relevance.

3. What determines the rate of diffusion of technological change? Full social benefits of innovations are not realized unless the new process or product is adopted by other firms. It is the imitation by other firms which moves technological progress to the industry level and enables its impact on macroeconomic variables.

4. To what extent can the specific initiatives of the space commericalization program influence positivelv the quantity and character of R&D activities of firms and industries?

The analysis of the study uses the theoretical and econometric models developed in the economics literature to isolate the key determining variables relevant to the questions posed in question (1), (2), and (3) above. 4 Specific commercialization program initiatives are than hypothesized as to their positive, negative or neutral effect on the total R&D expenditures of individual firms, the allocation of expenditures among alternative R&D projects and the intra firm rate of diffusion of R&D outcomes. The analysis is speculative given the lack of data and the vague articulation of the implementation of the initiatives. Both undoubtedly reflect the newness of the program.

NOTES

1. This relationship has been documented in numerous studies employing various methodologies. The more definitive including the following: E. Denison, The Sources of Economic Growth in the United States and the Alternatives Before Us (New York: Committee for Economic Development, 1962); R. Solow, "Technical Change and the Aggregate Production Function," Review of Economic and Statistics, August 1957, Technology and the American Economy, Report of the National Commission on Technology, Automation and Economic Progress (Washington, 1966).

2. Webster's New Collegiate Dictionary

3. Exploration is defined as a systematic search for discovery. Exploitation is defined as utilization or to obtain value for one's own advantage or profit. Exploitation is the word used by the National Space Policy published on July 4, 1982

4. The models used draw heavily on the seminal work of E. Mansfield, Industrial Reseach and Technological Innovation (New York. Norton & Co., 1968) and K. Arrow, "Economic Welfare and the Allocation of Resources for Invention," in the National Bureau of Economic Research Conference Report, The Rate and Direction of Inventive Activity (Princeton: Princeton University Press, 1962).

A STUDY OF POTENTIAL GASES FOR BLACKBODY-PUMPED TRANSFER LASER

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Abstract

The conversion of solar radiation into high-power laser radiation in space could have wide application in future space power and propulsion requirements. One concept is to collect and converge solar radiation in space into a blackbody cavity heating it to a temperature of, say, 2000 K. A gaseous material passing through a transparent chamber within the blackbody cavity is excited radiatively. The excited molecules, M_1, are then mixed with another gaseous material of molecules, M_2. In molecular collisions, M_1 transfer their excited energy to M_2; and this creates a population inversion in some energy level of M_2. This study deals with the investigation of potential materials that might be used in such a transfer laser.

The radiative temperature of the blackbody cavity would be in the range from 1500 K to 2500 K. The corresponding wavelengths of the maximum radiative intensities are 1.93 μm and 1.16 μm respectively. In the irfrared region of the spectrum, the molecules would be excited to higher vibrational levels. The intermolecular processes involve both vibration-vibration transfer and vibration-translation transfer of energy.

Diatomic heteronulear molecules are considered only for M_1, while triatomic and other polyatomic molecules are considered mainly for M_2. A prelimary list of 12 diatomic, 10 triatomic, 11 four-atomic, 10 five-atomic, 3 six-atomic, and 1 seven-atomic molecules is compiled. Their fundamental vibrational levels are noted. Large rate constants for vibration-vibration transfers between M_1 and M_2 are desired for higher laser efficiencies. In these cases, their vibrational levels should be matched closely in order for efficient resonant transfer to be acheived.

To illustrate the principles of the mechanics of the transfer laser operation, an example of laser-excited infrared laser with M_1=CO and M_2=CO_2 is discussed.

THE ANALYSIS OF HYDROCARBONS IN THE TROPOSPHERE

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An analytical system has been developed for the determination of trace volatile organic compounds in the atmosphere. Current testing is focused on the analysis of hydrocarbons in the troposphere as part of NASA's efforts to gain an understanding of tropospheric chemistry. As presently configured, the system utilizes a permaselective membrane (Dupont Nafion) for water removal, a low-pressure liquid nitrogen cryogenic trap for concentrating the sample, and a gas chromatograph with a flame ionization detector for separation and quantification of components in the sample. Gas sample sizes of 500 mL are sufficient for the determination of components at concentration levels as low as sub-part-per-billion volume mixing ratios.

To date the system has been used successfully in the field for the analysis of hydrocarbons in samples taken from 40,000 ft down to sea level. Altitude/concentration profiles were determined for normal alkanes and lower molecular weight aromatics. In addition to these atmospheric samples, the system has also been used to analyze trace hydrocarbon components in the nearly pure methane gas emitted from the anaerobic sediments found in freshwater swamps, salt marshes, rivers, and coastal waters. The reduced-pressure cryogenic trapping loop in the system proved to be very effective for the latter analyses, since methane is not concentrated in the loop, but higher molecular weight components are. Continued testing this summer will also include the analysis of soil gas and leaf litter decomposition products from forest floors.

TRANSONIC FLUTTER ANALYSIS BY A LEAST-SQUARES FINITE ELEMENT SCHEME

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Abstract

The problem under consideration is unsteady transonic flow about a harmonically oscillating airfoil, where the unsteadiness is taken to be a linear perturbation about a nonlinear steady state. This assumption plus harmonic time dependence results in a linear equation for a complex potential ϕ

$$\left(\left[\frac{1-M^2}{M^2\varepsilon} - (\gamma + 1)\,\phi_{0_x}\right]\phi_x\right)_x + \phi_{yy} - \frac{2i\omega}{\varepsilon}\,\phi_x + \left[\frac{\omega^2}{\varepsilon} - i\omega\,(\gamma - 1)\,\phi_{0_{xx}}\right]\phi = 0 \qquad (1)$$

having discontinuous coefficients which depend on the solution of the steady state equation

$$\left[\frac{1-M^2}{M^2\varepsilon} - (\gamma + 1)\,\phi_{0_x}\right]\phi_{0_{xx}} + \phi_{0_{yy}} = 0 \qquad (2)$$

In these equations M is the free stream Mach number, ε is a scaling parameter depending on M and airfoil thickness, γ is the ratio of specific heats and ω is the reduced frequency.

The test airfoil is a 6% thick parabolic arc and we solve for M = .872 and pitching amplitude of .1 degree. Symmetry considerations allow us to solve in the half plane shown in figure (1). In addition to equation (1), we must impose appropriate boundary conditions along the airfoil surface, wake, and outer boundary. The steady state potential ϕ_0 is computed using the finite difference code TSFOIL.

Examination of the coefficient term

$$CF = \frac{1 - M^2}{M^2\varepsilon} - (\gamma + 1)\,\phi_{0_x} \qquad (3)$$

provides an understanding of the main characteristics of this flow. Figure (2) is a plot of CF along the airfoil surface. When the curve first crosses the x-axis equations (1) and (2) change type from elliptic to hyperbolic and the flow changes from subsonic to supersonic. These characteristics are reversed abruptly near x = .75 signifying the root location of a shock, a line in the flow plane along which a discontinuous jump occurs in ϕ_{0_x} and CF.

A least squares approach is convenient for this problem because there is no type of dependence like that in finite difference methods, and boundary conditions are imposed with ease. In addition, the finite element grid is quite flexible and points can be clustered locally in regions of large gradients while leaving the grid coarse in the far field. A typical grid is shown in figure (3). Points are clustered in the two regions where singular behavior occurs, around the leading edge at (0, 0) and near the root of the shock at (.75, 0.).

Since the mesh used in TSFOIL consists solely of horizontal and vertical lines, the fitting of ϕ_{o_x} to the finite element grid points demand particular attention, especially near the shock. The difference scheme spreads the shock somewhat over 3 or more points whereas a discontinuous jump between two successive points is more reasonable. Thus it is necessary to fit the shock by extrapolating from either side so that there is a clean jump in ϕ_{o_x}. Figure (4) displays the fitted CF versus the finite difference data, at y = 0. A subroutine was written this summer to fit ϕ_{o_x} and $\phi_{o_{xx}}$ at each row of points which passes through the shock in a simple manner. The interpolation scheme for fitting ϕ_{o_x} and $\phi_{o_{xx}}$ to the finite element grid was revised to ensure the jump at the shock is preserved.

Because the derivatives of ϕ are of as much or more physical significance that ϕ itself, we solve a first order formulation of (1). The formulation used previously to this summer is

$$u_x + v_y - \frac{2i\omega}{\varepsilon}\phi_x + \left(\frac{\omega^2}{\varepsilon} - i\omega(\gamma - 1)\phi_{o_{xx}}\right)\phi = 0 \qquad (4)$$

$$u - CF\phi_x = 0$$

$$v - \phi_y = 0$$

This choice for the variables was deemed appropriate as it assured necessary continuity in the product of two discontinuous variables through the shock. Of primary interest is the jump across the airfoil in the pressure coefficient, which in linearized form is

$$C_p = -2\,(\phi_x + i\omega\phi) \qquad (5)$$

The pressure jump computed using equation (4) is shown in figure (5). A point of controversy among those studying this problem is whether or not the formulation accounts for shock motion, which is assumed to be harmonic. The apparent answer is no. Thus an additional condition must be imposed, namely

$$\left\langle \frac{2i\omega}{\varepsilon} + CF_x \right\rangle \lfloor\phi\rfloor - \lfloor CF\rfloor \langle\phi_x\rangle = 0 \qquad (6)$$

where $\langle\ .\ \rangle$ denotes average value and $\lfloor\ .\ \rfloor$ denotes the jump across the shock. This necessitates building the shock into the finite element grid as shown in figure (6). It is appropriate then to let the variable u represent ϕ_x since equation (6) contains the necessary continuity conditions.

Computer experiments are now being performed with this formulation to determine the optimal size of computational region and number of grid points. No analytical solution exists so comparisons will be made with experimental results and results using other methods.

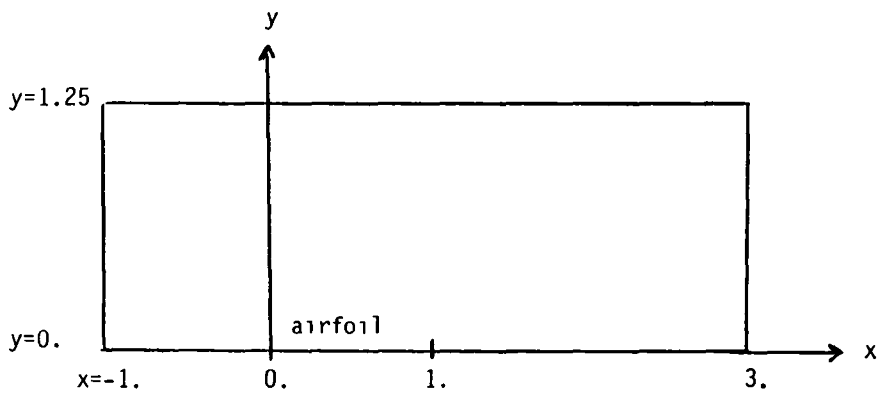

Figure 1. Computational Domain

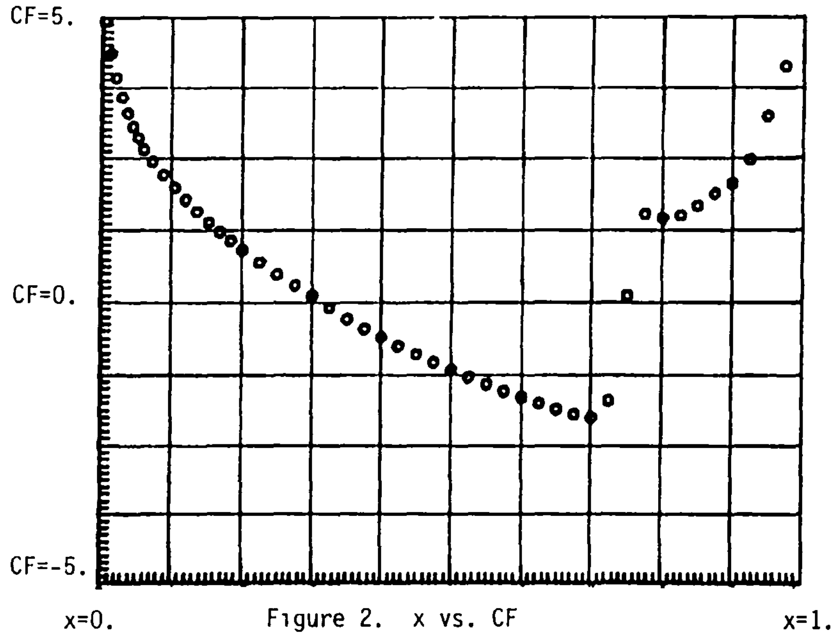

Figure 2. x vs. CF

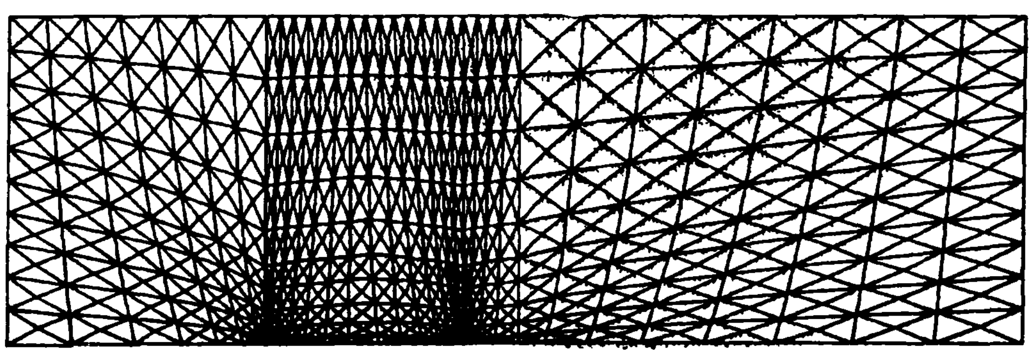

Figure 3. Finite Element Grid

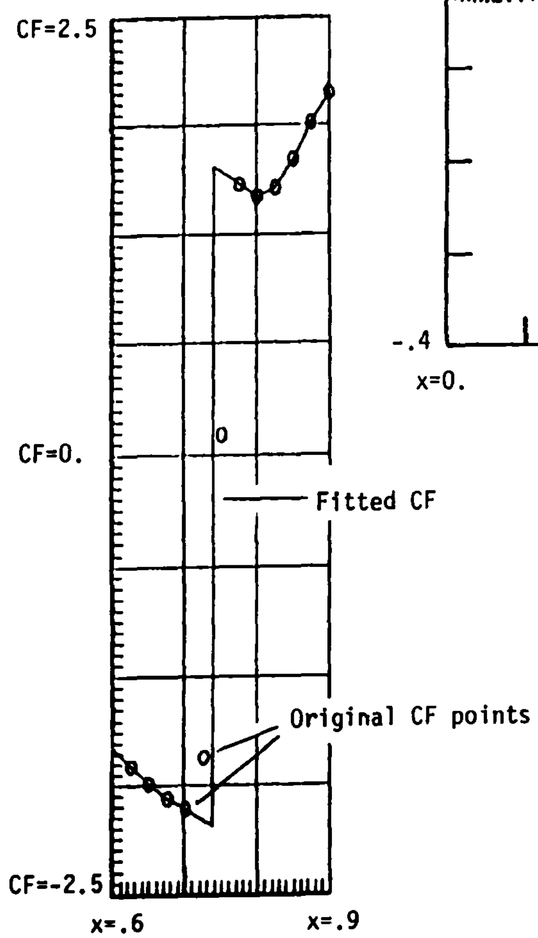

Figure 4.
Fitted CF

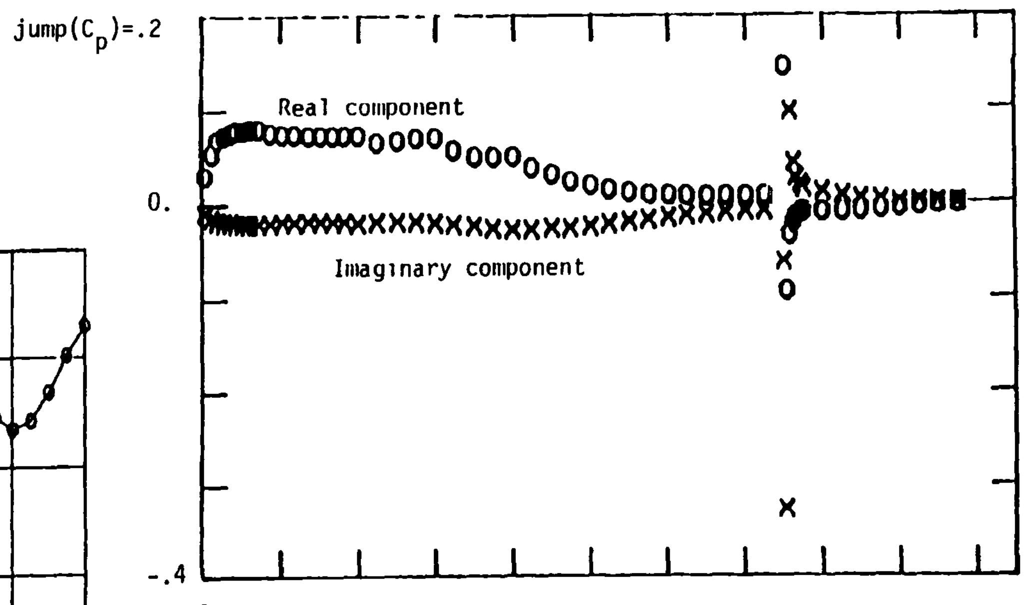

Figure 5. Jump in C_p along airfoil

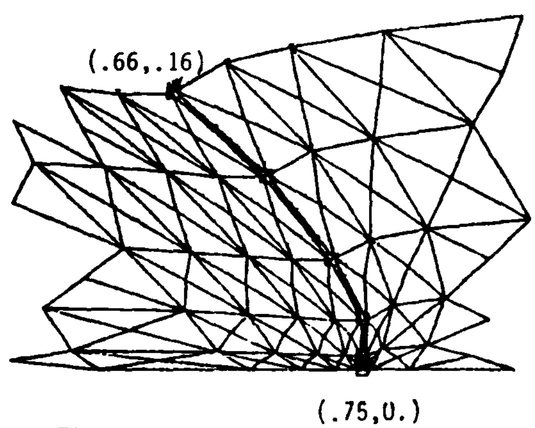

Figure 6. Grid fit around shock

SURVEY OF THE QUALITY OF THE
RESEARCH ENVIRONMENT AT NASA LANGLEY

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Background

The purpose of the project was to assess the quality of the research environment at Langley Research Center (LaRC). Specifically, the project was an effort to identify the aspects of the research environment which the LaRC scientists and engineers find to be of high quality, and the areas which are in need of improvement. Feedback on these topics will be provided to the Langley management. To more clearly define the aspects of the research environment on which to focus the study, interviews were first conducted with members of the LaRC senior staff. The areas of interest defined in these conversations were: (1) the amount of challenge, variety and freedom in the work assignments of the scientists and engineers; (2) the quality of the tools and support; (3) paperwork; (4) the research guidance process; (5) the NASA publication process; (6) communication within and between Langley organizations; (7) the ability of the scientists and engineers to initiate projects; (8) credit, recognition, and visibility of work; (9) career planning; (10) job satisfaction.

Study Design

Two methods were used to obtain data in these areas. The first method was a questionnaire distributed to 312 scientists and engineers in 5 LaRC Directorates (Electronics, Structures, Aeronautics, SE&O, and Space). Questionnaire items dealing with challenge, variety, freedom, job satisfaction, supervision, promotions, and awards were drawn from previously developed standardized questionnaires, and from questionnaires previously distributed by the Office of Personnel Management and NASA headquarters to LaRC scientists and engineers. Questionnaire items in other areas were generated by the author for the purposes of this study. Currently, completed questionnaires have been received from 184 of the employees. Data are presently being coded. Analyses will include presenting overall Center means and Directorate means for responses to the items. Comparison of present responses with those of past responses to the Office of Personnel Management and NASA headquarters items will also be made.

The second method used to collect data was in-depth structured interviews. The opinions of fewer researchers could be examined with this method compared to the questionnaire method; however, more detailed information could be gathered from each respondent. Interview questions were developed to assess the areas previously noted. A total of 23 researchers representing the five Directorates have presently been interviewed. All participants were asked the same set of questions and to elaborate on responses where approporiate. Each interview lasted approximately one hour. Interview participants were randomly selected from the pool of people who responded to the questionnaire.

Preliminary Results and Conclusions

Based on the interview data gathered thus far, several preliminary conclusions can be drawn about the research environment at LaRC.

(1) The scientists and engineers generally view their jobs as providing them with the opportunity to test new innovative ideas and to develop new methodologies. A number of respondents cited these opportunities as the major advantage of the job.

(2) The paperwork associated with submitting manuscripts for outside review at journals and conferences was viewed as redundant and unnecessary in many cases. Also the researchers felt too much time was spent in justifying the research that they were doing through paperwork and presentations.

(3) There was some mixed reaction to the tools and support available for conducting research. The LaRC Technical Library was described as excellent by a number of the respondents. Computer support was seen as adequate by some and inadequate by others. Generally, employees who had computers in their own branch were satisfied with their systems. The central computing facility was viewed as adequate, but turnaround time was described as problematic.

(4) Most of the scientists and engineers felt they had adequate opportunity to initiate research projects provided funding was available and the project was consistent with the goals of their branch. Ability to initiate projects relevant to work being conducted in other branches was thwarted. The scientists and engineers felt they had complete freedom to choose the methods they used to address their research problems.

(5) The participants felt that they were undercompensated relative to industry. Most were willing to accept the compensation differential for the opportunity to participate in the unique work at LaRC. However, many felt that the compensation gap between industry and NASA was growing larger, and if the gap became too large or if the research environment changed, the younger scientists and engineers may begin to look for opportunities in other organizations.

(6) Many of the scientists and engineers felt that the reviews provided by NASA technical review committees resulted in high quality NASA Technical Papers. There was not complete agreement on this issue however. Several of the respondents felt that at times papers were not given a thorough review through the NASA publication process. This situation was seen as prevalent when reviewers were chosen by the researcher, or when reviewers did not have the expertise to review the paper.

(7) The scientists and engineers generally felt that there was a good amount of technical communication within the branch. They also felt that there was not enough technical information shared between branches working on similar problems. Finally, the researchers felt that greater support for travel would greatly increase their contacts with professionals outside of LaRC.

MAKING SENSE OF FLIGHT TRANSITION MEASUREMENTS

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In a recently completed flight experiment, a Cessna Citation was used to measure boundary-layer transition in flight. The present report discusses that experiment and makes some recommendations for an upcoming NASA experiment using a Lear Jet. The purpose of the Citation experiment was to find how much Tollmien-Schlichting waves and cross-flow vortices interact in causing transition. The results were disappointing and do not allow any conclusions. The present author did several analyses to improve the results or explain the scatter. The effect of pressure measuring belts on pressure measurements was studied briefly, though the proper computational tools are not available. The airfoil and boundary-layer analysis codes available at Langley were run to compare with Boeing codes, in particular to determine if laminar separation could be blamed for transition in some cases. Finally, and most usefully, the difference between moving and stationary cross-flow vortices was checked to see if their motion must be accounted for. Better cross-flow vortex codes than are presently available will be needed to adequately interpret flight data.

COMPUTATION OF TRANSONIC FLOW OVER BODIES IN A WIND TUNNEL

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One of the goals of computational fluid dynamics is to supplement the wind tunnel as an aerodynamic design tool. Therefore it is desirable to have computational models for flow over bodies in a tunnel. Such models are useful for determining corrections to wind tunnel data.

During my previous experience at NASA Langley I developed a grid generation program for two dimensional bodies of general shape in a tunnel with shaped walls. The program uses a series of Schwarz - Christoffel transformations and shearing transformations to map the physical region between the body and tunnel walls into a rectangular computational domain. This procedure leads to an "O-type" mesh which is nearly orthogonal everywhere. The mesh is said to be O-type because one set of coordinate lines wraps around the body. The other set originates on the body surface and terminates on the tunnel walls. The resulting grid has desirable properties for the numerical solution of the inviscid flow equations.

The goal of my work this summer was to incorporate the tunnel grid coordinates into an existing Euler equation flow solver and hence produce a computational model for transonic inviscid flow over two dimensional bodies in a tunnel.

The Euler code chosen was FLO52, which was developed by Antony Jameson(Reference 1) and vectorized by J. Thomas and M.D. Salas of NASA Langley. The code solves the unsteady Euler equations using a finite volume scheme for spatial differences and a multistage Runge - Kutta scheme for the time step. Multigrid is used to advance the solution rapidly to steady state.

Early on in the work it was discovered that the grid generation program was not working completely satisfactorily. When it was applied to airfoils with blunt leading edges the scheme tended to produce small wiggles in the coordinate lines near the nose region. It was found that this was due to difficulties in the spline routine used to fit a smooth curve to the airfoil shape from the discrete input coordinates. A convenient way to fix this problem is to change the parameterization of the airfoil coordinates from y versus x to x versus s and y versus s, where x is distance along the chord, y is distance normal to chord, and s is arclength along the surface. The arclength parameterization avoids the singularity in derivative that occurs in y versus x at the leading edge. The spline routine had no difficulty fitting smooth curves to the two well behaved functions x(s) and y(s). The grid generation routine now works quite well and can treat airfoils of very general shape.

To incorporate a wind tunnel geometry into an Euler code written with free air boundary conditions in the far field, several considerations have to be taken into account. First a solid wall boundary condition replaces the free air boundary condition at the outer boundary. Inflow and outflow boundary conditions are needed at upstream and downstream infinity in the channel. Finally the calculation of the cell volumes has to be modified for cells at upstream and downstream infinity.

At this writing it is too early for any results but it is hoped that the resulting code will prove to be a useful tool for modeling transonic flow over bodies in a wind tunnel.

Reference 1: Jameson, A., "Solution of the Euler Equations by a Multigrid Method," Applied Mathematics and Computation, Vol.13,1983, pp.327-356.

EQUIVALENT CONTINUUM ANALYSIS OF PROPOSED LATTICE STRUCTURES FOR THE SPACE STATION

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This research develops a procedure for creating an equivalent continuum beam model for lattices of the type being proposed for the space station. The resulting equivalent beam models allow the following areas to be studied:

1. Stiffness comparisons of various configurations.

2. The relative coupling between the deformation modes.

3. The effect of joint stiffness on the stiffness and coupling parameters.

4. The effect of bi-linear joint stiffness on stiffness and coupling parameters.

5. The effect of non-uniform degradation or structural damage on stiffness and coupling parameters.

The equivalent continuum analysis is based on creating an equality between the strain energies of the lattice structure and the desired continuum model. The theoretical basis of this research is similar to the approach developed by Noor, Anderson, and Greene which utilizes an a-priori defined series expansion relating displacements and strain gradient terms (1). This work refines the approach developed by Dow, Feng, and Bodley which allows methods from linear algebra to be used to identify a set of linearly independent strain states from a candidate set in the displacement-strain gradient expansion (2). The development presented here is specialized to certain proposed space station configurations. This specialization to specific structures allows the method of Ref. 2 to be utilized in a more physically based and intuitive manner. In other words, the set of linearly independent strain gradient terms can be identified by inspection. The resulting compactness of the procedure makes it particularly suited for the preliminary design stage and implementation on personal computers.

The relationship between the nodal displacements and nodal rotations as a function of strain gradient quantities are developed for the two dimensional case in the first step. The two dimensional case contains enough detail to allow the results of the three dimensional development to be understood. The three dimensional results are included without proof. The coefficients of the displacements, rotations, and strains are given Tables 1-3. An interesting by-product of this derivation is the generation of the compatibility equations from elasticity. This can be seen in Table 3.

The second step identifies the linearly independent strain gradient quantities that characterize the space station lattice structure. Both, the case with hinged and the case with fixed joints, are considered. The terms identified by inspection are numerically verified for a candidate space station lattice.

The strain gradient parameters which characterize a beam with bending around two axes, rotation around the longitudinal axis, two orthogonal shear deformations, and longitudinal extension are then defined. These variables are called kinematic variables and they allow the first order stiffness and coupling parameters to be extracted from the stiffness matrix of the lattice structure. The remaining linearly independent variables can be included in the analysis to add the second order effects to the stiffness and coupling parameters.

With the identification of the linearly independent strain gradient quantities associated with the proposed space station lattice and the parameters that characterize a beam, the equivalent continuum beam parameters can be computed. This is done by transforming the strain energy in terms of the finite element stiffness matrix and nodal quantities to an expression in terms of the strain gradient quantities using the relationships developed in step 1. If only the kinematic variables are included, the first order stiffness and coupling parameters result. The secondary effects can be added in the beam parameters by using a static condensation procedure to implicitly include the secondary strain gradient parameters in the analysis.

The method is applied to a candidate structure and the effects of the second order terms are computed and discussed.

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TABLE 1 THE SIXTY COEFFICIENTS FOR DISPLACEMENT FUNCTIONS

i (1)	Term (2)	a_i for $u(x,y,z)$ (3)	b_i for $v(x,y,z)$ (4)	c_i for $w(x,y,z)$ (5)
1	1	u	v	w
2	x	ε_x	$\gamma_{xy}/2 + r$	$\gamma_{xz}/2 - q$
3	y	$\gamma_{xy}/2 - r$	ε_y	$\gamma_{yz}/2 + p$
4	z	$q + \gamma_{xz}/2$	$\gamma_{yz}/2 - p$	ε_z
5	x^2	$\varepsilon_{x,x}/2$	$(\gamma_{xy,x} - \varepsilon_{x,y})/2$	$(\gamma_{xz,x} - \varepsilon_{x,z})/2$
6	xy	$\varepsilon_{x,y}$	$\varepsilon_{y,x}$	$(-\gamma_{xy,z} + \gamma_{yz,x} + \gamma_{xz,y})/2$
7	xz	$\varepsilon_{x,z}$	$(\gamma_{xy,z} + \gamma_{yz,x} - \gamma_{xz,y})/2$	$\varepsilon_{z,x}$
8	y^2	$(\gamma_{xy,y} - \varepsilon_{y,x})/2$	$\varepsilon_{y,y}/2$	$(\gamma_{yz,y} - \varepsilon_{y,z})/2$
9	yz	$(\gamma_{xy,z} - \gamma_{yz,x} + \gamma_{xz,y})/2$	$\varepsilon_{y,z}$	$\varepsilon_{z,y}$
10	z^2	$(\gamma_{xz,z} - \varepsilon_{z,x})/2$	$(\gamma_{yz,z} - \varepsilon_{z,y})/2$	$\varepsilon_{z,z}/2$
11	x^3	$\varepsilon_{x,xx}/6$	$(\gamma_{xy,xx} - \varepsilon_{x,xy})/6$	$(\gamma_{xz,xx} - \varepsilon_{x,xz})/6$
12	x^2y	$\varepsilon_{x,xy}/2$	$\varepsilon_{y,xx}/2$	$(\gamma_{xz,xy} - \varepsilon_{x,yz})/2$
13	x^2z	$\varepsilon_{x,xz}/2$	$(\gamma_{xy,xz} - \varepsilon_{x,yz})/2$	$\varepsilon_{z,xx}/2$
14	y^3	$(\gamma_{xy,yy} - \varepsilon_{y,xy})/6$	$\varepsilon_{y,yy}/6$	$(\gamma_{yz,yy} - \varepsilon_{y,yz})/6$
15	y^2x	$\varepsilon_{x,yy}/2$	$\varepsilon_{y,xy}/2$	$(\gamma_{yz,xy} - \varepsilon_{y,xz})/2$
16	y^2z	$(\gamma_{xy,yz} - \varepsilon_{y,xz})/2$	$\varepsilon_{y,yz}/2$	$\varepsilon_{z,yy}/2$
17	z^3	$(\gamma_{xz,zz} - \varepsilon_{z,xz})/6$	$(\gamma_{yz,zz} - \varepsilon_{z,yz})/6$	$\varepsilon_{z,zz}/6$
18	z^2x	$\varepsilon_{x,zz}/2$	$(\gamma_{yz,xz} - \varepsilon_{z,xy})/2$	$\varepsilon_{z,xz}/2$
19	z^2y	$(\gamma_{xz,yz} - \varepsilon_{z,xy})/2$	$\varepsilon_{y,zz}/2$	$\varepsilon_{z,yz}/2$
20	xyz	$\varepsilon_{x,yz}$	$\varepsilon_{y,xz}$	$\varepsilon_{z,xy}$

$u(x,y,z) = a_1 + a_2x + a_3y + a_4z + a_5x^2 + \ldots + a_{20}xyz$; $v(x,y,z) = b_1 + b_2x + b_3y + b_4z + b_5x^2 + \ldots + b_{20}xyz$;

$w(x,y,z) = c_1 + c_2x + c_3y + c_4z + c_5x^2 + \ldots + c_{20}xyz$

TABLE 2. THE COEFFICIENTS FOR ROTATION FUNCTIONS

COL. #	TERM (1)	p(x,y,z) (2)	q(x,y,z) (3)	r(x,y,z) (4)
1	1	p	q	r
2	x	$(\gamma_{xz,y}-\gamma_{xy,z})/2$	$(-\gamma_{xz,x}+2\epsilon_{x,z})/2$	$(\gamma_{xy,x}-2\epsilon_{x,y})/2$
3	y	$(\gamma_{yz,y}-2\epsilon_{y,z})/2$	$(\gamma_{xy,z}-\gamma_{yz,x})/2$	$(-\gamma_{xy,y}+2\epsilon_{y,x})/2$
4	z	$(-\gamma_{yz,z}+2\epsilon_{z,y})/2$	$(\gamma_{xz,z}-2\epsilon_{z,x})/2$	$(-\gamma_{yz,x}-\gamma_{xz,y})/2$
5	x^2	$(\gamma_{xz,xy}-\gamma_{xy,xz})/4$	$(-\gamma_{xz,xx}+2\epsilon_{x,xz})/4$	$(\gamma_{xy,xx}-2\epsilon_{x,xy})/4$
6	xy	$(\gamma_{yz,xy}-2\epsilon_{y,xz})/2$	$(-\gamma_{xz,xy}+2\epsilon_{x,yz})/2$	$(\epsilon_{y,xx}-\epsilon_{x,yy})/2$
7	xz	$(-\gamma_{yz,xz}+2\epsilon_{z,xy})/2$	$(\epsilon_{x,zz}-\epsilon_{z,xx})/2$	$(\gamma_{xy,xz}-2\epsilon_{x,yz})/2$
8	y^2	$(\gamma_{yz,yy}-2\epsilon_{y,yz})/4$	$(\gamma_{xy,yz}-\gamma_{yz,xy})/4$	$(-\gamma_{xy,yy}+2\epsilon_{y,yx})/4$
9	yz	$(\epsilon_{z,yy}-\epsilon_{y,zz})/2$	$(\gamma_{xz,yz}-2\epsilon_{z,xy})/2$	$(-\gamma_{xy,yz}+2\epsilon_{y,xz})/2$
10	z^2	$(-\gamma_{yz,zz}+2\epsilon_{z,yz})/4$	$(\gamma_{xz,zz}-2\epsilon_{z,xz})/4$	$(\gamma_{yz,xz}-\gamma_{xz,yz})/4$

TABLE 3. THE COEFFICIENTS FOR STRAIN FUNCTIONS

TERM	$\epsilon_x(x,y,z)$	$\epsilon_y(x,y,z)$	$\epsilon_z(x,y,z)$	$\gamma_{xy}(x,y,z)$	$\gamma_{yz}(x,y,z)$	$\gamma_{xz}(x,y,z)$
1	ϵ_x	ϵ_y	ϵ_z	γ_{xy}	γ_{yz}	γ_{xz}
x	$\epsilon_{x,x}$	$\epsilon_{y,x}$	$\epsilon_{z,x}$	$\gamma_{xy,x}$	$\gamma_{yz,x}$	$\gamma_{xz,x}$
y	$\epsilon_{x,y}$	$\epsilon_{y,y}$	$\epsilon_{z,y}$	$\gamma_{xy,y}$	$\gamma_{yz,y}$	$\gamma_{xz,y}$
z	$\epsilon_{x,z}$	$\epsilon_{y,z}$	$\epsilon_{z,z}$	$\gamma_{xy,z}$	$\gamma_{yz,z}$	$\gamma_{xz,z}$
x^2	$1/2\epsilon_{x,xx}$	$1/2\epsilon_{y,xx}$	$1/2\epsilon_{z,xx}$	$1/2\gamma_{xy,xx}$	$1/2\gamma_{xz,xx}^*$	$1/2\gamma_{xz,xx}$
xy	$\epsilon_{x,xy}$	$\epsilon_{y,xy}$	$\epsilon_{z,xy}$	$\gamma_{xy,xy}^*$	$\gamma_{yz,xy}$	$\gamma_{xz,xy}$
xz	$\epsilon_{x,xz}$	$\epsilon_{y,xz}$	$\epsilon_{z,xz}$	$\gamma_{xy,xz}$	$\gamma_{yz,xz}$	$\gamma_{xz,xz}^*$
y^2	$1/2\epsilon_{x,yy}$	$1/2\epsilon_{y,yy}$	$1/2\epsilon_{z,yy}$	$1/2\gamma_{xy,yy}$	$1/2\gamma_{xy,yy}$	$1/2\gamma_{xz,yy}^*$
yz	$\epsilon_{x,yz}$	$\epsilon_{y,yz}$	$\epsilon_{z,yz}$	$\gamma_{xy,yz}$	$\gamma_{yz,yz}^*$	$\gamma_{xz,yz}$
z^2	$1/2\epsilon_{x,zz}$	$1/2\epsilon_{y,zz}$	$1/2\epsilon_{z,zz}$	$1/2\gamma_{xy,zz}^*$	$1/2\gamma_{yz,zz}$	$1/2\gamma_{xz,zz}$

* The terms starred are equal to the compatibility relations which are given **below**,

$$\gamma_{xy,xy} = \epsilon_{x,yy} + \epsilon_{y,xx} \qquad \gamma_{xy,zz} = \gamma_{xz,yz} + \gamma_{yz,xz} - 2\epsilon_{z,xy}$$

$$\gamma_{yz,yz} = \epsilon_{y,zz} + \epsilon_{z,yy} \qquad \gamma_{yz,xx} = \gamma_{xy,xz} + \gamma_{xz,xy} - 2\epsilon_{x,yz}$$

$$\gamma_{xz,xz} = \epsilon_{x,zz} + \epsilon_{z,xx} \qquad \gamma_{xz,yy} = \gamma_{xy,yz} + \gamma_{yz,xy} - 2\epsilon_{y,xz}$$

MECHANICAL AND EPR* STUDIES OF THE RADIATION-DURABILITY OF FIBERS AND FIBER/RESIN COMPOSITES

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The use of fiber-reinforced composite materials for space structural components has greatly increased in recent years. The principal advantages of these materials are high strength, high modulus of elasticity, and low density. Another advantage is the ability to tailor the materials to meet specific load and stiffness requirements. However, in aerospace applications, these composites are exposed to solar ultraviolet radiation and charged particles(protons and electrons). Therefore, if these composites are to be used as efficient high performance materials, their long term radiation-durability must be established.

The performance of fiber-reinforced composite materials depends not only on the strength of the component materials but also on the interaction at the fiber resin interface. The interfacial bonds, which influence the ultimate stress, modes of failure, interlaminar shear strength, and modulus of elasticity of the composites, are sensitive to radiation. Exposure of the structure to electron bombardment induces free radicals which can lead to profound changes in these mechanical properties of the material.

The goals of the study were: (1) to determine and analyze the effects of radiation on the mechanical properties of graphite and Kevlar fibers; (2) to determine and analyze the effects of radiation on the mechanical properties of graphite/resin composites fabricated from the same types of graphite fibers; (3) to see if a correlation exists between the radiation durability of the component materials and the fiber/resin composites.

Graphite (Celanese Celion 6000 sized with 0.1% polyimide, Celanese Celion 6000 nonsized) and Kevlar 49 fibers were exposed to 1 MeV electrons up to 9.5×10^9 rad. Since the results of investigations on the radiation-durability of Ultem, a polyetherimide, have been previously reported by my NASA associates, Drs. Edward and Sheila Long, Celion 6000 nonsized graphite/Ultem and Celion 6000 sized graphite/Ultem composites were fabricated.

*Electron Paramagnetic Resonance

These composites, with fibers oriented uniaxially in the longitudinal and transvers directions, were exposed to the same dosage of radiation as the isolated fibers. Characterization of the fibers and composites was performed by tensile tests and interlaminar shear strength tests, respectively, before and after irradiation. Electron paramagnetic resonance (EPR) data were used to detect, identify, and determine the densities of radicals created by the irradiation.

The mechanical data indicate that there were radiation induced changes in the tensile properties of the graphite and Kevlar 49 fibers. These results are supported by the presence of induced free radicals as shown by the EPR measurements. Interlaminar shear strength tests and EPR analysis of the composites are continuing.

SAMPLING AND ANALYSIS OF STRATOSPHERIC AEROSOLS

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ABSTRACT

A strategy for sampling and analysis of stratospheric aerosols will be discussed. The objective is to sort and strip out the various natural (oceanic, crustal, meteoric) and anthropogenic pollution components so that volcanic injections to the stratosphere can be determined separately. The ultimate goals are to follow the transport, transformation, and removal of these materials and to evaluate their climatic effect.

Rapid methods of analysis, such as x-ray emission spectroscopy coupled with scanning electron microscopy, have been commonly employed in the past. These methods are quite acceptable for rapid first approximations, but for the above objectives and goals, much more detailed chemical analyses are required.

Recommendations include obtaining larger samples, separate samples for chemical analyses and analyses using more sensitive methods of analyses whenever possible.

THE INSTRUMENTATION OF A MILLIMETER
WAVE COMPACT RANGE

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ABSTRACT

The basic principle behind compact ranges is discussed along with the attendant complexities and problems. A millimeter wave system is proposed that will help in reducing unwanted clutter and thus will better simulate outdoor conditions. The entire system is then controlled by a PDP11/23 computer in order to automate measurements and to provide on site signal processing.

INTRODUCTION

The compact range is an indoor chamber dedicated to measuring the radiation pattern of antennas or the backscatter from radar targets. Millimeter electromagnetic waves range from 30-300 GHz. The distinct advantages of a compact range are that measurements can be made regardless of weather conditions and that measurements can be made on scale models due to the theorem of similitude.

The chamber consists of the antenna feed system located at the focus of a parabolic reflector, the target located on a pedestal and the associated electronics and controller. The system is depicted in figure 1.

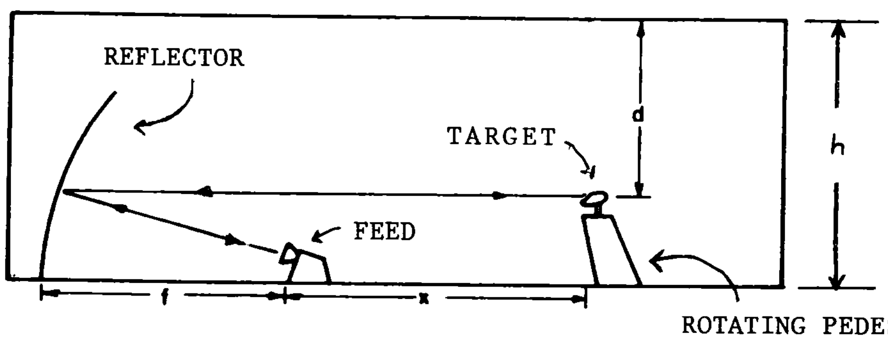

Figure 1. SIDE VIEW OF COMPACT RANGE

The inherent problem arising from use of an indoor range is that energy scatters not only from the target but also from the walls, ceiling, floor and reflector edge. The unwanted scattering mechanisms are called clutter, and due to their spatial location arrive at the receiver at different times.

MILLIMETER WAVE SYSTEM

One method of reducing the clutter is by pulsing the radar signal transmitted, waiting for the pulse to travel round trip to the target and back, and opening the receiver (gating) at the predicted instant in time associated with the target location. The gate is then closed to prevent clutter, traveling from further sources, from entering the receiver. This technique is called a pulsed-CW System. The total round trip delay is:

$$T_t = \frac{4f + 2x}{c} = 73\,\text{nsec} \tag{1}$$

The source frequencies are 27-40 GHz. The pulse repetition rate is 5 MHz and the pulse width is 50 nsec. The pulsed-CW System is shown in figure 2.

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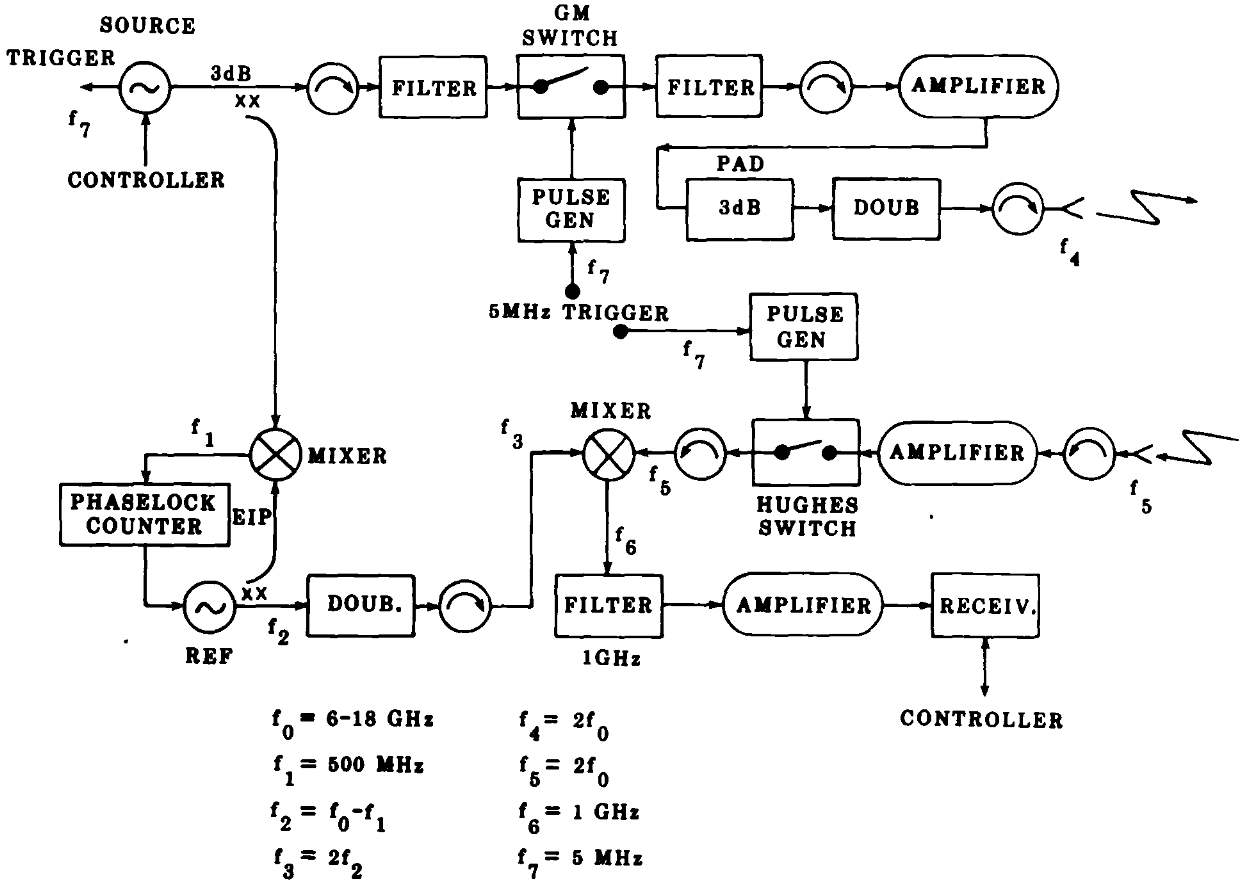
SOURCE
TRIGGER
f7
CONTROLLER
3dB
XX
FILTER
GM
SWITCH
FILTER
AMPLIFIER
PAD
3dB
DOUB
f4
PULSE
GEN
f7
5MHz TRIGGER
f7
PULSE
GEN
f1
MIXER
PHASELOCK
COUNTER
EIP
XX
REF
f2
DOUB.
f3
MIXER
f5
HUGHES
SWITCH
AMPLIFIER
f5
f6
FILTER
1GHz
AMPLIFIER
RECEIV.
CONTROLLER
f0 = 6-18 GHz
f1 = 500 MHz
f2 = f0-f1
f3 = 2f2
f4 = 2f0
f5 = 2f0
f6 = 1 GHz
f7 = 5 MHz

THE TRANSITION FROM NACA TO NASA AT LANGLEY RESEARCH CENTER, A HISTORICAL PERSPECTIVE

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Summary

The original parent organization of Langley Research Center was the National Advisory Committee for Aeronautics. Congress established the NACA in 1915 "to supervise and direct the scientific study of the problems of flight with a view to their practical solution." The NACA performed this assignment with distinction until 1 October 1958--when a new federal agency, the National Aeronautics and Space Administration, absorbed and continued the aeronautical duties of the NACA and took on the additional responsibility of exploring outer space. The crucial event in the transition from NACA to NASA occurred on 4 October 1957: the Soviet Union shocked the world by launching the first man-made satellite into Earth orbit. Huddling near radios and televisions, Americans heard the rebroadcast "beep-beep-beep" of Sputnik, and they were alarmed. The distant Russian satellite seemed to be signalling a new communist threat to their national security and to be mocking the United States and its preeminent scientific and technological establishment for failing to be first into space. Less than one month later, Sputnik II repeated the insult, and the space race was on.

This presentation outlines preliminary results of a historical investigation into the question, how did NACA Langley react to the Sputnik crisis? Findings will be used to support the writing of the first chapter of a sequel to my book _Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958_ (in press, NASA, Washington, D.C.). (See Attachment for chapter outline of _Engineer in Charge_, plus chapter outline of projected sequel.)

Analysis

In retrospect, it is surprising to find NACA Langley so unmoved by Sputnik. At the annual meeting of the Main Committee of the NACA on 10 October 1957 (only 6 days after the launching of the Russian satellite), the subject never came up. Nor was there any mention at all of Sputnik in Langley's in-house newspaper, the _Air Scoop_, until the 3 January 1958 issue. The NACA reaction was not unprecedented, though. When asked at a press conference on 9 October 1958 if Sputnik worried him, Eisenhower had replied, "so far as the satellite itself is concerned, that does not raise my apprehensions, not one iota." Eleven days later a member of the president's staff discounted the Russian achievement as an attempt to draw the U.S. into "an outer space basketball game."

Like Eisenhower, NACA leaders did not at first see Sputnik as a reason to upset the progress of the country's existing aircraft and missile programs. At a meeting of the House Select Committee on Aeronautics and Space Exploration in 1958 Hugh Dryden, the NACA's director for research, was asked if a crash program should be instituted to launch a man straight up into space and return him by parachute. (Werner Von Braun had suggested this earlier to the same committee as something that should be done just for the sake of beating the Russians.) But Dryden responded by calling the idea a mere "stunt" comparable to shooting a woman out of a cannon.

The predominant attitude of the NACA during the late 1940s and 1950s was to avoid "Buck Rogers" stuff. In 1947 a newspaper poll indicated that 29% of the American public expected interplanetary travel by 1960. Upon seeing the poll, Jerome Hunsaker, the NACA chairman, said to a colleague that all the poll really indicated was "that people who know about rockets like them. The same is no doubt true with regard to alcoholic drinks and chamber music." One prominent individual at Langley who was especially critical of "space cadets" was John Stack, chief of the Compressibility Research Division. Stack resisted the idea of an expensive space program long after Sputnik--in the early 1960s he told some colleagues that he did not buy all that "to-the-Moon-by-noon" garbage. (In June 1962 Stack retired from NASA to become vice-president of Republic Aviation Corporation--a post at which he could continue to work on aeronautical projects.)

Those NACA researchers who, unlike Stack, had been advocating increased work in astronautics were frustrated by the news of Sputnik, but they were perhaps even more frustrated by the overreaction of the American public to that news. The NACA had initiated studies "of the problems associated with unmanned and manned flight at altitudes from 50 miles up, and at speeds from Mach number 10 to the velocity of escape from the earth's gravity" as early as 1952. Subsequently, researchers at Langley and the NACA's other field centers had concentrated increasingly upon the solution of problems involved in the development of missiles and hypersonic aircraft. (At that time, most NACA researchers considered "space flight," not as the ballistic-type flight to which we became accustomed in the 1960s, but as a natural extension of aerodynamic flight through the atmosphere into space and return.) But until the launching of the Sputniks, "space" had been a dirty word, especially in American political arenas. A high-ranking NACA official recalls that the NACA in the pre-Sputnik period stood "as much chance of injecting itself into space activities in a real way as an icicle had [of surviving] in a rocket combustion chamber."

Langley's first official reaction was to allay public fears by putting Sputnik in proper perspective. Spokesmen for the research center informed the local news media that, although the Russian satellite program posed a serious challenge to the United States, the U.S. was well prepared to meet the challenge. Langley, specifically, was already engaged in research applicable to the problems of space flight. Given needed additional manpower and research equipment, the lab would soon be doing its part to conquer space.

ATTACHMENT

Outline of *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958* (in press, NASA, Washington, D.C.), plus projected outline of its sequel:

* * *

Foreword (by Dr. Donald Hearth, director of the Office of Space Science and Technology, University of Colorado, and former director of the NASA Langley Research Center)
Introduction
1. Foundations
2. Langley Personality, Formative Years
3. The Variable-Density Wind Tunnel
4. With a View to Practical Solutions
5. The Cowling Story: Experimental Impasse and Beyond
6. The Challenge of Teamwork
7. The Priorities of World War II
8. Exploring Unknown Technology: The Case of Jet Propulsion
9. The Transonic Problem
10. Defining the Research Airplane
11. The Slotted Throat and Area Rule
12. Hypersonics and the Transition to Space

Epilogue
Notes
Appendixes
Bibliographic Essay

Projected outline of sequel:

13. A New Mission
14. Genesis of the Lunar Orbit Rendezvous Concept
15. What Happened to the First "A" in NASA?
16. Planning for an American SST
17. Managing Lunar Orbiter
18. The Hypersonic Research Engine Project
19. A Viking Raid

Plus, updated appendixes, etc.

COMPUTATION OF TRANSONIC VORTEX FLOWS PAST DELTA WINGS-INTEGRAL EQUATION APPROACH

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Abstract

The steady full-potential equation is written in the form of Poisson's equation, and the solution of the velocity field is expressed in terms of an integral equation. The solution consists of a surface integral of vorticity distribution on the wing and its free-vortex sheets and a volume integral of source distribution within a volume around the wing and its free-vortex sheets. The solution is obtained through sucessive iteration cycles. The source distribution is computed by using a mixed finite-difference scheme of the Murman-Cole type. The method is applied to delta wings. Numerical examples show that a conical shock is captured on the suction side of the wing. It is attached to the lower surface of the leading-edge vortex but does not necessarily reach to the wing surface.

Introduction

Efficient aerodynamic design of fighter aircrafts is still a challenge for computational aerodynamicists due to the various flow regimes encountered during fighter aircraft missions such as during air-combat-fighter missions and air-to ground-strike missions. Throughout these missions, the flow field may vary from an essentially attached condition to a partly separated condition to a fully separated condition. In addition to these complex flow conditions, flow compressibility changes from low subsonic to supersonic Mach numbers during take-off, cruise, combat action, manuevering and landing. Bradley and Bhateley[1] reviewed the status of computational methods with emphasis on fighter design applications. Their ratings of the existing computational techniques for fighter aircraft applications ranged from poor to fair, a status which urgently calls for more improvements and developments.

In the present paper, we deal with the problem of transonic vortex flows around highly swept wings - a key aerodynamic problem for the future development of super maneuvering fighter aircrafts. The procedure is an extension of the method of reference 2 where we exploit the shock-capturing nature of the method through careful computation of the source distribution in the volume integral term which represents the full nonlinear compressibility in the flow-field. In addition, we discuss an alternative shock fitting technique which remains to be tried.

Concluding Remarks

The numerical results of the integral-equation approach for the transonic vortex flow problem clearly show that the integral-equation solution is able to capture the shock. The captured shock is of curved shape, its foot is attached to the lower surface of the leading-edge-vortex sheet, does not necessarily reach to the leeward side of the wing and is located almost at the spanwise location of the leading-edge vortex core. In the cases considered here, the shock was found to disappear at almost ten percent of the root chord behind the trailing edge. The computed results of the compressible flow, as compared to those of the incompressible flows, show that the leading-edge vortex core moves a little inboard from the leading edge and a little downward nearer to the suction side. The present velocity-field formulation is more advantageous than the earlier velocity-potential formulation for both the shock and vortex-sheet calculations.

It should be pointed out that no attempt has been made to show the convergence of the solution versus the number of grid points of the finite volume. More work is still needed to prove this point and moreover to sharpen the shock either by refining the grid in the shock region or by fitting the shock while using a relatively course grid. In addition the MNDV-method should be replaced by the NHV-method[1,2], and an additional half turn of the leading-edge vortex system should be considered to cure the problem of having the foot of the shock attached to the feeding vortex cut in the forward cross-flow planes. Finally, the merits of monotone differencing should be considered relative to the classical type of differencing. In addition to these improvements, the code should be transferred to a parallel processor.

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SIMPLIFIED FREE VIBRATION ANALYSIS OF COFS USING RECEPTANCE METHOD

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Abstract

Introduction: Over the last few years, NASA has been developing the space shuttle in order to place in orbit a new class of spacecraft called Large Space Structures (LSS). A flight research program, COFS[1,2] (Control of Flexible Structures), has been proposed. This experiment will systematically evaluate algorithms and techniques for on-orbit response prediction, system identification and flexible body control of large space structures. The program involves a series of flights (see Fig. 1) building progressively from modeling and modal characteristics of LSS to the more complex issue of flexible-body interactive control. The fourth in the series of flights may involve a beam-like structure with a fairly large attached structure, such as an antenna as shown in Fig. 2. To increase the challenge of identification of closely space coupled modes, it is desirable to have a rapid way to determine stiffness and mass characteristics of the structural components that will yield a design with closely space modes. In this study, the receptance method[3,4] (also known as mobility, or dynamic flexibility) is chosen to analyze the different design configurations.

Receptance Method: The receptance method is based on an electrical analogy called "Force - Current" analogy that involves Kirchoff's first law, which states that in any network the algebraic sum of all the current flowing towards a node equals zero. Receptance is defined as the ratio of amplitude of the harmonic response of a point in a subsystem produced by a harmonic force to the amplitude of the force F. If R is the amplitude of the response due to F, then

$$\alpha(\omega) = R(\omega)/F \tag{1}$$

Receptance methods are conveniently used to solve complex problems. In them, the complex system is resolved into subsystems that can be analyzed rather easily. These subsystems are then recombined to find the response at a point or points in the original system.

Analysis of COFS: The structure is divided into two subsystems, as shown in Fig. 3. Subsystem A consists of a cantilever beam having 6 degrees-of-freedom at its free end (3 translations and 3 rotations). Similarly, subsystem B consists of a free-free beam and a rigid tip mass (to simulate antennas) at its one end. The tip mass is at a distance "ℓ" from the beam end. This offset, that results in coupling axial and in-plane bending of the free-free beam and also torsion and out-of-plane bending, is expected to play a major role in producing coupled modes. Both the subsystems are joined through 6 degrees of freedom at the free end of the cantilever beam (see Fig. 4). The free vibration equation is given as [3]

$$\left| [\ \alpha(\omega)\ ]_A + [\ \alpha(\omega)\ ]_B \right|_{6x6} = 0 \qquad (2)$$

where $[\ \alpha(\omega)\ ]_A$ and $[\ \alpha(\omega)\ ]$ are the receptance matrices of the two subsystems. The natural frequencies of the system are obtained by solving Eqn. 2. A Bisection method is used to solve the above equation. It should be noted that the two receptance matrices contain various trigonometric and hyperbolic functions and all the frequencies can be obtained from the above 6x6 matrix. Finally efforts will be made to find small changes in w due to small modifications in system parameters.

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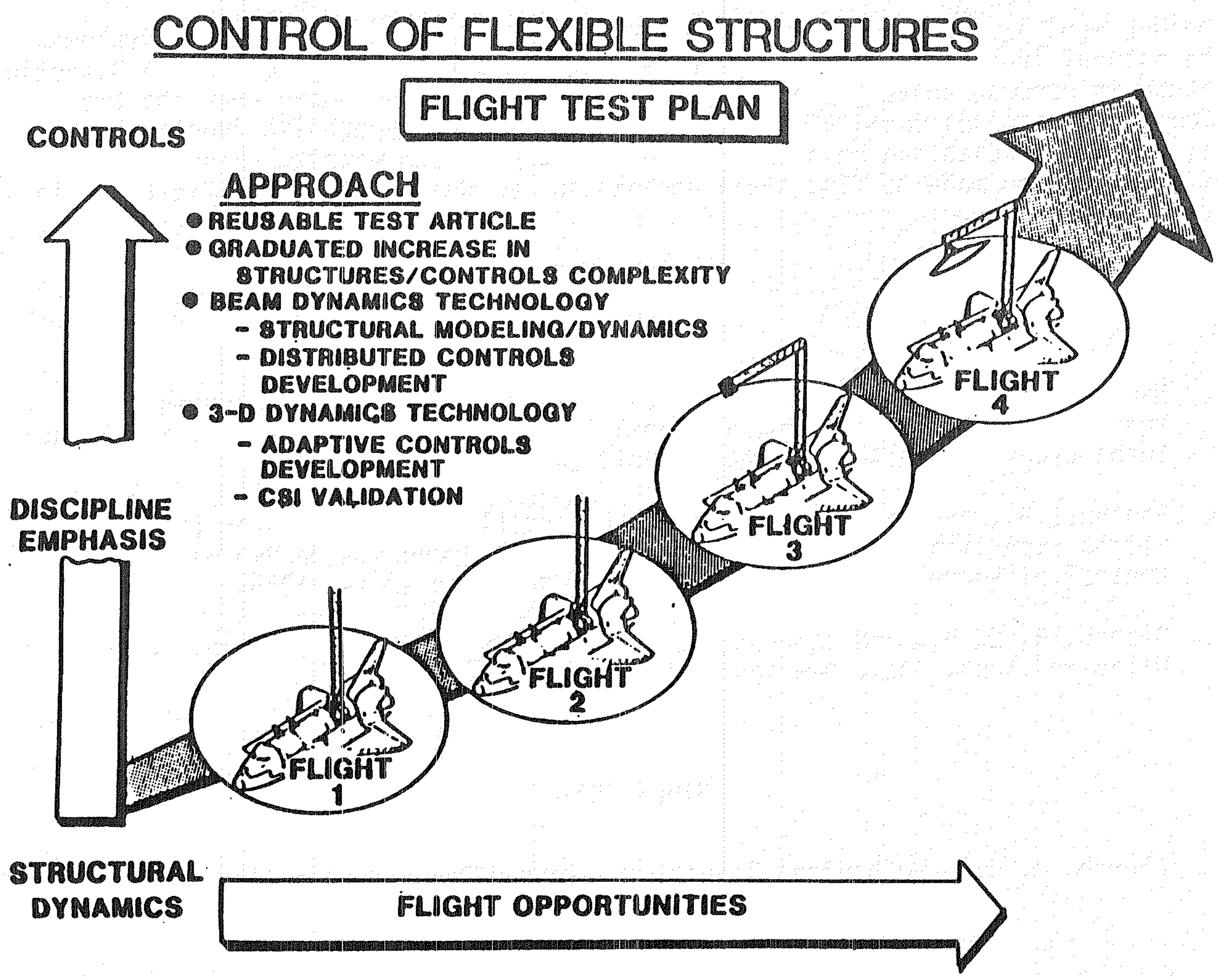


Figure 1.- Series of flights.

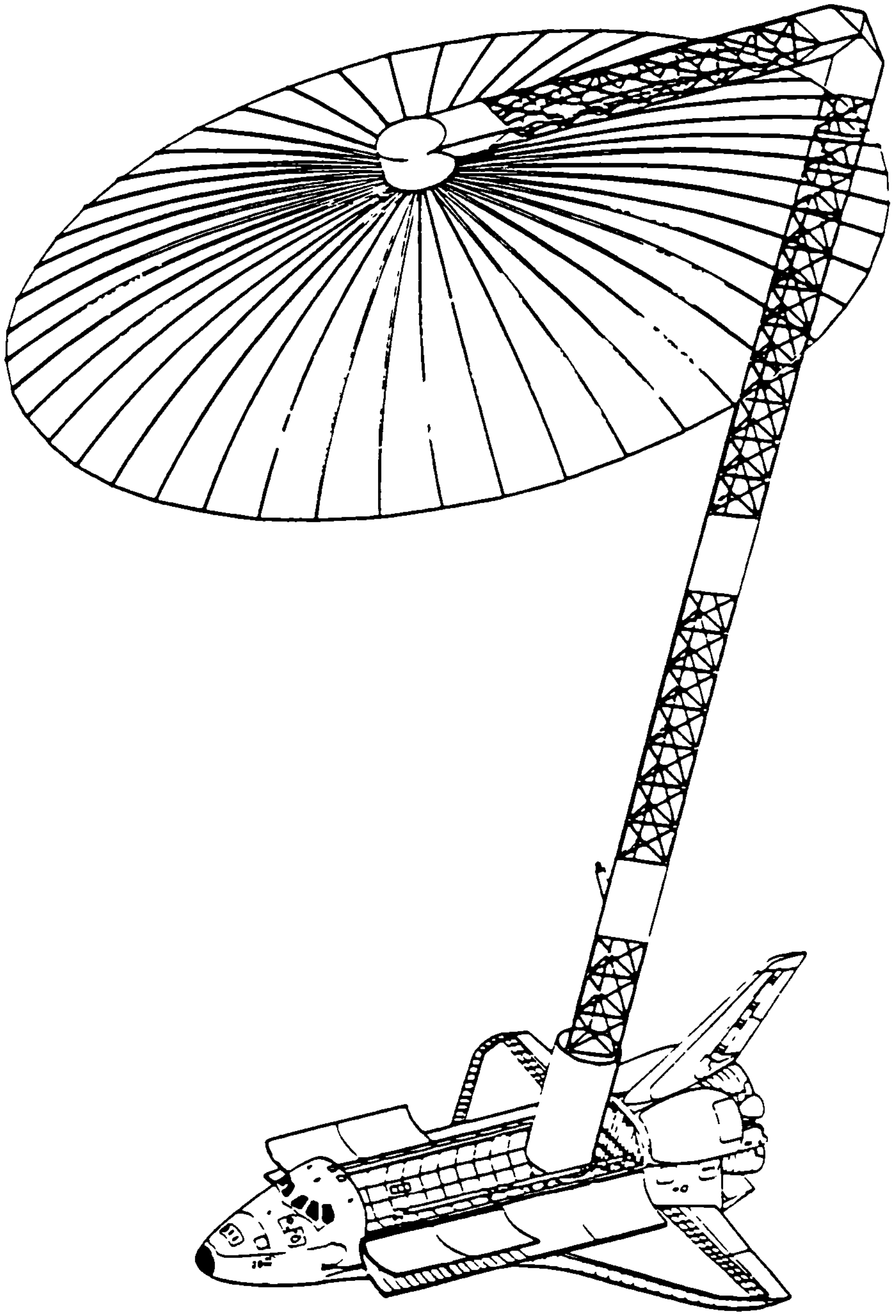
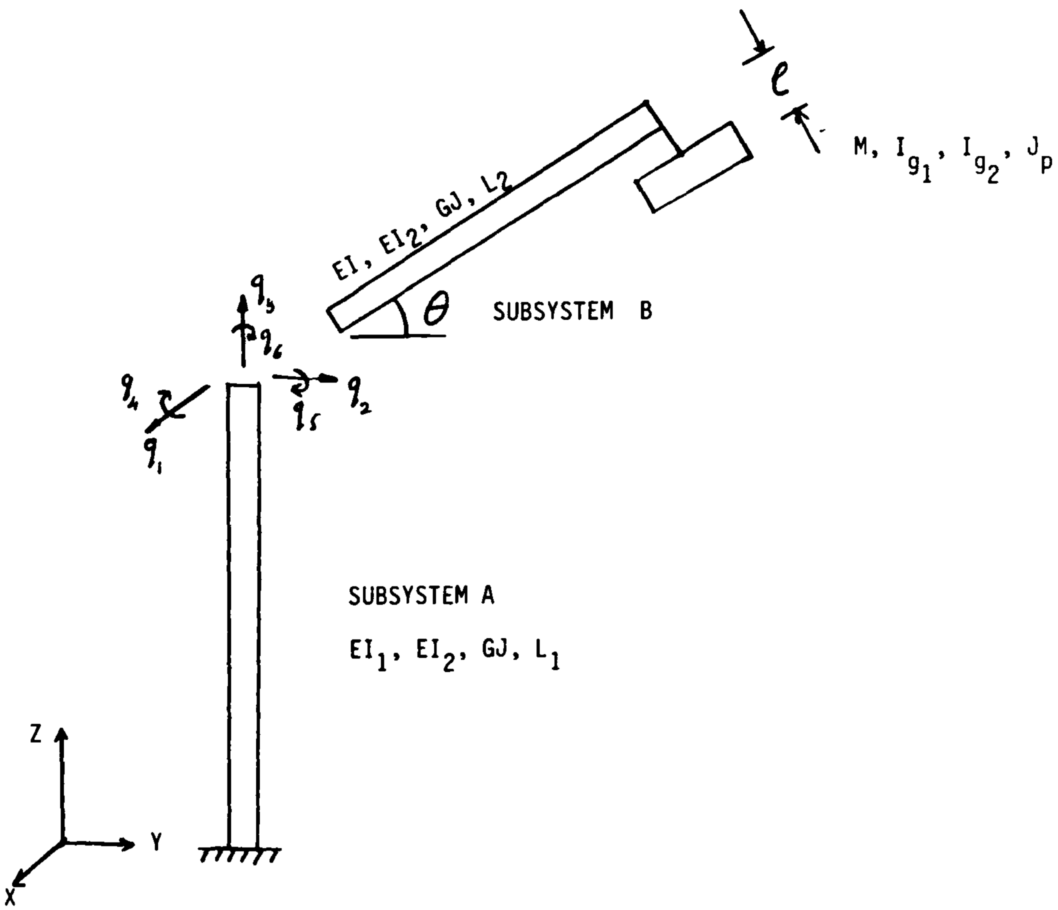


Figure 2.- LSS antenna.



EI_1 = BENDIND RIGIDITY FOR IN PLANE VIBRATIONS

EI_2 = BENDING RIGIDITY FOR OUT-OF-PLANE VIBRATIONS

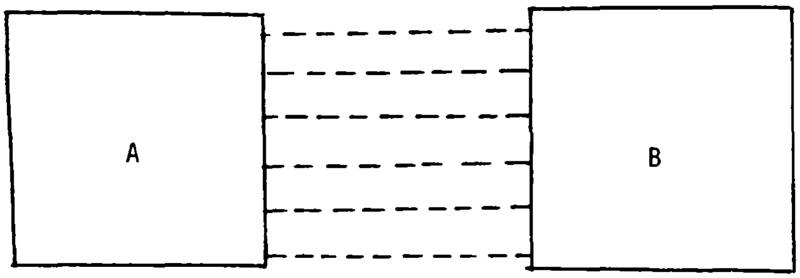
GJ = TORSIONAL RIGIDITY

L_1 = LENGTH OF VERTICAL BOOM

L_2 = LENGTH OF THE ARM

= OFFSET LENGTH

Figure 3.- Two subsystems of the complex COFS experiment.



FREE VIBRATION ANALYSIS

$$\left| [\alpha_A(\omega)] + [\alpha_B(\omega)] \right| = 0$$

$[\alpha_A(\omega)]$ = Receptance Matrix for Subsystem A

$[\alpha_B(\omega)]$ = Receptance Matrix for Subsystem B

Figure 4.- Combination of two subsystems at the free end of the cantilever beam.

ELECTRON RADIATION EFFECTS ON A POLYARYLENE ETHER

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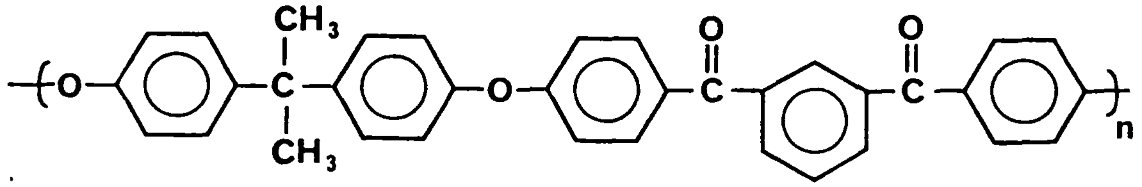
Structures in space such as antennas and platforms will likely be constructed with polymer-matrix-composite materials because of their light-weight, high-strength, and low-thermal expansion. However in geosynchronous orbit, such a structure would receive a radiation dose of 10^9 to 10^{10} rads over its necessary lifetime of 20 to 30 years. Since a dose of this level is known to initiate degradation and/or crosslinking in polymeric materials, a study of the effects of radiation on such materials has been under way in the Applied Materials Branch of the Materials Division.

In this specific project, a novel polyarylene ether, synthesized by chemists in the Polymeric Materials Branch, was subjected to various doses of electron radiation. Chemical effects of the radiation were determined by infrared spectroscopy. The molecular structure of the polymer is



The material, designated Polymer I in our study, is amorphous with a glass transition temperature (Tg) of 152°C. It is also soluble in several common solvents so that films could be easily made. Polymer I has some molecular features in common with polyether ether ketone (PEEK), a well-studied polymer used in composite materials. Unlike Polymer I, however, PEEK is largely crystalline and thus has limited solubility in organic solvents necessitating high-processing temperatures in any application.

Thin films of Polymer I were cast on glass plates from a solution in N,N-dimethylacetamide (DMAc). It was found that very thin films (about 0.3 mil) were necessary in order to obtain the best spectrum. Spectra were recorded from 4000 to 400 cm^{-1} with a Nicolet Model 3600 Fourier Transform Infrared Spectrometer (FT-IR) at a resolution of 2 cm^{-1}. Spectra were recorded and stored before and after irradiation. Holes were cut in the films to match two pins on the sample holder. Thus, the films could be placed on the sample holder after irradiation in exactly the same position as before the irradiation to ensure that the same portion of the film was viewed by the infrared spectrometer. The difference between spectra taken before and after irradiation was used to determine the chemical effects.

Strips of film were irradiated in a vacuum chamber with 70 keV electrons. Irradiation times of 45, 88, 120, and 190 hours were employed to give a total dose ranging from 4.9×10^9 to 2.1×10^{10} rads. Two films were simultaneously irradiated each time. The dose rate was monitored with a Faraday cup and was constant throughout all irradiations at 1.096×10^8 rads per hour.

The results showed a decrease in absorption for the irradiated films primarily at 1658, 1595, 1497, and 1244 cm^{-1}. These peaks are associated with vibrations of the phenyl-ether and phenyl-carbonyl linkages. A decrease in absorption after irradiation indicates that chain fission is occurring at both the ether and carbonyl bonds. A small decrease in absorption at 2968 cm^{-1} indicates that some methyl-hydrogen atoms are also removed during irradiation. These atoms apparently either form hydrogen gas or become attached to phenyl-carbon atoms but do not attach to oxygen atoms since there was no evidence for formation of hydroxyl groups.

In the 190 hour irradiation, possible effects of oxygen on the irradiated film were tested. The films were transferred from the vacuum chamber in a nitrogen-filled bag to a nitrogen-filled glove bag. Both films were mounted on sample holders and transferred to the spectrometer under nitrogen. Spectra of both films were recorded and stored, then one film was exposed to air while the other remained under nitrogen. Several spectra of both films were recorded throughout the course of the day. There was no discernable difference between the spectra of the two films either as a function of time or as a function of exposure to oxygen. Thus, for Polymer I, the chemical effects shown by infrared spectroscopy are apparently occurring during the irradiation.

The FT-IR data will be correlated with viscosity and gel permeation measurements performed on films irradiated simultaneously with the films used for infrared spectroscopy. In addition, mechanical measurements will be made on irradiated films of the same polymer.

DECONVOLUTION AND EQUICORRELATION PROBLEMS OF LIGHTNING DATA PROCESSING

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Abstract

The problem of separating out the particular aircraft and collection system influence from the F106 Lightning mission data is approached by designing a digital filter to recover input data from the output data collected. For the first stage the input signal is to be constructed from the soliton solution for the lightning stroke derived in NASA Technical Memorandum 86349 (Jan. 1985). By using the observed data as output a causal filter is constructed. From this an inverse operator is constructed with due regard for causality and this operator is then used to determine input data from observed output data. The input data so determined should then be free of the influence of the particular aircraft and collection system.

Since the filter is causal only past and present inputs and outputs are used to determine the system vector $\vec{S}$. The model is strictly discrete with (N+1) inputs and outputs so that

$$\vec{S} = X^{-1}\,\vec{Y} \qquad (1)$$

with the form of the matrix of input values given by

$$X = \begin{bmatrix} x_o & x_{-1} & x_{-2} & \cdots\cdots\cdots & x_{-N} \\ x_{-1} & x_{-2} & \cdots\cdots\cdots & x_{-N} & 0 \\ x_{-2} & \cdots\cdots\cdots & x_{-N} & 0 & 0 \\ & & & & \\ \cdots\cdots\cdots\cdots\cdots & 0 & 0 & 0 \\ \cdots\cdots\cdots & 0 & 0 & 0 & 0 \end{bmatrix} \qquad (2)$$

$x_{-N} \ldots 0 \quad 0 \quad 0 \quad 0 \quad 0$

The components of $\vec{S}$ are $s_0, s_1, \ldots\ldots s_N$ and those of $\vec{Y}$ are $y_0, y_{-1}, \ldots\ldots y_{-N}$. After use of the theoretical solution as input data together with the measured output data collected on actual flights an S matrix of the form

$$S = \begin{bmatrix} s_0 & s_1 & \ldots\ldots\ldots\ldots s_N \\ s_0 & s_1 & \ldots\ldots\ldots s_{N-1} \quad 0 \\ & \ldots\ldots\ldots\ldots\ldots\ldots s_{N-2} & 0 \quad 0 \\ s_0 & 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0 & 0 \end{bmatrix} \tag{3}$$

from which input data $\vec{X} = S^{-1}\,\vec{Y}$ unaffected by the collection system can be determined.

The second problem considered is the statistical problem of optimally combining multiple inputs of the same type of data (e.g. the time rates of change of electric displacement or magnetic induction) so as to arrive at a linear combination with minimal variance. For this the principle of equicorrelation is used.

It is shown that the optimal combination of the input data can be attained normalizing each channel against its own standard deviation and that the variance corresponding to this normalization is given in terms of the covariances by

$$\sigma_z^{\ 2} = N + 2 \sum_{k>m} C_{km}/\sigma_k\,\sigma_m \tag{4}$$

TRAINING ON PROGRAMMABLE CONTROLLERS

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ABSTRACT

The programmable controller, PC, is a significant component in today's industries and/or governmental agencies. It meets many of the industrial control needs today and has been designed to adapt to the changing needs of tomorrow.

This report focuses on aspects of training, with special emphasis on programming in ladder logic, that should be considered before attempting to train individuals on PC's. A review of the literature, informal detailed discussions with several PC manufacturer personnel, and actually attending two PC manufacturer (Allen-Bradley and Texas Instruments) training programs revealed that: (1) cost of training, (2) prerequisite for training, (3) use of simulators, (4) programming and (5) teaching aids (video based) are features that should be considered when developing a PC training program. A general instruction set in ladder logic was also developed in this study to assist PC users in their training.

LIMITS TO GROWTH:

AN OPERATIONS STUDY OF THE SPACE STATION

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Abstract

The projected traffic to and from the Space Station from ground thru orbital operations is evaluated by a simulation model. Included in the model are different Shuttle payload types (logistics, propellant, attached loads, etc.), a lower bound of 28 days for ground turnaround time, two launch pads at the Kennedy Space Center, propellant storage and boiloff losses at the station, one remote manipulating system at the station, and both Shuttle and orbital transfer vehicle manifesting procedures. Results are presented for both the transient and steady state cases with respect to system growth.

Prior to the advent of reusable space vehicles, operational issues were of secondary importance to performance criteria. Operational aspects of the Space Station must be evaluated prior to design to insure an effective use of resources. The Space Station transportation system is divided into two subsystems: ground operations and Space Station operations. Ground operations involve Shuttle support, which includes taking payloads to and from the Space Station. Operations on the Space Station involve OTV (orbital transfer vehicle) and OMV (orbital maneuvering vehicle) missions. These two subsystems have propellant storage and RMS (remote manipulating system) usage in common. Propellant for the OTV and OMV is stored in tanks at the Space Station. Shuttle missions are scheduled to deliver propellant to the Space Station based on the amount of propellant at the Station and the number of missions requiring propellant. The RMS is used to unload payloads from the Shuttle and to load payloads onto the OTV and OMV.

The model involves several classic problems in operations research. Queueing occurs as Shuttles wait for payloads to become available, and Space Station vehicles wait for payloads to arrive to the Space Station. Propellant delivery is an inventory problem involving probabilistic lead times and probabilistic demand. An optimization problem is also embedded within the system. Payloads waiting for integration into the cargo bay of any vehicle must be manifested subject to weight and space constraints imposed by the vehicle. Since the system is too complex for tractable analytic results, simulation is used to estimate measures of performance associated with the system.

The model is implemented as a network/discrete event/continuous model using the SLAM simulation package. The network portion of the model involves approximately 40 nodes and 40 nontrivial activities. Entities within the network represent Shuttles, payloads (logistics, propellant, attached payloads, low earth orbit missions, geosynchronous orbit missions and planetary missions), OTVs and OMVs. There are 15 discrete event subroutines in the model (approximately 500 lines of code). These subroutines perform functions such as manifesting payloads for Shuttle missions, boosting the station periodically so that it will remain in the same orbit, summarizing shuttle missions, scheduling propellant flights if the propellant inventory position is less than the reorder point, and manifesting payloads for OTV missions. The continuous portion of the model specifies differential equations which control propellant boiloff at the Space Station. The differential equations are solved numerically by the SLAM package.

The output estimates performance measures associated with the system for various resource capacities. Included in the output are OMV utilization, OTV utilization, RMS utilization, Shuttle delay times, launch pad utilization, and payload delivery time. Spot charts (plots of the Shuttle or OMV flights over time) are plotted to indicate periods of congestion and inactivity. Payload demand and resource capacities are varied to assess their impact on the system.

RESOLUTION LIMITS FOR A HOLOCINEMATOGRAPHIC VELOCIMETER (HCV) FOR TURBULENT FLOW MEASUREMENTS

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ABSTRACT

Turbulent flow is, in general, highly three-dimensional in nature, even in an exclusively two-dimensional mean flow. Predictive schemes require input as to the nature of the local turbulence in order to accurately model flow characteristics. Since there does not exist a closed form mathematical representation of turbulence, current computational procedures rely on empirical input to define their model. To this end, a new method of experimental measurements is being developed which is to determine much of the turbulent structure of a wide range of fluid flows.

This new technique, holocinematographic velocimetry (HCV), uses holographic imaging of a particle seeded flow. A high speed camera advances individual film frames which record a hologram of a portion of the flow. The hologram is then to be used to reconstruct images of the particles (approximately 40 μm diameter). Tracing particles from frame to frame will determine local velocity vectors.

Advantages of holography over other recording techniques include its three-dimensional characteristics which can be used to fully determine a local velocity vector. However, the resolution of particle images in and out of a plane normal to the direction of viewing is not as good as within the normal plane. In order to obtain uniform resolution information two orthogonal views are to be obtained simultaneously.

The design of a fluid flow experiment for HCV requires, among many other things, the proper seeding of the flow. The seed must (i) accurately follow the fluid fluctuations, (ii) be readily discernable in the holographic image and (iii) be of the proper number density. The first requirement necessitates small particles that are neutrally buoyant. The second requirement implies sufficiently large particles. The third requirement implies a sufficiently low density so as not to influence the flow or cause particle interaction, yet a high enough density to allow a detailed mapping to be obtained.

The present study addresses some of the resolution limitations of a specific proposed holographic recording and reconstruction technique. An in-line Fraunhofer optical arrangement is to be used to record the holographic image. The recording distance is to be approxiamtely 80 far-field distances (as limited by the experimental configuration). Roughly, the expected resolution is to be ± 5 μm in the image plane. In the proposed HCV the reconstructed holograms will be scanned with a digital television camera and image analyzer system which is to locate particle centers. It is the lack of resolution in the image plane-normal direction which may significantly increase the data reduction effort. A given particle is expected to stay in approximate focus over 1-3 mm. Over this focal range the data are to be cross

referenced with the orthogonal view to ultimately obtain ± 5 μm resolution in all three coordinates. Results of this study document the variation of image intensity versus deviations from the exact focal distance. An analytical study is also presented which determines the particle-to-background intensity ratio at the particle edge versus out of focus proximity of near-by particles.

In order to experimentally determine the resolution limits in-line Fraunhofer holography was used to image 38 μm size paricles which were vapor deposited onto a glass substrate. Particles were positioned relative to each other, both in and out of the focal plane. A series of reconstructed images were viewed through a television monitoring system with approximately a 3.0 mm by 3.0 mm field of view. Photographs were taken of the images on the television screen and studied with respect to the particle image intensity distribution. The individual particles were found to have a high intensity over approximately a ±4-6 mm span normal to the focal plane. This implies that rather restrictive limits will have to be placed on the threshold level of particle detection. By doing so the resolution normal to the focal plane can be enhanced to facilitate cross referencing of particles from orthogonal views.

The analytical results were obtained by assuming a linear film response and superimposing the amplitude functions of two particles with a given field of view. The intensity distribution of the reconstructed image was then determined from the amplitude function. The edge contrast was calculated based on the definition of visibility. The results show that as the particles are separated normal to the focal plane there is a gradual contrast variation to about 25 particle diameters.

One further resolution limit of the HCV system is the ability to reproduce the recording medium (film) configuration during reconstruction. Since rapid frame advancement is to be used in the hologram formation there is the potential for film bending out of a plane normal to the viewing direction. This will result in locally different effective focal distances in the reconstruction process. An analytical study was carried out to determine the allowable magnitude of bending. This is based on the Rayleigh resolution criteria. For the HCV system under consideration the film would be allowed to bow approximately 1.2 mm out of plane and be within the Rayleigh resolution (approximately 0.5 μm).

A STABLE FACTORIZATION APPROACH TO LARGE SPACE STRUCTURE CONTROL

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Abstract

Over the past few years, a significant body of new theory has appeared dealing with the so-called stable factorization approach to design of compensators for linear MIMO systems (see, for example, [1] and the references contained therein). The key feature of the approach is that the ring of proper, stable transfer function matrices is in fact a principal ideal domain. Thus, it is always possible to factor any rational transfer matrix as a product ND^{-1} (also $\tilde{D}^{-1}\tilde{N}$) where N and D ($\tilde{N}$ and $\tilde{D}$) are both proper, stable transfer matrices, and furthermore have a greatest common right (left) divisor of the identity matrix. This factorization of the plant P as $P=ND^{-1}$ ($P=\tilde{D}^{-1}\tilde{N}$) is known as a right-coprime factorization (r.c.f.) left-corprime factorization (l.c.f.) of P.

Once an r.c.f. and l.c.f. of the plant are found, there are many results which become available to the designer in designing a compensation scheme for the plant. For example, once an r.c.f. and l.c.f. (and the corresponding Bezout factors) are found for P, one may:

(1) Obtain a parametrization of all compensators which stabilize P.

(2) Determine the compensator which minimizes the sensitivity of P to random disturbances, while at the same time stabilizing P.

(3) Determine the compensator which maximizes the robustness to plant uncertainties, while at the same time stabilizing P.

(4) Determine the compensator which simultaneously accomplishes (2) and (3).

Thus far, the stable factorization theory has been applied to plants with unspecified structure (i.e. the plant transfer matrix is simply given as P). However, if the plant structure is specified, more specific results may be obtained about the compensators in (1)-(4) above.

Large space structures (LSS) are hyperbolic distributed parameter systems, and are commonly modeled for design purposes as lumped systems of high order. Furthermore, the LSS model always has a specific and well-known

form. Thus, if an r.c.f and l.c.f. for this model can be obtained, then the stable factorization approach may be applied to the control of LSS, and the designer may determine compensators which have properties such as (1)-(4) above.

The main result of this research thus far has been the determination of an r.c.f. and l.c.f. for an LSS together with the corresponding Bezout factors (using results in [2]). In fact, the factorization obtained is doubly coprime, and is in terms of known physical quantities of the LSS, i.e. rigid-body inertias, vibrational damping, and natural frequencies. Two immediate results for LSS are (1) a parametrization of all stabilizing compensators in terms of known physical quantities of the LSS, and (2) the fact that LSS are strongly stabilizable, i.e. can be stabilized using a stable compensator.

With this factorization, it is now possible to investigate such important questions as sensitivity minimization and robustness enhancement by compensators which can be specified in terms of known physical quantities of the LSS.

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CONTROL OF STRUCTURES WITH JOINT-TYPE NONLINEARITIES USING STOCHASTIC OPTIMIZATION

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ABSTRACT

This work is divided into two disjoint parts. Part I concerns the theoretical analysis of the structure. Part II considers the design of an actual damping device.

Part I:

Many space applications involve an antenna (or other large object) which requires a high degree of pointing accuracy. This pointing accuracy is achieved, in part, through the position control of the antenna's supporting structures. This work is directed toward developing a control positioning system for these supporting structures.

Because the structures planned for space use are very large, it has been suggested that they be collapsible. As a result these structures will have many joints; they are called joint dominated. Joint dominated structures consist of flexible struts connected by rigid joints with nonlinear stiffness and damping characteristics. A straightforward analysis of the complex behavior of joint dominated structures is not tractable. Here we propose to approximate the complicated nonlinear model by a simplier stochastic model. In this work we concentrate only on the modeling aspects (but with an eye toward control design).

Consider the simple model of a joint dominated structure shown in Figure 1, where the joints have the nonlinear stiffness characteristics shown in Figure 2. This system can be modeled by

$$\dot{x} = f(x), \ x(0) = x_0, \ t \geq 0 \tag{1}$$

where $x(t) \varepsilon \chi = R^{2n}$. Because we have modeled the nonlinearity as piecewise linear, (1) can be modeled as a set of linear differential equations as follows:

$$S_i: \ f(x) = A_i x \ \text{ if } x(t) \varepsilon \ \Omega_i$$

Here, the sets Ω_i look like

$$\Omega_i = \Omega_{12}^J \times \Omega_{23}^J \times \ldots \times \Omega_{n-1,n}^J$$

where $\Omega_{i,i+1}$ are regions in the (x_i, x_{i+1}) plane.

With each point $x(t)$ on a trajectory, we associate its corresponding dynamic model S_i. If we sample the trajectory, then we can associate each trajectory with a sequence of models $[M_n]$ where $M_n = S_i$ if $x(t_n) \varepsilon \Omega_i$. Now we attempt to approximate the nonlinear model by developing stochastic models of the sequences $[M_n]$. The transition probabilities are derived from an a priori distribution on the state space. This distribution, essentially a design parameter, is chosen by considering several simulations of the actual nonlinear system. The stochastic model is validated through Monte Carlo simulations.

Part II:

Large spacecraft are expected to be highly flexible and require systems that suppress vibrations excited following orientation maneuvers, articulation of subassemblies, and other necessary spacecraft operations. This paper presents the analysis and design of a passive vibration damping device. The device, the variable coefficient viscous inertial damper (VCVID), is self-contained with no relative motion between it and the structure that is damps. This allows the device to be sealed making it ideal for use in spacecraft. The principle of operation of the damper is that motions of the external case react via a viscous working fluid and cause a force between the case and a heavy mass called the proof mass (figure 3). The valve allows the coefficient of damping to be varied during various spacecraft operations.

Here we discuss the performance of this device on a flexible structure. The main tool in the analysis is the Dual Generalized Hessenberg Representation (Dual GHR). The Dual GHR is a state space representation which exposes the input/output structure as reflected into the internal dynamics. In particular, the (Dual) GHR can be used to identify nearly uncontrollable and/or unobservable subspaces. Near unobservability can be interpreted as near pole-zero cancellation.

In this paper the dynamics of a combined flexible structure and damper are represented by its Dual GHR. The NASA Langley Research Center Grid Apparatus is used as the structure. The effect of various parameters of the damper on the stability of the combined structure/damper is discussed. Based on a preliminary analysis using a high-order finite element modal model of the grid, the grid model is shown to be nearly unobservable. This leads to a reduced-order model of the grid for designing the damper. The reduced-order model was selected for closed-loop design based on a specified controller structure. However, closed-loop performance evaluations are made using the full-order modal model.

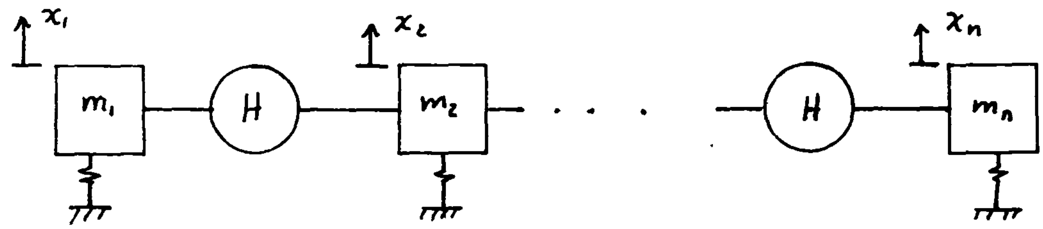

Figure 1

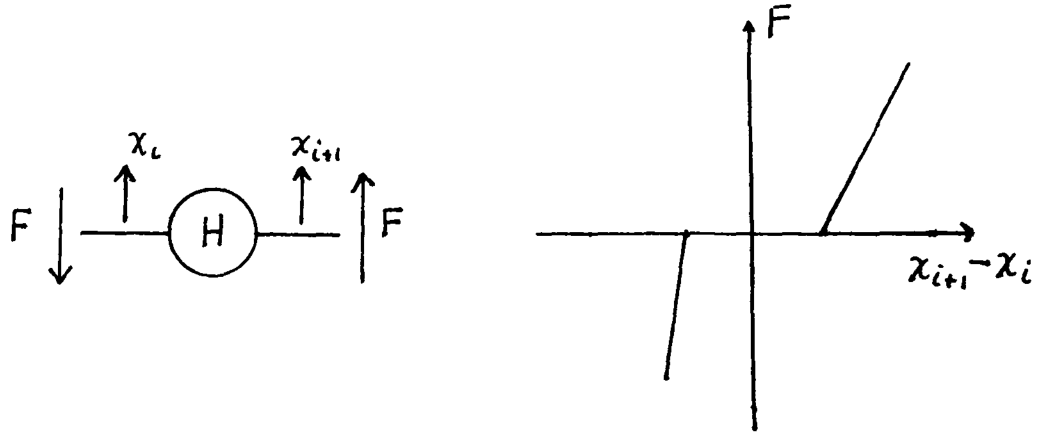

Figure 2

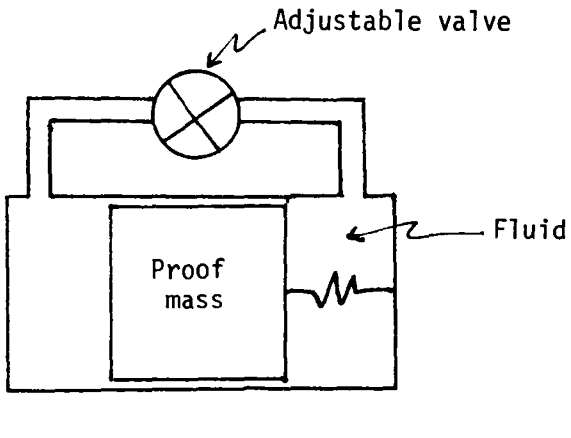

Figure 3

CONTRIBUTIONS TO IDENTIFICATION AND CONTROL OF STRUCTURES

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Abstract

The research effort divides into three separate but related problems which are expected to result in separate publications. One is a new algorithm to implement the ERA method of system identification which requires less computer storage and can enhance the accuracy of the results. The second is the development of a confidence criterion for identified parameters. This not only indicates how good the results are but also is expected to help one decide the proper order of the system model. The third research area is to extend a slewing control method, developed and experimentally tested by Dr. Jer-Nan Juang, to slewing of two flexible members attached one to the other. This work is expected to be tested experimentally by Dr. Juang. It has applications to robotics and to deployment of flexible structures.

Summary

Dr. Jer-Nan Juang and others at NASA Langley Research Center have developed an algorithm called ERA, or Eigensystem Realization Algorithm, for identification of structures from impulse response or from free decay data. The approach is an innovative generalization of the Ho-Kalman approach to identification, with new criteria developed to help determine system order and recognize noise contributions. ERA has been demonstrated to be a very effective structural identification method in application to modelling the Galileo spacecraft from test data.

The first of the three contributions this summer is the development of a new ERA style algorithm based on Grahm-Schmidt orthogonalization of data vectors rather than on singular value decomposition. The main objective was to generate an approach which would not require use of a main-frame computer, but there are a number of important potential advantages to the approach which might improve the numerical accuracy of the results.

The new approach allows one to build up to the proper order of the model by producing an orthogonalized sequence of data vectors, followed by a simplified identification step. The earlier approach required over-estimating the true order and then reducing to obtain the desired model. It has also been demonstrated that the larger the over-estimate, the larger the error in the final identified result due to measurement noise, which is one aspect which may produce an accuracy advantage to the new approach.

The new approach also has a valuable characteristic allowing one to choose which columns of data in the Hankel matrix are most important to the identification. A significant improvement has been shown in identification results when the columns of the Hankel matrix are allowed to skip various steps. In fact, this ability to skip steps is an important practical improvement of ERA over the original Ho-Kalman formulation. However, ERA has had only ad hoc methods to determine which steps to skip. The new ERA algorithm gives a way to pick which columns contain the most independent information about the system dynamics, and therefore supplies a criterion for choosing which columns to include in the Hankel matrix.

The new algorithm is presently being programmed and tested to determine its true numerical characteristics and to evaluate its advantages and disadvantages over the previous programs.

The second subject of research is the generation of a mathematical expression for the influence of white Gaussian noise in measurement data on the parameter identification using ERA. This gives, for the first time, a criterion expressing the confidence level associated with the identified system parameter. The result relies on linearization of the relationship between the parameters and the data to obtain an approximate covariance of the modal frequencies and damping.

In a paper by Dr. J. Juang and Mr. R. Pappa presented at the Astrodynamics Specialist Conference in August 1985 (Veil, Colorado), Monte Carlo studies were presented giving the scatter in identified parameters resulting from adding noise to simulated data. It was observed that when the model dimension is larger than the actual system dimension, the scatter in the parameters increases. This suggests that the mathematical expression for the covariance of the parameters can be used to help determine the proper system order to choose in the identification.

The third area of research is to extend the method of slewing control of a flexible appendage developed by Dr. Juang to the slewing of two flexible members, one attached to the end of another. The control was experimentally verified for one appendage, and shown to be very effective. It uses strain gauges to give feedback information on appendage vibration, which is particularly simple and inexpensive hardware. The control design is based on linear-quadratic control with frequency shaping.

Problems where one encounters slewing of flexible members attached to each other include deployment of spacecraft, shape control of hinged satellites, and robotics. In order to increase the operating speeds of robots, many people suggest the use of lightweight composite materials, which will require controllers that can supply good damping characteristics to vibration modes. So the results will be applicable to future generations of robots, as well as to spacecraft.

The multiple flexible body slewing control problem is fundamentally nonlinear. The controller design will use a mathematical model to cancel nonlinearities in order to be able to use linear contoller design. The same strain guage feedback measurements will be used on each link. Experiments will be performed once the contoller is designed, in order to study the practicality of the approach and to evaluate the dependence of performance on the accuracy of the model, both through the interpretation of the feedback measurements and throught the cancellation of nonlinearities.

Dr. Juang and co-workers will continue to work on each of these three research problems after my return to Columbia University in order to complete the work.

ABSOLUTE NONLINEAR ACOUSTIC MEASUREMENTS WITH LITHIUM NIOBATE TRANSDUCERS

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Recently, there has been considerable interest in the use of ultrasonic techniques to characterize composite materials and their precursors. This study is part of an on-going investigation which seeks to correlate the mechanical properties of polymeric materials, like ultrasonic attenuation, velocity, and nonlinearity, to curing parameters like viscosity, free volume, and glass transition temperatures. We seek to develop a technique for using contact transducers to measure material nonlinearity through harmonic generation by ultrasonic pulses.

When a high intensity ultrasonic wave passes through a nonlinear medium the waveform is distorted. This distortion arises because of a deviation from Hooke's law, which relates the pressure and volume (or stress and strain) in the medium, and is manifested by the generation of harmonics of the ultrasonic driving frequency (ref. 1). The measurement of harmonically generated elastic waves in solids is a well established technique for characterizing material nonlinearity. The absolute amplitudes of the fundamental and the harmonics can be used to calculate the higher order elastic constants which appear in the nonlinear wave equation for solids. The solution of the wave equation to second order yields the following relationship between the amplitude of the second harmonic A_2 and the amplitude of the fundamental A_1 (ref. 1).

$$A_2 = A_1^2\,(k^2/4)(K_3/K_2)x \tag{1}$$

where k is the propagation constant given by $2\pi/\lambda$ in which λ is the wavelength of the fundamental, K_2, K_3 represents the second- and third-order elastic constants corresponding to the crystalline propagation direction, and x is the distance in the material through which the fundamental wave has passed. Thus, a measurement of amplitudes A_1 and A_2 as function of x will provide a measure of the material nonlinearity.

Absolute measurements of this type are traditionally made using capacitive detectors, where the sample itself is one plate of a parallel plate capacitor. To achieve the required sensitivity the capacitor gap must be quite small and accurately calibrated. This would require both the sample face and the electrode of the detector to be lapped flat to within an optical wavelength, a process which would preclude the use of the technique for routine material characterizations. The goal of our study is to determine the feasibility of using acoustically bonded lithium niobate transducers to make these measurements.

The samples used were 2 inch diameter polycrystalline aluminum cylinders of lengths 1.0, 1.5, 2.0, 2.5, and 3.0 inches. The ends of the cylinders were carefully machined to be parallel and flat. A special apparatus was designed to maintain the alignment of the transducers along the cylinder axis and to insure a good reproducible bond between them and the surface. The experimental apparatus used in this investigation are shown in the block diagram in the figure 1. The rf output from a synthesizer was gated by a timing generator with the amplitude of the resulting tone burst set by a programmable attenuator under computer control. This high intensity frequency burst (the fundamental at 4 megahertz) was used to drive the 4 MHz transducer. The output of the 8 MHz transducer (the harmonic response of the sample) was filtered, amplified and digitized, then transferred to the minicomputer for off-line storage and processing.

Preliminary results show agreement with equation (1) with very little correction necessary for bond thickness and diffraction effects. Further measurements are now in progress.

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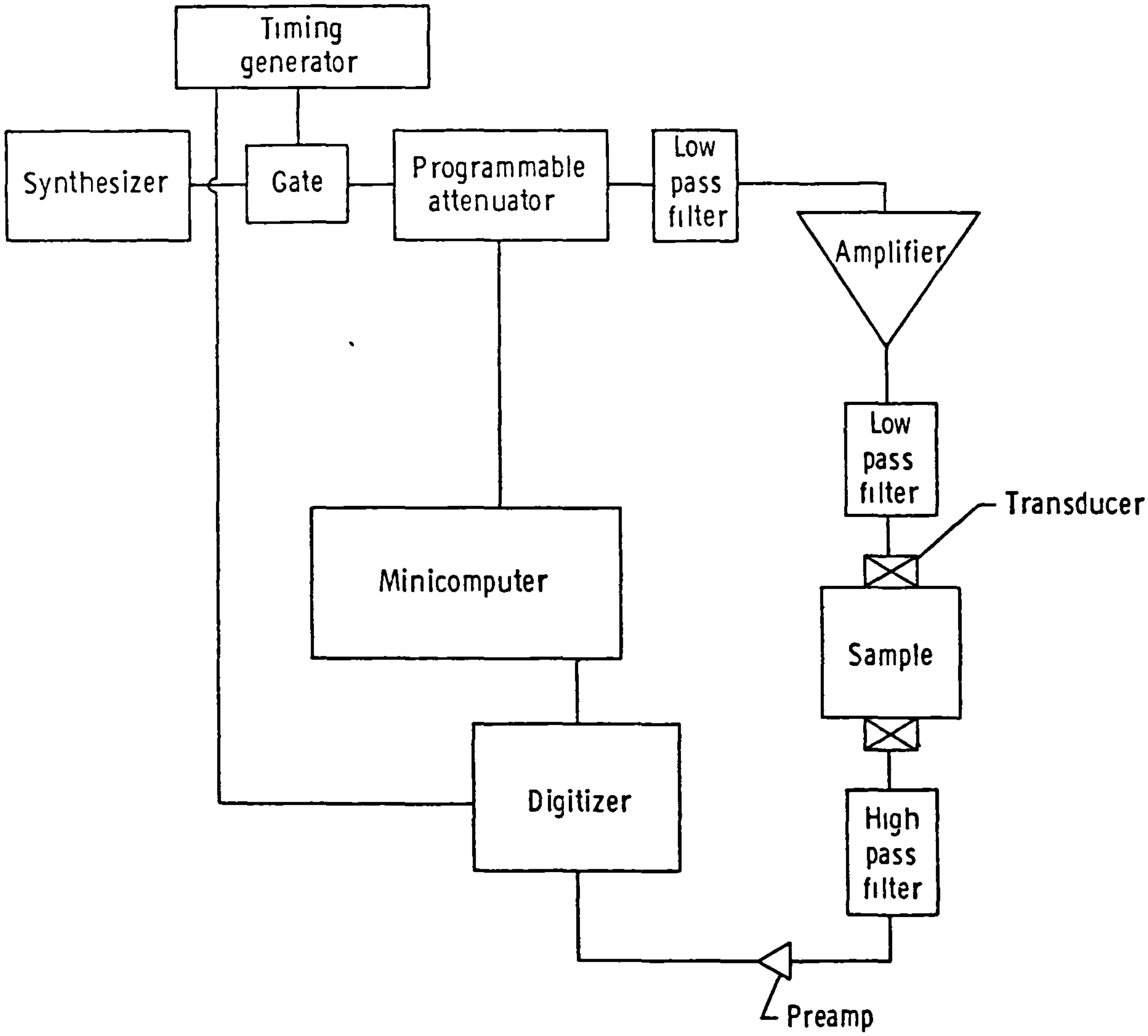

Figure 1.- Block diagram of measurement system.

THE DESIGN OF AN AIRFOIL FOR LOW REYNOLDS NUMBER APPLICATION

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An investigation into the design of an airfoil for a high-altitude, long-endurance remotely piloted vehicle (RPV) has been undertaken. The mission specified for this aircraft involves flight at altitudes of up to 70,000 feet and endurances of up to 120 hours. As revealed from the detailed set of requirements developed, the design of an airfoil tailored to the given mission is complicated by the high cruise lift coefficients dictated and the wide range of Reynolds numbers encountered. Particular difficulties are associated with the lower Reynolds numbers for which the transition process is characterized by the presence of laminar separation bubbles. Furthermore, the weight due to the large amount of fuel on-board initially pushes the need for a fairly high maximum lift coefficient to allow reasonable take-off runs. Also, while some degree of laminar flow is desired for low drag at cruise, it is necessary that the maximum lift coefficient is achieved with fully turbulent flow so that take-off performance is not sensitive to surface contamination of the airfoil. Because the penalty for even a small weight increase is significant when carried over such long durations, the design effort undertaken is for a flapless airfoil. This makes the achievement of high lift coefficients and low drag difficult; however, the potential payoff in simplicity and weight savings justifies the consideration of a flapless configuration. In this regard, the overall performance of a single-element profile is compared to a flapped section in which the possibilities of lower drag are traded-off against increased weight.

OPTIMAL: A LANGUAGE FOR MANIPULATING PARSE TREES

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Software tools for the rapid development of reliable software are of vital importance to the software engineer. These tools are so critical that it is not uncommon to find meta-tools, i.e., tools used for the production of other tools. One of these meta-tools, the parser generator, automatically generates a program that will parse input specified by a Backus-Naur Form (BNF) grammar. The parser generator accepts the grammar and produces a set of parse tables that describes the actions necessary to recognize the grammatical structure of input. A table-driven parser may then be instantiated with these tables, yielding a parser for a specific language. The grammar can be augmented with semantic actions to be performed as the structure of the input is recognized. These semantic actions may build an intermediate data structure to capture some information from the input for later processing. A complete data structure that represents the structure of the entire input is called a parse tree. For such a representation, tools can be constructed that are independent of the grammar at hand. Thus, parser generators are particularly useful for environments in which BNF-describable information is accessed through a set of tools.

Despite the fact that many programs have inputs that are describable by a BNF grammar, the use of parser generators has been limited to the production of programming languages processors. The complex interface to existing parser generators dissuades all but the expert for foraging into their realm. A user must know parsing theory and the particulars of the parsing algorithm for the parser generator to be used. Augmentation of the BNF grammar with viable semantics requires full knowledge of the grammar and may require modifying the grammar. Not all BNF grammars are acceptable to parser generators and slight changes can caused a grammar to be rejected. Even worse, the flow of control among the semantic actions is difficult to design, debug, and modify since parsing does not supply the traditional one-in/one-out control structure so desirable in high-level programming languages. The programmer is not prevented from directly accessing variables supplied by the parser and is sometimes even encouraged to do so. The resulting semantic actions are then inextricably intertwined with the parser. Since the programmar must structure information collected during parsing, the resulting data structure is frequently tailored to the task at hand, rather than building a parse tree, for instance. Such tailoring is efficient in computer resources but burdensome on programmer development and maintenance time. The result is a system that is difficult to maintain and code that is impossible to reuse.

A new programming language, OPTIMAL, has been designed to abstract the interface to parser generators. OPTIMAL allows the programmer to build and manipulate parse trees without knowledge of the underlying parser, its parsing technique, or the BNF grammar that drives the parsing. OPTIMAL therefore provides the power of a parser generator without the concomitant pitfalls. OPTIMAL requires no expertise, no complicated control flow to understand, no grammars to modify, and no intertwining of the task at hand with the parser internals. The programmer can then concentrate on producing a structured solution that is easier to maintain and modify.

To hide the details of the parser and its parsing technique, the language is an implied preprocessing language. OPTIMAL handles the low-level detail of reading the input and translating it into a convenient form, in this case, a parse tree. OPTIMAL provides operations for manipulating the resulting parse tree. Since a parse tree can be produced from any parser, OPTIMAL programs are therefore independent of any particular parser.

To hide the grammatical details from the programmer, the language provides a specification-by-example mechanism called a unit. To manipulate, say, Boolean expressions, the user defines 'boolexp' to be 'a < b'. The OPTIMAL processor then parses the supplied example ('a < b'), thus deducing the grammatical unit intended by the user. The unit 'boolexp' can then be used in conjunction with the parse tree operations supplied by OPTIMAL in order to find Boolean expressions in the input, instantiate Boolean expressions, and perform transformations involving Boolean expressions.

The main difficulty in designing an OPTIMAL language processor involves parsing of units. A new form of parsing, called unit parsing has been developed. It has been shown that for an input I acceptable to a parser, any substring S of I can be parsed in time linearly proportional to the time spent parsing S while parsing I. Unit parsing has been implemented for the MYSTRO parser generation system and is being incorporated into an OPTIMAL language processor.

NON-LTE EFFECTS IN THE MESOSPHERE

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Abstract

A study has been made to determine how to do radiative transfer calculations in non-equilibrium atmospheres. The stimulus for the project concerned data received from the Limb Infrared Monitor of the Stratosphere (LIMS). In inverting these data to determine atmospheric parameters, equilibrium conditions are assumed throughout the atmosphere. Some of the data from the upper atmosphere were received from regions which are very likely not in equilibrium. An attempt has been made to determine what effect this might have on the parameters determined by LIMS.

Summary

The Limb Infrared Monitor of the Stratosphere (LIMS) is a six-channel limb-scanning radiometer which flew on the NIMBUS 7 spacecraft and operated from October 1978 until May 1979. It was designed to measure radiance in six spectral channels in the infrared. These measurements were inverted to obtain temperature and pressure as functions of altitude, and concentrations of ozone, water vapor, nitrogen dioxide, and nitric acid as functions of altitude in the stratosphere and lower mesosphere. A description of the instrument and various results are given in Reference 1 and the other references cited therein. The LIMS viewing geometry is shown in Figure. 1.

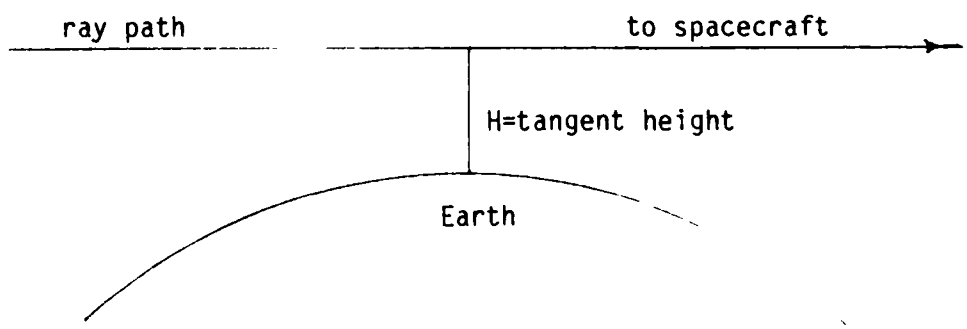

Figure 1

The inversion procedure mentioned above makes use of the radiative transfer equation. In applying this equation to the LIMS retrievals, the assumption is made that "local thermodynamic equilibrium" (LTE) applies to all parts of the atmosphere. This means that for any air parcel containing molecules in excited states, collisions between molecules are frequent enough to transfer energy and bring the parcel to an equilibrium state before the molecules have a chance to radiate their energy away. This assumption makes the radiative transfer calculation relatively straightforward, and is generally valid in the lower atmosphere where collisions are frequent due to high density.

As altitudes increase into the mesosphere (50-85 km), atmospheric density becomes low enough so that LTE may no longer be a valid assumption. For a tangent height of 60 km for example (see Fig. 1), much of the radiation along the ray path comes from altitudes higher than 60 km, hence, the need for radiative transfer calculations without assuming LTE. Very little has been done in this area, and much of my time has been spent investigating possible approaches to the problem.

A visit was made to the Air Force Geophysics Laboratory at Hanscom Air Force Base, Massachusetts. A group in the Infrared Technology Division there has developed a computer code for doing non-equilibrium radiative transfer calculations (2). Required for input for the program are kinetic temperature and number density profiles as functions of altitude, and also the so-called "vibrational temperature" as a function of altitude. This is a parameter which describes relative populations of excited states of molecules of a given species. It is an indication of how far the species deviates from equilibrium conditions within an atmospheric sample. By specifying a particular molecule, a spectral band, and various atmospheric profiles, the program calculates radiance along a ray path (see Fig. 1) as a function of tangent height. The group at the Air Force Geophysics Laboratory has provided us with a magnetic tape containing the program and various input files so that we may do sample radiance calculations with or without the assumption of LTE. The goal is to determine what effect non-equilibrium conditions might have on the results of the LIMS inversion procedure. Preliminary results indicate that the effect might be significant at a tangent height of 70 km, which is roughly the upper limit of the region of the atmosphere observed by LIMS. If the effect proves to be appreciable at lower altitudes as well, then the inversion technique might have to be modified.

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MONITORING AIRCRAFT SUBSYSTEMS WITH PROGRAMMABLE DISPLAY PUSHBUTTON DEVICES

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ABSTRACT

This project was conducted under the sponsorship of the Crew/Vehicle Interface Research 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) simulator. The ADEC utilizes the VAX-11/780 as a host computer and the Adage 3000 as a color graphics raster scan generator.

The purpose of this project was to design and develop an advanced interactive control/display interface system for monitoring transport aircraft engine/subsystems. This interface system also had to interact with the engine/subsystems during caution and warning situations.

An important design factor to be considered is the trend to use more dedicated controls/switches in the cockpit of transport aircraft. In order to reverse this trend, this project was designed around three multi-function, (multi-legend), programmable display push-button (PDP) devices. Each PDP features an interactive display consisting of 560 pixels in a 16 X 35 array and a solid state Hall effect switch.

The first phase of this project was to define the system logic which interfaces the ADEC simulator subsystem graphics with the PDP devices (controlled by the logic and refresh control unit) and the VAX-11/780 host computer.

A system being controlled by multi-function devices dictates that the system be user-friendly and yet be sophisticated enough to assist aircraft crews during high workload periods.

This was accomplished by using branching logic during normal engine/ subsystem operation and tailored logic during caution and warning situations. User-friendly philosophy was stressed throughout the design

since some caution and warning systems in transport aircrafts are considered themselves to be a hazard.

The final phase of this project was devoted to writing a Fortran program for the VAX-11/780 which supports the design objectives.

EPR CHARACTERIZATION OF METAL-CONTAINING EPOXIES

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High performance polymers are being considered for use as films, coatings, adhesives and composite matrix resins in aerospace applications.

Among these polymers, several types of thermoset epoxies are currently being used due to their extreme versatility, excellent processability, chemical resistance, low density and low cost.

Since pure polymers have not been able to meet the requirements needed for all aerospace applications, research efforts have been directed towards the modification of these materials, one of these modifications being the incorporation of metal ions into these potential aerospace resins.

Dramatic changes can occur in the properties of these polymeric materials when small quantities of metallic ions are introduced into the system, such as increases in mechanical strength, electrical conductivity and moisture resistance, although the reasons for these changes are not fully understood.

In order to obtain more information on the electronic structure and coordination of the metal ions in these polymer matrices, the magnetic properties of the systems have been studied using Electron Paramagnetic Resonance (EPR) Spectroscopy. Studies were carried out for MY-720 epoxy matrices containing Fe, Co, Ni and Cr metal ions in 1:50, 1:25 and 1:10 concentration ratios, as well as for an Epon-828-Cr 1:5 matrix.

Preliminary results indicate the existence of both high and low spin states for the metal ions in the resin, depending on the metal/resin formulation. For the Cr ion, similar occupancy sites in the polymer matrix have been found for both epoxy systems studied. For the Fe ion, changes in the EPR signal as a function of metal concentration indicate the possible existence of more than one occupancy site and/or metal state in the polymer matrix. Further characterization studies and semiquantitative results will be discussed in detail.

EXPERIMENTAL DETERMINATION OF THE
STIFFNESS MATRICES FOR SYMMETRIC LAMINATES

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Abstract

Graphite-epoxy composite materials have become of great interest in the aeronautics and space industry because of their high strength and stiffness to weight ratios. Acoustically induced material fatigue is of concern because of the pressure fields generated by aircraft and spacecraft propulsion systems on structures.

Scientists would like to mathematically predict the displacment response of composite panels to acoustically induced random pressure fields. The panel strains can be evaluated once the displacement response has been ascertained. Various investigators (1-3) have developed theories which predict the deflection response of symmetric laminate plates. Solution of these equations requires the determination of the extensional and bending stiffness matrices which can be predicted theoretically (4). This laminate theory is based upon the static experimental material properties of a single unidirectional lamina.

Concern exists about the validity of using static material properties in a dynamic analytic model. The modulus of elasticity (a measure of stiffness) can be determined indirectly by mechanically vibrating cantilever beams (5-8).

Classical lamination theory allows prediction of laminate stiffness characteristics where

$$A_{ij} = \sum_{k=1}^{N} (\bar{Q}_{ij})_k (z_k - z_{k-1})$$

$$B_{ij} = 1/2 \sum_{k=1}^{N} (\bar{Q}_{ij})_k (z_k^2 - z_{k-1}^2) \qquad [1]$$

$$D_{ij} = 1/3 \sum_{k=1}^{N} (\bar{Q}_{ij})_k (z_k^3 - z_{k-1}^3)$$

A_{ij} is called the extensional stiffness, B_{ij} the coupling stiffness, and D_{ij} the bending stiffness. Knowing the transformed reduced lamina stiffness $\bar{Q}_{ij}$ (4) and z_k, which is the distance from the plate middle surface to the k-th layer, the stiffness matrices can be calculated.

The force-moment relationships for a laminate, where ϵ_x^o, ϵ_y^o, and γ_{xy}^o are the normal and shear strains at the middle surface, κ_x, κ_y, and κ_{xy} the curvature, are

$$\begin{Bmatrix} N_x \\ N_y \\ N_{xy} \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} \\ A_{12} & A_{22} & A_{26} \\ A_{16} & A_{26} & A_{66} \end{bmatrix} \begin{Bmatrix} \varepsilon_x^o \\ \varepsilon_y \\ \gamma_{xy}^o \end{Bmatrix} + \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{12} & B_{22} & B_{26} \\ B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{Bmatrix} \kappa_x \\ \kappa_y \\ \kappa_{xy} \end{Bmatrix}$$

$$\begin{Bmatrix} M_x \\ M_y \\ M_{xy} \end{Bmatrix} = \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{12} & B_{22} & B_{26} \\ B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{Bmatrix} \varepsilon_x^o \\ \varepsilon_y^o \\ \gamma_{xy}^o \end{Bmatrix} + \begin{bmatrix} D_{11} & D_{12} & D_{16} \\ D_{12} & D_{22} & D_{26} \\ D_{16} & D_{26} & D_{66} \end{bmatrix} \begin{Bmatrix} \kappa_x \\ \kappa_y \\ \kappa_{xy} \end{Bmatrix} \quad [2]$$

where N_x, N_y, and N_{xy} are the normal and shear forces per unit width, M_x and M_y are the bending moments per unit width in the x and y directions respectfully, and M_{xy} is the twisting moment per unit width.

For the symmetric case we are considering, the laminas are geometrically symmetric around the middle surface as well as materially similar; the coupling matrix B_{ij} vanishes. Further simplifications can exist if the laminate is extensionally balanced, $A_{12} = A_{26} = 0$, or balanced in bending where $D_{16} = D_{26} = 0$.

When performing experiments, the loads are applied and the resulting deformations are measured. It is, therefore, advantageous to invert the force-moment equations because the deformations are the dependent variables. For a symmetric laminate, the coupling matrix B_{ij} vanishes and the inversion is simply (4):

$$\begin{Bmatrix} \varepsilon_x^o \\ \varepsilon_y^o \\ \gamma_{xy}^o \end{Bmatrix} = \begin{bmatrix} A'_{11} & A'_{12} & A'_{16} \\ A'_{12} & A'_{22} & A'_{26} \\ A'_{16} & A'_{26} & A'_{66} \end{bmatrix} \begin{Bmatrix} N_x \\ N_y \\ N_{xy} \end{Bmatrix} \quad [3]$$

$$\begin{Bmatrix} \kappa_x \\ \kappa_y \\ \kappa_{xy} \end{Bmatrix} = \begin{bmatrix} D'_{11} & D'_{12} & D'_{16} \\ D'_{12} & D'_{22} & D'_{26} \\ D'_{16} & D'_{26} & D'_{26} \end{bmatrix} \begin{Bmatrix} M_x \\ M_y \\ M_{xy} \end{Bmatrix} \quad [4]$$

We are using the notation what $A_{ij}^{-1} = A_{ij}'$. Verification of one set of stiffness implies verification of the other set. The stiffness matrices can readily be calculated from the inverted form.

The extensional matrix coefficients can readily be determined by applying unaxial forces to the laminate in preferred directions. Let us first consider the case where $N_y = N_{xy} = 0$, then from Equ. 3 we have

$\varepsilon_x^o = A_{11}' N_x$, $\varepsilon_y^o = A_{12}' N_x$ and $\gamma_{xy}^o = A_{16}' N_x$. We need only apply known uniaxial stress to a specimen, measure the surface strain, and determine the coefficients.

Similarly we can apply a uniaxial force N_y where $N_x = N_{xy} = 0$ and measure the surface strains and determine $A_{12}' = \varepsilon_x^o/N_y$, $A_{22}' = \varepsilon_y^o/N_y$ and and $A_{26}' = \gamma_{xy}^o/N_y$.

The stiffness coefficient A_{66}' is obtained by placing a laminate specimen in pure shear. For this case, $N_x = N_y = 0$ and from Equ. 3 we have $A_{66}' = \gamma_{xy}^o/N_{xy}$. We can also verify the shear coupling coefficients where $A_{16}' = \varepsilon_x^o/N_{xy}$ and $A_{26}' = \varepsilon_y^o/N_{xy}$ both of which can also be determined during the tension tests.

Examination of the equation for bending, Equ. 4, shows that we can determine the bending stiffness coefficients by applying pure bending and twisting moments to the test specimen. For example let $M_y = M_{xy} = 0$ we could then determine $D_{11}' = \kappa_x/M_x$, $D_{12}' = \kappa_y/M_x$ and $D_{16}' = \kappa_{xy}/M_x$. Using similar techniques for the bending moment M_y, and the twisting moment M_{xy}, we can determine the remainder of the bending stiffness coefficients.

Most of the bending stiffness coefficients can be found by using a simply loaded cantilever beam and measuring the strain near the support (6). We can find the twisting stiffness coefficient D_{66} by twisting a square plate sample by placing forces perpendicular to the plate at the corners. This is accomplished by exerting equal forces on the first and third (diagonal) corners while other equal forces press on the remaining corners in an opposing direction. Jones (4) states that $D_{66} = PL^2/4w$; where P is the applied load at the corners, L is the diagonal (corner-to-corner) distance of the plate and w is the vertical displacement at the corners with respect to the center of the plate.

A few tension tests have been performed on 8-ply T300/5208 graphite-epoxy angle ply laminates. This laminate consisted of nominally 1-mm (0.040-in.) thick material having a lay-up of $(0°, 45°, -45°, 90°)_s$, s designated symmetric laminate. The results of these tensile tests are shown in Table I where orientation refers to the outer fiber alignment in the direction of the applied tensile loads.

Based upon a lamina thickness of 0.172 mm (0.005 in.) laminate theory predicts $A'_{11} = A'_{22} = 18.86$-m/N and $A'_{12} = A'_{21} = -5.5756$-Gm/N for a total laminate thickness of 1.016 mm (0.040 in.). Inspection of Table I shows that $A'_{11} = A'_{22}$ within 1.2 % and $A_{12} = A_{21}$ within 0.9 %, we can, therefore, readily conclude that experimentally the coefficients are equal as predicted by the laminate theory.

The main concern is to determine if the laminate theory is valid. Review of Table I shows that A'_{11} (A'_{22}) was within approximately 3 % and A'_{12} was within approximately 4 % when comparing laminate theory with experimental results. Based upon these results, we can readily conclude that the laminate theory is accurate, at least for the extensional case considered.

It is recommended that the tension and shear tests be continued to determine the remaining extensional stiffness coefficients. The bending and twisting moment fixtures should be fabricated and appropriate tests performed to determine the bending stiffness matrix coefficients. The results of these tests will determine the validity of the laminate theory. It is further recommended that the vibrating cantilever beam tests be performed to determine if dynamic stiffness is different than for static conditions. These dynamic tests can be used for determining material damping which is required for the plate dynamic deflection response theory.

TABLE I

8-Ply Experimental Extensional Stiffness Data

Sample Comment	Orien. (deg)	* (mm)	A'_{11} $(G\frac{m}{N})$	A'_{22} $(G\frac{m}{N})$	$-A'_{12}$ $(G\frac{m}{N})$	$-A'_{21}$ $(G\frac{m}{N})$	E_{11} (GPa)	E_{22} (GPa)	V_{12} (unitless)
A-1-T	0	1.054	17.96	---	5.389	---	52.18	---	0.300
A-2-T	0	1.062	18.34	---	5.629	---	51.37	---	0.304
A-3-T	0	1.044	18.43	---	5.455	---	51.99	---	0.298
A-4-T	0	1.034	18.63	---	5.507	---	51.93	---	0.296
A-5-T	0	1.064	18.03	---	5.282	---	52.13	---	0.304
A-6-T	0	1.186	18.49	---	5.575	---	45.63	---	0.305
A-7-T	0	1.036	18.62	---	5.656	---	51.82	---	0.304
B-1-T	90	1.034	---	18.36	---	5.511	---	52.70	0.300
B-2-T	90	1.029	---	18.45	---	5.647	---	52.70	0.306
B-3-T	90	1.039	---	18.79	---	5.356	---	51.24	0.293
B-4-T	90	1.034	---	17.93	---	5.511	---	53.96	0.307
B-5-T	90	1.041	---	17.39	---	5.611	---	52.22	0.323
B-6-T	90	1.034	---	18.00	---	5.670	---	53.73	0.315
mean	---	1.053	18.36	18.15	5.499	5.551	51.01	52.76	0.304
6*	---	0.041	0.27	0.49	0.134	0.117	2.39	1.00	0.008
% Diff.	---	3.7	2.7	3.7	4.5	3.6	8.7	5.6	2.0

Theoretical Values: $A'_{11} = A'_{22} = 18.86$ Gm/n, $A'_{12} = A'_{21} = 05.756$ Gm/n and t = 1.016 mm,
DOD/NASA design data: $E_{11} = E_{22} = 55.9$ GPa and V = 0.31

* Standard deviation

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CONTROL OF FLEXIBLE BEAMS THROUGH ROOT ACTUATION

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The problem of controlling flexible structures in space is rapidly becoming more than an analytical exercise. We are being faced with the prospect of having to actually perform vibration and position control on light, lightly damped structures in space. The investigation of root control of beams in the laboratory (on the ground) is uncovering many idiosyncrasies of these systems that the analyses do not predict. The research performed during the 1985 summer is addressing some of these problems. This abstract will cover the following areas: modelling and control overview, the problem of motor friction, controlling the beams in the gravitational field, and introduction of flexibility control to the base of the beam.

We have addressed ourselves to the control of flexible beams via root actuation. We are attempting to do this task both in and out of the gravitational field. Our approach to this task is first to model the beams, actuators, and sensors and then add an analog linear state variable feedback law to place the eigenvalues of the resulting closed-loop system. The models for the actuator (a dc servo-motor with PWM power amplifier) and sensors (potentiometer for root angle and beam strain measurements) are made with standard assumptions. The beam continuum was discretized using a three-term Ritz approximation. The resulting model is an eighth-order ODE. Previous work (1984 NASA/ASEE Fellowship) demonstrated our ability to add significant damping to the system through state feedback using a geared motor with a standard dc amplifier. Our present work with a direct-drive motor has shown that the motor friction is now a significant factor. The friction we encountered was approximately three-fourths of the control torque required in one simulated slewing task.

We have attempted to eliminate the effects of this significant friction using a "tuneable" open-loop bang-bang function. We have added an analog circuit to the control law that is an approximation of the static friction torque characteristics of the motor. The analog circuit used is an operational amplifier with two diodes in the feedback loop with the motor speed measurement (voltage) as the input. These diodes are placed in opposite directions; one of them serves to limit the maximum value of the amplifier output; the other serves to limit the lower value of this output. These maximum and minimum values are equal to the breakdown voltages of the diodes; therefore, the upper and lower values can be set independently by proper choice of the diodes. We did not have this asymmetric coulomb friction and used the same type diodes for each limit. We found that this circuit tended to oscillate at zero speeds and added a low-pass filter to reduce the amplitudes of these oscillations. This circuit eliminated a major portion of the friction and allowed us to use the linear control law more effectively.

In order to understand the effect of the gravitational field we are attempting to control the beams with the gravitational field parallel to the plane of rotation. The resulting equations of motion are non-linear in the root angle (sine and cosine non-linearities). Our first approach to this control task has been to linearize the equations of motion at different root angles and then choose state feedback coefficients to set the eigenvalues of this linearized system. We wrote a one-mode approximation for the system and used a symbolic manipulation code (MACSYMA) to solve for the feedback gains as a function of the angle.

Another approach taken to this control task was to investigate the possibility of accomplishing it by controlling the stiffness of the support the beam has at the root. This work has only begun. The preliminary work has involved the simulation of a simple one-degree-of-freedom spring-damper system with a variable spring rate. We have approached this problem via controlling an analog simulation (on an EAI 2000) of this system by changing the stiffness externally. Our results have been mixed: some of the situations have demonstrated improved damping and others have not. More "experimental" work will be conducted along with an analysis of the time-variable parameter ODE that represents this variable flexibility situation.

REPRESENTING LINEAR SYSTEMS IN GRASSMANN MANIFOLDS

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Abstract

We shall discuss some aspects of geometric representations available for linear control systems. A technique used by many authors exploits Grassmann manifolds as a context for describing many important invariants of these systems. We hope, eventually, to use this method to describe phase and gain margins for multi-input and multi-output systems. Such a scheme presumably requires the use of a "natural" metric on the manifold so that, for example, one may reasonably estimate separation of a Nyquist locus form crucial singularities.

Meanwhile, we need to explain the variety of ways the Grassmann formalism is used. These may be briefly listed:

1. For (complex) p-planes in C, we may use an mxp matrix of spanning vectors as

$$\begin{bmatrix} G(s) \\ I \end{bmatrix}$$

where G is a rational proper transfer function and I is an identity matrix. This method is used by Brockett and Byrnes[1] and allows a reasonably straightforward description of the Nyquist locus.

2. For p-planes in C, we may use a homogeneous description of the plane as an nxn non-singular matrix. By passing to an appropriate equivalence class, we can get a single valued version of the plane. This method is used by Saeks and Murray[2] for the homogeneous representation of coprime (stable) factorizations of transfer functions.

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PROGRAMMING OF ROBOT ARMS BY GEOMETRIC DESCRIPTION

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Abstract:

We give a method for programming cooperating manipulators, which is guided by a geometric description of the task to be carried out. For this we must have a suitable language and a method for describing the workplace and the objects in it in geometric terms. A task level command language and its implementation for concurrently driven multiple robot arms is described. The language is suitable for driving a cell in which manipulators, end effectors and sensors are controlled by their own dedicated processors and these processors can communicate with each other through a communication network. A mechanism for keeping track of the history of the commands already executed allows the command language for the manipulators to be event driven. A frame based world modeling system is utilized to describe objects in the work environment and any relationships that hold between these objects. This system provides a versatile tool for managing information about the world model. Default actions normally needed are invoked when the data base is updated or accessed. Most of the first level error recovery is also invoked by the database by utilizing the concepts of demons. The package can be utilized to generate task level commands in a problem solver or a planner.

1.0 INTRODUCTION

In designing a controller for a manipulator the manufacturer uses diverse schemes to control the motion of the manipulator arm. These can be thought of as machine instructions for the manipulator. We give a standard instruction set which can be constructed from the manufacturers set. Thus different manipulators can be integrated in a system in a uniform manner. This set is adequate to implement task level conditional commands for a manipulator when we interface them with a data base.

2.0 STANDARD SET

For a manipulator we can implement the following basic commands (ref. 1) Orlando):

(INITIALIZE ARMNUMBER) --- (1)
(MOVE ARMNUMBER XYZOAT-LIST) --- (2)
(MOVE-ALONG ARMNUMBER DIRECTION-DISTANCE-LIST) --- (3)
(SET-ANGLES ARMNUMBER ANGLE-LIST) --- (4)
(POSITION ARMNUMBER) --- (5)
(STATUS ARMNUMBER IDENTIFICATION-NUMBER) --- (6)
(RESUME ARMNUMBER) --- (7)
(SUSPEND ARMNUMBER) --- (8)
(CANCEL ARMNUMBER) --- (9)

3.0 HISTORY MANAGEMENT

If the receiving unit is enabled it puts on its command queue commands of type (1)-(4) and carries them out sequentially. Whenever a command has been completed the central processing unit moves it to its history stack along with the identification number given to it by the issuing unit. Notice that the issuers event count is used even though the device may maintain its own time stamp. Commands of the type (5)-(9) are executed immediately even if it is necessary to suspend a command of type (1)-(4). For commands of type (5)-(9) the commanding unit waits for the response.

In a work cell system, as shown in figure 1, the connecting lines indicate the communication path between the central processing units.

4.0 DATA BASE FOR WORLD MODELLING

To be able to implement high level commands for the manipulators we have implemented a data base to represent the working environment using frames. In the implementation all the default actions normally needed are invoked when the data base is updated or accessed. Frames are structures to make declarative statements about objects and relationships between objects. Thus two typical frames in this world model, which describes an arm and an object of the system, would be:

```
(arm1 (type     (name    (puma)))
      (base     (radius  (150.0)))
      (init     (value   ((1064.4 681.461 1092.4 0.0 0.0 0.0))))
      (located  (value   ((1064.4 681.461 0.0 0.0 0.0 0.0))))
      (using    (hand    (hand1))))

(a    (type     (value (cube)))
      (height   (value (35.0)))
      (base     (radius (24.75)))
      (on       (object (p )))
      (located  (value ((1480.0 895.0 35.0 3.14 0.0 0.0)))))
```

5.0 CONCURRENT PROGRAMMING LANGUAGE

Using the above history management scheme we can now implement a language to program multiple arm cell. Thus for the command

(COND-PUT ARM OBJECT LOCATION SET-COND TEST-COND) --- (10)

all the information about the OBJECT is stored in a frame and suitable error recovery functions are invoked when the MOVE and PICK subcommands of the COND-PUT are issued. The COND-PUT waits for TEST-COND to be true before it starts executing and when completed sets the SET-COND to true. An interpreter for the language is implemented using the communication network, the time stamp and the history tables described above.

To illustrate some of the commands and how they can be used to describe a task in the language we give a program to build a seesaw of figure 2.

```
(PICK    ARM1 BAR)       ;These two are unconditional commands and thus
(PLACE   ARM1 BAR ON-A) ;do not test or set conditions
;Commands beginning with a C are conditional commands like (10)
(CPICK   ARM2 A2  C21 T) ; --- (21)
;Because the TEST-COND is true CPICK is not blocked
;C21 will be set to T when CPICK has picked up the object A2
(CPICK   ARM1 A1  C11 T) ; --- (11)
;C11 will be set to T when the CPICK command has been executed
(CMOVE   ARM2 A2  RIGHT-END C22 C21)
;Tests C21 from the CPICK command (21) above before continuing
;C22 will be set to T when CMOVE has completed
(CMOVE   ARM1 A1  LEFT-END  C12 C11)
;This command waits for (11) above to complete
(CPLACE  ARM1 A1  LEFT-END  C14 (AND C12 C22))
;(AND C12 C22) guarantees that both objects A1 and A2 are immediately
;above the bar so that if one cube is placed before the other the bar
;would not fall
(CPLACE  ARM1 A2   RIGHT-END C23 C12)
(CRETURN ARM1 HOME1 C13      C14)
(CRETURN ARM2 HOME2 C24      C23)
```

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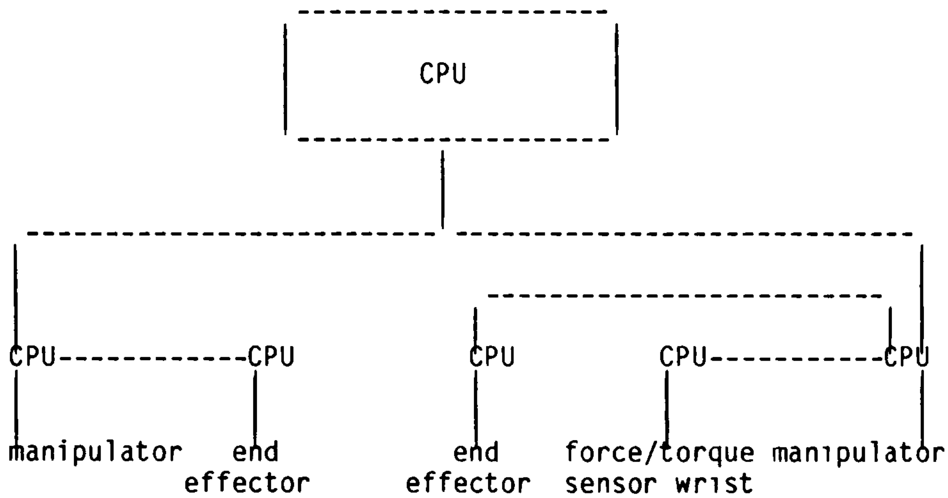

Figure 1: Multiple robot arms cell

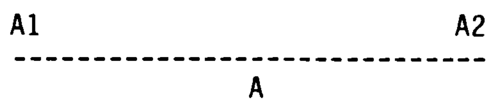

Figure 2: A seesaw

CONVENTIONAL CONTROL AND DATA DISPLAY MODIFICATIONS FOR ADVANCED MLS APPLICATIONS

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NASA Langley Research Center (LaRC) in a joint effort with the FAA, has begun a study of advanced applications of the microwave landing system (MLS). This program has the objective of defining an envelope of usable MLS approach paths considering pilot-vehicle performance, pilot-passenger acceptance, and ATC integration factors.

The MLS consists of three major components: (1) ground-based scanning beam transmitters, (2) ground-based precision distance measuring equipment (DME/P), and (3) airborne MLS equipment for azimuth, elevation, and range determination. These components together with area navigation (RNAV) computation will be used to fly complex MLS procedures which include straight line segments and curved paths. The wide area coverage of the MLS permits curved path approaches representing a relatively new pattern or landing configuration for pilots, and requires modification of existing control and data display.

Various levels of airborne equipment sophistication will be explored in the MLS study. The lower end of cockpit sophistication will be represented by conventional electromechanical instrumentation. The upper end of cockpit sophistication will be represented by an advanced configuration with fly-by-wire type controls and electronic displays. The conventional configuration studies will be conducted with the LaRC Visual Motion Simulator (VMS) and the LaRC DC9-30 fixed base full systems simulator, representing a category C aircraft. The advanced configuration studies will utilize the LaRC Transport Systems Research Vehicle (TSRV) fixed-base simulator, which also represents a category C aircraft. Studies in the VMS have begun.

The VMS is a six-degree-of-freedom, motion-base simulator capable of presenting realistic acceleration and attitude cues to the pilot. A general purpose, scientific mainframe computer with a nonlinear, high fidelity digital representation of DC9-30 twin-jet commercial transport airplane provides inputs to drive the VMS motion base system. Audio cues for engine thrust and aerodynamic buffet will also be provided. The simulator has a generic cockpit with conventional flight controls and instrumentation. Flight controls include a column and control wheel, rudder pedals, and throttle, speed brake, and flap controls located on a center console. Flight instrumentation includes conventional flight and navigation instruments and engine instrumentation.

Initial tests in the VMS indicate that high pilot workload in complex MLS procedures will be a major limiting factor in designing usable approaches. Efforts to reduce pilot workload have included the design and implementation of an autothrottle and the design of a flight director control panel. Pilot comments have also led to the design of a test to measure possible reduction of pilot workload by displaying airplane track angle instead of magnetic heading on the horizontal situation indicator (HSI).

The automatic throttle system consists of pilot interface hardware, aircraft state measurements, functional algorithms, and thrust setting commands. Pilot interface hardware consists of an autothrottle engage/disengage lever located on the throttle quadrant, disengage button and go-around palm switches on the throttle levers, commanded airspeed knob and readout located on the indicated airspeed instrument, and a fast/slow airspeed bug on the airplane attitude indicator. The algorithm for throttle setting is a modification of one used on the NASA TSRV and is based upon several variables including calibrated airspeed, commanded airspeed, along track acceleration, bank angle, and engine pressure ratio.

The flight director control panel (FDCP) will be used to select guidance options available to the pilot in the VMS and subsequently in the fixed base DC-9 simulator. The FDCP is a modification of the FD-109 panel and will accommodate the original functions plus the addition of MLS and RNAV provided by the flight guidance and control system. The FDCP provides pitch select, mode select, and altitude hold inputs for the pilot. Selectable modes include GA (go-around), HDG (heading), NAV/LOC (VOR type navigation), APPR (ILS and MLS straight in type approach), and RNAV (area navigation including curved path MLS approaches).

A plan of test has been developed to obtain comparative measures of the dependence of pilot workload and performance on displaying airplane track angle or magnetic heading on the HSI during a precision approach. Four to six airline pilots will be used as test subjects to fly airborne tracking navigation tasks in the VMS using the DC9-30 simulation software. Quantitative pilot workload and performance measurements will be recorded during each run and will include oculometer, heart rate, airplane track, airplane state, and pilot input measurements that will be time correlated for later analysis. Subjective evaluations will be obtained through pilot comments during and after each run and by pilot ratings, questionnaires, and debriefing after each session.

The advanced application study is expected to continue through an approximate three year period. Joint simulation with the FAA using their ATCSF in conjunction with a NASA simulator and a FAATC-LaRC tie line is planned to address the MLS-ATC integration issues.

VAPOR SCREEN FLOW VISUALIZATION EXPERIMENTS IN THE NASA LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL

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Now that the National Transonic Facility has been given operational status, experimenters are routinely listing among their test requirements the capability of visualizing surface and freestream flow fields.[1] Unfortunately, there are presently no operational techniques for visualizing cryogenic flows. One candidate technique, vapor screening, is being examined in the present series of experiments.

The vapor screen flow visualization technique, which is described in reference 2, is being used for the first time to accomplish flow visualization in a cryogenic environment. In the experiments that have been performed to date, this technique has been used to visualize the flow over a 65° half-span delta-wing model 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 freestream saturation temperature. The density of the fog was varied (by varying freestream temperature) in an effort to produce an optimum fog density. The fog was illuminated by an intense sheet of light from a 15-mW helium-neon laser. Personnel from the Instrument Research Division designed the illumination system shown in figure 1. 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 vortex on the leeward side of the delta-wing model was visualized at several different tunnel conditions. Mach number (M) was varied from 0.4 to 0.8; total pressure (p_t) was varied from 1.3 to 5.0 atmospheres; total temperature (T_t) was varied from 83 to 101 K and angle of attack was varied from 13° to 30°. Vapor screen photographs of the subject flow field are presented in figure 2 at several angles of attack with M = 0.6, p_t = 3.0 atm. and T_t = 92.0 K. These flow visualization photographs are presently being interpreted relative to phenomenological implications.

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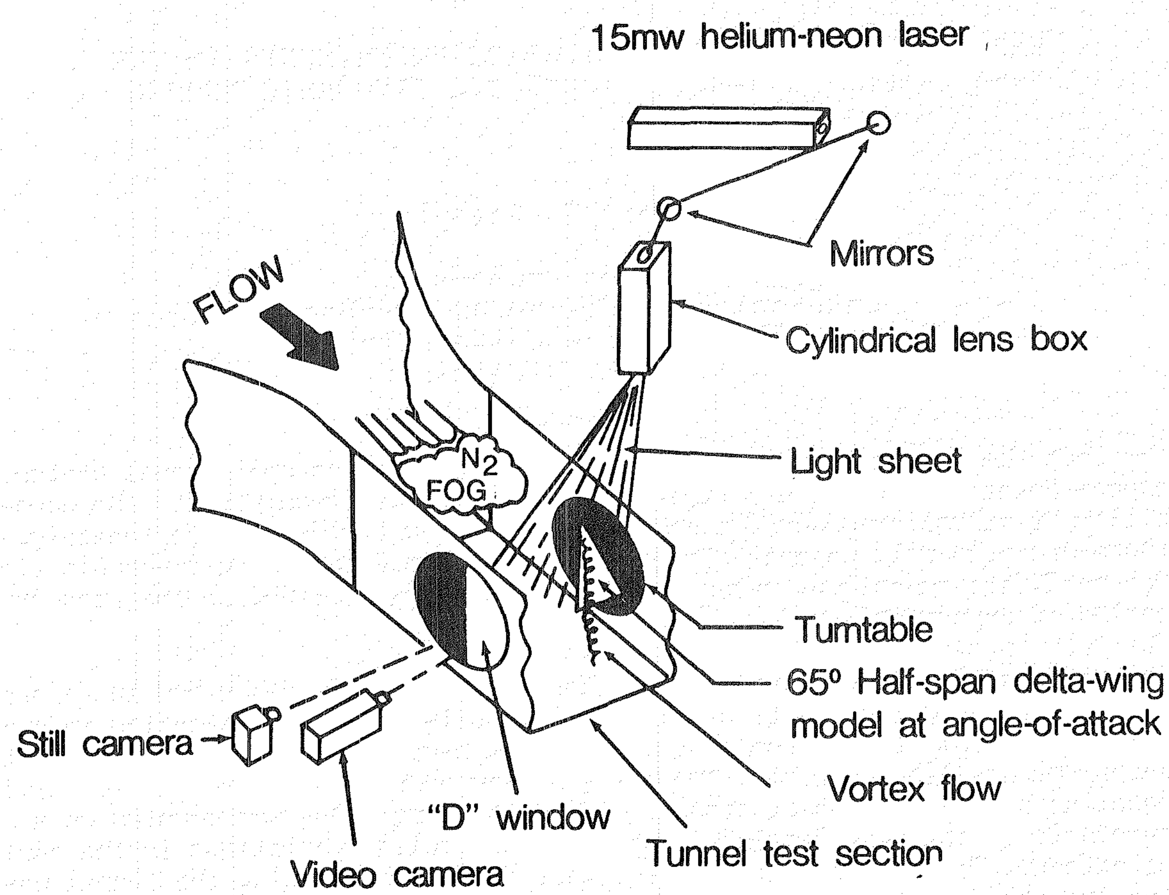
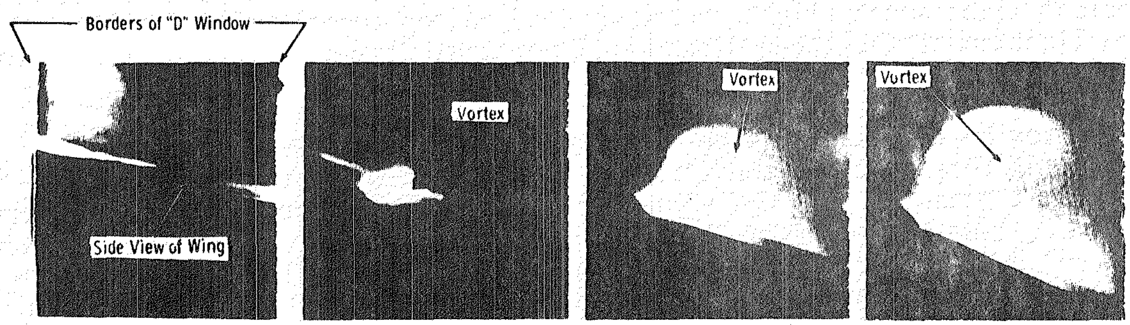


Figure I. Schematic of Illumination System Used in Vapor Screen Experiments



A. No Flow B. $\alpha = 15°$ C. $\alpha = 20°$ D. $\alpha = 25°$

Figure 2. View through D Window of the flow over a 65 Half-Span Delta Wing at Various Angles of Attack ($M = 0.6$, $p_t = 3.0$ atm. and $T_t = 92.0$ K)

CONSIDERATIONS IN THE DESIGN OF CONTROL SYSTEMS FOR FLEXIBLE SPACECRAFT

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Abstract

A great deal of work has been dedicated to the development of structural control theories. Although the developments are extensive, the designer often finds it difficult to apply many of these theories to "real structural control problems." Indeed, it is of primary concern to bridge the gap between engineering design and the structural control theories.

The focus of the research into structural control theories is diverse. Many of the researchers are concerned with practical implementation problems and toward that end promote decentralized control (Refs. 1, 2). Others promote a centralized modal control approach and toward that end point out that a control theory should not destroy certain characteristics which are natural to a structure (Refs. 3-5). Still others, in search for the global optimum, are concerned with distributed controls (Refs. 6, 7). Much attention is also given to describing the robustness of the control theories in the presense of modeling errors, particularly in view of the fact that it is difficult to characterize structural stiffness in mathematical models (Refs. 8-10).

All of the these approaches support the objective to uniformly dampen the motion of a spacecraft. As it turns out, a uniform damping control is a robust, decentralized, natural control with near globally optimal performance (Ref. 11). Thus, a uniform damping control answers the concerns raised in the previously sited references.

In this paper, uniform damping is examined and specifically uniform damping is compared with globally optimal controls. This paper also investigates the effects of discretization of the controls in space, i.e., the effects of using a limited number of control forces. Also the effects of discretization of the controls in time are investigated. Finally, this work investigates the combined effects of discretization of the controls in time and space. As numerical examples, simple beams as well as complex truss structures are considered.

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CONFIGURATION CONTROL OF COMPUTER-GENERATED DRAWINGS

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The purpose of this report is to define the procedures necessary to implement effective configuration control of electronically generated designs. As this writer was assigned to the Model Engineering Section (MoES), the work and techniques were used as examples for this report. However, the control measures discussed can be applied beyond the generation of model designs to any of the varied design work done at Langley Research Center or throughout industry.

Little previous research could be found concerning control of electronically generated designs. Even though the capability has existed to integrate design and fabrication with computers for some time, few organizations have yet adopted such a system on a large scale, as the MoES has. Therefore, the approach taken was to first study and document the methods used in generating hand-drawn designs. Those steps were then updated to accommodate designs that were developed on the computer and machine-plotted. Finally, the total electronic creation and use of engineering designs were investigated.

In the past designs have been formalized on engineering drawings so that the researchers, engineers, and technicians could visualize the end product. Because of the time consuming process of producing an original drawing the procedure of requiring approval signatures on the original was sufficient to assure control. However, a new plotted drawing considered to be an original can be generated from an electronic definition in a matter of minutes. New plotted "originals" are being generated for even the smallest change or modification to a part. Though approvals are still required in this process, it is much easier to have multiple drawings carrying the same drawing number, but with minor differences in the configuration. At the least this leads to confusion, and more likely to higher costs and poor quality control. With the potential to produce and use design data without ever producing even one physical drawing, the control problem is compounded.

Because of these problems effective configuration control procedures must be implemented. This paper presents some recommendations on where those controls should be placed and how they can be used without imposing unnecessary delays on the process of producing hardware from engineering designs. This paper also briefly discusses the controls used in the past with hand-generated original drawings, as well as those currently being used for computer-generated plotted drawings.

TURBULENCE FOR FLIGHT SIMULATION

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It is established that third-order velocity-product moments are of paramount importance in the faithful simulation of atmospheric turbulence. It is also established that turbulence superimposed upon a sheared mean-flow does not have the same statistical characteristics that a turbulence superimposed upon a constant mean-flow does.

INTRODUCTION

Faithful simulation of atmospheric turbulence is a problem of great concern to the aviation industry in general. In the early years of this discipline commonly used methods for artificially generating turbulence time-histories employed a Gaussian model of turbulence[1], but in recent years the trend has been toward more realism with a modified Gaussian model[2-6], where fourth-order moments are not obtained directly from the second-order moments; none of these two fundamental models, however, produces odd-order moments in the simulated "turbulence," and the net result is a random time-history that pilots who "fly" through this simulated disturbance in state-of-the-art flight simulators often describe as too "continuous" and too "monotonous" when compared to real atmospheric turbulence. Pilots refer to these collective features in the simulated time-histories as "lacking the [all-important] element of surprise" of authentic hydrodynamic turbulence.

In view of this discrepancy between (as currently) simulated and real turbulence an effort was initiated to establish the role of third-order moments, as well as that of wind-shear, in the dynamical characteristics of the correlation structure of atmospheric turbulence; it is hoped that the results of this endeavor will stimulate the search for non-Gaussian turbulence models which duly reflect the true nature of the phenomenon, and simultaneously elevate the art of turbulence simulation to that of turbulence emulation. Briefly, the role of third-order moments is essentially to provide a "driving force" for the turbulence two-point velocity correlations, while the effects of wind shear are required in the simulation of turbulence occurring near the ground--as would be encountered in the situation where an aircraft is taking off or landing. Turbulence superimposed upon a wind shear of any type does not at all have the same statistical structure that a turbulence superimposed upon a uniform wind does; this striking and often unrecognized characteristic is due to the continual interplay between turbulence and the underlying mean-flow, an interplay which manifests itself through the nonlinear convective term in the Navier-Stokes equation.

CONCLUSIONS

Third-order velocity-product moments are of paramount importance in the correlation structure of turbulence and should accordingly be included in any faithful numerical simulation of the same. These moments ingress as a "driving force" into the differential equation for the two-point velocity-correlation of the turbulence, and as such convey upon it its characteristically unique features; indeed without them, the dynamical aspects of turbulence reduce to those of Gaussian diffusion, and unjustly purloin from it its natural "self-interaction" as well as its interaction with the underlying mean-flow. Turbulence superimposed upon a sheared mean-flow does not have the same structure as does a turbulence superimposed upon a constant mean-flow; this distinction is due to the natural interplay between (real) turbulence and the mean-flow. The presence of shear produces an alteration of the "viscous-friction" factor in the turbulence, to the point where this effect is operative even in the "high" Reynolds number situation; in unsheared flow this is typically not the case, and viscous forces are negligible whenever the turbulence Reynolds number is "high."

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ERROR ESTIMATES FOR ADAPTIVE FINITE ELEMENT COMPUTATIONS

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The objective of this research is to investigate the implementation of "a posteriori" error estimates for adaptive refinements in finite element computations. For many model problems these methods have been well developed, yet they are still not in common use in practice. Here we discuss one such method, which has good prospects for wide use.

We will consider elliptic partial differential equations which can be put into the following variational formulation:

(1) Given $f \in H_2'$, find $u \in H_1$ such that
$$B(u,v) = (f,v) \text{ for all } v \in H_2,$$

where H_1 and H_2 are Hilbert spaces and B is continuous, coercive and bilinear form.

Now, let V_1 and V_2 be finite dimensional subspaces of H_1 and H_2 respectively. Then the finite element formulation corresponding to (1) is :

(2) Find $u_h \in V_1$ such that
$$B(u_h,v) = (f,v) \text{ for all } v \in V_2.$$

The objective of adaptive methods is to design techniques to minimize the error, $u-u_h$, measured in some appropriate norm. It has been shown by I. Babuska and W. C. Reinbolt that if $J=(\Psi,T,V_2)$ is an admissible family, then

$$(3) \quad D_1\eta \leq \| u-u_h \|_{H_1} \leq D_2\eta$$

with
$$\eta^2 = \sum_{i=1}^{m(\Psi)} \eta_i^2 , \quad \eta_i = \sup_{v \in H_2} \frac{B(u-u_h, \psi_i v)}{\|\psi_i v\|_{H_2}},$$

where D_1 and D_2 are bounded constants.

We have applied these estimates to two model problems. In these applications the quantities η_i provide a heuristic for optimization. To compute the η_i's one must solve a local auxiliary problem. The constants D_1 and D_2 are independent of the size of the elements used, but they do depend on their shape.

APPENDIX V

ASEE-NASA Langley Summer Faculty Program

Sample Questionnaires

EVALUATION OF SUMMER RESEARCH PROGRAM

(NASA-ASEE)

BY

FELLOWS

Please complete and return to Gene Goglia by July 26, 1985, NASA MAIL STOP 122.

1. Were you able to obtain sufficient information regarding the program?

   YES NO (Circle One)

   Comments: ____

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   ____

2. Was the contact with your anticipated research associate an early one to allow some preparation for the research assignment?

   YES NO (Circle One)

   Comments: ____

   ____

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3. Were you given a choice of research topics?

   YES NO (Circle One)

   Comments: ____

   ____

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   ____

4. Have you found your research problem:

   A. Challenging? YES NO (Circle One)

B. Within your chosen field of interest? YES NO (Circle One)

Comments: ______________________________

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5. Do you plan to embark on research of similar nature upon your return to your home institution?

YES NO (Circle One)

Comments: ______________________________

____

____

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6. First-Year Fellows: Do you plan to return to Langley next year, if invited?

YES NO (Circle One)

Comments: ______________________________

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7. Did you find the lectures that you attended of interest? Any suggestions for the future.

YES NO (Circle One)

Comments: ______________________________

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8. Your comments regarding the stipend you received would be appreciated.

   Comments: ____

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9. Did you experience difficulty in locating suitable housing?

   YES NO (Circle One)

   Comments: ____

   ____

   ____

   ____

10. Was the administration of the program to your satisfaction?

    YES NO (Circle One)

    Comments: ____

    ____

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    ____

11. Additional comments regarding the program as a whole. You may use the back of this page also.

PAGE FOUR

12. If you anticipate publishing a paper as a result of your research this summer, please provide the title of paper and journal in which you anticipate it being published.

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13. If you plan on submitting a proposal for continuance of your research effort this summer, please provide title of proposal and agency to which proposal will be submitted.

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Signature ____________________

NASA-ASEE

SUMMER FACULTY RESEARCH PROGRAM

QUESTIONNAIRE FOR RESEARCH ASSOCIATES

Please complete and return to Gene Goglia by July 26, 1985, NASA MAIL STOP 122.

CIRCLE ONE

1. Would you say that your Fellow was adequately prepared for his/her research assignment? YES NO

   Comments: ______________________________

2. Would you comment on the diligence, interest, and enthusiasm with which your Fellow approached his/her research assignment.

   ____

3. Would you be interested in serving as a research associate again? YES NO

   Comments: ______________________________

4. Would you be interested in having your Fellow (if eligible) return a second year?

   Comments: ______________________________

PAGE TWO

5. Any recommendations regarding improvement of the program will be appreciated.

Signature ______________________

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