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SECTION I

ORGANIZATION AND MANAGEMENT

The 1992 Hampton University (HU)-NASA Langley Research Center (LaRC) Summer Faculty Fellowship Research Program, the twenty-ninth such institute to be held at LaRC was planned by a committee consisting of the University Co-Director, LaRC Technical Assistants (TAs) from the research Directorates, and the University Affairs Office. It was conducted under the auspices of the Langley Research Center's Chief Scientist, Dr. Michael F. Card.

Each individual applying for the program was provided a listing of research problems available to the LaRC 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 or her liking was given serious consideration.

An initial assessment of the applicant's credentials was made by the NASA LaRC Assistant University Affairs Officer and 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. Once this process was completed, a meeting was scheduled with the Directorate Technical Assistants (TAs) where applications were distributed and instructions concerning selection were discussed. At a later date, the TAs notified the ASEE office of the selections by each division.

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. As letters of acceptance were received, contact was made with each TA advising them of their Fellows for the summer program.

Each Fellow accepting the appointment was provided material relevant to housing, travel, and payroll distribution. Each Fellow, in advance of commencing the program, was contacted by his or her Research Associate or a representative of the branch.

At the orientation meeting which was held on the first day of the summer program, Mr. Edwin J. Prior, Acting University Affairs Officer, welcomed everyone and introduced the Langley Deputy Director,
Dr. H. Lee Beach, Jr., who gave greetings on behalf of the Senior Staff.
Dr. Michael F. Card, NASA Langley Research Center's Chief Scientist, then presented an overview of the Center followed by a schedule overview given by Mr. Robert L. Yang, Assistant University Affairs Officer. Overviews of the

Technical Library, Computational Facilities, Mail Room, Cafeteria, and Activities Center were given by representatives from each area. Mr. O. J. Cole presented a security briefing. Occupational Health Services available through the clinic on Center was discussed by Mr. Peter J. Edgette. The Safety Management Section, represented by Mr. Clarence F. Breen, showed a safety video. Following the overviews, a program breakout session was held enabling the ASEE Co-Director to meet with the 1992 Fellows to discuss administrative procedures. At the end of the breakout session, NASA LaRC Associates were introduced to their Fellow and at that time, departed for their respective work sites. An evaluation of the orientation meeting was completed. Refer to Section VI for results.

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 gave a talk on his/her research within the division. The Research Associate then forwarded to the Co-Director the name of the person recommended by the division for the final presentation. Thirteen excellent papers were presented to the Fellows, Research Associates, and invited guests.

Each Fellow and Research Associate was asked to complete a questionnaire provided for the purpose of evaluating the summer program.

SECTION II

RECRUITMENT AND SELECTION OF FELLOWS

Returning Fellows

An invitation to apply and possibly participate in the Hampton University (HU)-NASA Langley Research Center (LaRC) Program was extended to the individuals who held 1991 fellowship appointments and were eligible to participate for a second year. Eighteen individuals responded to the invitation and sixteen were selected (Table 1). Fifteen applications were received from Fellows from previous years. Five were selected.

New Fellows

Although ASEE distributed a combined brochure of the summer programs, many personal letters were mailed to deans and department heads of various engineering schools in the East, South, and Midwest, by Mr. John H. Spencer of Hampton University (HU) and by Dr. Surendra N. Tiwari of Old Dominion University requesting their assistance in bringing to the attention of their faculties the HU/ODU-LaRC 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 Co-Director from HU sent over three hundred letters to deans and department heads, and to all of the minority institutions across the United States soliciting participants (Table 2). These efforts resulted in a total of one-hundred and ten formal applications, all indicating the HU/ODU-LaRC Program as their first choice and a total of fifty-one applications indicating the HU/ODU-LaRC Program as their second choice. The total number of applications received came to one-hundred sixty-one (Table 3).

Thirty-eight applicants formally accepted the invitation to participate in the program. Seven applicants declined the invitation. Several Fellows delayed their decisions while waiting for acceptance from other programs. The top researchers seem to apply to more than one program and will make their selection based on research interest and stipend. Twenty-six positions were initially budgeted by NASA. Twelve positions were funded by the LaRC divisions (Table 4).

The average age of the participants was 40.

TABLE I - DISTRIBUTION OF 1992 ASEE BY YEAR IN PROGRAM

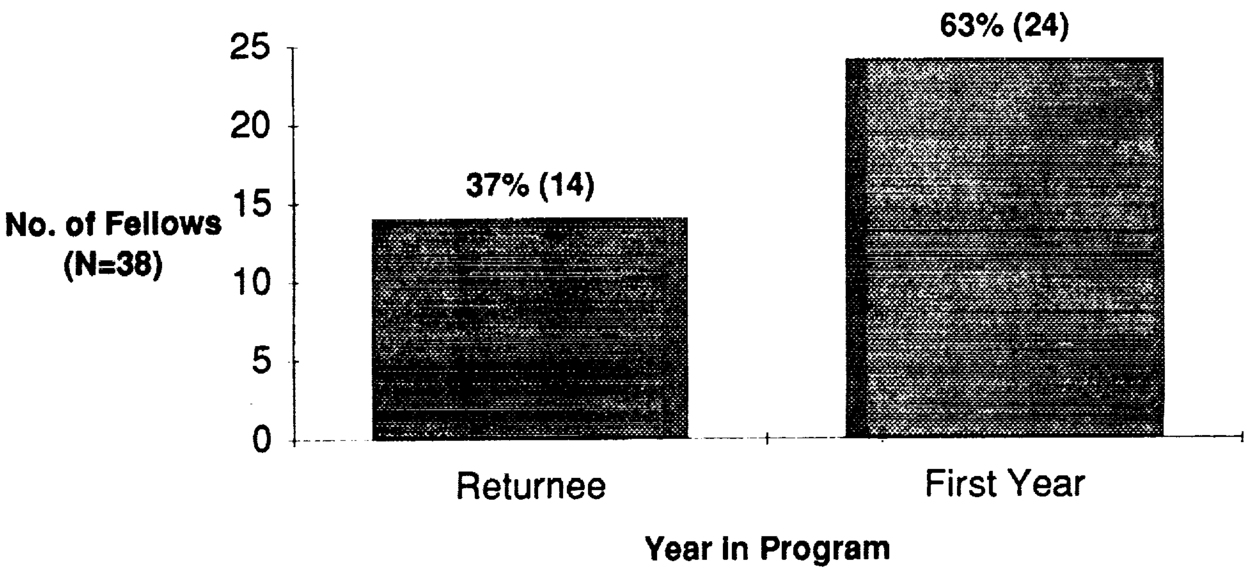


TABLE 2 - DISTRIBUTION OF 1992 ASEE BY UNIVERSITY

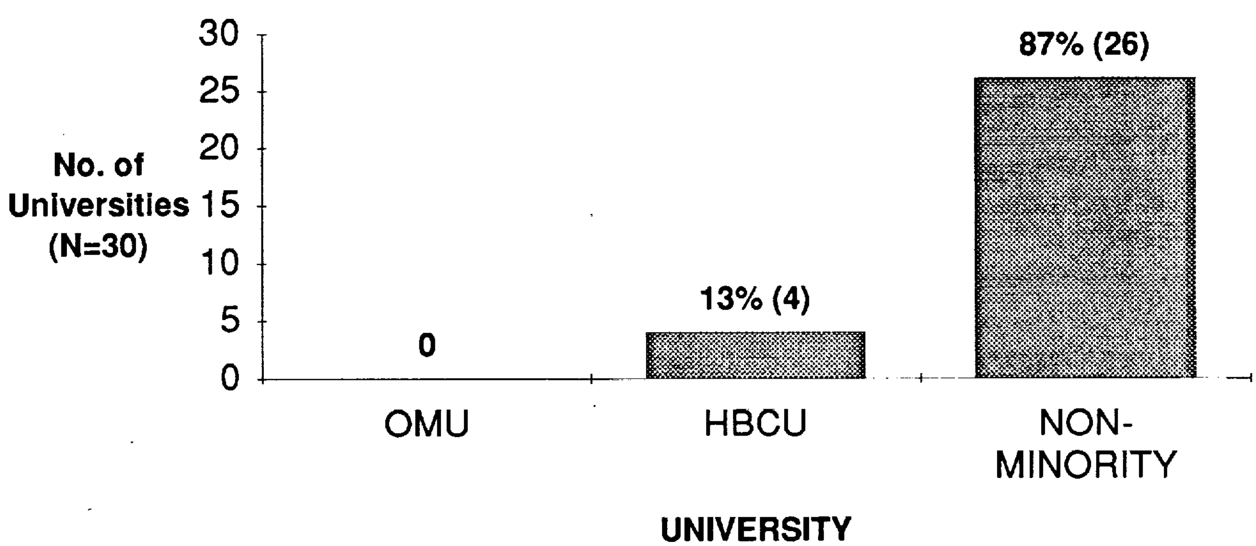


TABLE 3 - DISTRIBUTION OF 1992 ASEE BY SELECTION

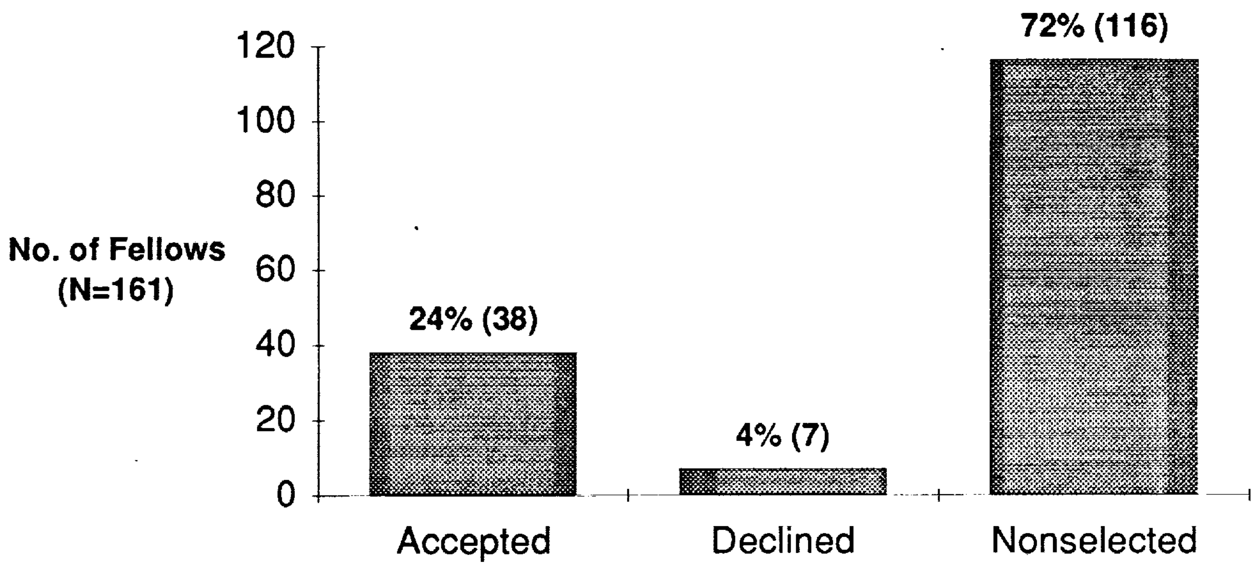
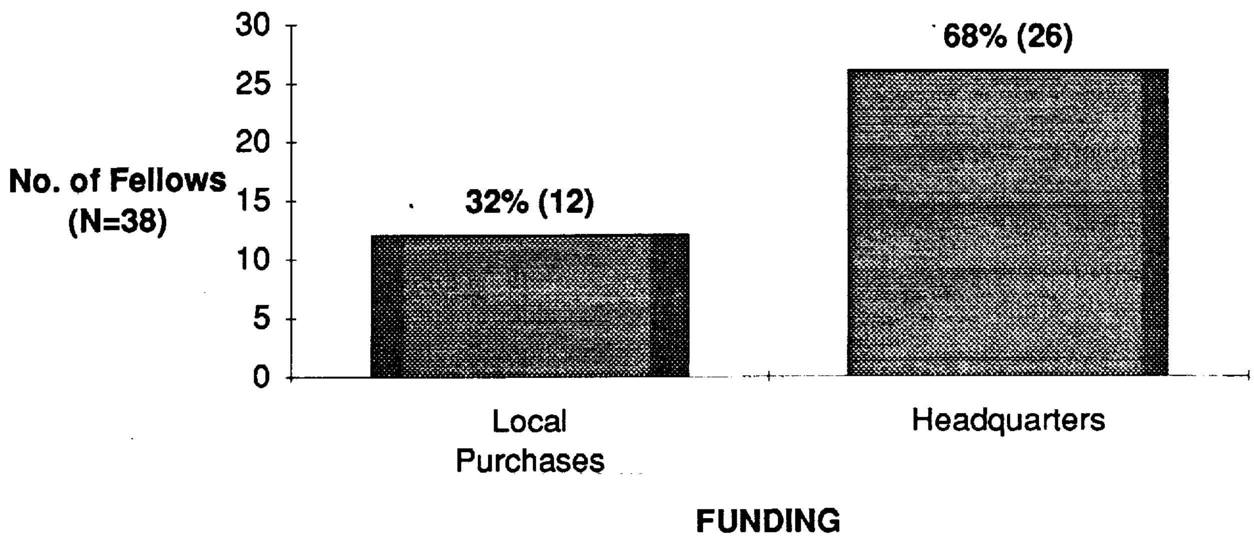


TABLE 4 - DISTRIBUTION OF 1992 ASEE BY FUNDING



SECTION III

STIPEND AND TRAVEL

A ten week stipend of $10,000 was awarded to each Fellow. This is a $1,000 increase over last year's stipend. Although this is a definite improvement over previous years, this stipend still falls short of matching what most professors could have earned based on their university academic salaries. The decision to participate in the summer faculty research program clearly reflects the willingness of the Fellow to make some financial sacrifice in order to have the experience of working with NASA's finest scientists and researchers.

Mileage or air fare expenses incurred by the Fellows from their homes to Hampton, Virginia, as well as their return trip, were reimbursed in accordance with current HU regulations. A relocation allowance of $1,000 was provided for the Fellows traveling a distance of 50 miles or more.

SECTION IV

1992 ASEE SFFP ACTIVITIES

Lecture Series

Due to the past success, the Lecture Series was again scheduled for this summer's program. There were five lectures given by invited Langley scientists and researchers. (See Appendix III).

Picnic

An annual picnic was held on Friday, June 12, 1992 for the Fellows, their families, and invited guests. This was a huge success. It allowed informal interaction between the Fellows, as well as with the administrative staff.

"Dutch" Luncheons

At the request of the Fellows, we again arranged for informal luncheons following the weekly lecture. Tables were reserved in the dining hall. The Fellows purchased their lunches and sat as a group which allowed for informal interactions between them and the administrative staff. This was a time of sharing research ideas with one another, and asking any questions of the staff that were of importance to them.

Unsolicited Proposals Workshop

An Unsolicited Proposals Workshop was held for the Fellows on Thursday, July 9, 1992. The Assistant University Affairs Officer, Robert L. Yang, presented an overview of the proper procedures to adhere to in submitting an unsolicited proposal to NASA. This was very well received by the Fellows.

Seminar/Banquet

On Wednesday, July 22, 1992, a seminar/banquet was held for the Fellows and their spouses. The banquet took place at the beautiful Langley Air Force Base Officer's Club. ASEE Certificates and group pictures were presented to each Fellow at the banquet.

Other Activities

Other activities included a tour of the 7' x 10' Wind Tunnel, the Robotics Laboratory, and the Landing Dynamics Facility; a tour of the Virginia Air & Space Museum; a moonlight cruise for the Fellows and their spouses; and a "Happy Birthday" cookout honoring the Fellows who had birthdays during the summer and perhaps were not able to be with their family or friends.

SECTION V

RESEARCH PARTICIPATION

The HU-LaRC 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 LaRC Research Associates with whom the Fellows worked, provide convincing evidence of the continued success of this part of the program. The Fellow's 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
1	Applied Aerodynamics Division
1	Analysis and Computation Division
1	Flight Applications Division
3	Flight Electronics Division
2	Facilities Engineering Division
3	Fluid Mechanics Division
1	Flight Management Division
2	Guidance and Control Division
2	Human Resources Division
3	Instrument Research Division
2	Information Systems Division
4	Materials Division
5	Structural Dynamics Division
1	Space Exploration Initiative Office
3	Structural Mechanics Division
3	Space Systems Division
1	Space Station Freedom Office

Thirty-three (87%) of the participants were holders of the doctorate degree. Five (13%) held masters degrees. The group was again highly diversified with respect to background. Areas in which the last degree was earned:

Number	Last Degree
1	Aeronautical Engineering
2	Aerospace Engineering

Number	Last Degree
1	Applied Mechanics
1	Chemical Physics
2	Civil Engineering
4	Computer Science
1	Education-Instructional Media
3	Electrical Engineering
1	Engineering Management
1	Engineering Mechanics
1	Industrial Engineering
1	Management
8	Mechanical Engineering
2	Operations Research
1	Organic Chemistry
1	Physical Chemistry
2	Physics
1	Psychology
2	Structural Engineering
1	Structural Mechanics
1	Theoretical Physics

Extensions

A portion of the funds remaining in the travel and relocation budget was used to grant extensions to eight Fellows in the program. To be considered for the extension, the Fellow submitted a statement of justification which was supported by the Research Associate. The requests were reviewed by the University Co-Director and the Assistant University Affairs Officer. The following individuals were granted a one week extension:

Dr. Fathi Finaish
Dr. Anthony Ghorieshi
Dr. Dave Sree
Dr. Omar Zia

Attendance at Short Courses, Seminars, and Conferences

During the course of the summer there were a number of short courses, seminars, and conferences, in which the subject matter had relevance to the 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:

Stephen Cha attended the AIAA 17th Aerospace Ground Testing Conference.

Fathi Finaish attended the 1992 ASHRAI Annual Meeting held in Baltimore, MD, June 27-July 7, 1992.

Anthony Ghorieshi attended a seminar on Experimental Stress Analysis Techniques for the Teaching Laboratory.

Mark Glauser attended the Joint AFOSR/ONR Grantees and Contractors Meeting on Turbulence Research held in Chicago, IL.

Steven Gray attended a seminar entitled "A Neural Approach to Space Vehicle Guidance". He participated in a short course entitled "Introduction to Neural Networks". He also had the opportunity to give the following seminars himself: "Input-Output Maps and Realization Theory, Part I: Fliess Functional Expansions in Continuous-Time", "Controllers for a Magnetic Suspension System" also by S. Mercurio, and "Input-Output Maps and Realization Theory, Part II: Fliess Functional Expansions in Discrete-Time".

Robert Hodson attended a Super Computing Workshop in San Diego, CA.

David Johnson attended a short course on Virtual Reality Environments-Demonstrations held at the University of North Carolina at Chapel Hill.

F. Bary Malik attended the XV International Workshop on Condensed Matter Theories held in Puerto Rico. He also gave an invited talk and chaired a session. He attended a workshop at CEBAF. He attended a seminar at the Virginia Commonwealth University on "Reaction Theories for All Seasons".

Denise Siegfeldt attended the Association of Management Conference in Las Vegas, Nevada.

S. Ballou Skinner attended two workshops: (1) Convolver for Real-Time Image and Signal Processing, and (2) Eastern NDT Instrumentation. He attended a seminar on "Thin Plastic Film Research" at Wallops Island.

William T. Smith attended the IEEE Symposium.

Srinivasan Sridharan attended an ONR Workshop on "Mechanics of Composites" held at the University of Maryland.

Omar Zia attended the American Control Conference held in Chicago, IL.

Papers Presented

"An Intelligent Decomposition Approach for Coupled Engineering Systems", MDO Conference (AIAA). Another to AIAA/AHS/ASME SDM Conference journal versions of each - Bloebaum, Christina L., Dr.

Abstract submitted for approval to the 34th Structures, Structural Dynamics and Materials Conference - Carpenter, William C., Dr.

"Holographic Interferometric Tomography for Reconstructing Flow Fields: A Review", Paper AIAA 92-3934, American Institute of Aeronautics and Astronautics, 1992 - Cha, S. Stephen, Dr.

"Spiral Fracture Patterns in Adhesives & Coatings", paper to be presented at Adhesion 1993 - Dillard, David A., Dr.

"Functional Expansions of Nonlinear Discrete-Time Input-Output Mappings", 1993 IEEE ACC and IEEE ICNN 1993 - Gray, W. S., Dr., D. I. Soloway, and O. Gonzalez.

"Damper Placement Problem for CSI-Phase 1 Evolutionary Model", submitted to the SDM Conference - Kincaid, Rex, Dr.

"Quantifying Parameters for Bayesian Prior Assumptions When Estimating the Probability of Failure of Software", IEEE Transactions on Software Engineering - Long, Jacquelyn E., Prof.

"Generalized Equation for Pairs", to be presented in part at XVI International Workshop on Condensed Matter Theories - Malik, F. Bary, Dr.

"Prediction of Thermal Cycling Induced Matrix Cracking", submitted to AIAA SDM Conference - McManus, Hugh, Dr., Bowles, and Tompkins.

"A Variational Method for Finite Element Stress Recovery and Error Estimation", to be submitted to the AIAA 34th Structures, Structural Dynamics, and Materials Conference - Riggs, H. Ron, Dr.

"Advanced NDE Research in Electromagnetics, Thermal, and Coherent Optics at Langley Research Center", to be presented at the Science Division Seminar, USC/Coastal Carolina College - Skinner, S. Ballou, Dr.

A presentation will be made to the IEEE Antenna and Propagation Society Conference - Smith, William T., Dr.

A presentation to Paul D. Camp College faculty on "Desktop Computing Integration" will be made - Tureman, Robert L., Prof.

Papers Presented (Continued)

"SSTO Configuration Selection and Vehicle Design" will be presented at the AIAA/AHS/ASEE Aerospace Design Conference in February, 1993 - Unal, Resit, Dr., D. O. Stanley, W. C. Engelund, and R. A. Lepsch.

"Navier-Stokes Calculation of Transonic Flow Past a 65°-Delta Wing at High Reynold's Number" planned to be submitted to the AIAA Applied Aerodynamics Conference - Wu, Chivey, Dr.

"On the Control Aspect of Laser Frequency Stabilization" was presented to the American Control Conference on June 23-26, 1992, in Chicago, IL - Zia, Omar, Dr.

Anticipated Papers

Although not a "publication", this summer's research will result in a comprehensive technical video presentation to be circulated NASA-wide and elsewhere. - Beam, Sherilee, Prof.

"Spiral Fracture Patterns in Adhesives & Coatings", Journal of Adhesion; "An Improved Technique for Tapping Cracks in Fracture Specimens Through an Eccentric Compressive Load", unknown journal; "Physical Aging Effects in LaRC-TPI", data not complete yet - Dillard, David A., Dr.

"Developing a Control System for ARES II", Journal of the American Helicopter Society - FitzSimons, Philip, Dr.

"Survey of Artificial Reality Environments", ACM; "Decision Aids for Project Management", Project Management Journal; "Bringing Virtual Reality into the Undergraduate Classroom", and "Virtual Reality as a Classroom and Learning Lab", Technology in Higher Education Journal - Johnson, David, Prof.

Papers to be submitted to the American Society for Quality Control or The Institute of Industrial Engineers - Masud, Abu, Dr.

"Diode Injection Seeded 940 nm $Ti:Al_2O_3$ Laser", NASA LaRC Report (FED), July 17, 1992 - Miller, George E., Dr.

"Parallel -Vector Computations with Bean-Plate-Shell Element Types for CSI Design Code", - Nguyen, Duc, Dr.

"Influence of Affect on a Dynamic Decision Making Task", Midwestern Psychology Association; "Individual Differences in Decision Making Behavior: The Effects of Framing", Human Factors Society - Nygren, Thomas E., Dr.

One untitled paper submitted to The Journal of Acoustics - Schreiber, Will, Dr.

Anticipated Papers (Continued)

"Total Quality Management: Strengths and Barriers to Implementation and Cultural Adaptation", to be submitted to the Human Resources Management Division at LaRC; "Total Quality Management at Langley Research Center", The Langley Researcher Newspaper, September, 1992 - Siegfeldt, Denise, Dr.

"Estimation of Turbulence Spectra from Laser Velocimetry Data: Effect of Non-Poison Samples", and "On Velocity Bias Corrections in Laser Velocimetry", agency to be submitted not determined yet - Sree, Dave, Dr.

"Postbuckling Response of Composite Stiffened Panels", and "Mode Interaction in Composite Stiffened Shells", AIAA Journal - Sridharan, Srinivasan, Dr.

Paper not yet titled to be done in conjunction with Prof. David Johnson and submitted to SIGCSE - Tureman, Robert, Prof.

Anticipated Research Proposals

A proposal will be submitted to NASA Langley Research Center, Interdisciplinary Research Office - Bloebaum, Christina, Dr.

A preliminary proposal has been submitted to NASA Langley Research Center, Interdisciplinary Research Office - Carpenter, William, Dr.

"Theoretical Basis for Design of Polymers for Use in High-Performance Applications" to be submitted to NASA Langley Research Center - Celarier, Edward A., Dr.

"Design and Development of an Advanced Control System for ARES II" will be submitted to NASA Langley Research Center - FitzSimons, Philip, Dr.

"Nonlinear and Neural Controllers for a Magnetic Suspension System" to be submitted to the National Science Foundation, Engineering Systems Division; "Nonlinear and Neural Controllers for a Magnetic Suspension Windtunnel" to be submitted to NASA Langley Research Center, Applied Aerodynamics Division - Gray, W. Steven, D. I. Soloway, and M. Kam.

"SODR Memory Buffer Control ASIC" to be submitted to NASA Langley Research Center - Hodson, Robert F., Dr.

"A Software InfraStructure for a Parallel Software Development Environment" to be submitted to NASA Langley Research Center - Jipping, Michael, Dr.

"Enhanced Human Interface for the Large Structures Assembly System" to be submitted to NASA Langley Research Center - Johnson, David W., Prof.

Anticipated Research Proposals (Continued)

"Discrete Optimization Techniques for Placing Passive Dampers on Large Flexible Truss Structures" to be submitted to NASA Langley Research Center, IRO/Structural Dynamics Division - Kincaid, Rex K., Dr.

A proposal will be submitted to Kansas Technology Enterprises (KTEC) - Masud, Abu S. M., Dr.

"Prediction of Thermal Cycling Induced Matrix Cracking", and "Matrix Cracking Induced by Isothermal Aging", to be submitted to NASA - McManus, Hugh, Dr.

"Cognitive and Affective Components of Mental Workload in a Flight Task" to be submitted to NASA Langley Research Center and to the Federal Aviation Administration (FAA) - Nygren, Thomas E.

"Improved Stress Recovery and Error Estimation in Finite Element Analysis" to be submitted to NASA Langley Research Center - Riggs, H. Ronald, Dr.

"Development of Techniques for Reliable Estimation of Turbulence Spectra and Turbulence Scales from Laser Velocimetry Data" to be submitted to NASA Langley Research Center, Experimental Methods Branch - Sree, Dave, Dr.

"Mode Interaction in Stiffened Shells Subject to Combined Mechanical and Thermal Loading" to be submitted to NASA Langley Research Center - Sridharan, Srinivasan, Dr.

"Multidisciplinary Design Optimization for Space Transportation Systems" to be submitted to NASA Langley Research Center, Space Systems Division - Unal, Resit, Dr.

"CFD Validation of Transonic Data at High Reynold's Number" submitted to NASA Langley Research Center - Wu, Chivey, Dr.

Funded Research Proposals

"A Modern Curriculum on the Control of Nonlinear Dynamical Systems", NASA Langley Research Center - Gray, W. Steven, Dr.

"Mode Interaction Analysis of Stiffened Composite Shells Using 'Locally Buckled' Shell Elements" - NASA Langley Research Center; "Buckling, Postbuckling, and Mode Interaction in Thick Stiffened Ring Stiffened Cylinders - ONR - Sridharan, Srinivasan, Dr.

"Mathematical Model of Lasers Used in NASA Experiments" - NASA Langley Research Center - Zia, Omar, Dr.

SECTION VI

SUMMARY OF PROGRAM EVALUATION

A program evaluation questionnaire was given to each Fellow and to each Research Associate involved with the program. A sample of each questionnaire is in Appendix X of this report. The questions and the results are given beginning on the next page.

A. Program Objectives

1. Are you thoroughly familiar with the research objectives of the research (laboratory) division you worked with this summer?

   Very much so __29__ (80%)
   Somewhat __6__ (17%)
   Minimally __0__
   Not at all __1__ (3%)

2. Do you feel that you were engaged in research of importance to your Center and to NASA?

   Very much so __32__ (89%)
   Somewhat __3__ (8%)
   Minimally __0__
   Not at all __1__ (3%)

3. Is it probable that you will have a continuing research relationship with the research (laboratory) division that you worked with this summer?

   Very much so __26__ (72%)
   Somewhat __8__ (22%)
   Minimally __2__ (6%)

4. My research colleague and I have discussed follow-up work including preparation of a proposal to support future studies at my home institution, or at a NASA laboratory.

   Yes __28__ (78%)   No __8__ (22%)

5. What is the level of your personal interest in maintaining a continuing research relationship with the research (laboratory) division that you worked with this summer?

   Very much so __35__ (97%)
   Somewhat __0__
   Minimally __0__
   None __1__

B. Personal Professional Development

1. To what extent do you think your research interests and capabilities have been affected by this summer's experience? You may check more than one.

   Reinvigorated ___18___ (50%)
   Redirected ___7___ (19%)
   Advanced ___23___ (64%)
   Just maintained ___3___ (8%)
   Unaffected ___1___ (1%)

2. How strongly would you recommend this program to your faculty colleagues as a favorable means of advancing their personal professional development as researchers and teachers.

   With enthusiasm ___25___ (69%)
   Positively ___12___ (33%)
   Without enthusiasm ___1___ (3%)
   Not at all ___0___

3. How will this experience affect your teaching in ways that will be valuable to your students? You may check more than one.

   By integrating new information into courses ___24___ (67%)

   By starting new courses ___7___ (19%)

   By sharing research experience ___31___ (86%)

   By revealing opportunities for future employment in government agencies ___15___ (42%)

   By deepening your own grasp and enthusiasm ___9___ (25%)

   Will affect my teaching little, if at all ___2___ (6%)

4. Do you have reason to believe that those in your institution who make decisions on promotion and tenure will give you credit for selection and participation in this highly competitive national program?

   Yes ___23___ (64%) No ___11___ (31%)

C. Administration

1. How did you learn about the Program? (Please check appropriate response.)

   18 (50%) Received announcement in the mail
   3 (8%) Read about in a professional publication
   13 (36%) Heard about it from a colleague
   4 (11%) Other (explain 1. Past participant; 2. At a meeting where HESB presented a paper; 3. Don't recall.

2. Did you also apply to other summer faculty programs?

   Yes 13 (36%) No 22 (61%)

   0 (0%) DOE
   3 (8%) Another NASA Center
   4 (11%) Air Force
   3 (8%) Army
   7 (19%) Navy

3. Did you receive an additional offer of appointment from one or more of the above? If so, please indicate from which.

   Yes 26 (72%) No 4 (11%)

   Air Force; NASA Jove Program; Nave

4. Did you develop new areas of research interest as a result of your interaction with your Center and laboratory colleagues?

   Many 8 (22%)
   A few 27 (75%)
   None 1 (3%)

5. Would the amount of the stipend ($1,000 per week) be a factor in your returning as an ASEE Fellow next summer?

Yes __18__ (50%) No __18__ (50%)

If not, why?

Would expect same level of funding; adequate; research is the primary goal; not competitive with senior researcher salary; desire to become familiar with current research & technologies in areas of interest; won't be applying; in Jove Program; pay comparable to current 9 month salary; not enough money; a bit low, but I don't mind; money not only reason for program; state-of-the-art research & learning new information are the reasons for returning, not money!; current stipend is satisfactory; the experience gained is invaluable; the important thing in my decision is the capability of doing research.

6. Did you receive any informal or formal instructions about submission of research proposals to continue your research at your home institution?

Yes __29__ (80%) No __7*__ (20%)

*An unsolicited proposal seminar was conducted, but several Fellows were not able to attend.

7. Was the housing and programmatic information supplied prior to the start of this summer's program adequate for your needs?

Yes __31__ (86%) No __1__ (3%) N/A __4__ (11%)

8. Was the contact with your research colleague prior to the start of the program adequate?

Yes __32__ (89%) No __4__ (11%)

9. How do you rate the seminar program?

Excellent	11	(30%)
Very good	15	(42%)
Good	10	(28%)
Fair	0	
Poor	0	

10. In terms of the activities that were related to your research assignment, how would you describe them on the following scale? Check one per activity.

	Time Was			
Activity	Adequate	Too Brief	Excessive	Ideal
Research	16	12	0	8
Lectures	22	2	3	7
Tours	27	1	0	8
Social/Recreational	24	3	0	9
Meetings	23	2	1	8

11. What is your overall evaluation of the program?

Excellent	19	(53%)
Very good	15	(42%)
Good	1	(3%)
Fair	0	
Poor	1	(3%)

12. If you can, please identify one or two significant steps to improve the program.

See Fellow's Comments and Recommendations

13. For second-year Fellows only. Please use this space for suggestions to improve the second year.

See Fellow's Comments and Recommendations

D. Stipend

1. To assist us in planning for appropriate stipends in the future, would you indicate your salary at your home institution.

   Academic Year __34__ (94%) Full Year __2__ (6%)

   SALARY MEDIAN WAS: $46,696.00 Basing all on academic year

2. Is the amount of the stipend the primary motivator to your participation in the ASEE Summer Faculty Fellowship Program?

   Yes __1__ (3%) No __21__ (58%) In part __14__ (39%)

3. What, in your opinion, is an adequate stipend for the ten week program during the summer of 1993?

   $10K-14 (39%); $11K-4 (11%); $12K-6 (17%); $12.5K-1 (3%); $13K-2 (6%); $14K-1 (3%); Others-8 (22%); base on rank; pro-rate based on academic year with a floor of $11K

E. American Society for Engineering Education (ASEE) Membership Information

1. Are you currently a member of the American Society for Engineering Education?

   Yes __12__ (33%) No __24__ (67%)

2. Would you like to receive information pertaining to membership in the ASEE?

   Yes __15__ (42%) No __21__ (58%)

Percentages have been rounded off to the next whole number.

Percentage figures are based on the number of responses to the specific question.

Eighty-nine percent of the Fellows believed their research was of importance to LaRC and NASA.

Ninety-seven percent of the Fellows had a personal interest in maintaining a continuing research relationship with the division they worked in this summer. Seventy-eight percent have already discussed follow-up work with their colleague, many to include the preparation of a proposal to support future studies at their home institution or at NASA.

Sixty-four percent of the Fellows felt their research interests and capabilities have been advanced by their summer experience. Fifty percent have been reinvigorated while nineteen percent were redirected.

Sixty-nine percent of the Fellows would recommend the ASEE Program to their faculty colleagues with enthusiasm and another thirty-three percent would recommend it positively.

Fifty percent of the respondents said the stipend amount would be a factor in whether or not they would return as an ASEE Fellow next summer; however, fifty-eight percent said the stipend would not be the **primary** motivator.

Thirty-nine percent of the Fellows indicated a stipend of $10,000 as satisfactory, while twenty-two percent stated that the stipend should be rank dependent based on the academic status ranging from $10,000 for assistant professors to $18,000 for full professors.

Sixty-seven percent of the Fellows indicated they are not members of the American Society for Engineering Education.

Fellow's Comments

This program is great. It helped me a great deal in keeping up my research work and in developing professional growth. I would like to come back next year also. Much of the Orientation Meeting is a waste of time. Thanks to all concerned who worked hard to keep the program going efficiently. Excellent Program and people directing it. I think both the participants and NASA benefit a great deal. Keep it going as it is. I have great admiration for the staff of the ASEE office because they made me feel at home, and they did their utmost to make our stay pleasant and useful. The staff's very pleasant manners, organizing the picnic and other social gatherings were excellent. My special thanks to Dr. Tiwari, Prof. Spencer, Debbie Young, Mary Fagley, and Myra

Green. GREAT PROGRAM! Thank you for the opportunity. Excellent Director and staff. Thanks for letting me start early, otherwise, I would not have been able to participate. Only complaint is housing is too expensive. Once again, I am very favorably impressed with the administration of the program. Bob Yang's Unsolicited Proposal Workshop was top-notch. The University Affairs Office is an excellent asset for NASA and academia. I enjoyed my research here at NASA LaRC this summer and truly appreciated the opportunity to participate in the ASEE Program. I feel significant progress was made deepening a research-based relationship with NASA LaRC and my university. My overall assessment of the program is excellent. I can think of no better way for a young faculty member to integrate into the research community than through such a program. NASA and its university sponsors have created an ideal summer research program. It would help if somehow it would work out that the stipend is not taxable because this way it would help narrow the financial loss of attending here in the summer. I would like to express my appreciation for the wonderful job the director and staff performed. The staff certainly made the ASEE Program at NASA LaRC a rewarding and enjoyable experience.

Fellow's Recommendations

Seminars and tours just for ASEE, not with LARSS. More constructive advising on grant writing and submission. Increase relocation allowance to $2,000. Equipment not available for experimental work, either advise Fellow of this or plan better to provide ahead of time. Remove restriction of a 2 year limit. Locate more 10 week leases for housing. Make proposal workshop more focused. Have the proposal workshop earlier in the summer. Have more exposure through one on one meetings with other groups within NASA with similar research interests. Educate Associates regarding Fellows' needs for the research program. Allow the Fellows to work with talented students. Provide use of the center during the regular school term. Separate lectures for ASEE and LARSS. Provide better map of the region. Division directors should take more interest. Provide adequate library facilities, office space, secretarial facilities, etc. Provide better library hours, holdings, circulation plan, shelf access, and provide immediate access to duplicate articles for summer Fellows so hours are not wasted. NASA and ASEE should consider basing the summer stipend on the Fellow's positions. "Make sure the Fellow is placed correctly in interest area and not politically manoeuvered around due to in-house fighting amongst branch chiefs. There is too much in-house fighting and complaining. It leaves a poor image of this place. People here should know why they do what they do." Increase the stipend. More social and professional contact with other Fellows would be nice. Allow Fellows to start early if possible. ASEE should try to provide travel funds for presenting papers as a result of the summer research. Provide Research Associates with more program information. Research proposals should have more emphasis and time. Get rid of the Orientation. No suggestions - the program is excellent! Update the research topics list sent to prospective participants. Provide a list of Fellows' names, affiliations, and areas of interest early in the program. There should be public recognition of the Associates, possibly include them in the banquet/seminar. Brief **all** NASA Associates that grant proposals are an important objective of the program and should be actively encouraged and facilitated. Earmark a pool of money in the upcoming budget for ASEE proposals. Fund follow-up site visits. Provide a welcome fund for PhD dissertations and help build a network of people and other resources. Provide more flexibility with the start/end of tenure. Cover travel expenses completely, especially for those who come a very long distance. Give the opportunity to apply for an additional week extension **before** the program starts. Great Program - no recommendations - leave it as it is, both the people and the program!

SUMMARY OF ASSOCIATES' EVALUATION

The following comments and recommendations were taken from the questionnaire distributed to the ASEE Associates requesting them to evaluate the overall performance of their ASEE Fellow. Most all of the Associates responding indicated an overwhelming satisfaction with the Fellow's knowledge of their subject, diligence, interest in assignment, and enthusiasm.

Research Associates' Comments

A hard working professional - used time effectively and productively.

Accomplished more than the established goals.

This program is useful to Langley because it exposes our researchers to new people and ideas. I would be happy to serve as a Research Associate in the future.

I found it to be an interesting and enlightening experience.

This program has always been valuable to our organization.

The program will improve as the individual research organizations attract the "best" from academia.

Research Associates' Recommendations

A number of the Associates indicated the program is great as it is - no areas need significant improvement.

Others indicated the following:

Please give two weeks notice as to the exact start of the fellowship program.

This program would benefit from an additional link - that to industry, to accelerate the U. S. competitiveness.

Expedite costing of suballotments to NASA Headquarters for purchased ASEE slots.

More orientation for new Associates.

Have Fellows submit proposals for work to be done. Increase communication between Fellow and LaRC Associate prior to arrival.

Extend the length of the program.

Fellows should be invited because (1) they are experts in a field which branch members need to learn more about, (2) they proposed a new solution to some existing problem, or (3) they have previous connection to the branch. Ten weeks is too short a time if the Fellow arrives with no idea of what should be accomplished.

SECTION VII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Comments from the Research Fellows and the Research Associates indicates a continued high level of satisfaction with the program. The Fellows feel that the research is important to them in terms of professional growth and important to the Center and NASA. The Associates indicated the importance of the research to the Center and 97% of the Associates responding stated they were very interested in serving as a Research Associate again in the future.

Eight percent of the Fellows responding stated they were thoroughly familiar with the research objectives of their research division. This is a great improvement over 1991 (71%) and 1990 (64%). The information circulated prior to the start of the program and communication between the Fellow and Research Associate is probably responsible for this gain.

The probability of continued research relationships is up to 72% from 67% in 1992. The percentage of Research Fellows who discussed follow-up work and submittal of proposals for future research was at 78%. This is up from 71% in 1991 and 69% in 1990.

Personal interest on the part of the Research Fellow in maintaining a continuing research relationship with their research division was at 97%. This is up from 91% in 1991 and 85% in 1990.

Statements from the Fellows indicate that the amount of the stipend is not the important factor when deciding to participate in the program.

Although the contact with the Research Associate prior to the start of the program was considered to be adequate, an improved time of communications can be pursued.

Although the majority of the responses from the Research Fellows and the Research Associates were positive, there is a continuing strain throughout:

(1) Communications between the Fellow and Associate prior to the visit

(2) More communications with the Research Associate regarding the nature of the program

(3) The ten week time line sometimes proves to be too short

Conclusions (Continued)

(4) Allow greater flexibility in the start and end dates of the program for the Fellows

While there are many small frustrating items, the kind that go with any large complicated operation, it can be stated that the overall indication from the Research Fellows and the Research Associates is that the program is highly successful and certainly achieves the objectives of the program as stated by NASA and ASEE.

Recommendations

Continue to urge increased contact between the Research Associate and the Research Fellow prior to arrival.

Encourage the Research Fellow to contact the Research Associate for information.

Urge greater communication between the Research Associate and Research Fellow during the ten week research period. Broaden the communications base to include other persons and activities with the Division.

Establish work area and office equipment prior to the arrival of the Research Fellow.

Arrange for required computer access by the Research Fellow.

APPENDIX 1

PARTICIPANTS - ASEE/NASA LANGLEY

SUMMER FACULTY RESEARCH PROGRAM

RETURNEES

1992 NASA-ASEE-HU FELLOWS RETURNEES

FELLOW	DIVISION	RESEARCH ASSOCIATE
Ms. Sherilee Beam Assistant Professor Education-Instructional Media Hampton University Hampton, VA 23669	Analysis & Computation Division	Mr. Bill von Ofenheim Building 1268 Mail Stop 125A Tel. 864-6712
Dr. William C. Carpenter Professor Civil Engineering University of South Florida Tampa, FL 33620	Structural Dynamics Division	Dr. Jean Francois Barthelemy Building 1229 Mail Stop 246 Tel. 864-2809
Dr. Edward A. Celarier Assistant Professor Chemical Physics Hampton University Hampton, VA 23669	Materials Division	Dr. Jeffrey A. Hinkley Building 1293A Mail Stop 226 Tel. 864-4259
Mr. Milton W. Ferguson Assistant Professor Physics Norfolk State University Norfolk, VA 23504	Instrument Research Division	Dr. Min Namkung Building 1230B Mail Stop 231 Tel. 864-4962
Dr. Mark N. Glauser Assistant Professor Mechanical Engineering Clarkson University Potsdam, NY 13699	Fluid Mechanics Division	Dr. Thomas B. Gatski Building 1192D Mail Stop 156 Tel. 864-5552

FELLOW	DIVISION	RESEARCH ASSOCIATE
Mr. David Johnson Professor Operations Research-Information System St. Paul's College Lawrenceville, VA 23868	Facilities Engineering Division	Mr. Robert D. Feldhousen Building 1209T-8 Mail Stop 445 Tel. 864-7288
Dr. Abu S. M. Masud Associate Professor Industrial Engineering Wichita State University Wichita, KS 67208-1595	Space Exploration Initiative Office	Mr. Edwin B. Dean Building 1237T Mail Stop 253 Tel. 864-8200
Dr. Duc T. Nguyen Associate Professor Structural Engineering Old Dominion University Norfolk, VA 23529	Guidance and Control Division	Mr. Joseph E. Walz Building 1293B Mail Stop 230 Tel. 864-4053
Dr. Thomas E. Nygren Associate Professor Psychology (Quantitative) Ohio State University Columbus, OH 43210	Flight Management Division	Dr. Alan T. Pope Building 1168 Mail Stop 152E Tel. 864-6642
Dr. William T. Smith Assistant Professor Electrical Engineering University of Kentucky Lexington, KY 40506-0046	Guidance and Control Division	Dr. M. C. Bailey Building 1299 Mail Stop 490 Tel. 864-1802
Dr. Naushadalli K. Suleman Assistant Professor Organic Chemistry Hampton University Hampton, VA 23668	Materials Division	Dr. Sheila T. Long Building 1293A Mail Stop 229 Tel. 864-4250

FELLOW	DIVISION	RESEARCH ASSOCIATE
Dr. Resit Unal Assistant Professor Engineering Management Old Dominion University Norfolk, VA 23529	Space Systems Division	Mr. Douglas O. Stanley Building 1224T-9 Mail Stop 365 Tel. 864-4518
Dr. Chivey Wu Associate Professor Mechanical Engineering California State University, LA Los Angles, CA 90032	Applied Aerodynamics Division	Mr. Lawrence E. Putnam Building 1236 Mail Stop 267 Tel. 864-5115
Dr. Omar Zia Associate Professor Electrical Engineering California Polytech State University San Luis Obispo, CA 93407	Flight Electronics Division	Dr. Stephen P. Sandford Building 1299 Mail Stop 488 Tel. 864-1836

APPENDIX II

PARTICIPANTS - ASEE/NASA LANGLEY SUMMER FACULTY RESEARCH PROGRAM

FIRST YEAR

1992 NASA-ASEE-HU FELLOWS
FIRST YEAR

FELLOW	DIVISION	RESEARCH ASSOCIATE
Dr. Christina L. Bloebaum Assistant Professor Aerospace Engineering State University of New York-Buffalo Buffalo, NY 14260	Structural Dynamics Division	Dr. Jaroslaw Sobieski Building 1229 Mail Stop 246 Tel. 864-2802
Dr. Soyoung S. Cha Associate Professor Mechanical Engineering University of Illinois-Chicago Chicago, IL 60680	Instrument Research Division	Mr. Alpheus W. Burner Building 1230 Mail Stop 236 Tel. 864-4613
Dr. David A. Dillard Associate Professor Engineering Mechanics Virginia Polytechnic Institute & State Univ. Blacksburg, VA 24061	Materials Division	Dr. Terry L. St. Clair Building 1293A Mail Stop 226 Tel. 864-4273
Dr. Fathi A. Finaish Assistant Professor Aerospace Engineering University of Missouri-Rolla Rolla, MO 65401	Structural Dynamics Division	Dr. Robert M. Bennett Building 1192E Mail Stop 173 Tel. 864-2274
Dr. Philip M. FitzSimons Assistant Professor Mechanical Engineering Michigan State University East Lansing, MI 48824-1226	Structural Dynamics Division	Mr. William T. Yeager Building 648 Mail Stop 340 Tel. 864-1271

FELLOW	DIVISION	RESEARCH ASSOCIATE
Dr. Anthony Ghorieshi Associate Professor Applied Mechanics Wilkes University Wilkes-Barre, PA 18702	Facilities Engineering Division	Mr. Warren C. Kelliher Building 1271 Mail Stop 416A Tel. 864-4172
Dr. William S. Gray Assistant Professor Electrical Engineering Drexel University Philadelphia, PA 19104-2884	Information Systems Division	Ms. Pamela J. Haley Building 1202 Mail Stop 478 Tel. 864-1705
Dr. Robert F. Hodson Assistant Professor Computer Science Christopher Newport College Newport News, VA 23606	Flight Electronics Division	Mr. Steve G. Jurczyk Building 1299 Mail Stop 488 Tel. 864-1865
Dr. Michael J. Jipping Assistant Professor Computer Science Hope College Holland, MI 49423	Information Systems Division	Dr. Dave E. Eckhardt Building 1202 Mail Stop 478 Tel. 864-1698
Dr. Rex Kincaid Associate Professor Operations Research College of William & Mary Williamsburg, VA 23187	Structural Dynamics Division	Ms. Sharon L. Padula Building 1229 Mail Stop 246 Tel. 864-2807
Ms. Jacquelyn E. Long Assistant Professor Computer Science Norfolk State University Norfolk, VA 23504	Space Station Freedom Office	Ms. Susan J. Voigt Building 1244 Mail Stop 288 Tel. 864-1711

FELLOW	DIVISION	RESEARCH ASSOCIATE
Dr. Fazley B. Malik Professor Theoretical Physics S. Illinois University, Carbondale Carbondale, IL 62901-4401	Space Systems Division	Dr. Lawrence W. Townsend Building 1200 Mail Stop 493 Tel. 864-1417
Dr. Hugh L. McManus Assistant Professor Mechanical Engineering Massachusetts Institute of Technology Cambridge, MA 02139	Materials Division	Dr. David E. Bowles Building 1205 Mail Stop 191 Tel. 864-3095
Dr. George E. Miller Associate Professor Physical Chemistry Norfolk State University Norfolk, VA 23504	Flight Electronics Division	Mr. James C. Barnes Building 1202 Mail Stop 474 Tel. 864-1637
Dr. Cyrus Ostowari Associate Professor Aeronautical Engineering Texas A&M University College Station, TX 77843-3141	Flight Applications Division	Dr. Stanley J. Miley Building 1244A Mail Stop 261 Tel. 864-1969
Dr. H. Ronald Riggs Associate Professor Structural Engineering University of Hawaii Honolulu, HI 96822	Structural Mechanics Division	Dr. Alexander Tessler Building 1229 Mail Stop 240 Tel. 864-3178
Dr. Willard C. Schreiber Associate Professor Mechanical Engineering University of Alabama Tuscaloosa, AL 35487-0276	Space Systems Division	Dr. Willard E. Meador Building 1200 Mail Stop 493 Tel. 864-1434

FELLOW	DIVISION	RESEARCH ASSOCIATE
Dr. Gregory V. Selby Associate Professor Mechanical & Aerospace Engineering Old Dominion University Norfolk, VA 23529-0247	Fluid Mechanics Division	Dr. Stephen K. Robinson Building 1247A Mail Stop 163 Tel. 864-5541
Dr. Denise V. Siegfeldt Assistant Professor Management Troy State University-Naval Base Norfolk, VA 23511-5500	Human Resources Management Division	Dr. Michael Glenn Building 1195C Mail Stop 309 Tel. 864-8555
Dr. Ballou S. Skinner Professor Physics Univ. of South Carolina Conway, SC 29526	Instrument Research Division	Dr. Joseph S. Heyman Building 1230B Mail Stop 231 Tel. 864-4970
Dr. Nahil A. Sobh Assistant Professor Civil Engeering & Applied Mathematics Old Dominion University Norfolk, VA 23529	Structural Mechanics Division	Dr. Damodar R. Ambur Building 1148 Mail Stop 190 Tel. 864-3174
Dr. Dave Sree Assistant Professor Mechanical Engineering Tuskegee University Tuskegee, AL 36088	Fluid Mechanics Division	Mr. Scott O. Kjelgaard Building 1247A Mail Stop 170 Tel. 864-2224
Dr. Srinivasan Sridharan Professor Structural Mechanics Washington University St. Louis, MO 63130	Structural Mechanics Division	Dr. James H. Starnes Building 1148 Mail Stop 190 Tel. 864-3168

FELLOW	DIVISION	RESEARCH ASSOCIATE
Mr. Robert L. Tureman Assistant Professor Computer Science Paul D. Camp Comm. Coll. Suffolk, VA 23434	Human Resources Management Division	Dr. James F. Meyers Building 1195C Mail Stop 120 Tel. 864-2555

APPENDIX III

LECTURE SERIES

PRESENTATIONS BY RESEARCH FELLOWS

1992

NASA/ASEE Summer Faculty Fellowship Program
and Langley Aerospace Research Summer Scholars Program

TECHNICAL LECTURE SERIES
Location: Activities Center Auditorium, Bldg. 1222
Time: 10:00 a.m. - 11:00 a.m. - Lecture
11:00 a.m. - 11:15 a.m. - Questions and Answers

DATE	TOPIC	SPEAKER
June 9	High-Performance Computing and Communications	Dr. Thomas Zang Fluid Mechanics Division Aeronautics Directorate
June 16	NDE Measurement Science: Looking With New Eyes	Dr. Joseph Heyman Instrument Research Division Electronics Directorate
June 23	Global Change: Atmospheric and Climatic	Dr. Joel Levine Atmospheric Sciences Division Space Directorate
June 30	Sonic Boom Research	Mr. W. L. Willshire Acoustics Division Structures Directorate
July 7	Wind Shear Research	Dr. Roland Bowles Wind Shear Program Office Flight Systems Directorate

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM
LANGLEY RESEARCH CENTER
SCHEDULE OF FINAL PRESENTATIONS BY SUMMER FACULTY FELLOWS

H.J.E. Reid Conference Center, Bldg. 1222

Wednesday, August 5, 1992

8 a.m. - 4:30 p.m.

TIME	NAME/DIVISION UNIVERSITY	TOPIC
8:00	Welcome	Assistant University Affairs Officer and ASEE Co-Director
8:15	Dr. Chivey Wu/AAD California State University, LA	Calculation of Transonic Flow Past a Delta Wing
8:45	Dr. Robert Hodson/FED Christopher Newport University	Spacecraft Optical Disk Recorder (SODR) Memory Buffer Control
9:15	Dr. Thomas Nygren/FltMD Ohio State University	Cognitive and Affective Components of Mental Workload: Understanding the Effects of Each on Human Decision Making Behavior
9:45	Dr. Resit Unal/SSD Old Dominion University	Multi-Disciplinary Design Optimization Using Response Surface Methods
10:15	Dr. Hugh McManus/MD Massachusetts Institute of Tech.	Prediction of Thermal Cycling Induced Matrix Cracking
10:45	Mr. David Johnson/FEngD St. Paul's College	Virtual Reality Systems
11:15	Dr. Robert Tureman/Hum Res Paul D. Camp Community College	Desktop Computing Integration Project
11:45	LUNCH	

7/30/92

TIME	NAME/DIVISION UNIVERSITY	TOPIC
1:00	Mr. Milton Ferguson/IRD Norfolk State University	Fatigue Damage Study in Al(2024-T3)
1:30	Dr. Abu Masud/SEIO Wichita State University	Fuzzy Set Approach to Quality Function Deployment: An Investigation
2:00	Dr. Fathi Finaish/SDyD University of Missouri, Rolla	Preliminary Efforts Toward Development of Data Handling and Analysis Software for Unsteady Flow Measurements
2:30	Dr. Mark Glauser/FldMD Clarkson University	Structure Based Turbulence Modeling
3:00	Dr. W. Stephen Gray/ISD Drexel University	Functional Expansion Representations of Artificial Neural Networks
3:30	Dr. William Smith/GCD University of Kentucky	Antenna Analysis Using Neural Networks
4:00	Closing Remarks	ASEE Co-Director, John H. Spencer

APPENDIX IV

GROUP PICTURE OF RESEARCH FELLOWS

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

1992 NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM
List of Attendees

Back Row: Left to Right

Dr. William C. Carpenter, Dr. Naushadalli K. Suleman, Dr. Thomas Wangler, Dr. Edward A. Celarier, Dr. George E. Miller, III, Dr. Milton W. Ferguson, Dr. F. Bary Malik, Dr. Thomas E. Nygren, Dr. Denise V. Siegfeldt, Dr. Chivey C. Wu, Dr. H. Ron Riggs, Dr. Hugh L. McManus.

Middle Row: Left to Right

Prof. John H. Spencer (ASEE Co-Director), Prof. Jacquelyn E. Long, Prof. Robert L. Tureman, Dr. S. Ballou Skinner, Dr. Omar Zia, Dr. Christina L. Bloebaum, Prof. David W. Johnson, Dr. Fathi A. Finaish, Dr. Philip M. FitzSimons, Dr. Gregory V. Selby.

Front Row: Dr. Resit Unal, Dr. Anthony Ghorieshi, Dr. Abu S. M. Masud, Dr. Cyrus Ostowari, Dr. Robert F. Hodson, Prof. Sherilee F. Beam, Dr. Dave Sree, Dr. W. Steven Gray, Dr. Rex K. Kincaid, Ms. Debbie Young (ASEE Admin. Asst.).

Kneeling: Left to Right

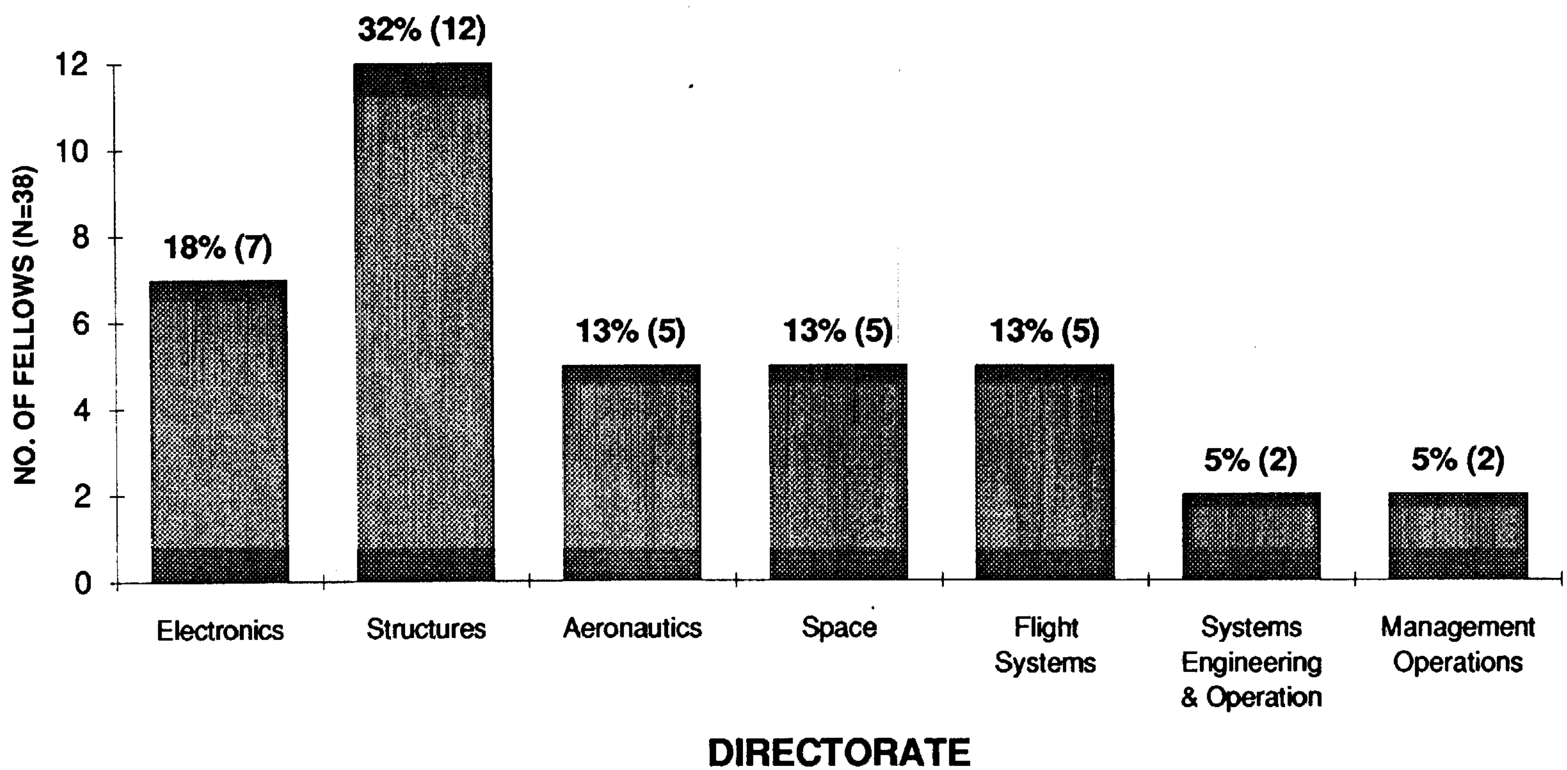
Dr. David A. Dillard, Dr. William T. Smith, Dr. Willard C. Schreiber.

Not Pictured:
Dr. S. Stephen Cha, Dr. Mark N. Glauser, Dr. Michael Jipping, Dr. Duc Nguyen, Dr. Nahil Sobh, Dr. Srinivasan Sridharan.

APPENDIX V

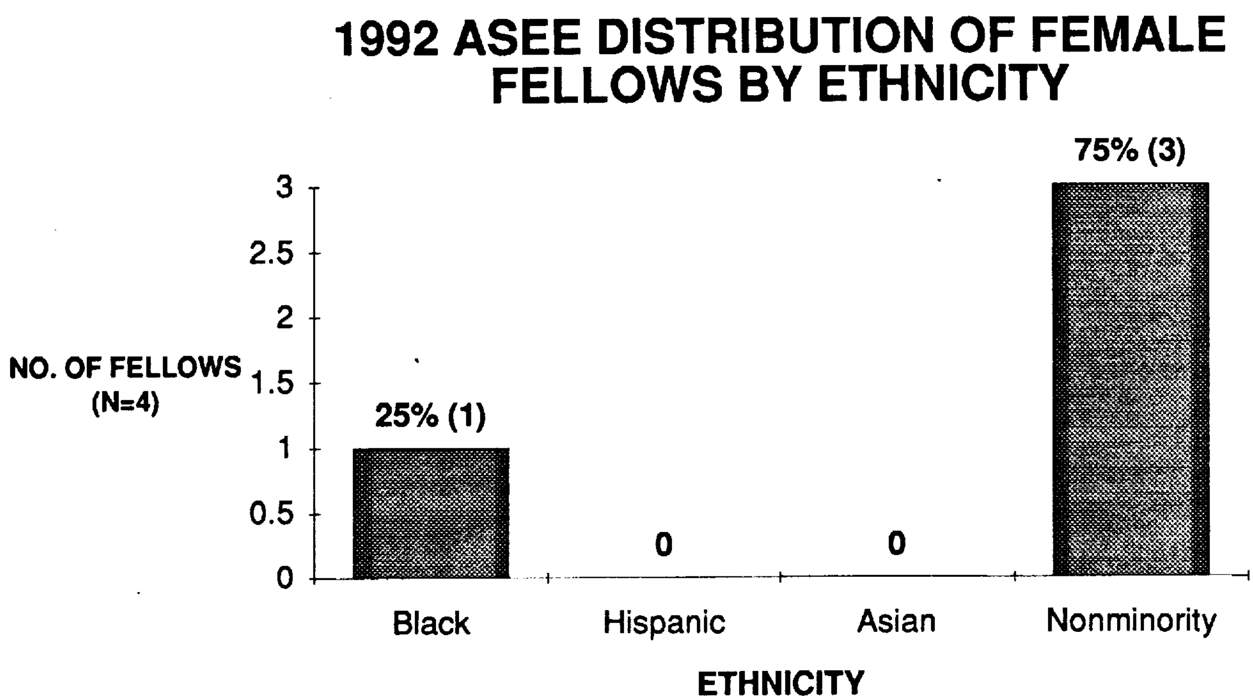
DISTRIBUTION OF FELLOWS BY DIRECTORATE

1992 ASEE DISTRIBUTION OF FELLOWS BY DIRECTORATE



APPENDIX VI

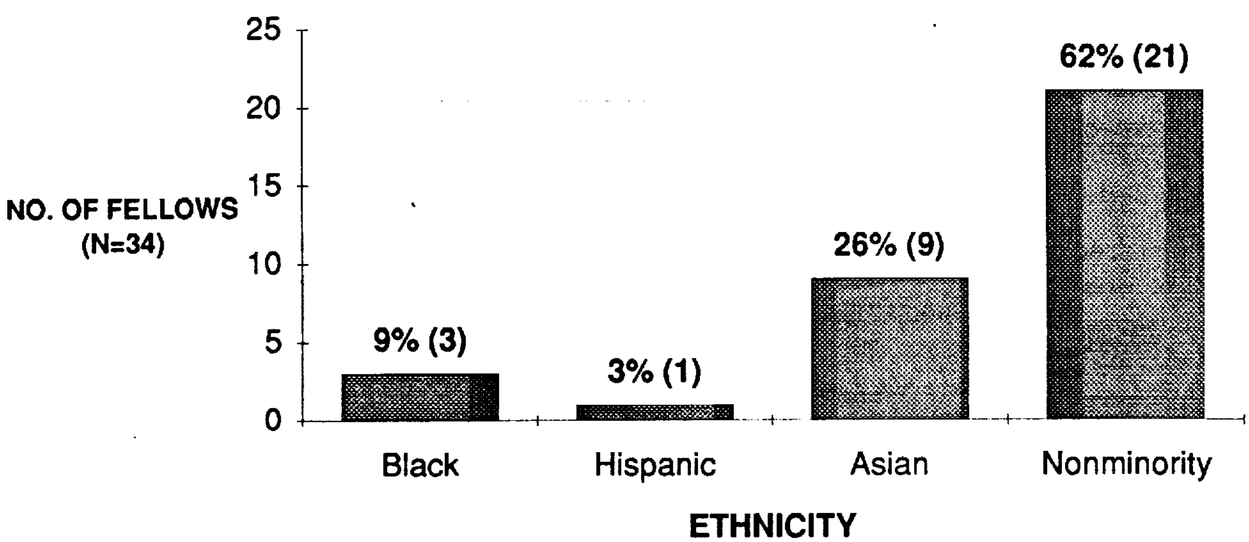
DISTRIBUTION OF FELLOWS BY ETHNICITY/FEMALE


1992 ASEE DISTRIBUTION OF FEMALE FELLOWS BY ETHNICITY
NO. OF FELLOWS (N=4)
3
2.5
2
1.5
1
0.5
0
25% (1)
0
0
75% (3)
Black
Hispanic
Asian
Nonminority
ETHNICITY

APPENDIX VII

DISTRIBUTION OF FELLOWS BY ETHNICITY/MALE

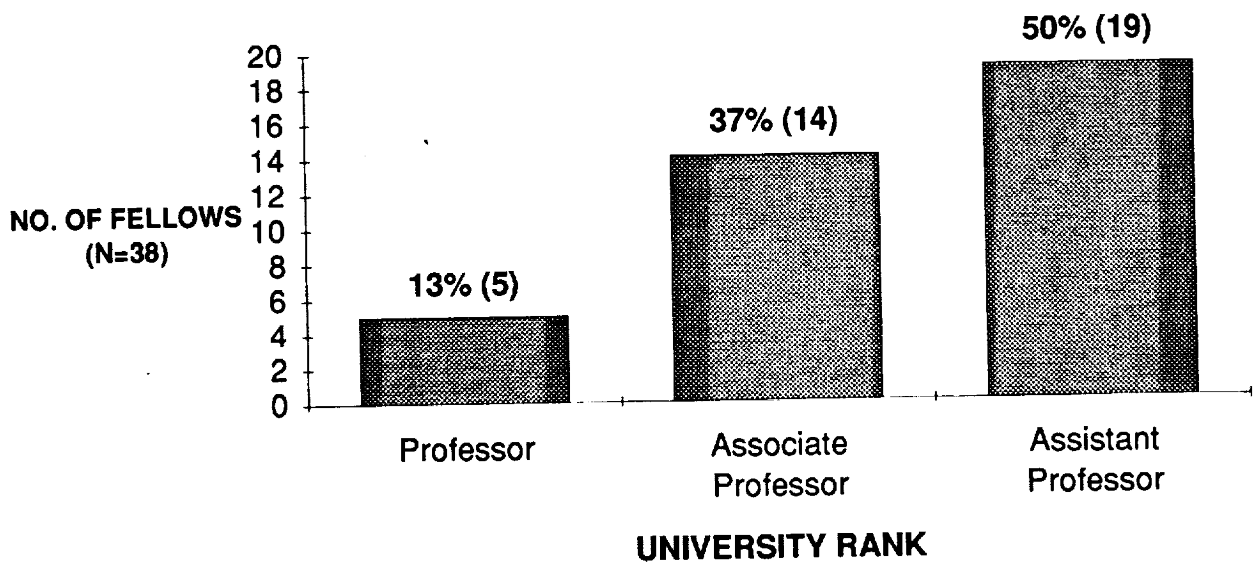
1992 ASEE DISTRIBUTION OF MALE FELLOWS BY ETHNICITY



APPENDIX VIII

DISTRIBUTION OF FELLOWS BY UNIVERSITY RANK

1992 ASEE DISTRIBUTION OF FELLOWS BY UNIVERSITY RANK



APPENDIX IX

DISTRIBUTION OF FELLOWS BY UNIVERSITY

1992 ASEE SUMMER FACULTY FELLOWSHIP PROGRAM
INSTITUTION PARTICIPATION

University/College	No. of Fellows
California Polytechnic State University	1
California State University-LA	1
Christopher Newport University	1
Clarkson University	1
College of William & Mary	1
Drexel University	1
Hampton University	3
Massachusetts Institute of Technology	1
Michigan State University	1
Norfolk State University	3
Ohio State University	1
Old Dominion University	4
Paul D. Camp Community College	1
Southern Illinois University-Carbondale	1
St. Paul's College	1
State University of New York-Buffalo	1
Texas A&M University	1
Troy State University-Naval Base	1
Tuskegee University	2
University of Missouri-Rolla	1
University of South Carolina	1
University of South Florida	1
University of Alabama	1
University of Hawaii	1
University of Illinois-Chicago	1
University of Kentucky	1
Virginia Polytechnic Institute & State University	1
Washington University	1
Wichita State University	1
Wilkes University	1
TOTAL NUMBER OF FELLOWS	**38**
TOTAL NUMBER OF INSTITUTIONS REPRESENTED	**30**

APPENDIX X

SAMPLE QUESTIONNAIRES

American Society for Engineering Education

NASA/ASEE Summer Faculty Fellowship Program
Evaluation Questionnaire

(Faculty Fellows are asked to respond to the following questions)

Name: ______________________________

Birthdate: ______________________________

Social Security Number: ______________________________

Permanent Mailing Address: ______________________________

____

____

____

Home Institution: ______________________________

NASA Center and (Laboratory) Division: ______________________________

Name of Research Associate: ______________________________

Brief Descriptive Title of Research Topic: ______________________________

A. Program Objectives

1. Are you thoroughly familiar with the research objectives of the research (laboratory) division you worked with this summer?

   Very much so ______
   Somewhat ______
   Minimally ______

2. Do you feel that you were engaged in research of importance to your Center and to NASA?

   Very much so ______
   Somewhat ______
   Minimally ______

3. Is it probable that you will have a continuing research relationship with the research (laboratory) division that you worked with is summer?

   Very much so ______
   Somewhat ______
   Minimally ______

4. My research colleague and I have discussed follow-up work including preparation of a proposal to support future studies at my home institution, or at a NASA laboratory.

   Yes ____ No ____

5. What is the level of your personal interest in maintaining a continuing research relationship with the research (laboratory) division that you worked with this summer?

   Very much so ______
   Somewhat ______
   Minimally ______

B. Personal Professional Development

1. To what extent do you think your research interests and capabilities have been affected by this summer's experience? You may check more than one.

   Reinvigorated _____
   Redirected _____
   Advanced _____
   Just maintained _____
   Unaffected _____

2. How strongly would you recommend this program to your faculty colleagues as a favorable means of advancing their personal professional development as researchers and teachers.

   With enthusiasm _____
   Positively _____
   Without enthusiasm _____
   Not at all _____

3. How will this experience affect your teaching in ways that will be valuable to your students? (you may check more than one)

   By integrating new information into courses _____
   By starting new courses _____
   By sharing research experience _____
   By revealing opportunities for future employment in government agencies _____
   By depending your own grasp and enthusiasm _____
   Will affect my teaching little, if at all _____

4. Do you have reason to believe that those in your institution who make decisions on promotion and tenure will give you credit for selection and participation in this highly competitive national program?

   Yes _____ No _____

C. Administration

1. How did you learn about the Program? (Please check appropriate response)

   _____ Received announcement in the mail.

   _____ Read about in a professional publication.

   _____ Heard about it from a colleague.

   _____ Other (explain). ______________________________

2. Did you also apply to other summer faculty programs?

   Yes _____ No _____

   _____ DOE

   _____ Another NASA Center

   _____ Air Force

   _____ Army

   _____ Navy

3. Did you receive an additional offer of appointment from one or more of the above? If so, please indicate from which. No _____ Yes _____

   ____

4. Did you develop new areas of research interest as a result of your interaction with your Center and laboratory colleagues?

   Many _____
   A few _____
   None _____

5. Would the amount of the stipend ($900 per week) be a factor in your returning as an ASEE Fellow next summer?

   Yes _____
   No _____
   If not, why ____
   ____

6. Did you receive any informal or formal instructions about submission of research proposals to continue your research at your home institution?

   Yes _____ No _____

7. Was the housing and programmatic information supplied prior to the start of this summer's program adequate for your needs?

   Yes _____ No _____

8. Was the contact was your research colleague prior to the start of the program adequate?

   Yes _____ No _____

9. How do you rate the seminar program?

   Excellent _____
   Very good _____
   Good _____
   Fair _____
   Poor _____

10. In terms of the activities that were related to your research assignment, how would you describe them on the following scale?

Check one per activity	Time Was			
Activity	Adequate	Too Brief	Excessive	Ideal
Research				
Lectures				
Tours				
Social/Recreational				
Meetings				

11. What is your overall evaluation of the program?

Excellent _____

Very good _____

Good _____

Fair _____

Poor _____

12. If you can, please identify one or two significant steps to improve the program.

____

____

____

____

13. For second-year Fellows only. Please use this space for suggestions no improving the second year.

____

____

____

____

D. Stipend

1. To assist us in planning for appropriate stipends in the future would you indicate your salary at your home institution.

   $ ____________per Academic year____ or Full year ____. (check one)

2. Is the amount of the stipend the primary motivator to your participation in the ASEE Summer Faculty Fellowship Program?

   Yes _____ No _____ In part _____

3. What, in your opinion, is an adequate stipend for the ten-week program during the summer of 1991?

   $ ____________________________________

E. American Society for Engineering Education (ASEE) Membership Information

1. Are you currently a member of the American Society for Engineering Education?
   Yes _____ No ____

2. Would you like to receive information pertaining to membership in the ASEE?
   Yes _____ No _____

PLEASE USE THIS PAGE FOR YOUR COMMENTS TO ANY QUESTION

1992 NASA/ASEE SUMMER FACULTY FELLOWSHIP RESEARCH PROGRAM

QUESTIONNAIRE FOR RESEARCH ASSOCIATES

Please complete and return to John H. Spencer by Tuesday, Sept. 8, 1992, MS 105A. Thank you.

Research Fellow's Name ______________________________

Research Associate's Name ______________________________

1. Was your Fellow adequately prepared for his/her research assignment?

   Yes No (Circle One)

   Comments: ______________________________

   ____

   ____

   ____

2. In the rating scale below, please give your opinion on how your Fellow approached his/her research assignment.

	Outstanding	Above Avg.	Avg.	Fair to Good	Poor
a. Knowledge of subject					
b. Diligence					
c. Interest in Assignment					
d. Enthusiasm					

3. Did your Fellow accomplish the research goals established by you for the ten week period?

Yes No (Circle One)

Comments: ______________________________

____

____

____

4. Was there any change in assignment from that expected by your Fellow?

Yes No (Circle One)

If yes, please give reason(s) for change: ______________________________

____

____

____

5. Would you be interested in serving as a Research Associate again?

Yes No (Circle One)

Comments: ______________________________

____

____

____

6. How did your Fellow compare overall with other faculty researchers you have worked with? (Please check one)

[ ] Equal to the Best   [ ] Very Good   [ ] Above Average   [ ] Average   [ ] Below Average

7. Would you recommend your Fellow for employment in your organization?

Yes   No   (Circle One)

Comments: ____

____

____

____

8. Please give recommendations for improving the program.

Comments: ____

____

____

____

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____

____

____

APPENDIX XI

ABSTRACTS - RESEARCH FELLOWS

N93-16761

THE NASA HIGH-SPEED RESEARCH PROGRAM

by

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Abstract

For over 25 years NASA has been involved in research to develop a Supersonic Transport vehicle. The original research program was discontinued in the early 1970's due to inadequate technology to support such a program and public concern over the possible environmental effects from the aircraft. However, research on variable cycle engines and in atmospheric sciences continued and would eventually play roles in a new program.

About six years ago, NASA-sponsored studies conducted by Boeing and McDonnell Douglas provided forecasts for high economic growth rates in countries of the Pacific Basin by the turn of the next century. Market analyses translate the growth rates into increased demands for passenger transportation to and from this area. (fig. 1)

Since its inception, one of NASA's commitments has been to develop the technology to advance aeronautics. As such, a new High-Speed Research Program was activated to develop the technology for industry to build a High-Speed Civil Transport--a second generation SST.

The baseline for this program is the British Concorde, a major technological achievement for its time, but an aircraft which is now both technologically and economically outdated. Therefore, a second generation SST must satisfy environmental concerns and still be economically viable. In order to do this, it must have no significant effect on the ozone layer, meet Federal Air Regulation 36, Stage 3 for community noise, and have no perceptible sonic boom over populated areas. These three concerns are the focus of the research efforts in Phase I of the program and are the specific areas covered this video report. If the results of the research show that an HSCT can built within these guidelines, Phase II will begin in earnest. The HSR program is being conducted at Langley, Lewis, Ames, and Dryden, and managed from NASA Headquarters in Washington, D. C. The design concept being used in these studies is a Boeing Mach 2.4 configuration, capable of carrying approximately 300 passengers and flying 6000nm. (fig. 2)

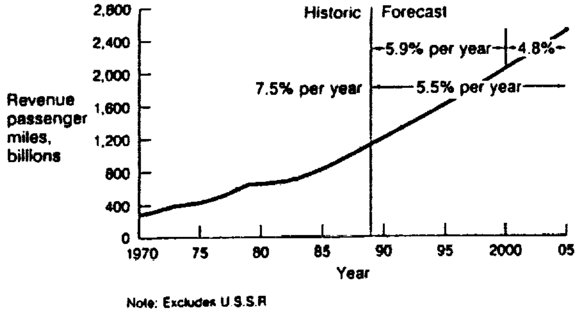
To date, scientists have been using both laboratory experiments and flight experiments on board an ER-2 and a DC-8 to measure atmospheric

effects from NOx emissions. From NASA specifications, an independent firm is building an unmanned, remote-controlled aircraft--the Perseus--which will carry a payload of test instruments to take measurements in the upper atmosphere. Databases are being collected and maintained at Langley, where they can be accessed by the international community, which will eventually establish emissions regulations for aircraft. The emissions technology being investigated at Lewis indicates that it is possible to build an engine capable of operating supersonically well within recommended NOx guidelines. Two concepts are being tested--a Lean Premixed Pre-vaporized combustor, which mixes fuel and air upstream of the burning and allows sufficient time for the liquid fuel to vaporize completely. and a Rich Burn-Quick Quench-Lean Burn combustor, which mixes fuel with air in the first stage to reduce the NOx and completes the combustion process in the second stage. (figs. 3, 4)

To meet the FAR 36, Stage 3, researchers are involved in a multi-faceted effort to reduce source noise and yet improve aerodynamic efficiency. Different variable cycle engine candidates are being evaluated for their performance from subsonic through supersonic flight regimes, as well as their inherent noise levels. Since these engines produce a high-velocity jet exhaust flow, noise levels would be extreme; however, concepts are being studied which can entrain and mix outside air with the exhaust flow to reduce the velocity. (fig. 5) Different flap configurations are being designed and tested to improve high lift characteristics to allow the aircraft to take off and climb quickly away from the airport. Researchers at Langley and Dryden are using two F16-XL airplanes to conduct supersonic laminar flow experiments, which employ suction methods or a passive glove, in an effort to improve drag reduction. (fig. 6) Such a reduction would decrease the fuel levels and thus reduce the gross take-off weight.

As yet, researchers at Ames and Langley are unable to eliminate the sonic boom produced by an SST; however, they are testing model configurations for reshaping the N-wave and hence, the sonic boom. (fig. 7) Human-response studies in the lab, at home, and community-wide will eventually provide data for determining the acceptability criteria. In addition, flight corridors are proposed over non-populated or sparsely populated areas.

Originally, this project was conceived as a Langley-only report; however, given the scope of the HSR program, it was prudent to include research efforts at all participating centers. The change occurred about five weeks into the project, and subsequently, dictated numerous changes. Through meetings with the Langley project manager and information received from managers at the other centers, the primary areas of research were identified. Since there is interrelated research at different centers, it was necessary to travel to Dryden, Ames, Lewis, and Headquarters to conduct interviews with the specific researchers, videotape research efforts, and collect scientific visualization. Video support is being provided by both the Video Section of the Research and Information Applications Division and the Analysis and Computation Division. The technical video report will include actual soundbites from interviews with more than 30 researchers and managers, live video from wind tunnel tests, experiments--both real and simulated, illustrative graphics, comprehensive Computational Flow Dynamics, and scientific visualization. Every effort is being made to preserve the original quality of any visualization. The primary narrative will be provided by the researchers themselves. The final version will be approximately 30 minutes in length, and projected completion is November-December of 1992.



Market Forecast for World Air Travel Through the Year 2005

fig. 1

Rich-Burn Quick-Quench Lean-Burn Combustor

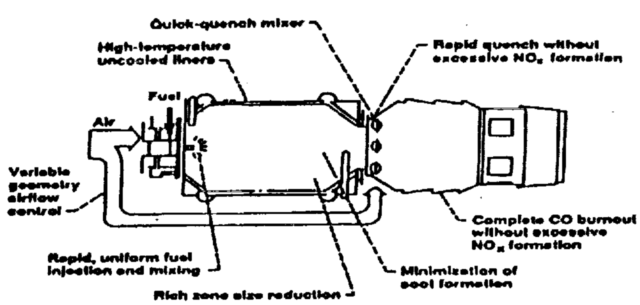


fig. 2

Lean Premixed Prevaporized Combustor

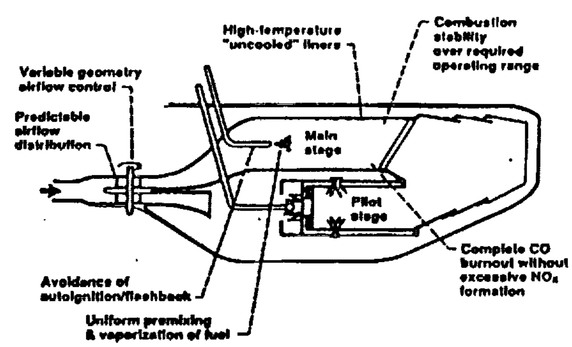
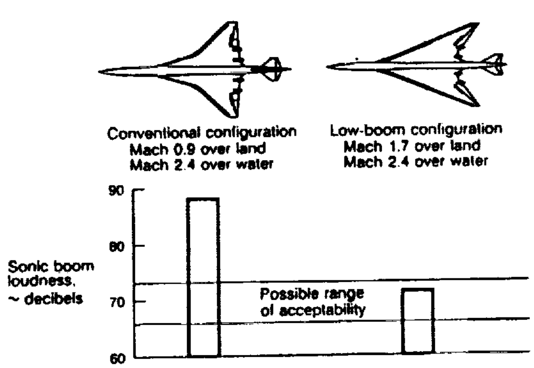


fig. 3



Design for Reduced Sonic Boom

fig. 4

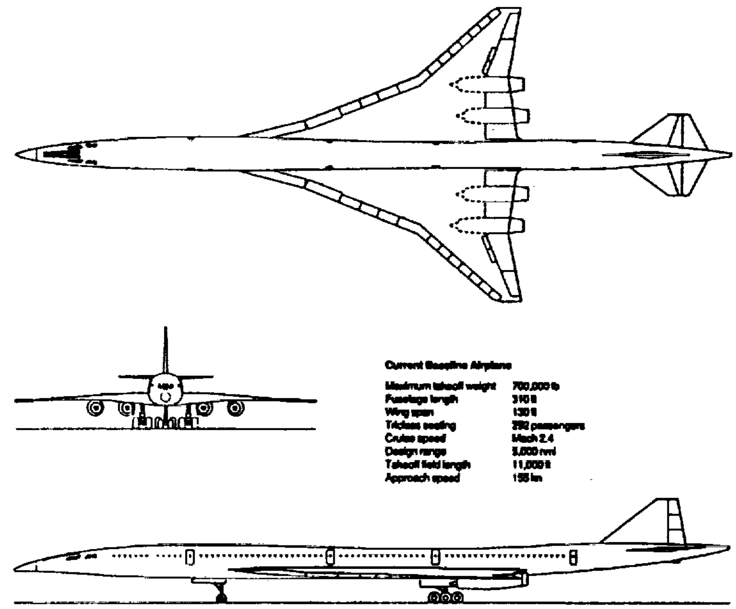
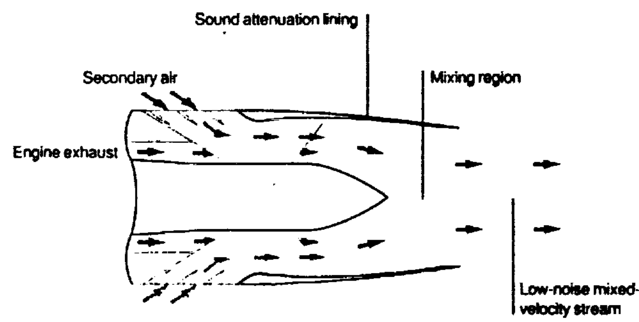
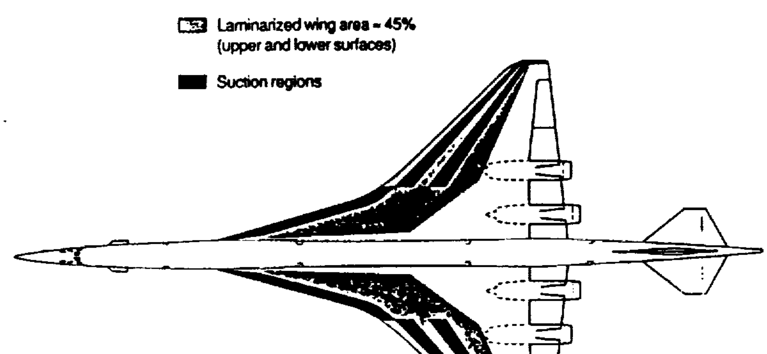


fig. 5



Internally Mixed Ejector-Suppressor Nozzle Concept

fig. 6



HSCT Laminar Flow Control Concept

fig. 7

N93-16762

An Intelligent Decomposition Approach for Efficient Design of Non-Hierarchic Systems

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Abstract

The design process associated with large engineering systems requires an initial decomposition of the complex system into subsystem modules which are coupled through transference of output data. The implementation of such a decomposition approach assumes the ability exists to determine what subsystems and interactions exist and what order of execution will be imposed during the analysis process. Unfortunately, this is quite often an extremely complex task which may be beyond human ability to efficiently achieve. Further, in optimizing such a coupled system, it is essential to be able to determine which interactions figure prominently enough to significantly affect the accuracy of the optimal solution. The ability to determine 'weak' versus 'strong' coupling strengths would aid the designer in deciding which couplings could be permanently removed from consideration or which could be temporarily suspended so as to achieve computational savings with minimal loss in solution accuracy. An approach that uses normalized sensitivities to quantify coupling strengths is presented. The approach is applied to a coupled system composed of analytical equations for verification purposes.

Introduction

Several decomposition approaches have recently been demonstrated to be applicable for performing optimization in non-hierarchic engineering systems [1-3]. However, substantial room for improvement and advancement on these methods exist. One possibility of improvement lies in the incorporation of a knowledge-based system to assist in the determination of subsystem interactions, participating disciplines, and order of execution of the decomposed subsystems. An intelligent decomposition approach, based on Rogers' DeMAID (*Design Manager's Aide for Intelligent Decomposition*) [4], is presented which incorporates artificial intelligence and data management techniques in such a manner to achieve an efficient integrated design capability. This approach has applications in any highly coupled environment in which the input and output information associated with each participating analysis can be quantified. A human interaction capability allows for inclusion of problem-dependent heuristics and designer experience. A system sensitivity analysis provides information corresponding to analysis coupling strengths, thus permitting intelligent choice of participating analyses, according to their impact on the overall system solution. The identification of 'weak' versus 'strong' couplings is made based on normalized sensitivities associated with the Global Sensitivity Equation (GSE) Method [1].

Intelligent Decomposition Approach

A non-hierarchic system is one in which the interactions among subsystem modules cannot be distributed in a traditional top down hierarchy. Non-hierarchic systems are characterized by subsystem analyses coupled through transference of output data, creating a complex network. The solution for such systems begins with a decomposition approach which effectively breaks large intractable problems into smaller subproblems, while maintaining the couplings among them. Such an approach is particularly amenable to the design organization setting in which engineers work in groups divided by task and disciplinary specializations, thus taking advantage of the division of labor, while permitting the concurrency of operations. A representative non-hierarchic system is shown in Figure 1, where three subsystems interact.

Each participating discipline or analysis in the complex system can be modeled as a subsystem for which inputs and outputs are identifiable. The complex system of Figure 1 can be represented as a square design structure matrix [5], wherein each of the subsystems is denoted as a box along the diagonal. The influence of one subsystem upon another depends on the location of the interface between the two subsystems, with feedforwards in the upper diagonal and feedbacks in the lower. A module with a feedback requires information before it is actually available, thus necessitating initial guesses with an associated iterative framework to achieve convergence. Therefore, it is beneficial to minimize the number of feedbacks by reordering the modules along the diagonal. Applying DeMAID to the analytical system of coupled subroutines associated with the system of Figure 1 results in the ordering shown in Figure 2. Each subroutine is denoted by a reference to its subsystem and to the output associated with it. Modules pertaining to the design variables are included to make the identification of subsystem inputs easier.

Normalized Sensitivities for Determining Coupling Strengths

In this work, coupling strengths are defined in terms of local normalized sensitivities. These local sensitivities are used in the GSE to obtain total behavioral response derivatives with respect to the design variables. The local derivatives are thus already available to the designer. The GSE approach involves defining total derivatives of the output response quantities in terms of local sensitivities of the outputs of each subsystem with respect to that subsystem's inputs. For example, for the coupled system of Figure 3 in which two subsystems, A and B, interact through transference of output information, local sensitivities would be $\partial YA/\partial YB$, $\partial YA/\partial XA$, $\partial YB/\partial YA$, and $\partial YB/\partial XB$. Since the components of the output response vector Y and the design variable vector X are of varying magnitudes, a normalization scheme [6] is implemented to ensure that the conditioning of the system is such that accuracy of the solution is not threatened. The local subsystem sensitivity information can be used to quantify the strengths of participating analysis couplings. Such information can then be used to provide the basis for developing heuristics that will indicate which couplings are "weak" enough to be temporarily or permanently suspended. Obviously, in a complex problem involving computationally expensive analyses which must be performed within an iterative framework (such as structural finite element analyses) the ability to reduce the system complexity without sacrificing solution accuracy is of utmost importance. The question then becomes, **"to what extent may solution accuracy be compromised in order to achieve solution efficiency?"**

Application to Analytical System

Figure 4 graphically identifies the "largest" and "smallest" normalized sensitivities associated with the couplings for the analytical system and aids in the determination of which couplings to remove or temporarily suspend during the optimization process. From Figure 4 it can be seen that the smallest absolute value of the normalized sensitivities is associated with module number 16, which corresponds to output z3. Both the feedbacks associated with z3 are considered to be small in comparison with the system's other normalized sensitivities. Therefore, it can be hypothesized that z3 could be either removed from the analysis altogether or suspended for some number of cycles during the optimization, which turns out to be the case. When the analysis associated with z3 is removed altogether, the percent differences in the system solution is uniformly less than 1%. Figure 4 also demonstrates that the output z2 (module 10) has small normalized sensitivities in comparison with the other output analyses. Two of its four interactions are considered very small while two others are in a medium range. Therefore, one might hypothesize that removal of z2 would result in percent differences that are slightly higher than those associated with the removal of z3, which Figure 5 demonstrates. The largest percent difference in subroutine solutions was for w2 in which a 7.153% difference was calculated, with the next associated with y1, while all other differences were less than 1%. The final possibility for simplifying the system is with respect to the subroutine for z1 (module 15). With only one of its three feedbacks considered weak, however, one would not expect to obtain a high level of system solution accuracy with its elimination. Furthermore, one can see that z1 is a feedback into y3 and w1. Both of these modules have large normalized sensitivities associated with their outputs. This increases the chances of large errors associated with the remaining analyses if z1 were to be eliminated. Figure 6 demonstrates that an almost 21% difference in the y1 solution results with elimination of z1. The heuristics previously developed regarding removal of modules was incorporated into an analytical optimization problem to determine the potential effects on the optimal solution. Figure 7 shows the convergence history associated with the elimination of z3 from consideration as a changing output. It demonstrates that the difference in optimal solutions is minimal, with the convergence history paralleling the original path.

Concluding Remarks

Large coupled systems are not amenable to traditional top-down hierarchies and require a framework which permits the exploitation of discipline-dependent technologies and computer facilities that correspond to groups within a design organization setting. An intelligent decomposition approach was presented which uses technologies of artificial intelligence and concurrent information management to facilitate use in a design organization setting. A system sensitivity analysis was introduced which provides information corresponding to analysis coupling strengths, thus permitting intelligent choice of participating analyses in the optimization process. The approach was applied to a coupled system composed of analytical equations for verification purposes. Results obtained demonstrated that elimination and/or suspension of couplings can be achieved with minimal loss of solution accuracy. Numerous areas for future work exist. Two of these include application of the approach to a physical problem and incorporation of an embedded knowledge-based system to control the decision-making process regarding participating disciplines or subsystems.

References

1. Sobieszczanski-Sobieski, J., "On the Sensitivity of Complex, Internally Coupled Systems", AIAA Journal, Volume 28, No. 2, pp. 153-160.

2. Sobieszczanski-Sobieski, J., "Optimization by Decomposition: A Step from Hierarchic to Non-Hierarchic Systems", Recent Advances in Multidisciplinary Analysis and Optimization, NASA CP-3031, 1988.

3. Bloebaum, C.L., Hajela, P., and Sobieszczanski-Sobieski, J., "Non-Hierarchic System Decomposition in Structural Optimization", 3rd Air Force/NASA Symposium on Recent Advances in Multidisciplinary Analysis and Optimization, San Francisco, California, September 1990.

4. Rogers, J.L., "A Knowledge-Based Tool for Multilevel Decomposition of a Complex Design Problem", NASA TP 2903, May 1989.

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6. Hajela P., Bloebaum, C.L., and Sobieszczanski-Sobieski, J., "Application of Global Sensitivity Equations in Multidisciplinary Aircraft Synthesis", Journal of Aircraft, Volume 27, No. 12, 1990, pp. 1002-1010.

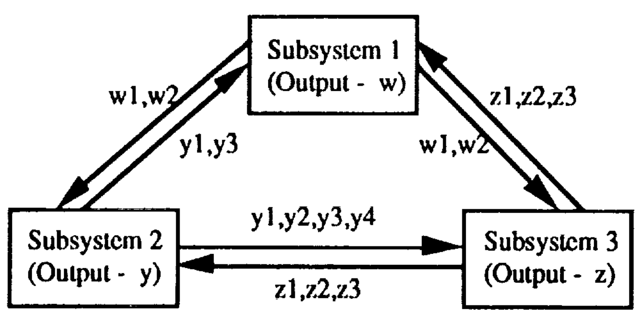

Figure 1. Non-hierarchic analytical system providing testbed for coupling strength comparisons.

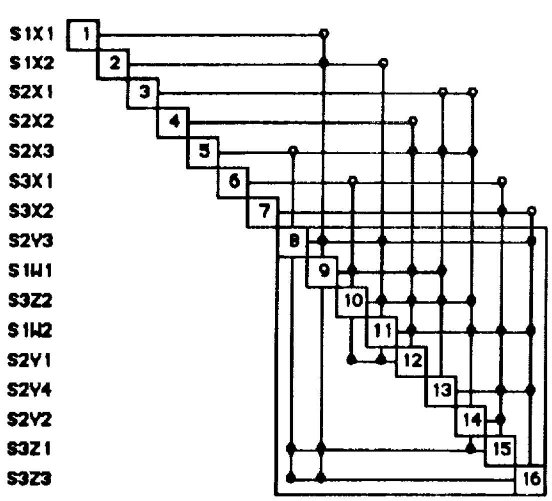

Figure 2. Subroutine modules with minimized feedbacks.

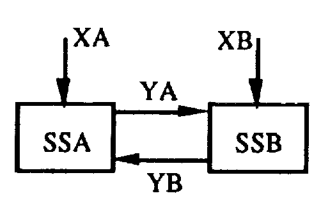

Figure 3. Interactions in two subsystem non-hierarchic environment.

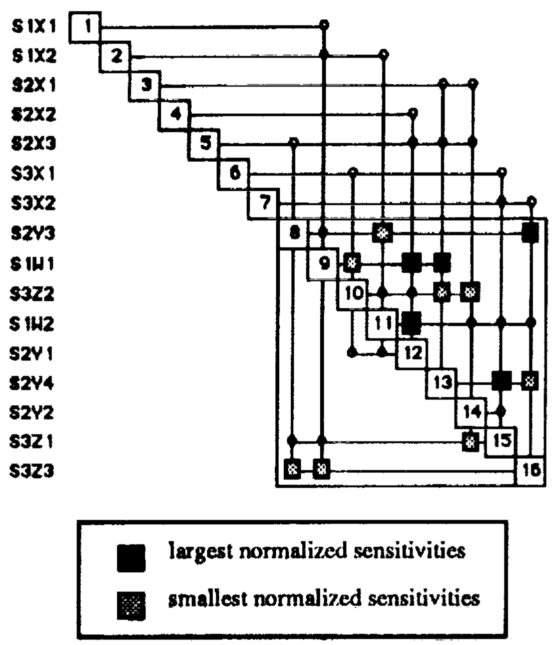

Figure 4. Comparison of normalized sensitivities for coupled system.

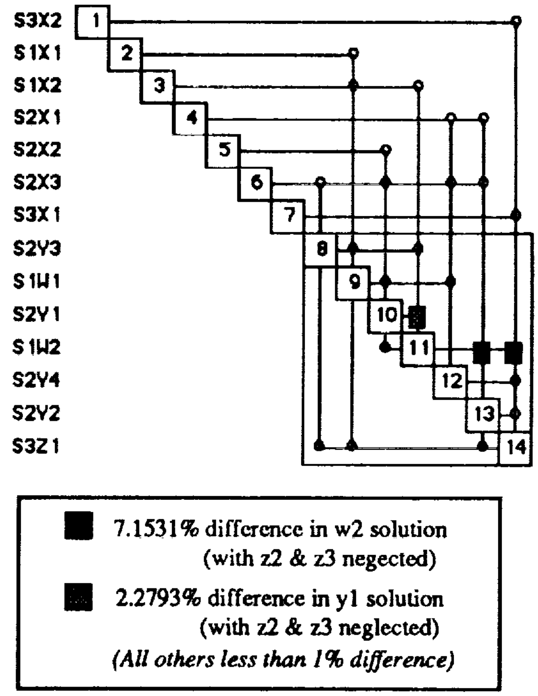

Figure 5. Differences in w2 and y1 solutions with removal of z2 and z3.

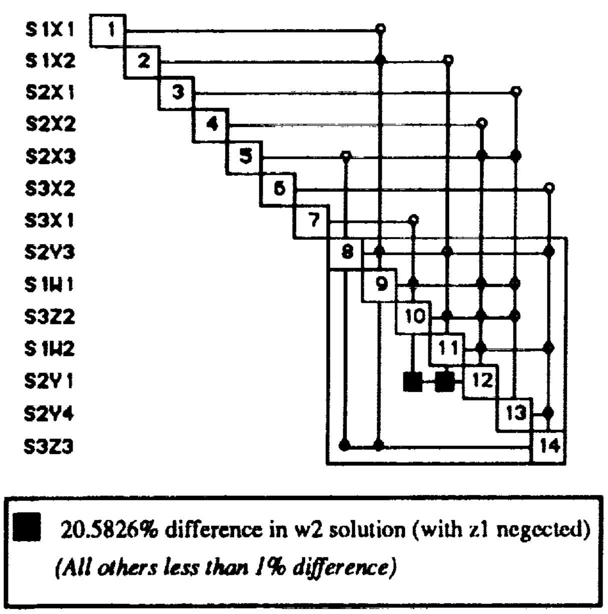

Figure 6. Percent differences in w2 solution with removal of z1 module.

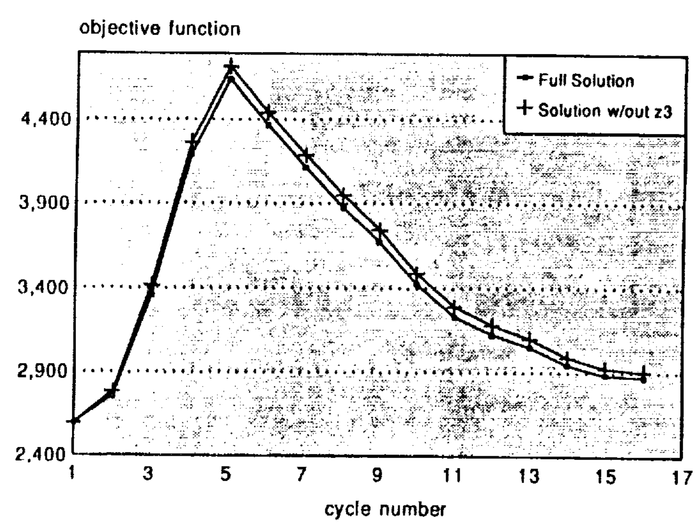

Figure 7. Optimization convergence history for full and modified problem.

N93-16763

The Role of Under-determined Approximations In Engineering and Science Application

from

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ABSTRACT

There is currently a great deal of interest in using response surfaces in the optimization of aircraft performance. The objective function and/or constraint equations involved in these optimization problems may come from numerous disciplines such as structures, aerodynamics, environmental engineering, etc. In each of these disciplines, the mathematical complexity of the governing equations usually dictates that numerical results be obtained from large computer programs such as a finite element method program. Thus, when performing optimization studies, response surfaces are a convenient way of transferring information from the various disciplines to the optimization algorithm as opposed to bringing all the sundry computer programs together in a massive computer code.

Response surfaces offer another advantage in the optimization of aircraft structures. A characteristic of these types of optimization problems is that evaluation of the objective function and response equations (referred to as a functional evaluation) can be very expensive in a computational sense. Because a great number of functional evaluations may be required in the solution of a typical engineering optimization problem, optimization of aircraft performance can require a large computing effort. Response surfaces may provide increased computational efficiency for these types of engineering optimization problems. Instead of performing exact functional evaluations during the optimization process, approximations to response can be initially developed and the approximations then optimized. Development of the approximations requires a number of initial functional evaluations. Here, however, parallel processing can provide increased computational efficiency which may speed up the total computational process.

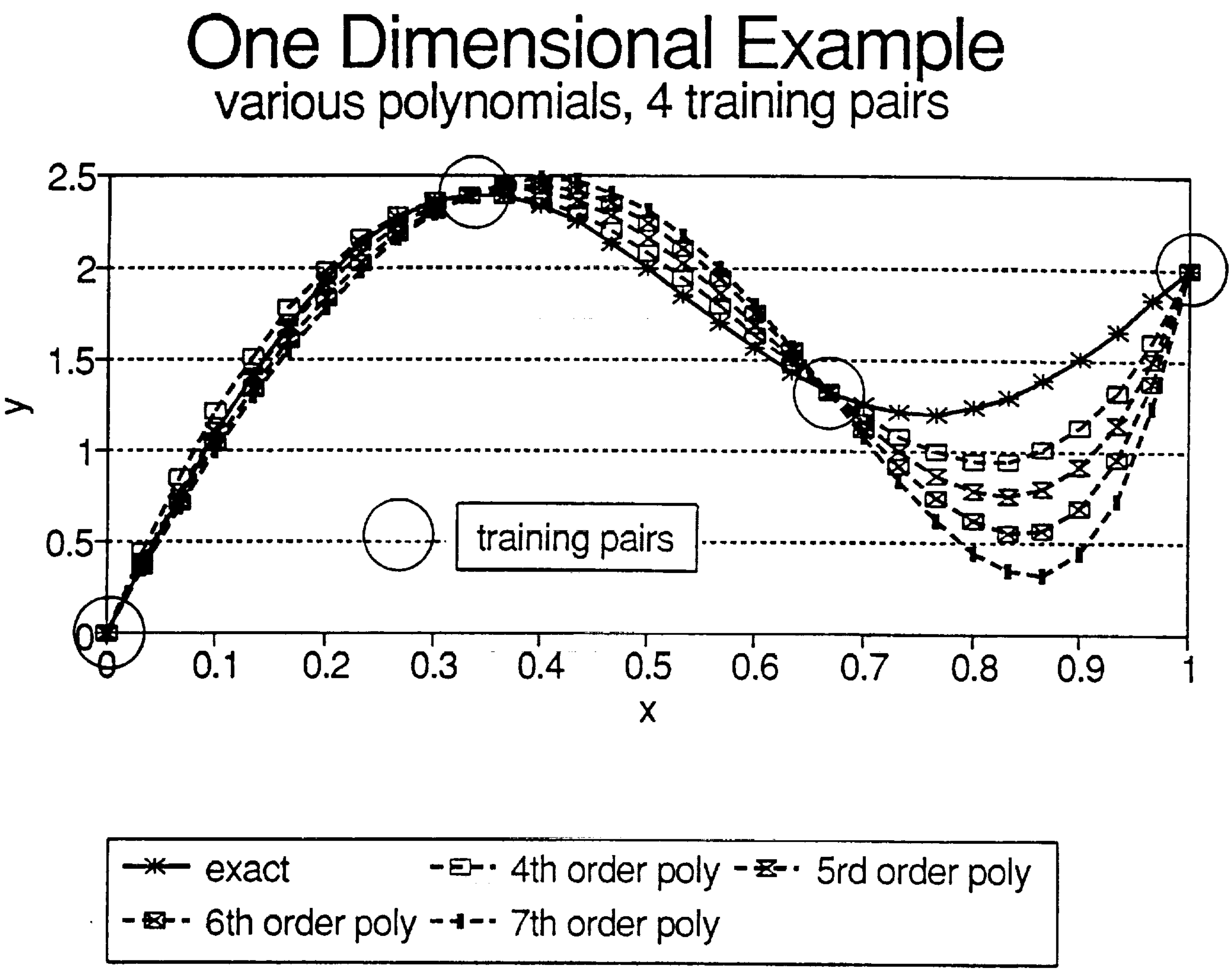
Because of the computational expense in obtaining functional evaluations, the present study was undertaken to investigate under-determined approximations. An under-determined approximation is one in which there are fewer training pairs (pieces of information about a function) than there are undetermined parameters (coefficients or weights) associated with the approximation. Both polynomial approximations and neural net approximations were examined. Three main example problems were investigated.

In Example 1, a function of one design variable was considered. Various order polynomial approximations and neural net approximations were developed. Typical curves showing approximations of the function are included at the end of this abstract. The significant finding from this example is that under-determined approximations yield non-unique approximations. The approximation obtained depends upon such factors as initial assumed values of the undetermined parameters associated with the approximation and on the training algorithm employed.

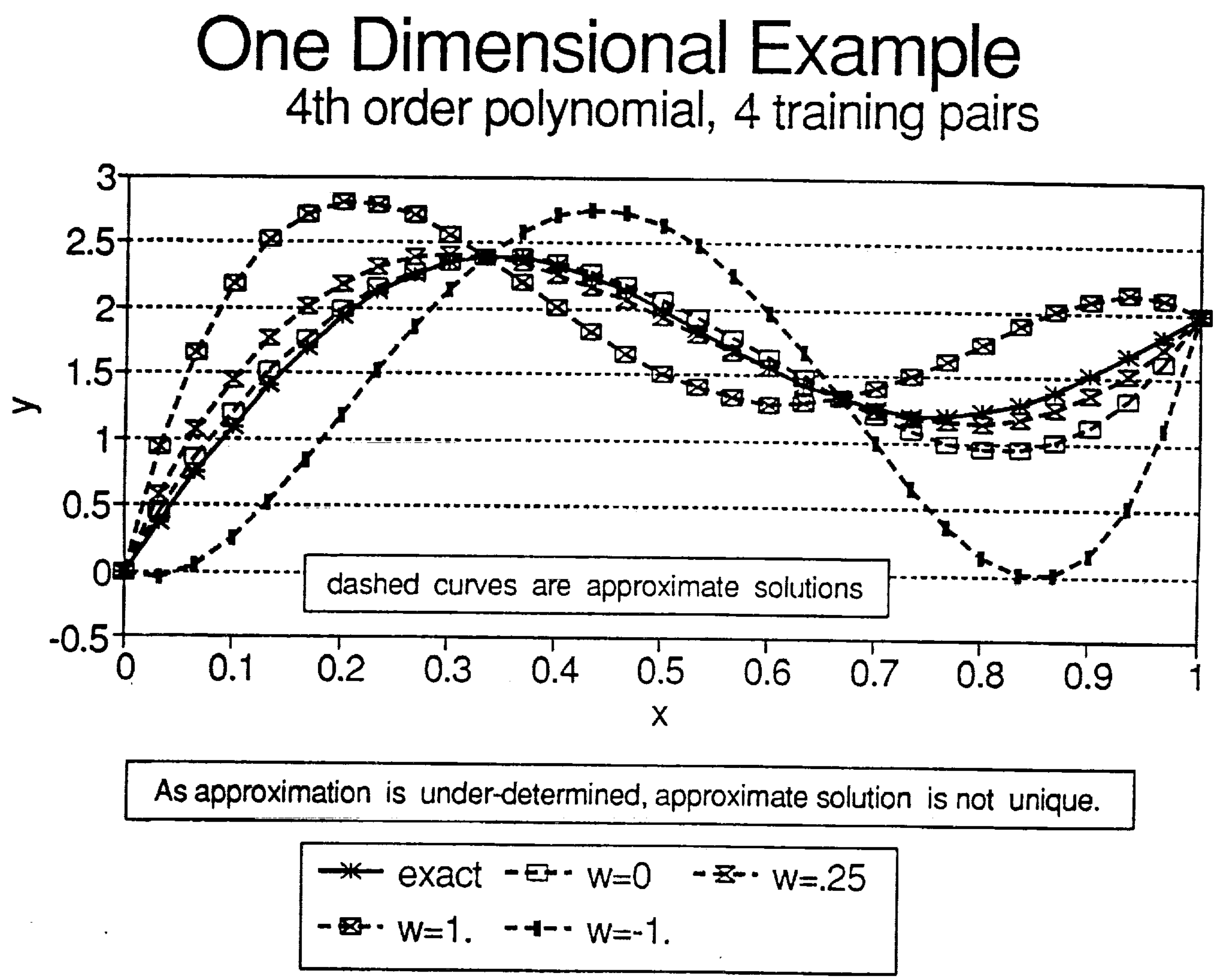
In Example 2, a function of two design variables was considered. A contour plot of the function (the banana function) is given at the end of this abstract. Here again, under-determined approximations gave non unique approximations. A figure is presented at the end of this abstract showing the variations in a parameter v_G, a measure of how well the approximation fits the function over a region of interest, for three trainings of a neural net approximation. One can see that for under-determined approximations, there is a large variability in the results which can be obtained

In Example 3, a 35 bar truss with 4 design variables was considered. Under-determined neural net approximations were considered. A figure at the end on this abstract shows that these under-determined approximations have more variability than exactly-determined or over-determined approximations.

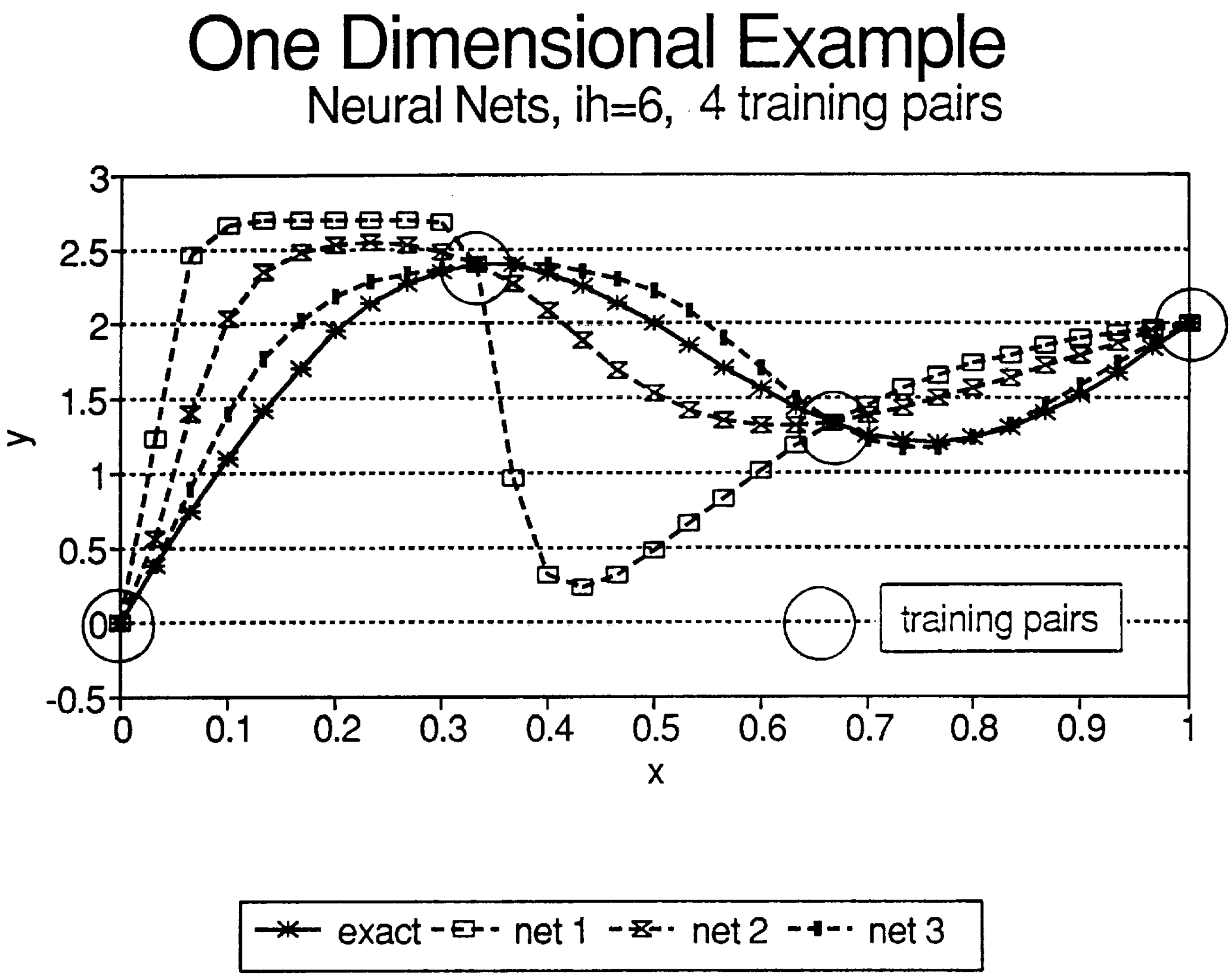
The findings of this study are very important to work going on at NASA and in the aerospace industry. A number of recent papers have appeared reporting that under-determined approximations were being developed and used in optimization studies. This study points out that the use of under-determined approximations should be discouraged because the approximations thus obtained, while they may satisfy the training pairs, are not unique and may yield very poor approximations over a region of interest.



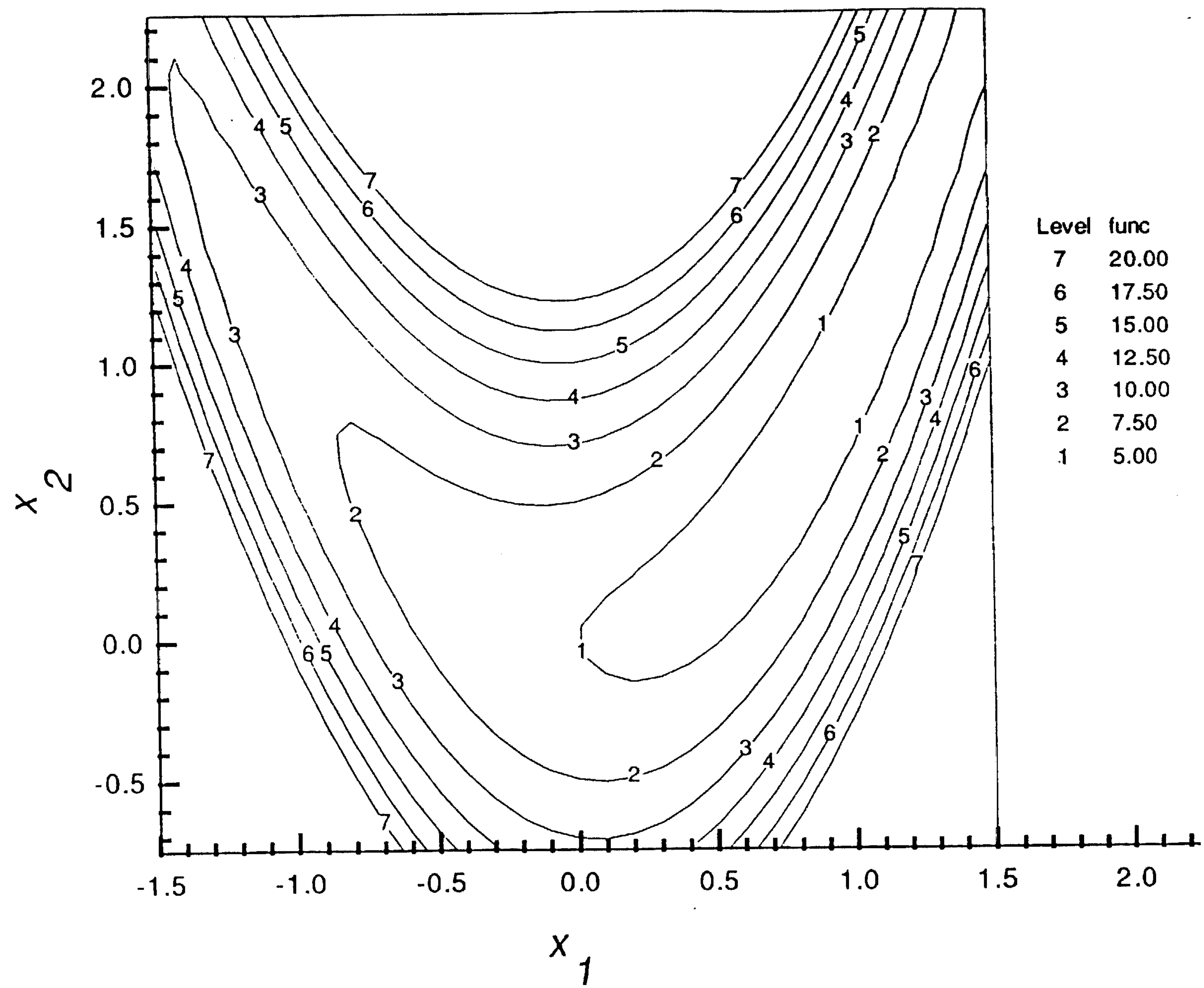
3. One Dimensional Example, Polynomial Approximations



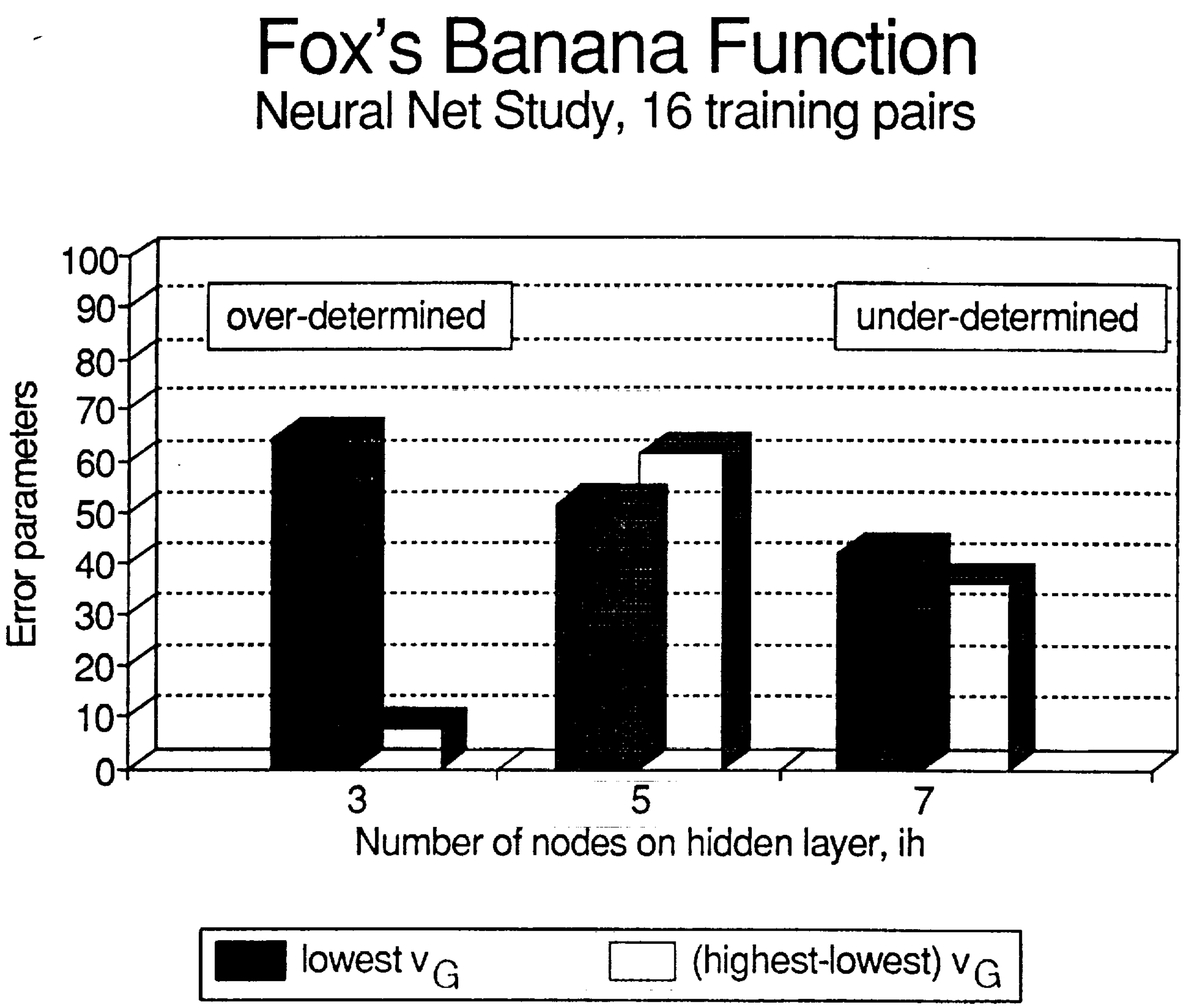
5. One Dimensional Example, various solutions using a 4th order polynomial



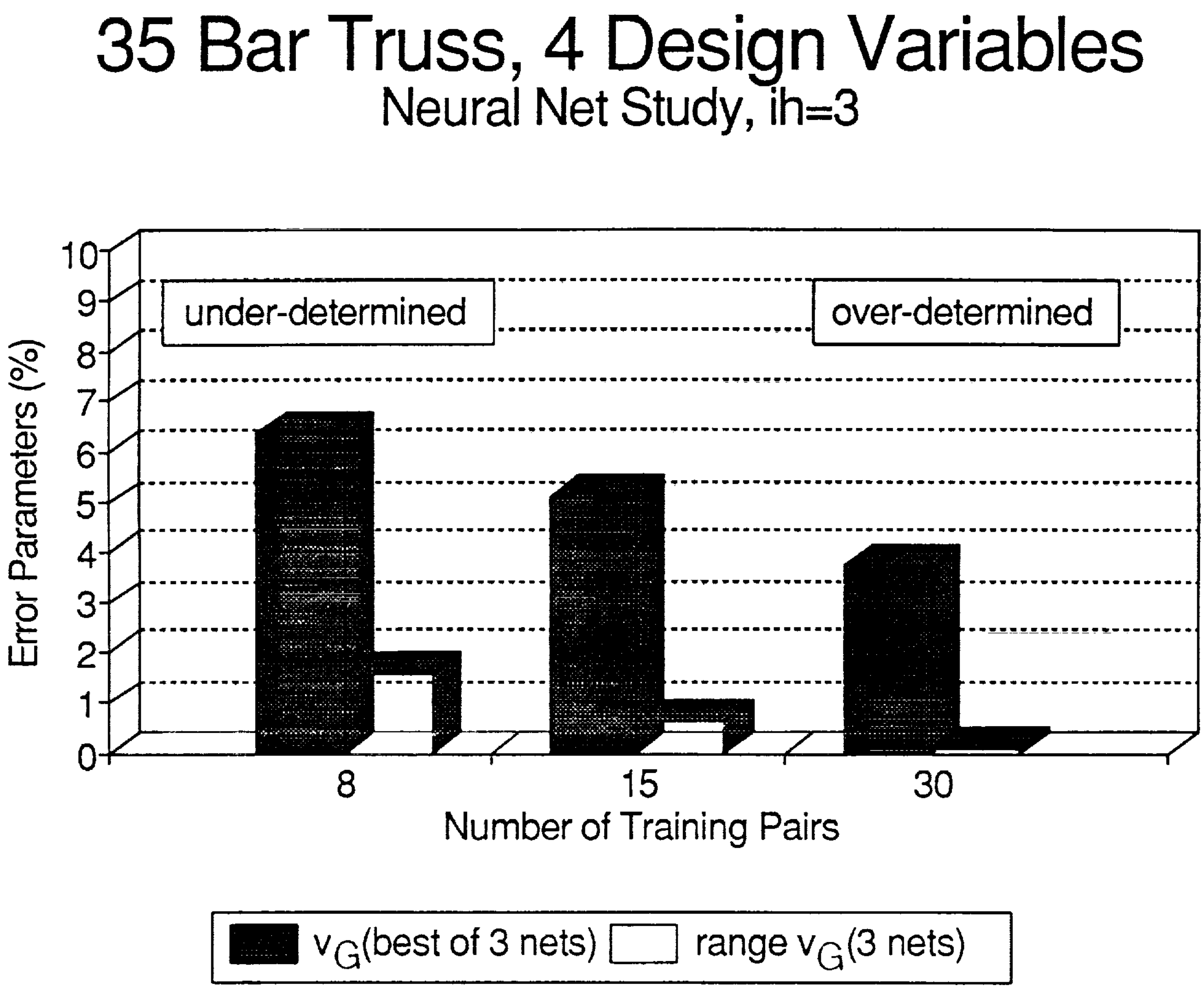
8. One Dimensional Example, Neural Nets, ih=6, 4 Training Pairs



10. Fox's Banana Function



13. Fox's Banana Function, Error Parameters for 3, 5, and 7 Nodes on the Hidden Layer



23. 35 Bar Truss, Error Parameters for 8, 15, and 30 Training Pairs

UNDERSTANDING CRYSTALLINITY IN AROMATIC POLYIMIDES

by

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N93-16764

Aromatic polyimides are a class of polymers that show remarkable thermal stability, strength, and toughness. These properties make them attractive candidates for use in high-performance carbon fiber composites for airborne and spaceborne structural components.

The range of possible polymers one could produce in the laboratory is vast. Consequently, there is a need to develop an understanding of the relationship between some of the thermochemical or thermomechanical properties of polyimides and their chemical structures and processing histories, in order to guide the selection of candidate polymers for synthesis.

The physical properties of a polymer are determined not only by the chemical identities of the monomeric units, but also by the microscopic morphology (amorphous, polycrystalline, distribution of voids) of the material, and by the presence of foreign material. Change in morphological properties with time accounts for the physical process of polymer aging; foreign material (fillers) are widely employed (for example in the rubber tire industry) to tailor physical properties.

Polymer microcrystallites are, in a way, like foreign particles embedded in the amorphous polymer, but since they are also intimately involved in the amorphous phase, they are less prone to exclusion as the material ages than particles of an inhomogeneous filler. The profound effects the presence of microcrystallites can have on the physical properties of polymers make it desireable to be able to control their formation during synthesis and processing. Our research centered on the development of an understanding of the underlying process of crystallite formation in a particular class of aryl polyimides for which there are some x-ray crystallographic data available. The ultimate aim of the project is to be able to develop a model sufficiently flexible to be able, on the basis of the chemical structure of a polymer in this class, to predict: (1) whether it will be prone to form crystallites; (2) crystallographic features of the crystallites; and (3) synthesis and/or processing conditions that will be favorable or unfavorable to crystallite formation. This will provide guidance to the laboratory chemists in their choice of candidate polymers and processing methods.

The process of crystal formation in high polymers is dominated by kinetic factors; the true state of thermodynamic equilibrium is virtually unattainable. The kinetic factors are dependent upon bond rotations within the molecule, as well as the interactions between adjacent lengths of polymer. Characteristically, aromatic polyimides have monomeric units that are relatively long (on the order of 15-30 Å), but have relatively few (2-5) articulations, and thus have few rotatable bonds per monomeric unit. The imide functionality endows the monomers with localized dipole moments, more or less in the chain direction, and other pendant or in-chain groups, such as trifluoromethyl or carbonyl groups, may also contribute to local dipole moments. Both the interaction between these local dipoles along the chain, and ordinary dispersion (van der Waals) interactions are thought to dominate inter-chain cohesion which may be inter- or intra-molecular.

The model compounds studied were (see Figure 1) poly(N-*para*phenylenebisphthalimide) (I), poly(N-*para,para*biphenylenebisphthalimide) (II), and poly(N-*meta*phenylenebisphthalimide) (III). Of these, (II) and a number of its functionalized analogs are known to crystalize, and x-ray crystallographic data have been published for drawn fibers. It is strongly suspected that (I) does and (III) does not crystallize.

C-2

Cheng *et al.*[1] have studied analogs of (II), and the data indicate that the crystallites that form, both in spun and in drawn fibers, have thicknesses of only about 18-22Å, *i.e.* the length of a single monomeric unit in the polymer chain direction. They also found that, with increasing draw ratio, the crystals tend to get larger in the directions transverse to the chain, but do not grow in the chain direction. These conclusions rest on a number of assumptions about the origin of the x-ray reflections, starting with the assumption that the ordering is really crystalline, as opposed to smectic or nematic; for such small crystllite sizes, the data are difficult to interpret rigorously.

Semiempirical quantum chemical calculations (MOPAC/AM1) were carried out to investigate the potential energy versus bond rotation about all of the rotatable bonds in the monomeric units. In each of these bonds (the bisphthalimide bond, the phenylene-phthalimide bond, and the biphenylene bond), the energy minima correspond to dihedral angles of 25 - 35 degrees between the aromatic ring systems, the potential energy barrier to rotation through the coplanar conformation is at most on the order of kT at 300K above the minima, the minima are relatively flat (small second derivative of potential energy with respect to dihedral angle), and there is a very large barrier to rotation through the conformation with the rings perpendicular to each other, of around 10 kT. In practical terms, these results mean that, once the conformation around a bond has been established in synthesis, it is essentially frozen in excursions of up to 90 degrees are thermally accessible, but not excursions through larger angles. This point is illustrated in Figure 2: Both sets of conformations indicated can result from the synthesis of the polyimide by the usual synthetic techniques, but a single such bond, once formed, may not cross the barrier around $\varphi = 90°$.

As the polymer is formed, the conformations at the bisphthalimide bonds are random. Since to form a crystallite that is extended for two or more monomer units along the chain direction, all the involved monomers must have the same conformation type, the fact that the conformations are random along the chain means that that condition generally won't be met. Furthermore, besides a correlation of conformations along the chain, there must be a correlation of monomeric conformations on adjacent chains. Again, the randomness of the conformations frustrates this crystallinity. See Figure 3.

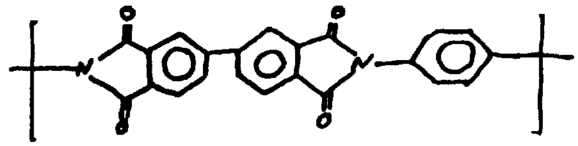
These observations lead us to the suggestion that the crystallites are of the fringed micelle type. This is also consistent with the observation that the crystallites seem to grow as the fiber is drawn, but transverse to the chain direction. It is proposed that, as the fiber is drawn, the polymer chains undergo reptation, which would lead both to extension of the crystallites at their edges (Figure 4a), and perfection of the crystallites (Figure 4b). The latter occurs as conformational impurities, whose interactions with the rest of the crystal are weaker, are drawn out of the crystallite, and replaced by monomers with the correct conformation, located further down the polymer chain, which would "click" into place, owing to their stronger interactions with the rest of the crystal. The removal of conformational impurities could also enhance coöprative effects contributing to extension.

This understanding of the nature of crystallinity in this family of aromatic polyimides suggests a number of approaches to increasing the degree of crystallinity: The correlation of conformations along the polymer chains must be brought under control. One possible approach to that might be to synthesize the amic acid polymer precursor to the polyimide, and draw it into sheets or fibers to effect conformational alignment, and then dehydrate it to form the polyimide. Another approach might be to employ bulky functional groups attached to the phthalic 6-rings at the position *ortho* to the bisphthalic bond to enhance conformational purity in the polymer. Finally, surface "template", or enzyme-mediated syntheses might be developed to produce polymers in a conformationally specific way.

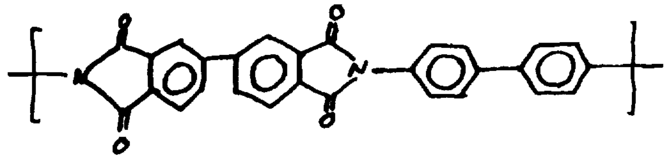
---

[1] S.Z.D. Cheng, Z-Q Wu, M. Eashoo, L.C. Hsu, and F.W. Harris: "A high-performance aromatic polyimide fibre: 1.," *Polymer*, **32**, 1803 (1991).

(I)



(II)



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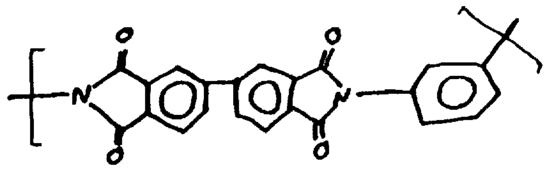

Figure 1. Three model polymers used in the study.

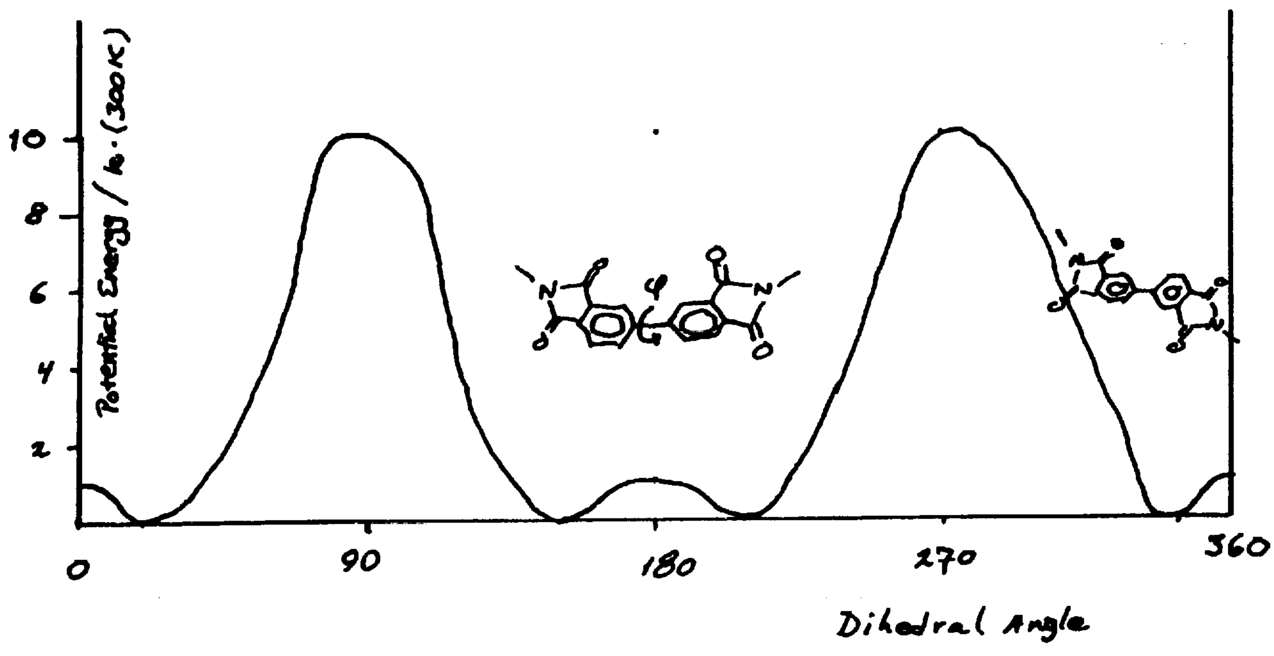

Figure 2. Schematic representation of the potential energy curve corresponding to rotation about the bisphthalimide bond. The lower barriers are on the order of kT at $T = 300K$, while the higher barriers are on the order of $10 \times kT$ so, once formed in a particular conformation, excursions of dihedral angle may range over only about 90°, and may not pass over the barrier. Hence, there will be very few transitions between the conformers shown.

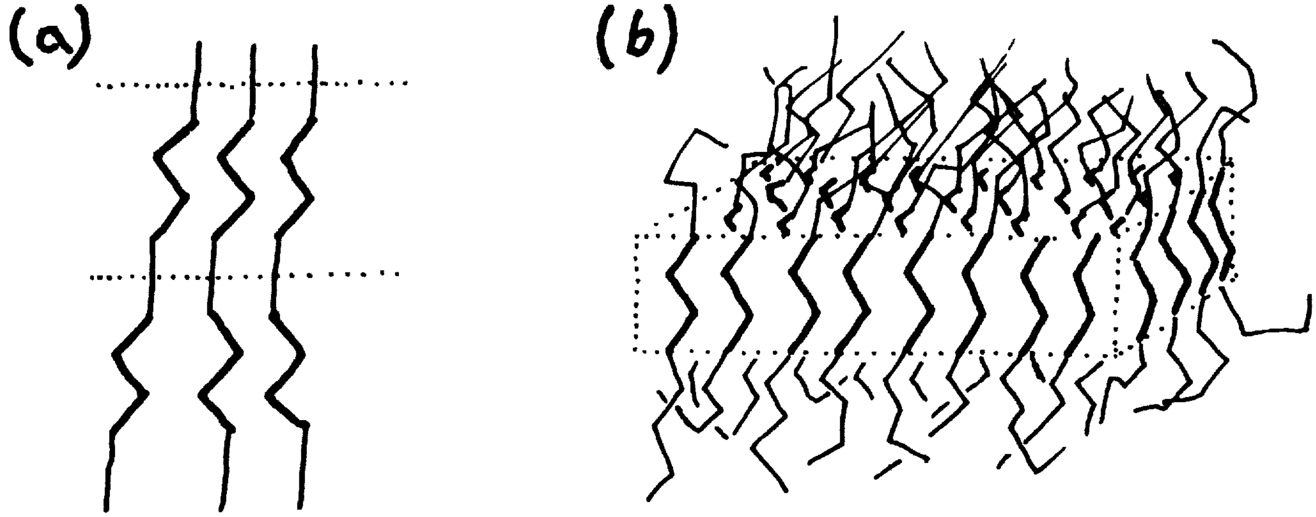

Figure 3. Schematic representation of monomer conformations in polymer chains involved in crystallite formation. (a) The conformationally significant region is shown as the bold zig-zag, and the two conformers are represented by the two possible orientations of the zig-zag. Because there is no correlation in conformations of adjacent monomer units along the chains, even though within the crystallite (between the dotted lines) the monomers establish conformational order, that order cannot be retained above or below. This leads to crystallites whose thickness is the length of a monomer unit. (b) Schematic representation of a crystallite, showing conformational order within the crystallite, and the remainder of the polymer chains involved in the amorphous regions above and below the crystallite. A single polymer chain could be involved in a number of such crystallites. These crystallites are a special instance of the "fringed micelle" type.

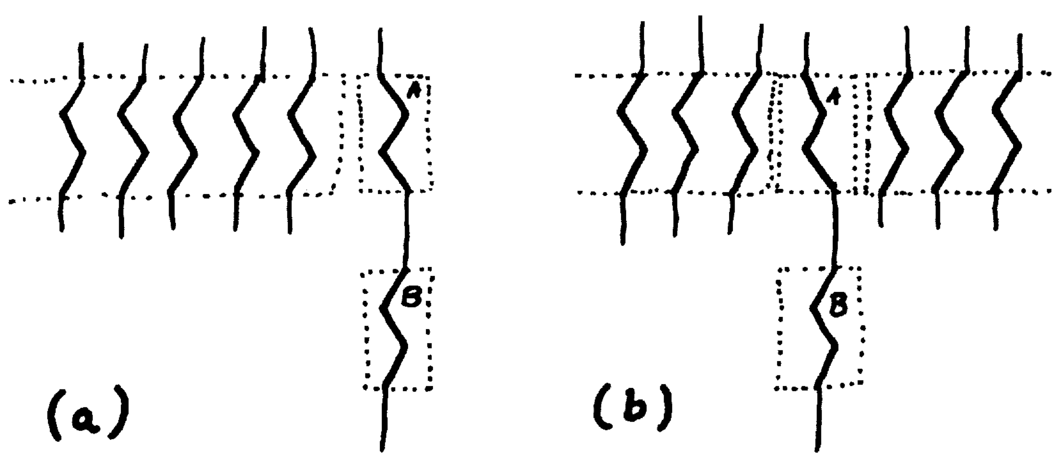

Figure 4. The process of reptation (vertical motion of the chains in the figures) can result in: (a) lateral extension (growth) of the crystallite as monomers with the appropriate conformation are drawn alongside an existing crystallite; and (b) perfection of a crystallite which contained a conformational impurity. In both cases, reptation leads to the removal of monomer unit 'A', and its replacement by the monomer unit 'B', which fits into the existing crystallite structure. Reptation is a typical mode of motion in polymers, and would probably be a prevalent mode when the material is being stretched or drawn.

N93-16765

Interferometric Reconstruction of Three-Dimensional High-Speed Aerodynamic Flows

by
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ABSTRACT

Holographic interferometry can be a very useful diagnostic tool in high-speed aerodynamic testing. It offers various merits, that is, global field capture, nonintrusive remote sensing, quantitative measurement, high spatial resolution, and excellent sensitivity. Since it detects only the phase change during two exposure, it can be easily implemented with low-quality optics. Consequently, those schlieren optical systems in the current aerodynamic testing facilities can be effectively utilized. The usefulness of the method has been well demonstrated in two-dimensional or axisymmetric flows. However, modern aerodynamics demand ever-sophisticating analyses. These frequently require global pictures of complex coherent/incoherent spatial flow structures that arise in three-dimensional steady as well as unsteady phenomena. For this purpose, it is very attractive to develop a technique that allows instantaneous capture of three-dimensional fields by inter-breeding the tomographic concept with holographic interferometry.

Holographic interferometric tomography can thus provide aforementioned various merits; however, aerodynamic wind-tunnel testing confronts formidable challenges for experimental implementation. First, the large-scale test section and the opaque enclosure inhibit instantaneous full angular scanning around the object. Second, the opaque model together with the enclosure blocks a substantial portion of probing beams, causing incomplete projections. The testing environment is also relatively harsh producing a relatively high noise level. The current aerodynamic facilities can typically provide only 30 to 40 percent instantaneous angular scanning and 60 to 80 percent data along each projection line. Under these circumstances of limited data, the reconstructions lead to erroneous results with various artifacts when ordinary computational tomographic techniques, especially those developed in x-ray imaging, are applied. In recent years (1), there have been substantial advances in computational tomographic techniques, which are tailored specifically to interferometric reconstruction of three-dimensional flow fields.

During this summer research period, various possible approaches for accurately reconstructing three-dimensional flows from limited data have been examined. The approach based on the combination of the following three techniques appears to be promising (1).

1. Continuous Local Basis Function Method: This computational tomographic method has a power to accurately reconstruct continuous regions and is appropriate from well-conditioned to moderately limited data.

2. Variable Basis Method: This computational tomographic method provides accuracy near discontinuities, i.e., shock regions, and is appropriate from moderately-limited to severely-limited data.

3. Complementary Field Method: This is a general iterative reconstructor that can be coupled with any computational tomographic techniques. Mathematically, it can be shown that this method can provide better accuracy than the direct reconstruction as in a conventional approach.

Our numerical simulation of experiments demonstrated improved reconstruction results even when these techniques were individually tested. In general, 40 to 60° angular scanning could result in

reliable reconstruction. The fully-combined power of these three methods is expected to far exceed that of any independent technique. The combination is believed to provide satisfactory accuracy even for severely-limited data with 30 to 40° angular scanning and a sizable opaque object in the field. Diffuser illumination can allow instantaneous angular scanning ranging from 30 to 50°. Hence, the combined technique can truly enable instantaneous capture of three-dimensional flows under existing aerodynamic testing environments.

During this summer research, the 15-inch Mach 6 high temperature tunnel at the Experimental Hypersonics Branch was evaluated to find the application feasibility of holographic interferometric tomography. Two typical test fields, whose interferograms might resemble those frequently appearing in practical testing, were selected. For the test fields, their approximate fringe patterns were theoretically calculated and appropriateness of interferometric testing was evaluated. The criteria for the application feasibility study were interferometric signal level and minimum facility modification in setting up experiments. In addition, the strategies for short-term, intermediate-term, and long-term plans for utilizing interferometric tomography have been formulated.

Some facilities cannot allow even the minimum angular-scanning requirement for reasonable tomographic reconstruction. For flow field reconstruction under this circumstance, a new holographic technique that is termed planar slicing interferometry has been studied (2). This technique, while requiring small optical ports, provides only limited resolution along the observation direction. The technique can be attractive for local region examination with restricted accessibility at the expense of resolution and accuracy. The schematic of the initially formulated system is shown in figure 1. The measurements in the observation planes along the optical axis yield the one-dimensional Fourier transforms of sliced sections of the test object. After reassembling and inverting the Fourier transforms, the object can be reconstructed. The accuracy and practicality of the method needs to investigated. Further modification and elaboration of the system shown here is necessary as the research progresses in the future.

1. S. S. Cha, Holographic Interferometric Tomography for Reconstructing Flow Fields; a Review, AIAA paper 92-3934, 1992

2. F. O. Weinberg and N. B. Wood, Interferometer Based on Four Diffraction Gratings, J. Sci. Instrum., 36, 227 (1959).

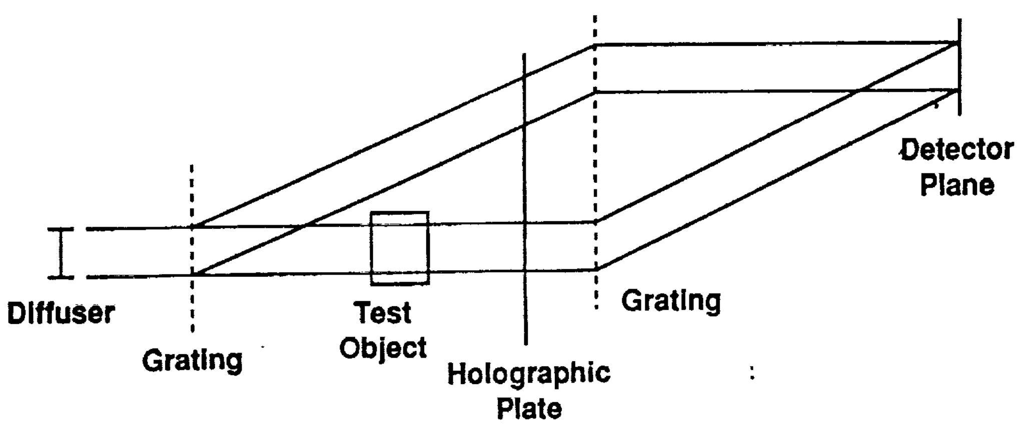

Figure 1. Schematic for planar slicing holographic interferometry

N93-16766

PHYSICAL AGING AND SOLVENT EFFECTS ON THE FRACTURE OF LaRC-TPI ADHESIVES

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When amorphous materials are quenched below their glass transition temperature, excess enthalpy is trapped in the glassy material because the viscosity is too great to allow the material to remain in volumetric equilibrium. Over time, this excess free volume is reduced as the material slowly approaches its equilibrium configuration. This process, known as physical aging, leads to substantial changes in the constitutive behavior of polymers, as has been widely discussed in the literature [1]. Less is known about the effects of this physical aging process on fracture and fatigue properties of aged materials [2]. The original goal of the summer was to investigate the effects of physical aging on the fracture and fatigue behavior of LaRC-TPI, a thermoplastic polyimide developed at NASA-Langley. Preliminary results are reported, although a lack of equipment availability prevented completion of this task. In the process of making specimens, the current LaRC-TPI, produced by Mitsui Toatsu, was observed to be extremely susceptible to environmental stress cracking [3]. A study of the unique failure patterns resulting from this degradation process in bonded joints was conducted and is also reported herein.

The first step in studying physical aging was to identify the aging kinetics for the LaRC-TPI material system. Specimens were subjected to short aging times, and loaded to measure the momentary creep compliance response, as shown in Fig. 1. This testing was conducted at VPI because of a lack of suitable equipment at NASA. These creep compliance curves were shifted in log time space to form the smooth master curve as indicated. Collecting data at several different temperatures allowed us to establish preliminary aging kinetics for this polymer, as illustrated in Fig. 2. These results seem quite consistent with those reported in the literature [1].

Fracture and fatigue testing of aged specimens was planned for neat polymer samples (notched 3-point bend, ASTM E-399) and bonded joints with titanium adherends (double cantilever beams (DCB)). Specimens were fabricated and subjected to aging times of 1, 10, 100, and 1000 hours at 350°F and 400°F. These temperatures were selected to simulate anticipated skin temperatures for the HSCT. Testing of these specimens was not completed, although plans are being made to complete the testing in the near future. Additional specimens continue to be aged in order to achieve 10,000 hour of aging time.

Although previous LaRC-TPI materials do not show susceptibility to environmental stress cracking, the Mitsui Toatsu versions of this material system have been end-capped at a carefully controlled molecular weight in order to optimize processing. Apparently the reduced molecular weight has resulted in a material which is highly susceptible to a variety of organic solvents including acetone, diglyme, methyl ethyl ketone, and toluene [3]. In the presence of these solvents, the molecular entanglements are no longer sufficient to maintain structural integrity. The combination of even small stresses and any of these solvents results in profuse cracking. When the polymer film is constrained by an adherend, as when used as an adhesive or coating, very interesting cracking patterns result, as shown in Fig. 3. The polymer is under residual in-plane tensile stresses from the cool-down process. The solvent weakens the material and allow "mud cracking" to occur to relieve these stresses. Of particular interest are the curious spiral fracture patterns which spiral inward over time, as shown in Fig. 4. Although a recent reference to spiral cracks growing outward from an inclusion has been found [4], the phenomenon we have observed does not appear to have been reported in the literature. A number of interesting micrographs and video tapes of this failure process have been obtained.

Slightly bent films of the Mitsui Toatsu LaRC-TPI exposed to solvent immediately fracture, suggesting the tremendous drop in strength of these materials because of the environmental stress cracking phenomenon. If the solvent is allowed to dry, however, the strength returns, perhaps to original levels in the free films which have not sustained any damage. Since bonded joints exposed to even small amounts of solvent will crack profusely, we were interested to measure the effects of prior solvent exposure on bonded joint strength. DCB specimens were tested in accordance with ASTM D-3433 in order to obtain the propagation and arrest values of the material's strain energy release rates. The crack length was corrected using modified beam theory, and good correlation was observed with theoretical compliance, as shown in Fig. 5. Typical results for the critical strain energy release rates, as a function of crack length are illustrated in Fig. 6. A summary of the propagation (by 5% offset/maximum load method) and arrest values are given in Fig. 7 for several different exposures. It is seen that while the strength is significantly reduced when liquid solvent is present, there appears to be no substantial strength reduction in joints which have been exposed to solvents and then dried. This is somewhat astonishing in light of the severe damage which is present in the exposed specimens. A possible explanation is recognized by realizing that all of the observed damage cracks are nearly perpendicular to the bond plane. Since the DCB specimen is a mode I test, these cracks are not aligned with the mechanically induced fracture surfaces. The highly fragmented adhesive layer lacks continuity, so can no longer be under plane strain loading conditions. The relieved constraint and the crack stopping ability of the individual adhesive prisms seems to result in no substantial strength reduction if all of the solvent has been removed. The long term durability of these damaged joints would be of great concern, however. Of particular interest would be to determine if solvent induced cracks in these materials can be used as an accelerated characterization technique to predict damage states which result over time without solvents.

Finally, a special loading technique was developed in order to assist in pre-cracking notched 3 point bend fracture specimens [5]. By making use of the concept of the kern for a cross-section, an eccentric compressive load is applied to the specimen to allow a crack to be tapped into the specimen without severing the sample. By making the load eccentric, the large compressive stresses at the notch root are eliminated, and a more favorable stress field is induced to permit pre-cracking of the specimens in order to utilize them as fracture specimens.

1) L C E Struik, *Physical Aging in Amorphous Polymers and Other Materials*, Elsevier, 1978.

3) J P Berry, *Journal of Polymer Science: Part A*, 2 (2), 1964, p 4069.

4) L B Freund and K S Kim, "Spiral Cracking around a Strained Cylindrical Inclusion in a Brittle Material and Implications for VIAS in Integrated Circuits", *Materials Research Journal*, 1991.

5) J G Williams and M J Cawood, "European Group on Fracture: K_c and G_c Methods for Polymers", *Polymer Testing*, 9, 1990, p15-26.

2) G Allen, D C W Morely and T Williams, "The Impact Strength of Polycarbonate", *Journal of Material Science*, 8, 1973, 1449-1452.

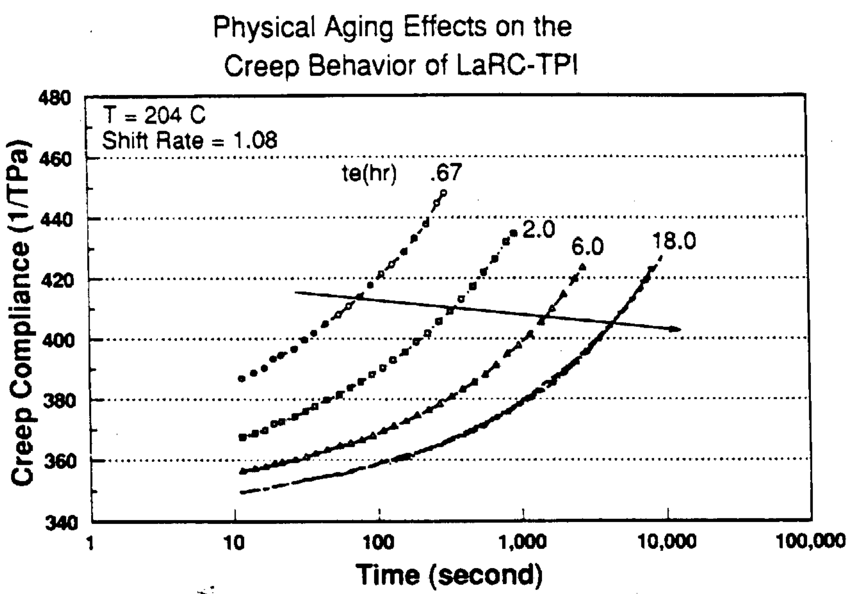

Figure 1. The effect of aging time on the creep compliance of LaRC-TPI at 204°C.

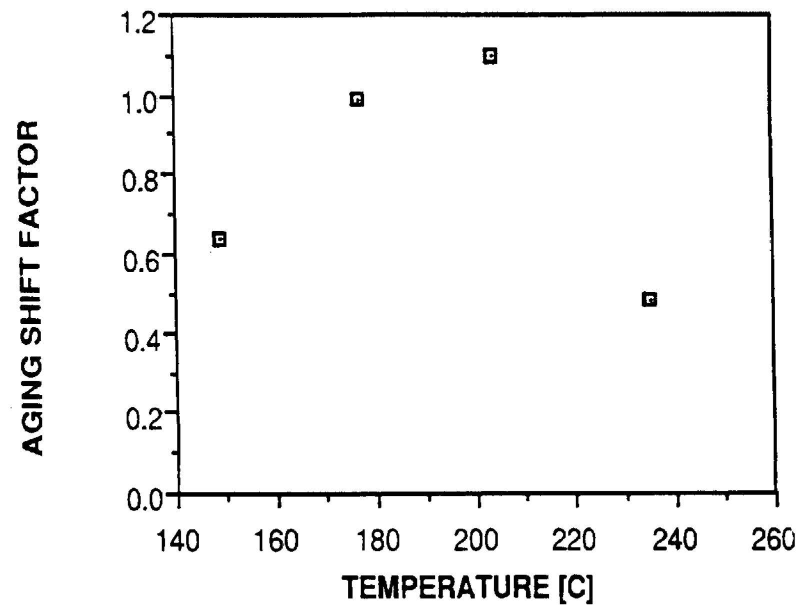

Figure 2. Preliminary physical aging kinetics for LaRC-TPI at several temperatures.

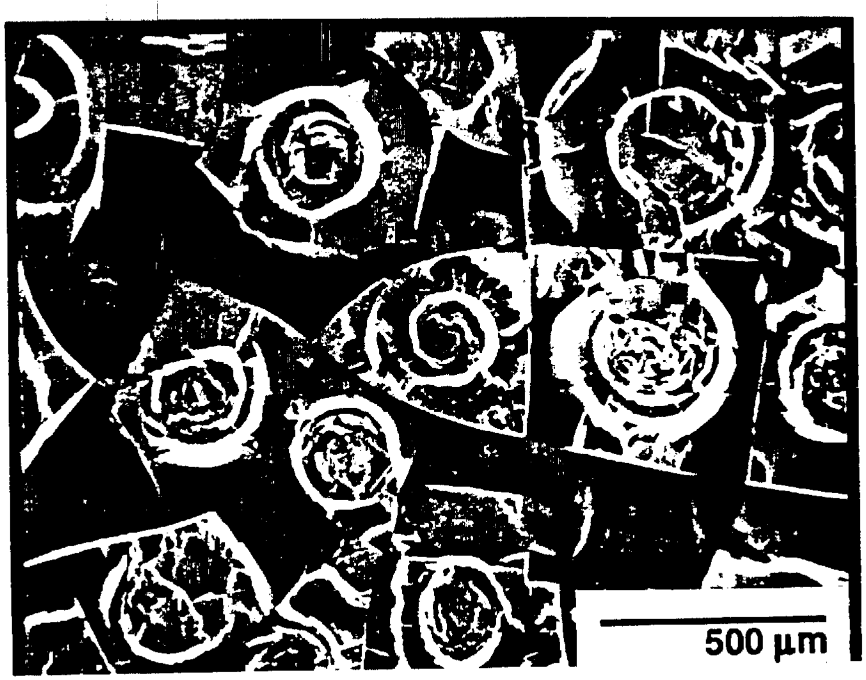

Figure 3. LaRC-TPI adhesive exposed to diglyme, showing fragmented adhesive layer.

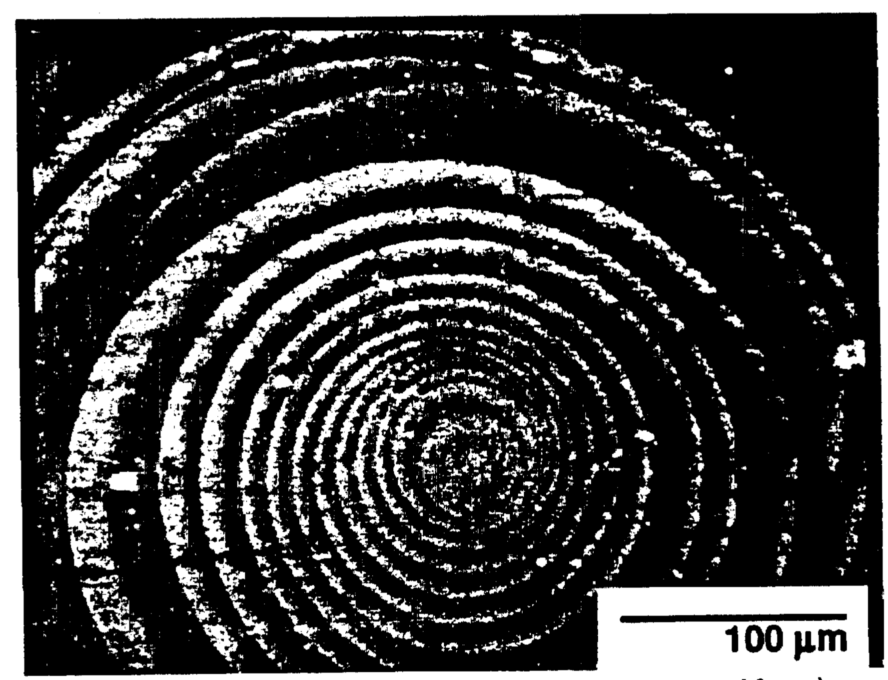

Figure 4a. Subsurface spiral cracks on a LaRC-TPI adhesive layer removed from glass.

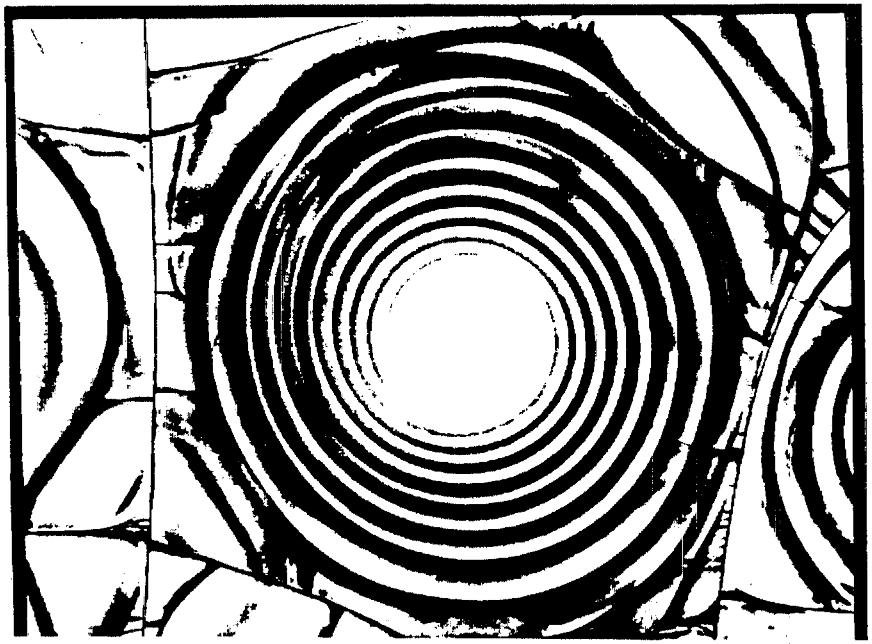

Figure 4b. Spiral crack in a LaRC-TPI adhesive bonded between glass slides.

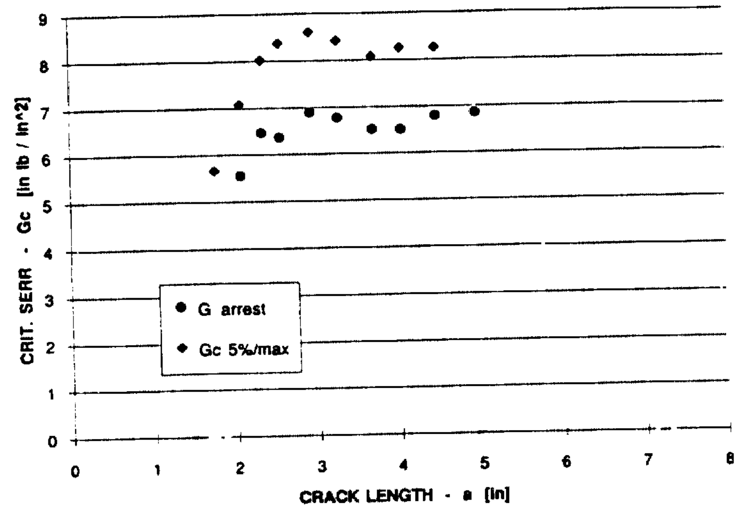

Figure 6. Typical strain energy release rates for a titanium / LaRC-TPI DCB specimen.

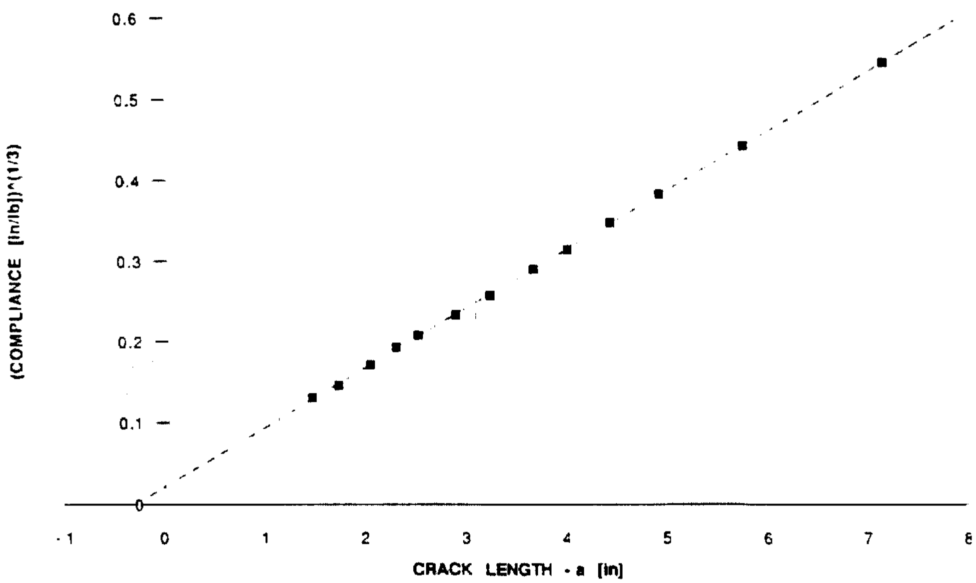

Figure 5. Effective crack length determination by modified beam theory.

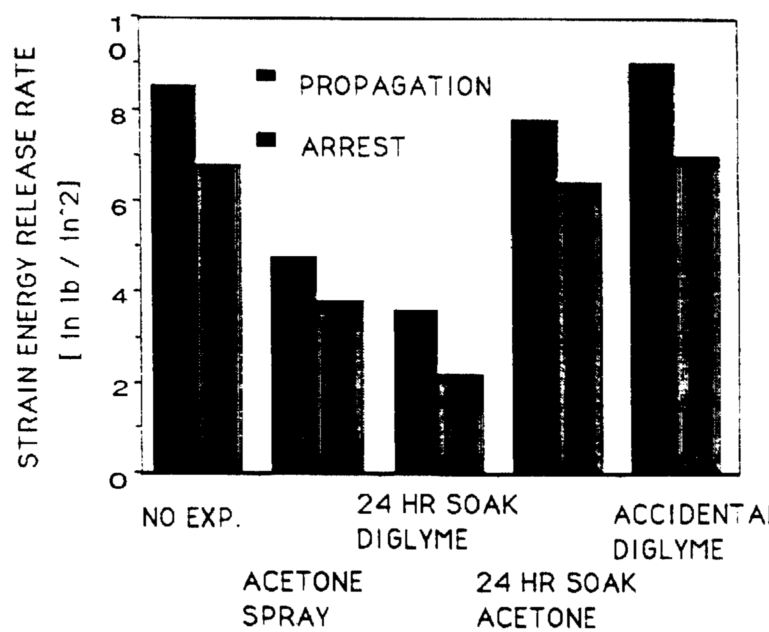

Figure 7. The effect of exposure on the fracture resistance of Ti / TPI DCB specimens.

N93-16767

FATIGUE DAMAGE STUDY IN ALUMINUM-2024 T3 ALLOYS

by

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Fatigue behavior accounts for a majority of service failures in ground, air, and sea vehicles. Cyclic stress-strain deformations may alter the microstructure of a material thereby leading to instabilities that determine the fatigue performance. Therefore, in order to understand fatigue properties in a fundamental sense, it is essential to characterize these materials on a microscopic level. The size, shape, and orientation of grains in polycrystalline materials are known to have profound effects on strength, residual stress, and magnetic behavior, respectively (ref. 1). Consequently, the purpose of this study is to investigate the grain structure of aluminum 2024, a commonly used commercial alloy, and to correlate these findings with the fatigue property of the material.

X-ray diffraction is a powerful method used to evaluate crystalline quality (ref. 2). A technique which is especially sensitive to crystal structure analysis is the x-ray rocking curve (XRC). The XRC is initiated by scanning the sample to find the Bragg angles. Subsequently, the sample is mounted on a goniometer at a particular Bragg angle and irradiated by a highly monochromatic x-ray beam while being rotated ("rocked") step by step about this angle. At each step, the reflection intensity is acquired and recorded by a computerized data system. A plot of the reflecting power as a function of the angle between the sample surface and the incident x-ray is the rocking curve. The degree of orientation and information on grain size is determined by the width, position, and smoothness of the XRC relative to the normal scan.

Samples of aluminum 2024 were polished and etched in different reagents. Optical micrographs (at 500X) of samples etched in Keller's reagent revealed grain boundaries as well as some particles present in the microstructure. Normal x-ray scans of samples etched for different intervals of time in Keller's reagent indicates no significant variations in diffraction peak positions; however, the width of the rocking curve increased with the time of etching. This results is consistent with the direct dependence of the width of the rocking curve on the range of grain orientation. Etching removes the preferred orientation layer of the sample produced by polishing; thereby, causing the width to increase.

Samples of aluminum 2024 which are currently being fatigued will be investigated.

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PRELIMINARY EFFORTS TOWARD DEVELOPMENT OF DATA HANDLING AND ANALYSIS SOFTWARE FOR UNSTEADY FLOW MEASUREMENTS: AN APPLICATION FOR AEROELASTIC TRANSONIC FLOW CONFIGURATIONS

by

N93-16768

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A few years ago the Structural Dynamics Division at LaRC started ambitious experimental research efforts known as the Benchmark Models Program. The primary objective of this program was to provide experimental data that may serve as a calibration source for CFD efforts that deals with aeroelastic unsteady flow configuration. It also focuses on the understanding of complex flow phenomenon associated with unsteady flow developments. The overall plan for the program has been described by Bennett, et al. (1991), including a presentation of initial test results of flutter of a rigid wing mounted on flexible supports. Figure (1), shows an example of a test model employed to measure the dynamic response along with corresponding pressure distributions. This model incorporates eighty pressure transducers distributed along two spanwise stations. In addition, the models are equipped with four accelerometers and two strain gages. Additional results of testing on this model are reported by Rivera, et al. (1991).

Comments on the Flow Problem

The complexity of unsteady flow developments and the large associated parameter space imposes severe limitations on most research efforts. As sketched in Figure (2), unsteady aeroelastic flow configurations may encounter a wide range of complex flow developments such as boundary layer separation and transition, vortex developments & interaction, and shock wave formations & oscillations. The recent research efforts and limitations are reviewed by Edward and Malone (1991). In addition to the complexity of flow developments, the large parameter space of the flow problem limited even ambitious research programs to spot investigations. The efforts of the Benchmark Models Program are aimed toward minimizing these limitations by performing quantitative and qualitative parametric studies. However, this type of experimentation leads to acquiring large data sets that demand development of a specialized data handling and analysis system. The purpose of such a system is to provide a reliable tool designed specifically for data gathering, reduction, storing, and analysis for unsteady flow measurements. The development of such a system is essential in providing an adequate environment for performing parametric analysis that surveys the dependence of the main parameters of the flow problem.

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Present Effort and Sample Results

The data handling system for the Benchmark Model Program is currently under development. As a part of these efforts, a preliminary effort toward the development of such a system was conducted. Several interactive computer routines designed for user interface, dynamic memory allocation, unsteady flow measurements data extraction, and further data processing were developed. As shown in Figure (3), based on a specified user input, a main driver can activate several utilities designed to extract experimental measurements and perform requested analysis. These utilities were written in the C programming language for the UNIX environment. Two-dimensional and three-dimensional Fortran plotting routines, developed initially by Bland (1992), were modified and integrated into the developed package.

The developed software was tested by using several data files for the 0012 Benchmark model. To present a few examples of measured data, the unsteady pressure distributions and the wing model dynamic response were plotted. Figure (4) shows a three-dimensional plot of streamwise unsteady pressure distributions along with a two-dimensional plot showing a movie frame of instantaneous pressure. In Figure (5), the pressures were subtracted from the mean pressure distribution and plotted. Figure (6) shows an example of maximum, minimum, and mean pressure distributions over the wing model upper surface. Figure (7) shows an example of wing vertical and angular amplitudes and their corresponding phase plots. This data was obtained by strain gages that measure the bending and torsion of the flexible apparatus that holds the wing model. It is hoped that this initial effort will be extended to develop the needed interactive software for efficient pre and post data processing and analysis system. This system is a key element to accomplish the objectives of the Benchmark Models Program.

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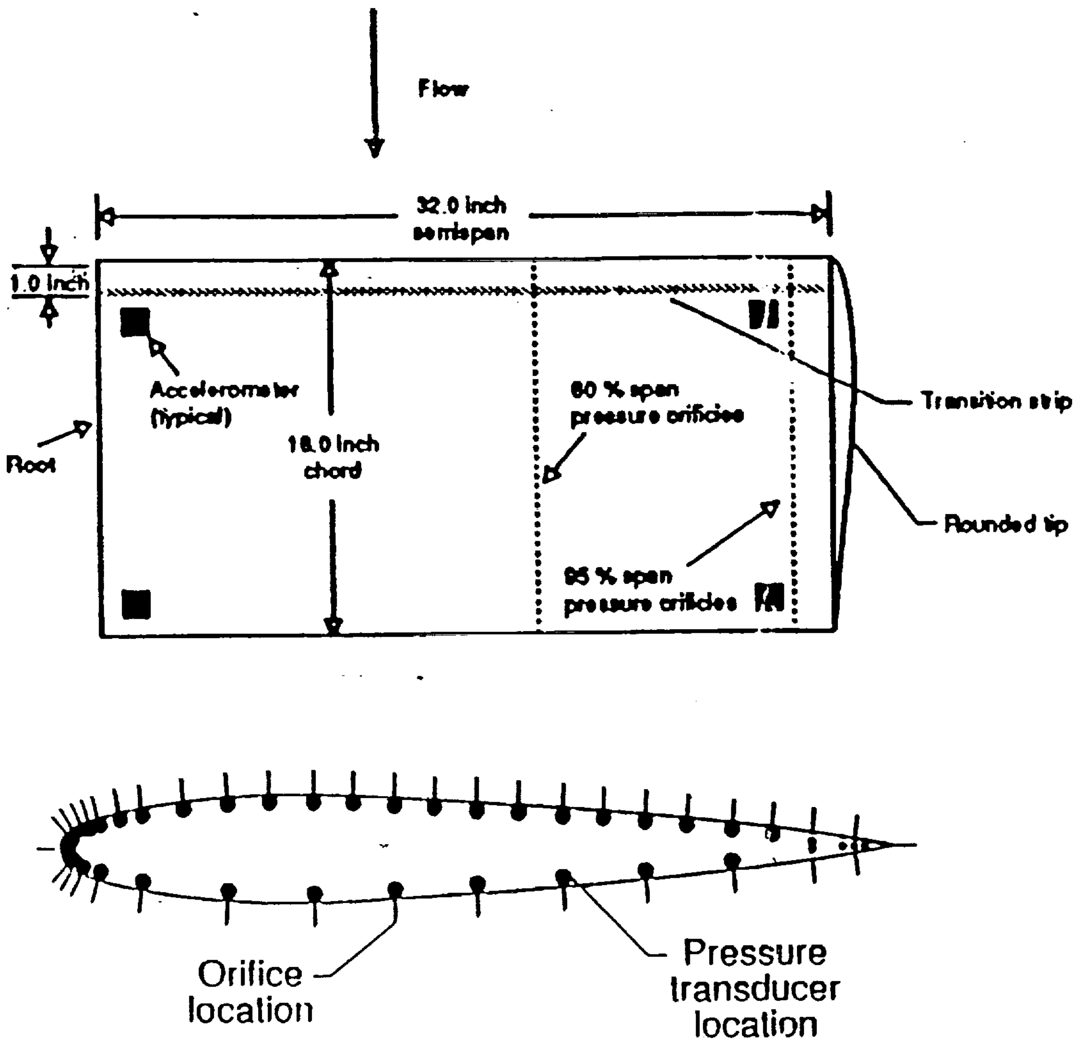


Figure 1. An example of a test model used in the Benchmark Models Program. (Taken from Ref. 4)

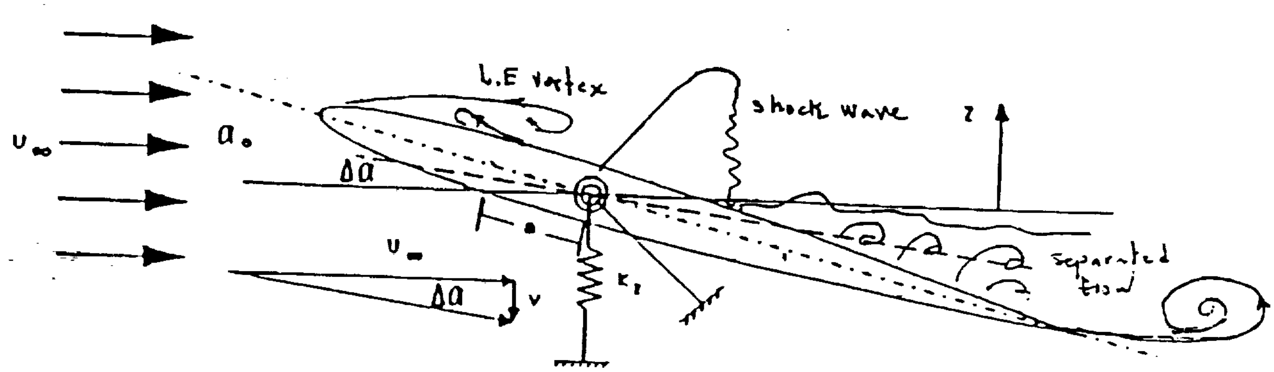
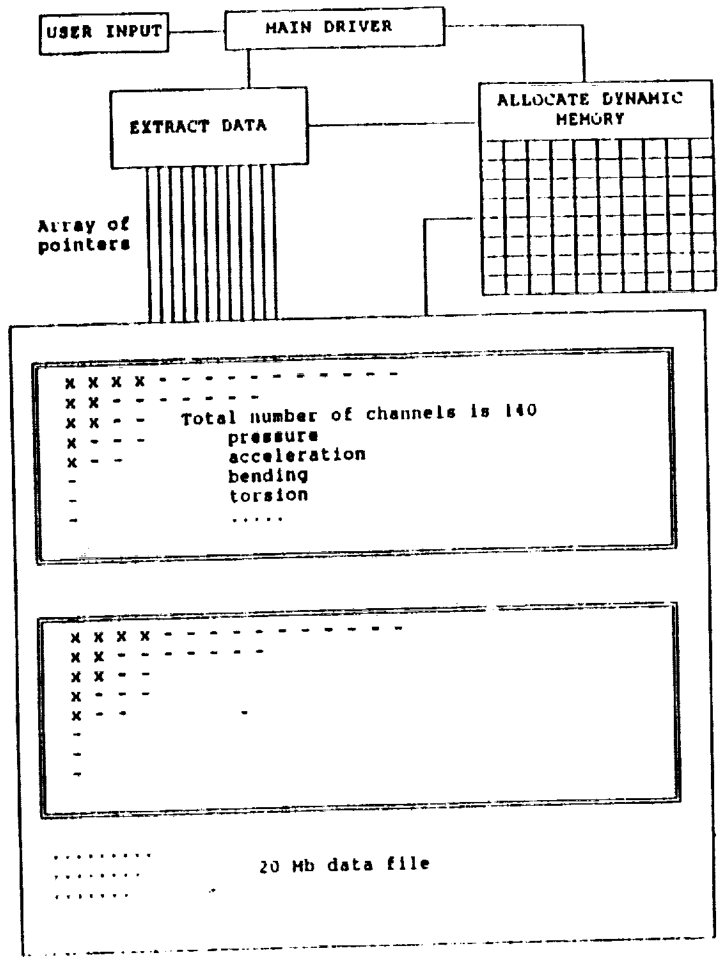


Figure 2. Schmatic of a wing model mounted on elastic supports (Taken from Ref. 3)



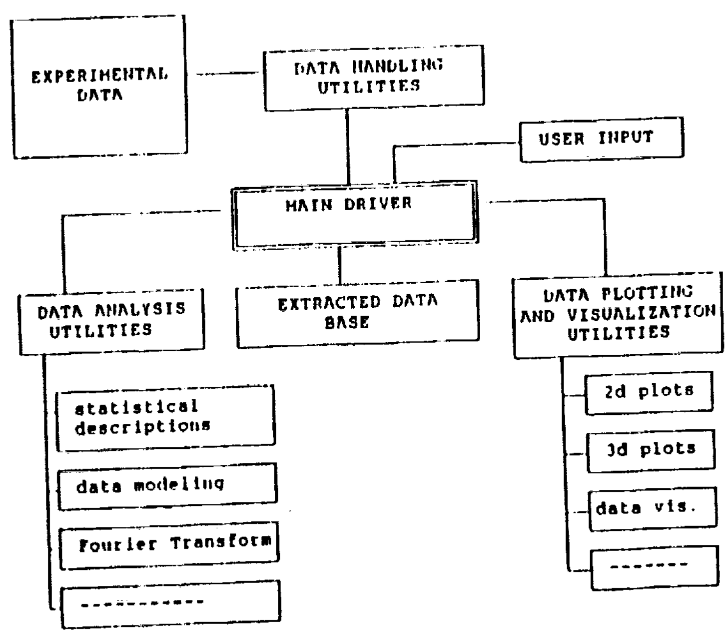


Figure 3. A schematic of developed data handling and analysis setup

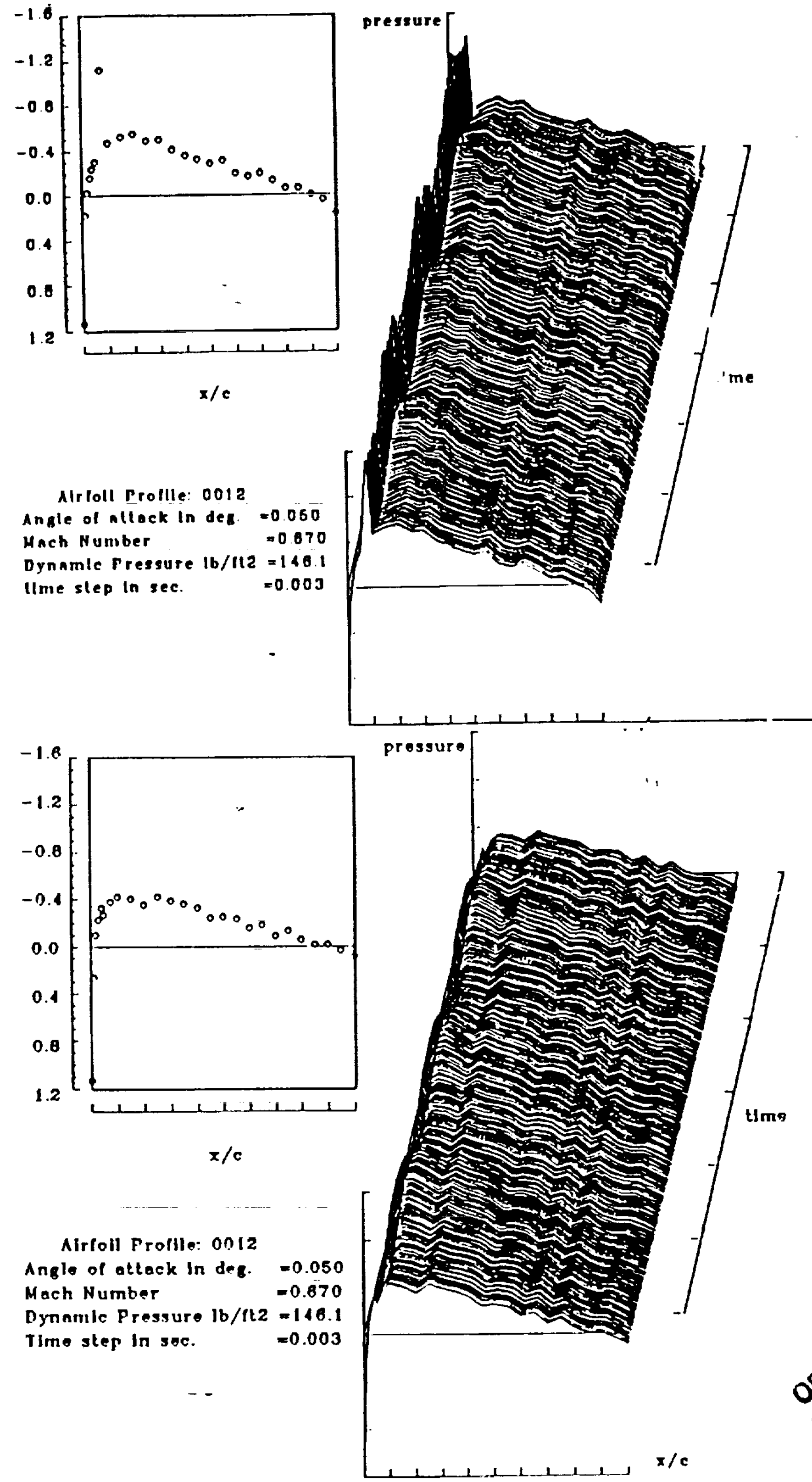


Figure 4. An example of streamwise unsteady pressure distribution over the wing model upper surface.
(Top: along 60% span, Bottom: along 95% span)

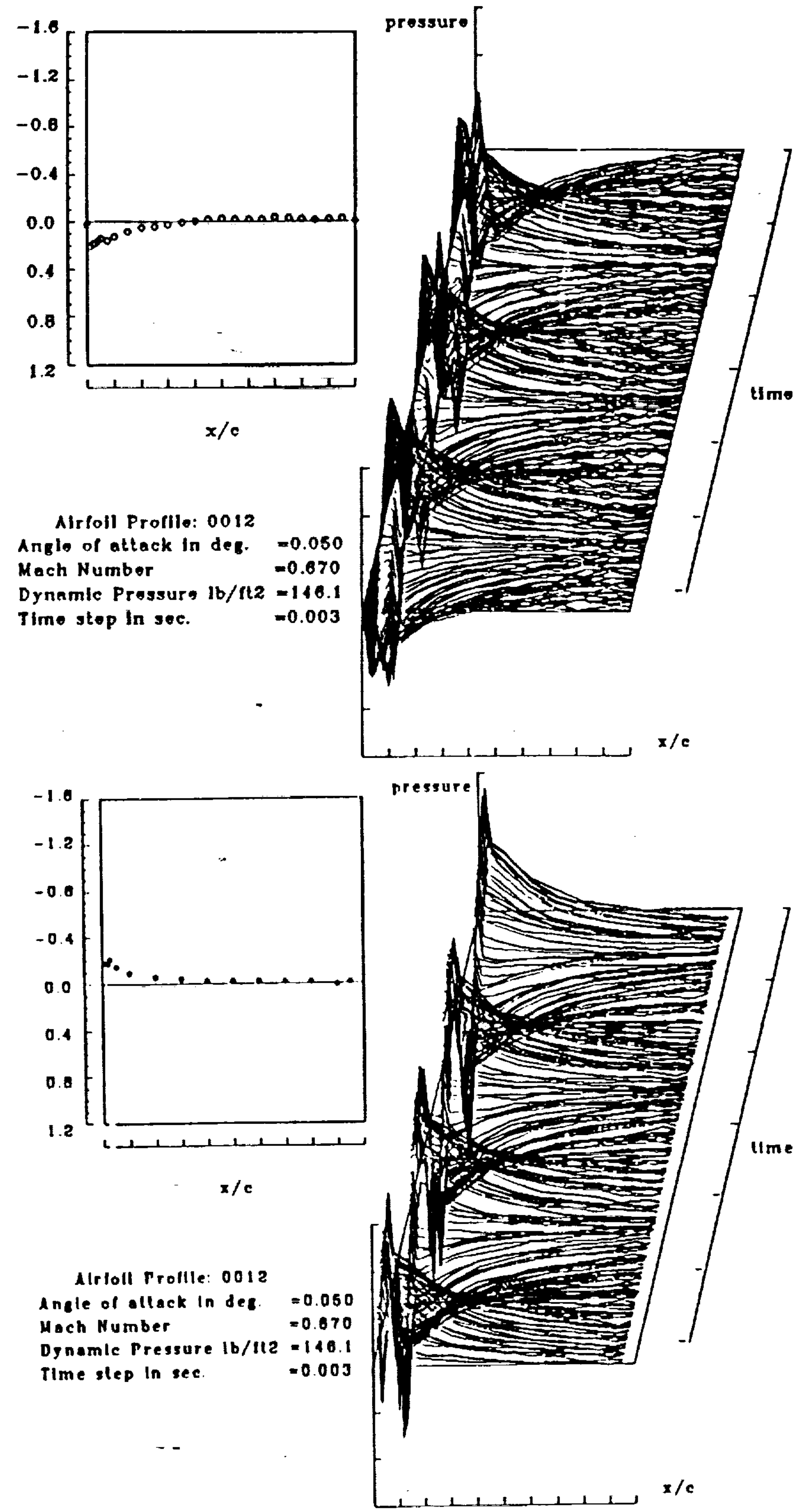
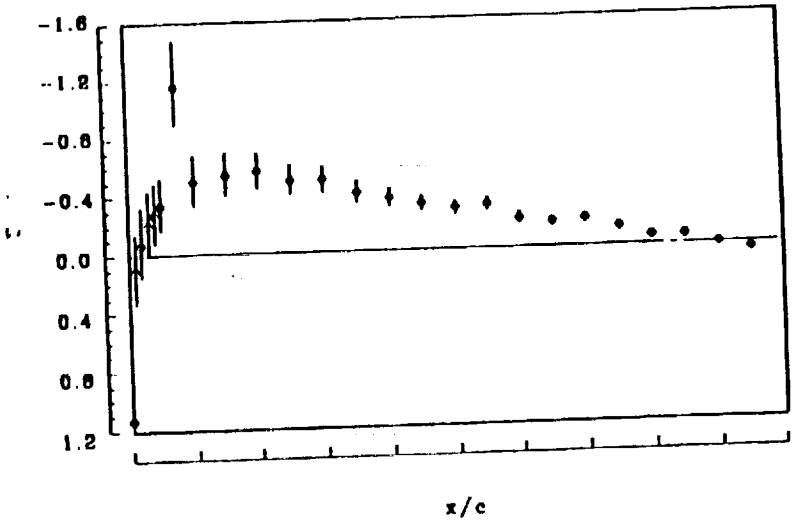
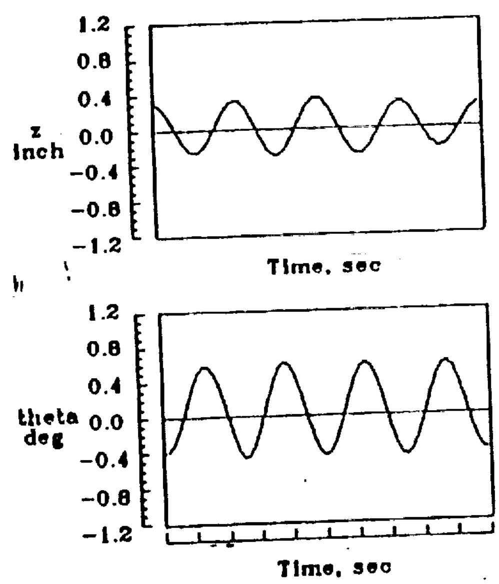


Figure 5. An example shows pressure distribution subtracted from mean pressure
(Top:upper surface, Bottom:lower surface)



Airfoil Profile: 0012
Angle of attack in deg. =0.060
Mach Number =0.670
Dynamic Pressure lb/ft2 =146.1
Time step in sec. =0.003

Figure 6. An example shows maximum, minimum, and mean pressure distribution over the wing model upper surface.



Angle of attack in deg. =0.060
Mach Number =0.624
Dynamic Pressure lb/ft2 =159.5
Time step in sec. =0.003

Figure 7. An example shows wing model vertical and angular response

Developing a Control System for ARES II

N93-16769

by

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Abstract

A great deal of analysis and testing is conducted at the NASA Langley Research Center to support the development of safe and reliable helicopter rotor systems. This work is performed by the Rotorcraft Aeroelasticity Group located in the Transonic Dynamics Tunnel (TDT) facility. Over the past two decades a wide variety of tests have been successfully conducted in the TDT and their results have contributed significantly to the understanding of aeromechanical phenomena in rotor systems. This has led to improved tools for analysis and design, and ultimately to the development, of improved rotor systems. The TDT facility is ideally suited for these tests due to its unique ability to use a heavy gas as a working medium. This allows the model to be scaled such that the results obtained may be readily extrapolated to full scale.

Until recently, the rotor system to be tested has been mounted on a fixed balance which is attached to the longeron which is attached to the stand through a single pitching degree of freedom. The testbed used is known as the Aeroelastic Rotor Experimental System (ARES I) and is shown in the test section of the TDT in Figure 1. ARES I has been used extensively and is well suited for rotor dynamics, loads and performance tests. Another testbed is available to investigate specific rotor/body dynamic coupling. It allows for pitch and roll of the balance relative to the longeron and uses elastomeric springs and rotary viscous dampers to control the stiffness and damping of the pitch and roll axes. This system is referred to as ARES 1.5 and is shown in Figure 2. In order to extend the experimental capabilities to investigate the full rotor/body dynamic coupling present in a rotorcraft, a very ambitious project has been undertaken to design and construct a six degree of freedom system that can be controlled so as to emulate the inertial characteristics of a prescribed model fuselage. The electronic and mechanical hardware for this system has already been designed and constructed. This system is known as ARES II. The mechanical layout of this new testbed is shown in Figure 3 without the rotor system. The rotor and its drive system are mounted on the balance which is attached to the longeron via six hydraulic actuators. This six degree of freedom parallel linkage is referred to in the literature as a Stuart Platform. By properly adjusting the length of the hydraulic actuators it is possible to position and orient the balance relative to the longeron. The longeron is attached to the stand via a pitch degree of freedom to allow testing over various forward flight regimes.

One major task remaining to complete this testbed is the design and synthesis of a control system. To do this properly requires an understanding of the kinematics and dynamics of the system and robust control design. A brief description of the development of a control design over the course of the Summer of 1992 is given below. It was first necessary to determine the kinematics relating the motion of the various components of the testbed. Next, the equations of motion used to describe the dynamics of the system were derived using a Newton/Euler formulation for the sake of simplicity. A FORTRAN simulation was then written to support the control design effort. The topology of the control system was chosen based on the required functionality and simplicity. It consists of three main components. A diagram showing its layout is presented in Figure 4. The first, and most critical component, is six wide bandwidth inner loops to control the motion of each of the hydraulic actuators. The second is the nonlinear transformation relating the desired balance

location and orientation to the required actuator lengths. This allows one to prescribe the desired behavior of the balance over a wide range of frequencies. The final component is a two mode input system. One mode simply allows for direct operator control of the balance position and orientation (switch in the upper position in Figure 4). The other mode allows the operator to prescribe a c.g. location, mass and moments of inertia of a model fuselage and have the balance respond to the rotor forces and moments as if it had the prescribed characteristics (switch in the lower position in Figure 4).

Accomplishments to date include:

1) Familiarization with the electronic and mechanical hardware
2) Familiarization with the intended use of ARES II
3) Determination of the kinematics
4) Derivation of the system dynamics and a FORTRAN simulation model
5) Determination of a control system topology

Work that remains to be done:

1) Finish verification of the simulation model
2) Inner loops controlling the hydraulic actuators need to be closed
3) Implementation of the control in digital/electronic hardware
4) Effects of stand flexibility need to be evaluated

Figure 1   ARES I

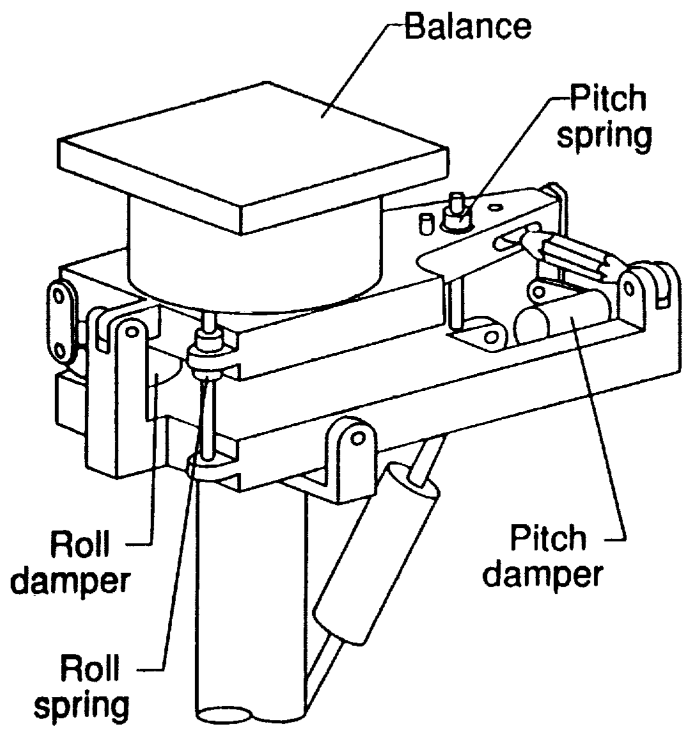

Figure 2 ARES 1.5

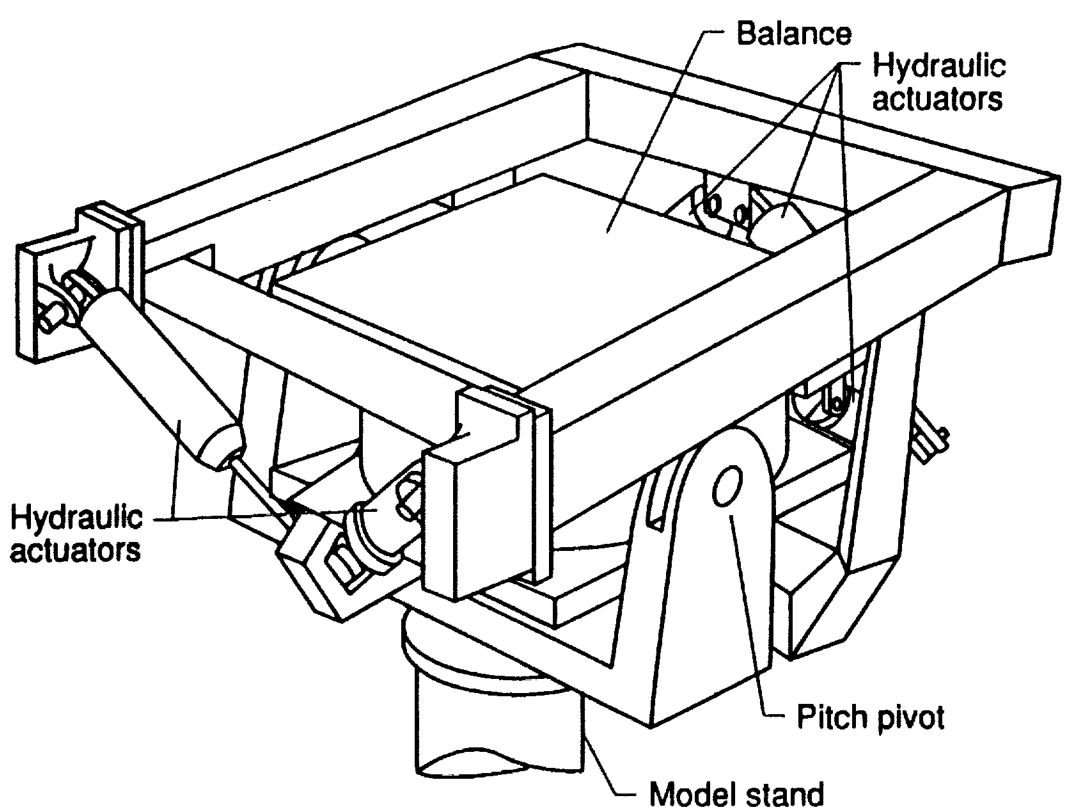

Figure 3 ARES II

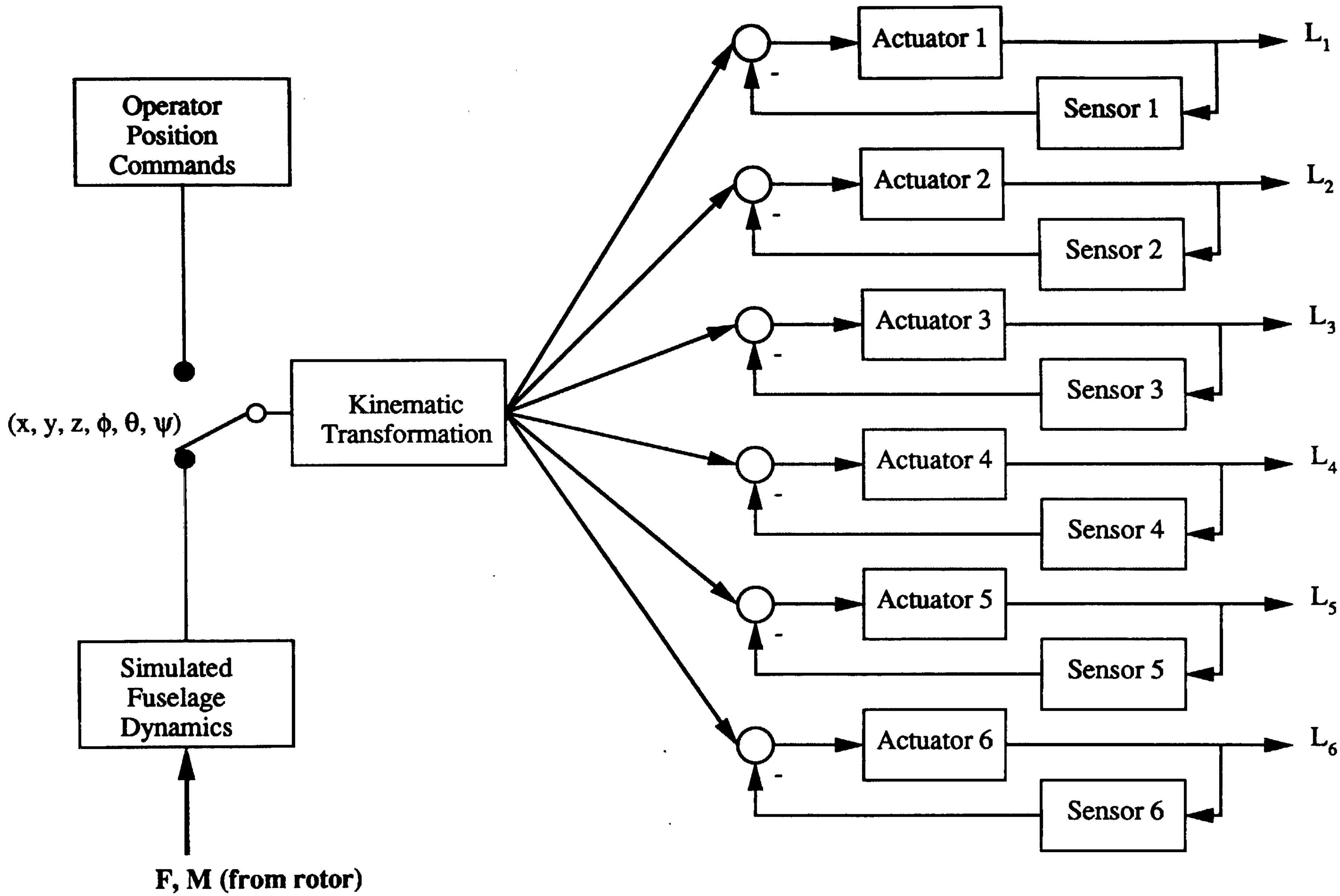

Figure 4 ARES II Control System

N93-16770

Wind Tunnel Seeding Particles for Laser Velocimeter

by

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• INTRODUCTION

The design of an optimal air foil has been a major challenge for aerospace industries. The main objective is to reduce the drag force while increasing the lift force in various environmental air conditions.

Various techniques, over several decades, have been utilized in search of efficient air foil, namely analytical, computational and experimental. Today each of these methods have been improved, expanded or advanced to provide better insight in understanding of physics of air foils.

Experimental verification of theoretical and computational results is a crucial part of the analysis because of errors buried in the solutions, due to the assumptions made in theoretical work. Experimental studies are an integral part of a good design procedure; however, empirical data are not always error free due to environmental obstacles or poor execution, etc. The reduction of errors in empirical data is a major challenge in wind tunnel testing. One of the recent advances of particular interest is the use of a non-intrusive measurement technique known as laser velocimetry (LV) which allows for obtaining quantitative flow data without introducing flow disturbing probes, e. g. pitot tube. This laser velocimeter technique is based on measurement of scattered light by seeding particles introduced into flow stream in the wind tunnel (1). LV measures the velocity of the particles present in the flow but not velocity of the flow. Therefore for an accurate flow velocity measurement with laser velocimeters two criterions have to be investigated. First is how well the particles track the local flow field. A complex relationship exists between the particle motion and the local flow field. and this relationship is dependent on particle size, size distribution, shape and density. The smaller the particle the better the response to flow fluctuations and gradients and therefore the more accurate velocity measurement. Second is the requirement of light scattering efficiency to obtain signals with the LV which, in general, is better as particle size is increased. These two criteria are in a direct conflict for which particles should be (2):

- Small enough to follow the flow field
  - Size
  - Shape
  - Density
- Large enough for the LV to "see" it
  - Size
  - Shape
  - Index of refraction

In order to demonstrate the concept of predicting the flow velocity by velocity measurement of particle seeding, the theoretical velocity of the gas flow is computed and compared with experimentally obtained velocity of particle seeding. The result of such a comparison is shown in figure 1, where the theoretically predicted gas velocity is compared with measured laser velocimeter data for a variety of particle sizes with a 0.6 Mach number velocity (3). This figure shows the curve trend for small particles is much closer to predicted gas velocity and for a successful laser velocimeter system the particles would have to be much smaller than 10 microns. Furthermore, figure 2 indicates that one micron particle size has exactly the same velocity as theoretically predicted gas velocity. This illustrates that one micron particle seeding will follow the flow streamline very well.

The desired characteristics of wind tunnel seeding particles can be defined as follows (4):

A. Monodispersed particle size distribution
B. Selectable particle size
C. Large scattering cross section
D. Low mass density
E. Non-toxic, non-contaminating
F. Readily available and reasonably priced

The choice of seeding material for LV applications is limited to using:

- Particles naturally present in the flow
- Injecting liquid droplet in the flow
- Injecting solid particles in the flow

The size of natural particles is generally unknown and very few in number yielding low data rate. This leads to unknown measurement accuracies and long test times. Liquid seeding however usually have fairly wide size distribution which are typically skewed toward the large sizes. Solid particle seeding is the best because of being able to provide large numbers of particles while maintaining their size distribution.

Typical seeding material are Kerosene, Kaolin and Polystyrene. The kerosene vapor after injection into the test section of wind tunnel begins to condense and form larger particles. It has low data rate, therefore undesirable as seeding material. Kaolin (hydrated aluminum silicate clay) is inexpensive, however it is polydisperse, and has nonspherical platelets having aspect ratio of 4/1. Specific gravity and index of refraction for Kaolin are 2.58 and 1.56 respectively.

The best seeding material for wind tunnel is Polystyrene (2) which satisfy the following characteristics:

- Solid particles
- Low density (1 gm/cc)
- High index of refraction (1.56)
- Capable of being made monodisperse
- Capable of being made spherical

The above wind tunnel seeding materials are not suitable for high temperature flow testing. For high temperature testing various metal oxide powders are used because of their high melting points (3). Typical material used are:

Material	Index of reflection	Density(gm/cc)	Melting temp. °F
MgO	1.74	3.98	5072
Al_2O_3	1.76	3.96	3660
TiO_2	2.6-2.9	3.7-4.1	3326

These materials however are polydispersed and not very desirable for LV seeding purposes because of formation of large agglomerates which do not closely follow the flow velocity. A hydrophilic material described as flame phase silica is usually used in break up of agglomerates. However it will only reduce the agglomerates in metal oxide power aerosols yielding a narrow band polydispersed seeding.

POLYSTYRENE PREPARATION

The preparation of wind tunnel seeding particles is well developed. A typical procedure used here to produce polystyrene seeding was formulated in LaRC (5). The monodisprese spherical polystyrene can be prepared for various particle diameter sizes according to table 1. The particle diameter depends on the required flow velocity in wind tunnel and LV used in velocity measurement. Following is the procedure used here to prepare polystyrene seeding particles:

- A water bath filled with tap water is heated to reach 65 °C.
- A pyrex reaction kettle is filled with 2369 (ml) high purity distilled water, 56 (ml) magnesium sulfate, and 265 (ml) styrene. An agitator is also placed in reactor and then it is covered.
- The reactor is placed in the water bath until the temperature of the mixture reaches 65 °C. During this period nitrogen gas is flowing through the mixture to purge all oxygen with the agitator turning at a rate of 150 RPM.
- Potassium persulfate solution was added to the reactor at 65 °C.
- For polymerization to take place, the mixture was run for 18-24 hours. At the end of this period the reactor was removed from the water bath and filtered through 100 mesh cheese cloth into a clean storage container. The measurement of particle size showed that polystyrene particle of 1.9 μM diameter size was produced. Polystyrene of typical sizes are shown in figure 3.

This procedure seemed simple and straight forward, however, it has to be done carefully, with exactness and most of all it needs experience to produce particles with the desired diameter size. In general repeatability is the hardest part because a slight change in the variables causes the particle diameter change drastically.

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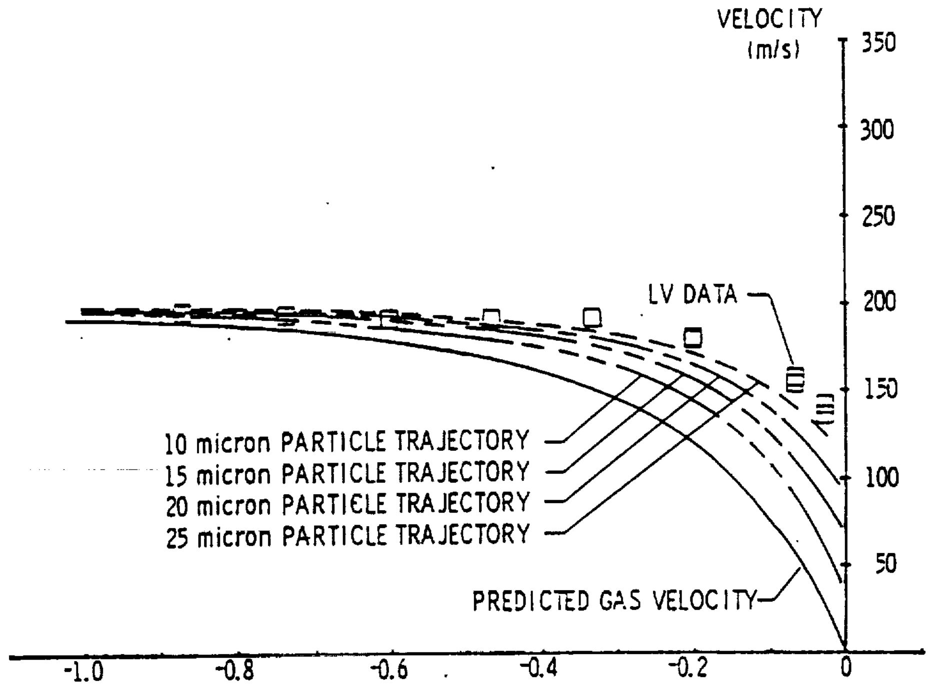

FIGURE 1

COMPUTED LAG OF A ONE-MICRON PARTICLE IN HEMISPHERE FLOW FIELD

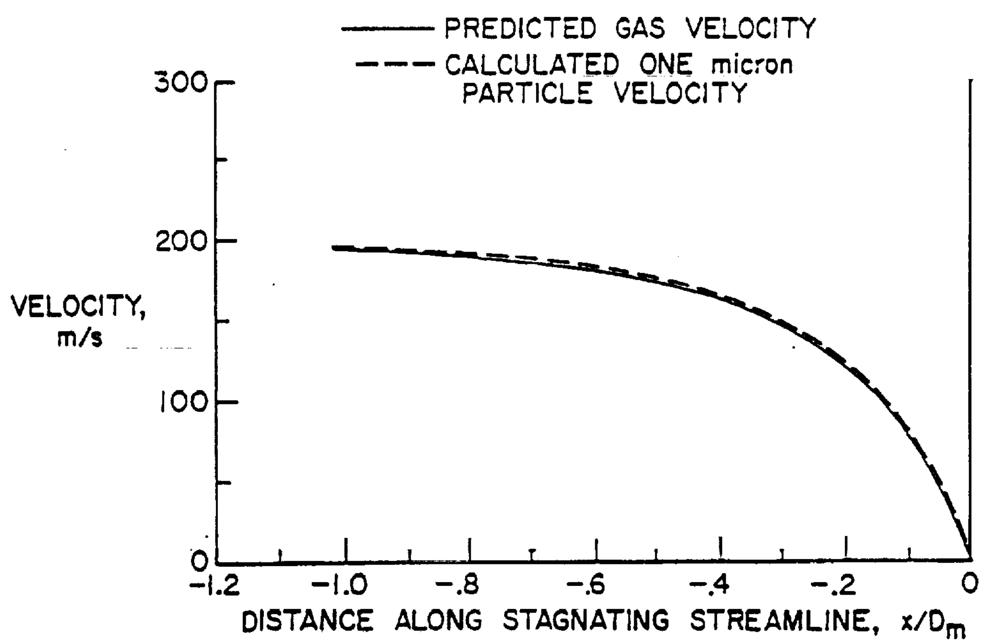

FIGURE 2

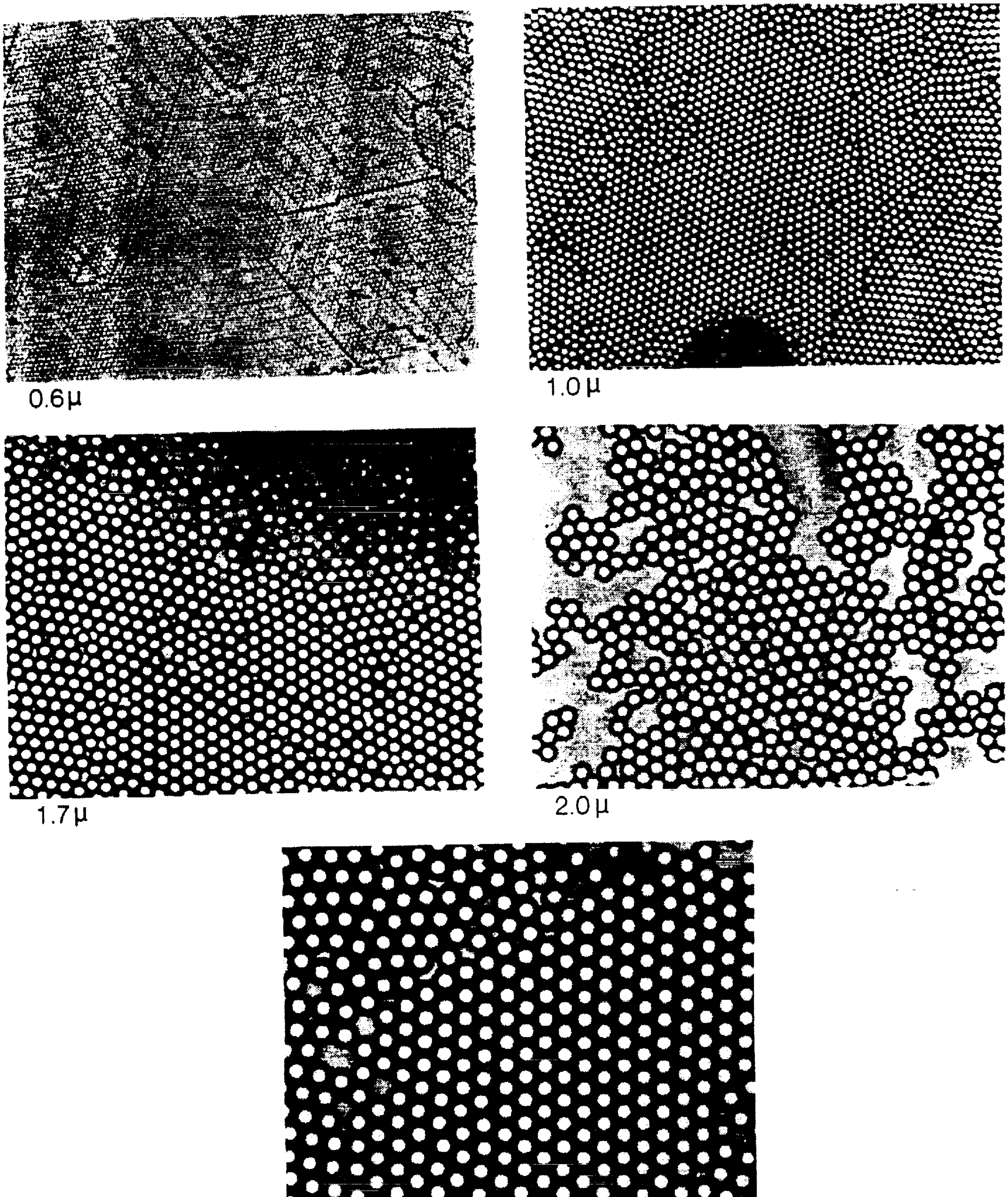

Figure 3 – Polystyrene Microspheres (2000x)

TABLE 1

FORMULATIONS FOR POLYSTYRENE LATEX, MONODISPERSE, SPHERICAL

	Particle diameter, microns				
	0.6	1.0	1.7	2.0	2.7
Water (ml)	2849	2329	2369	2200	2339
Magnesium Sulfate (ml)	-0-	56	56	56	56
Styrene (ml)	265	265	265	265	263
Potassium Persulfate (ml)	46	150	110	278	139

N93-16771

NEAR-WALL RECONSTRUCTION OF HIGHER ORDER MOMENTS AND LENGTH SCALES USING THE POD

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ABSTRACT

An analysis of the near-wall behavior of the proper orthogonal decomposition (POD) eigenfunctions[1] derived from direct numerical simulation (DNS) of channel flow[2] is performed. Consistent with previous studies, a low order multi-mode reconstruction of the kinetic energy and Reynolds shear stress suffices. A similar reconstruction of the isotropic dissipation rate is shown to be insufficient, however. An analysis is performed of the multi-mode composition of the dissipation rate in the near-wall region, and it is shown that a significant number of higher-order modes are required to achieve the correct asymptotic consistency in the near-wall region. In an attempt to avoid this problem, a length scale definition is proposed in terms of an integration of the correlation tensor which factors in the presence of the wall. The wall is accounted for by only integrating out to $2y^+$ and not over the entire domain. Viscous and inviscid estimates for the dissipation were used in the near-wall and core regions respectively, in conjunction with this length scale representation to obtain an estimate of the dissipation throughout the domain. The resulting dissipation exhibits the proper behavior near the wall and in the inertial layer. A 1 POD mode estimate of the length scale is computed and found to agree quite well with the length scale obtained when the entire correlation tensor is used.

Figure 1 shows the near-wall asymptotic consistency of the POD reconstruction of the kinetic energy and shear stress. As can be seen, even a first mode reconstruction has the correct functional behavior in both cases. Higher order modes contribute to the correct amplitude level so that with the seven mode reconstruction the correct near-wall asymptotic behavior results.

Figure 2 shows the reconstruction of the turbulent dissipation rate ($\epsilon^+ = \overline{\left[\frac{\partial u_i}{\partial x_j}^2\right]}$. The figure shows only the contribution from the terms which are derivatives of distance from the wall. The 1D POD reconstruction can only handle these terms directly while the remaining terms can must be obtained using symmetry assumptions. It suffices here to present only the contribution that can be obtained directly. As the figure shows several modes are needed to accurately reproduce the near-wall behavior from the DNS results.

Figure 3 shows the length scale L_{ii} computed 2 different ways; the dashed line represents the scale obtained by accounting for the wall and the solid line that obtained by integrating out over the entire domain. Note how the latter definition blows up at the origin which demonstrates the need to factor in the wall. Figure 4 shows the a calculation of the dissipation from the length scale which factors in the wall and the kinetic energy, compared to the dissipation computed directly from the DNS results. Note the proper behavior for $y^+ < 5$ and $y^+ > 30$ and the discrepency for $5 < y^+ < 30$. It is possible to argue that this discrepency is due to an inappropriate definition for the dissipation (in terms of the kinetic energy and length scale) in this buffer layer and *not* the length scale. A formal matching procedure may be a useful approach for this region. Figure 5 shows a 1 POD mode estimate of the length scale (the dashed line) compared to the length scale computed earlier using the full tensor in the near-wall region. The comparison is remarkable when compared to the number of modes required to obtain the dissipation as shown in Figure 5.

The results presented confirm the ability of the POD to properly reconstruct the second moments in the near-wall region of a turbulent flow. It appears that the present one-dimensional reconstruction is insufficient to properly account for the near-wall treatment of the turbulent dissipation rate. In an attempt to avoid this problem, a length scale definition has been proposed in terms of an integration of the correlation tensor which factors in the presence of the wall. The dissipation computed from this length scale and the kinetic energy exhibits the proper behavior near the wall and in the inertial layer. A 1 POD mode estimate of the length scale is computed and found to agree quite well with the length scale obtained when the entire correlation tensor is used.

The question that naturally arises at this point is whether the extra processing of simulation data is necessary since the various turbulent stresses and budgets can be directly obtained from simulation data. The answer lies in the relatively low Reynolds number range of the simulations to date. It has recently been shown by Sirovich and Rodriguez[3] for the Ginzburg-Landau equation that the lower-order eigenfunctions are somewhat Reynolds number independent. If this were to hold for the Navier-Stokes equations, then the model development, based on the eigenfunction reconstruction would have a wider range of applicability.

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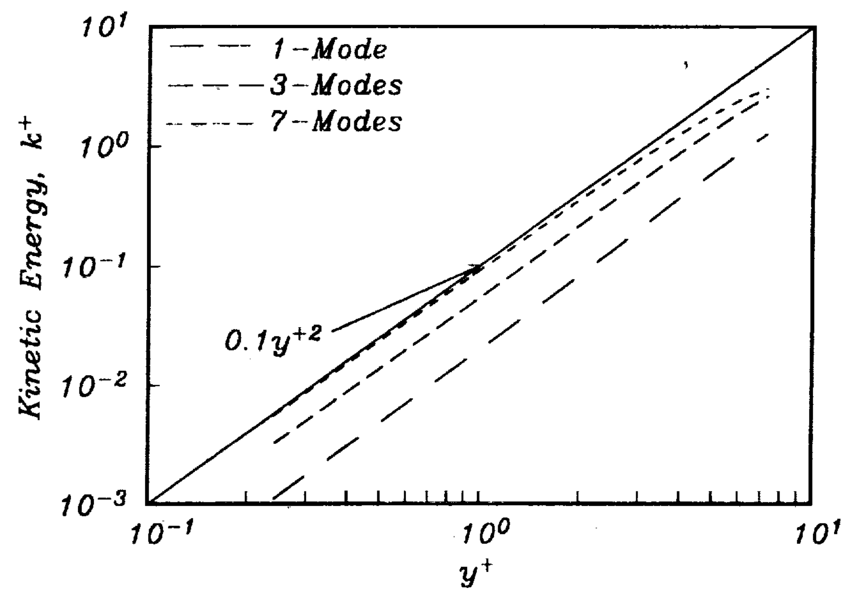

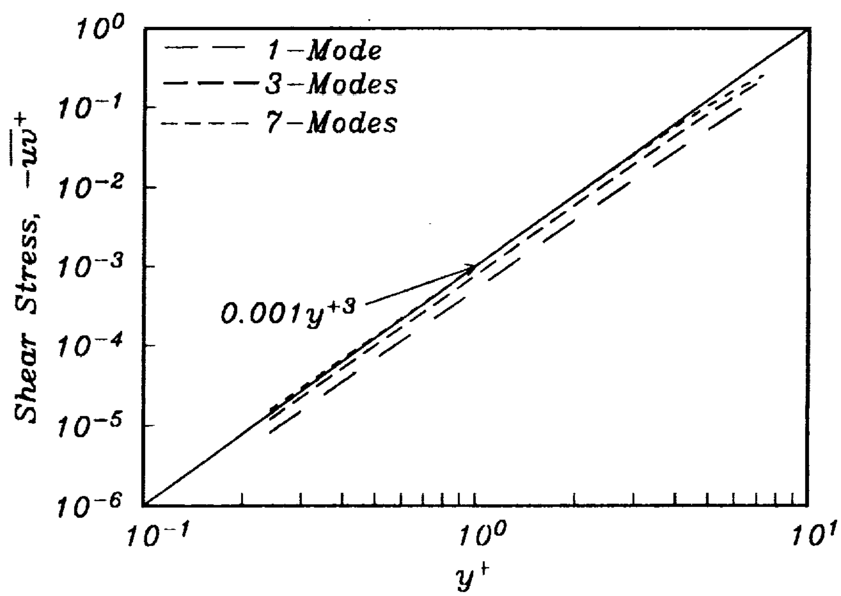

Figure 1: Asymptotic consistency of kinetic energy and shear stress with y^+ in near-wall region.

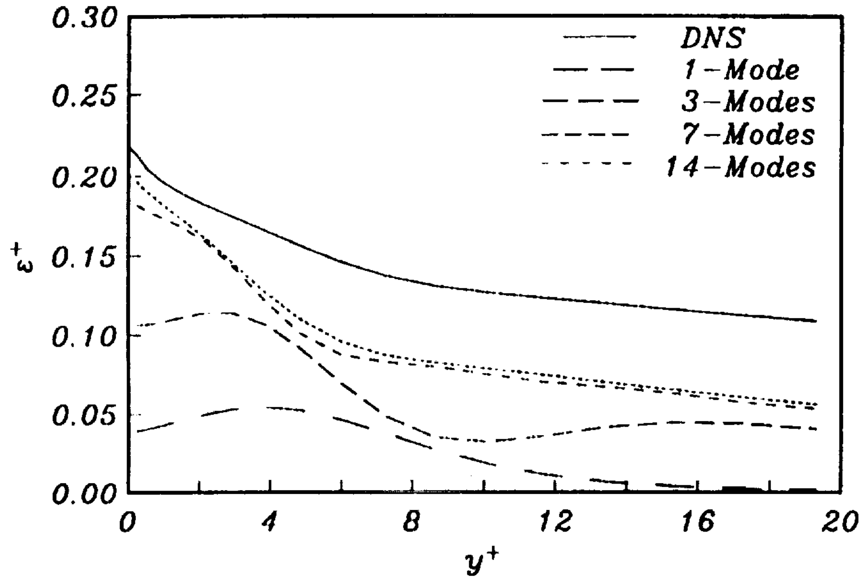

Figure 2: Effect of mode addition on ϵ^+ in close proximity to wall.

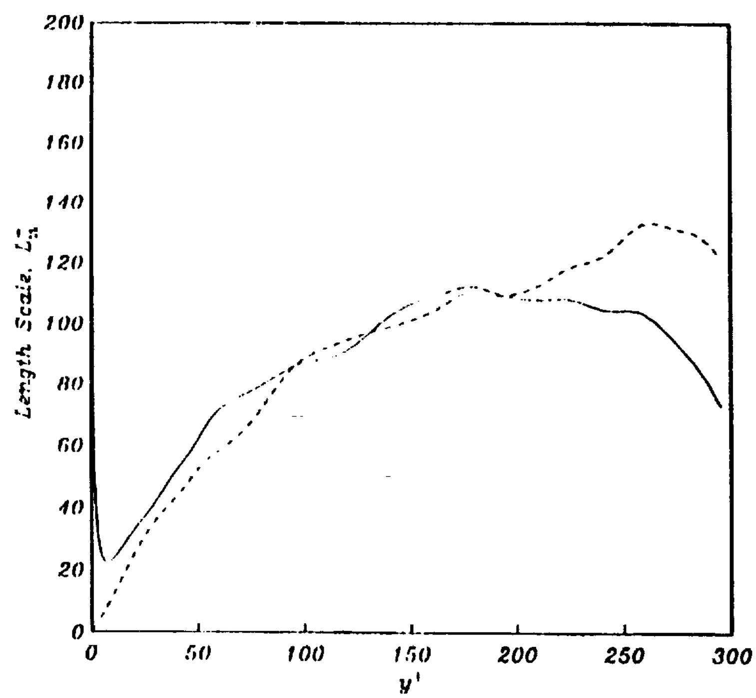

Figure 3: Length Scales computed with and without accounting for the wall

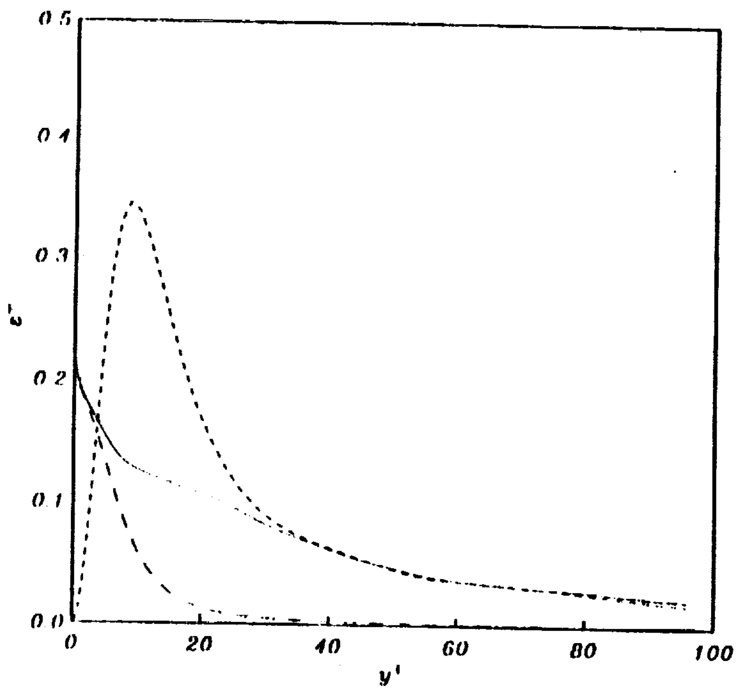

Figure 4: Dissipation computed from length scale compared to DNS.

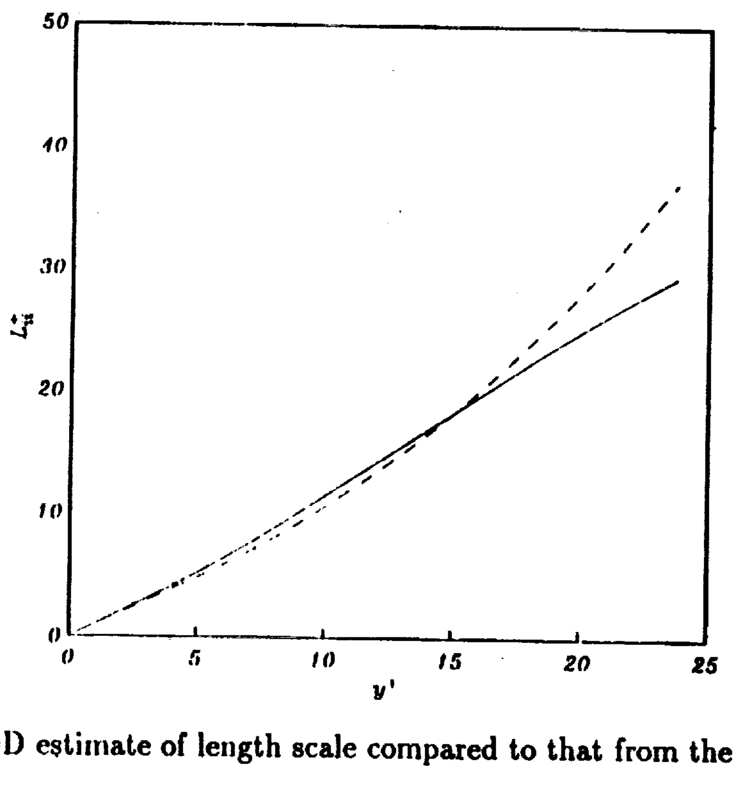

Figure 5: 1 POD estimate of length scale compared to that from the full tensor.

N93-16772

Functional Expansion Representations of Artificial Neural Networks

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Abstract

In the past few years significant interest has developed in using artificial neural networks to model and control nonlinear dynamical systems [8]. While there exists many proposed schemes for accomplishing this and a wealth of supporting empirical results, most approaches to date tend to be ad hoc in nature and rely mainly on heuristic justifications. The purpose of this project was to further develop some analytical tools for representing nonlinear discrete-time input-output systems, which when applied to neural networks would give insight on architecture selection, pruning strategies, and learning algorithms. A long term goal is to determine in what sense, if any, a neural network can be used as a universal approximator for nonlinear input-output maps with memory (i.e., realized by a dynamical system). This property is well known for the case of static or memoryless input-output maps [1,5].

The general architecture under consideration in this project was a single-input, single-output recurrent feedforward network described by the n nonlinear difference equations

$$x(t+1) = \sigma(Ax(t)+bu(t)), \qquad x(0)=x_o \tag{1}$$
$$y(t) = cx(t), \tag{2}$$

where $\sigma_i \quad i=1,\ldots n$ are the individual activation functions for each neuron, b and c are the input and output connection vectors, A is the recurrent neural network weight matrix, and $x(\cdot)$ is the state vector composed of the outputs of each neuron [4]. For the purpose of modelling input-output behavior we found it convenient to introduce a state-space transformation $z=\sigma^{-1}(x)$ such that the system in (1)-(2) is input-output equivalent to

$$z(t+1) = f(z(t))+g(z(t))u(t), \qquad z(0)=\sigma^{-1}(x_o)\triangleq z_o \tag{3}$$
$$y(t) = h(z(t)), \tag{4}$$

where $f(z)=A\sigma(z)$, $g(z)=b$, and $h(z)=c\sigma^{-1}(z)$. The main advantage to using this latter state-space model is that the system is affine in u, and thus, more amenable to analysis by the geometric methods used in nonlinear control theory [2,6]. The basic objective was then to determine a *tractable* functional expansion of the input-output map corresponding to system (3)-(4) in terms of the realization (f,g,h,z_o). A Volterra type expansion

$$y(t)=\sum_{k=0}^{\infty}\sum_{i_1\ldots i_k=1}^{\infty} V_k(i_1,\ldots,i_k)u(t-i_1)\ldots u(t-i_k) \tag{5}$$

has been published in the literature [4,9], but the expressions for the Volterra kernels, V_k, are too complex for any serious analysis. Thus, we took the alternative approach of deriving a discrete-time analogue of the Fliess functional expansion for general discrete-time nonlinear systems and then applying it in particular to the neural network realization in equations (3)-(4). The resulting expansion was significantly simpler in structure than those published to date and appears promising for future analysis of such systems.

An interesting innovation resulting from this work was the discovery of a natural adaptation of Fliess's work to discrete-time systems. This subject has been studied by other researchers [7,10], but it appears that this particularly tractable approach has been overlooked. One of two main results is described in the following theorem [3]:

Theorem *Suppose the sequence $\{u(k)\}$ is bounded in magnitude on $[0, N]$ and each function of a discrete-time realization (f, g, h, z_o) is analytic on an open subset U of $\Re^n$. Then for sufficiently small N, the input-output mapping can be represented by a convergent generating series*

$$F : u \to y = \sum_{\eta \in I^*} c(\eta) E_\eta, \tag{6}$$

where

$$I^* \text{ is the set of multiindices for the index set } I = \{0, 1\}; \tag{7}$$

$$c(\eta) = c(i_k \ldots i_0) = L_{g_{i_0}} \ldots L_{g_{i_k}} h(z_o) \qquad (g_0(z) \triangleq f(z) - z); \tag{8}$$

$$E_\eta(t) = E_{i_k \ldots i_0}(t) = \sum_{j=0}^{t-1} u_{i_k}(j) E_{i_{k-1} \ldots i_0}(j) \qquad t \in [0, N] \tag{9}$$

$$(E_\phi(t) \triangleq 1, \;\; u_0(t) \triangleq 1, \;\; and \;\; u_1(t) \triangleq u(t)). \tag{10}$$

($L_g h$ denotes the Lie derivative of h along g.)

Clearly this result applies to the system (3)-(4). Furthermore, as in the continuous-time case, it is possible to derive a simple series expansion for each Volterra kernel in terms of the coefficients $\{c(\eta) : \eta \in I^*\}$. The details of this analysis are reported in [3].

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Spacecraft Optical Disk Recorder Memory Buffer Control

N93-16773

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I. Project Goals

The goal of this project is to develop an Application Specific Integrated Circuit (ASIC) for use in the control electronics of the Spacecraft Optical Disk Recorder (SODR). Specifically, this project is to design an extendable memory buffer controller ASIC for rate matching between a system Input/Output port and the SODR's device interface.

The aforementioned goal can be partitioned into the following sub-goals:

1) Completion of ASIC design and simulation (on-going via ASEE fellowship),
2) ASIC Fabrication (@ ASIC manufacturer),
3) ASIC Testing (NASA/LaRC, CNU).

II. Project Description

My research activities during my NASA-ASEE fellowship have been part of the SODR project in the Flight Electronics Division. The SODR project will develop a space qualified optical disk storage system for mass storage and high data rate applications. The system architecture calls for a reconfigurable and extendable optical disk storage system. A multiport system will support terabit capacity and gigabit transfer rates. The disk drive (two devices) requirements call for 10 Gbytes of disk capacity and sustained data rates of 300 Mbps. The high level SODR system architecture is shown in Figure 1.

The specific system being developed in this project is the Memory Buffer Controller (MBC). The function of the MBC is to interface a system I/O port to a SODR device (note each optical disk drive is two devices). Since the instantaneous data rates of the I/O port and the SODR device may vary, a buffer memory is required for data rate matching between these two interfaces.

The current MBC system design calls for an 8-bit data path which is cascadable to support a 32-bit HPPI (High Performance Parallel Interface) data I/O port. The HPPI data port (or multiple HPPI data ports) will be the data I/O path for the SODR system. The MCB's SODR device interface is currently designed to support SCSI II protocol (16-bit, fast). Both interfaces selected have ANSI standards and support the high data rates specified by the SODR system requirements.

Functionally, the MBC ASIC decomposes into the following sections:

1) The HPPI source and destination interface,
2) The SCSI II interface to the optical disk recorder,
3) The Group Controller interface for MBC control and testing,
4) The memory buffer interface,
5) The MBC system controller.

Figure 2 shows the MBC ASIC with all the major interfaces in a 32-bit I/O port configuration.

III. NASA-ASEE Summer Research Activities

Research activities include:

1) System architecture development,
2) Interface definitions,
3) Memory subsystem design & simulation,
4) Control algorithm development.

Various system architectures were studied for ASIC implementation. Factors such as device pinout and gate count were considered in determining the final architecture. Interface definitions were determined for both internal subsystems and external ASIC signals. The detailed design of the memory subsystem was completed along with a simulation of this subsystem to verify the subsystem timing. Furthermore, system control algorithms were developed to control data flow and synchronization through the memory buffer and its associated interfaces.

IV. ASEE Related Issues

In addition to my research activities, I had the opportunity to use a powerful set of design tools for ASIC development. The use of these tools will extend to the classroom for both undergraduate and graduate courses. Contacts made during my NASA-ASEE fellowship have, in-part, made it possible to bring these tool into a university environment.

V. Acknowledgments

Special thanks to my associate, Steve Jurczyk, and other members of the SODR team for their help and encouragement.

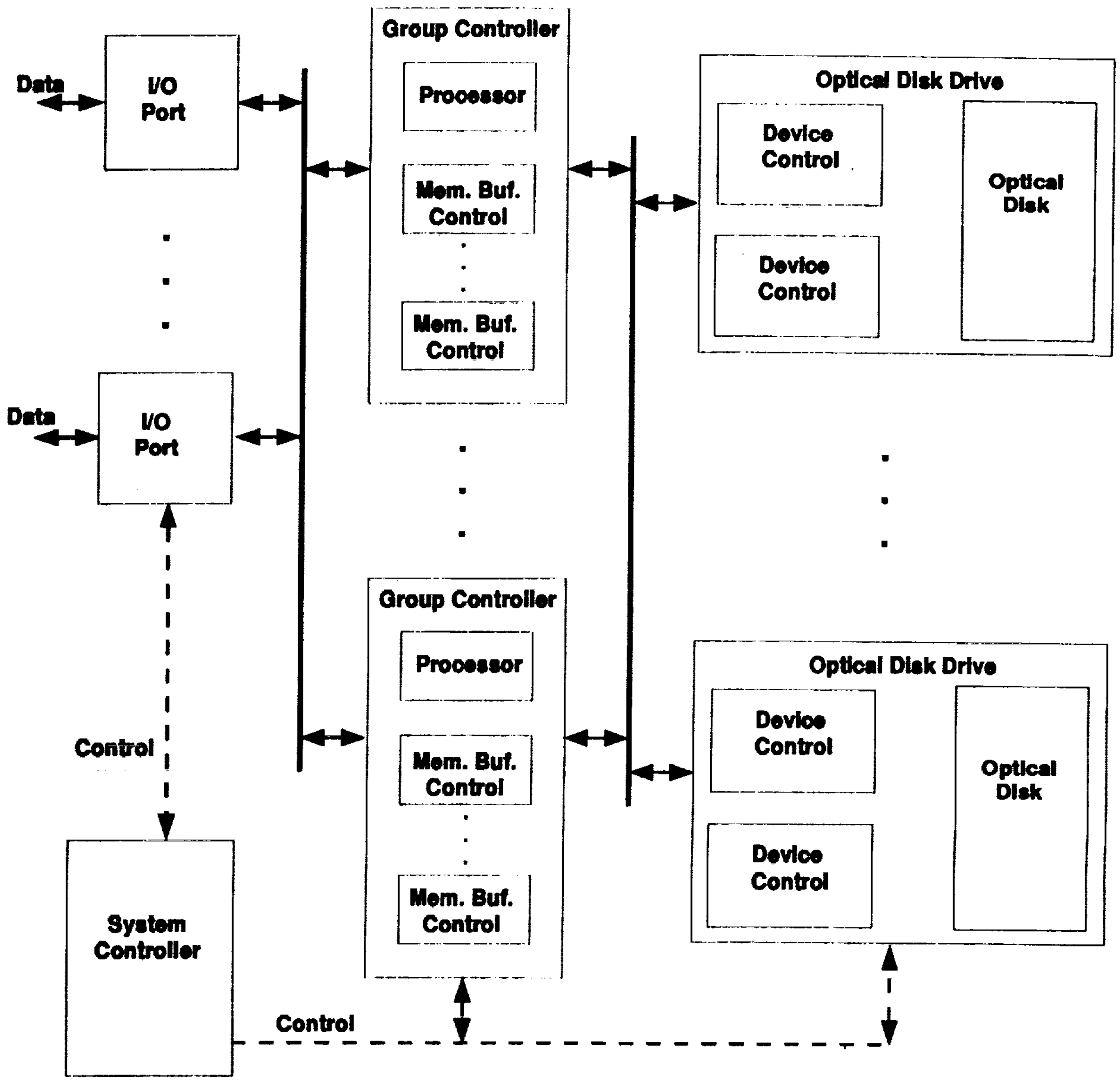

Figure 1. SODR System Architecture

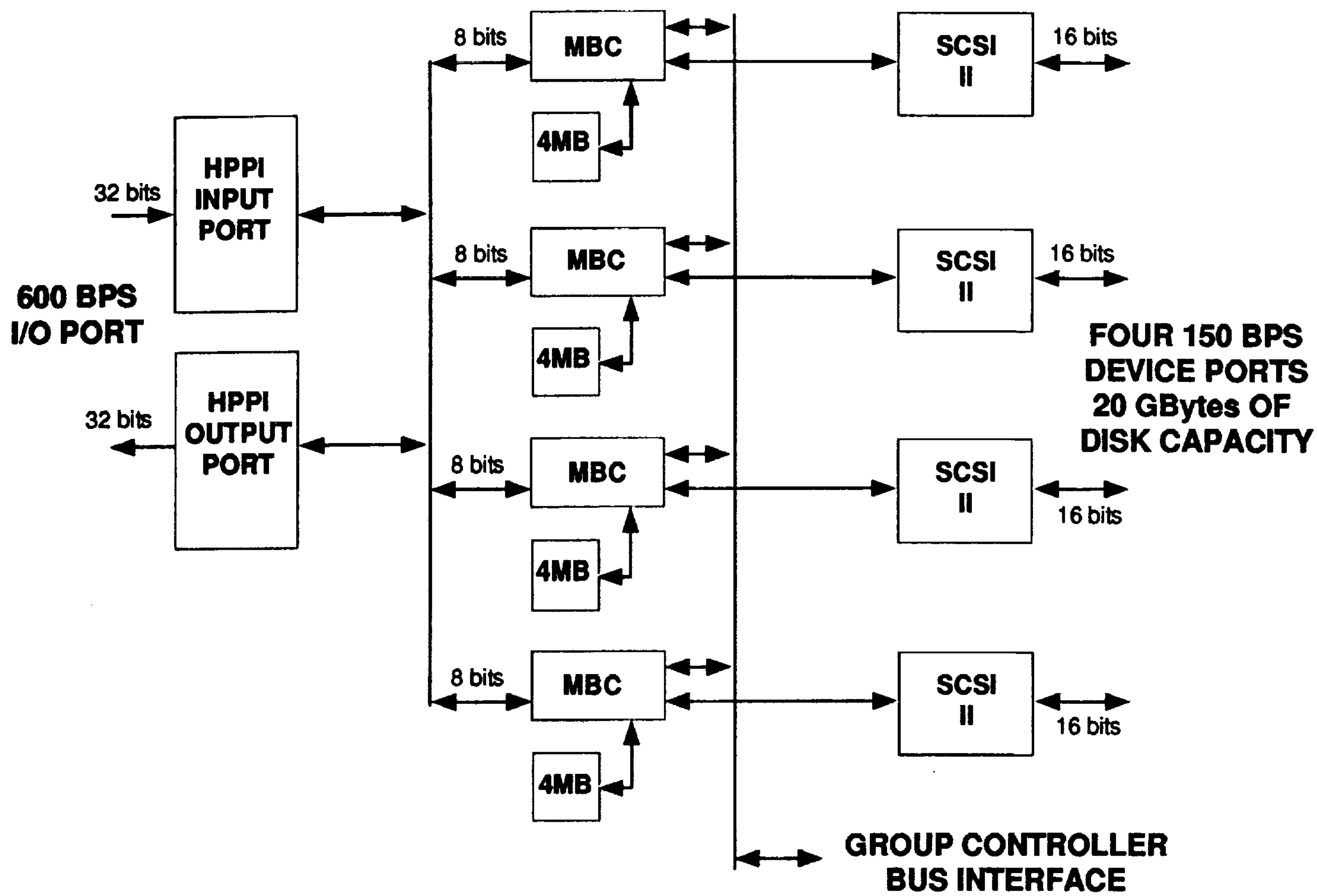

Figure 2. MBC with 32-bit HPPI and 16-bit SCSI

Creating an Open Environment Software Infrastructure

by

N93-16774

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Abstract

As the development of complex computer hardware accelerates at increasing rates, the ability of software to keep pace is essential. The development of software design tools, however, is falling behind the development of hardware for several reasons, the most prominent of which is the lack of a software infrastructure to provide an integrated environment for all parts of a software system. The research undertaken by the author at NASA LaRC in the summer of 1992 has undertaken to provide a basis for answering this problem by investigating the requirements of open environments.

1 Introduction

With the rapid development of digital processing technology, NASA programs have become increasingly dependent on the capabilities of complex computer systems. Current flight control research, for example, advocating active controls and fully integrated guidance and control systems , relies heavily on digital processing technology. These advanced guidance and control systems, designed to optimize aircraft performance, will demand high-throughput, fault-tolerant computing systems. The functional performance, reliability, and safety of these systems are of great importance to NASA and thus research within NASA's Aeronautics Controls and Guidance Program is directed toward the development of design, assessment, and validation methodologies for flight crucial systems.

The state-of-the-art of this technology, however, is reflected in a primary issue resulting from a NASA-LaRC workshop on digital systems technology i.e. " lack of effective design and validation methods with support tools to enable engineering of highly-integrated, flight-critical digital systems". Design methods are generally fragmented and do not support integrated performance, reliability, and safety analysis and there is a growing recognition that such integrated studies will require an integrated design and evaluation environment .

The research focus of the Systems Architecture Branch of NASA-LaRC is the Automated Design Technology (ADT) for engineering safety-critical software and architecture systems for advanced aircraft avionics. This work is motivated by the belief that focused research on application-specific domains will result in significant gains in productivity and quality. The need for such research was also recommended in a 1989 National Research Council Computer Science and Technology Board workshop – "it is critical to recognize the legitimacy of specialization to the domain at the expense of expressive generality".

2 The Project

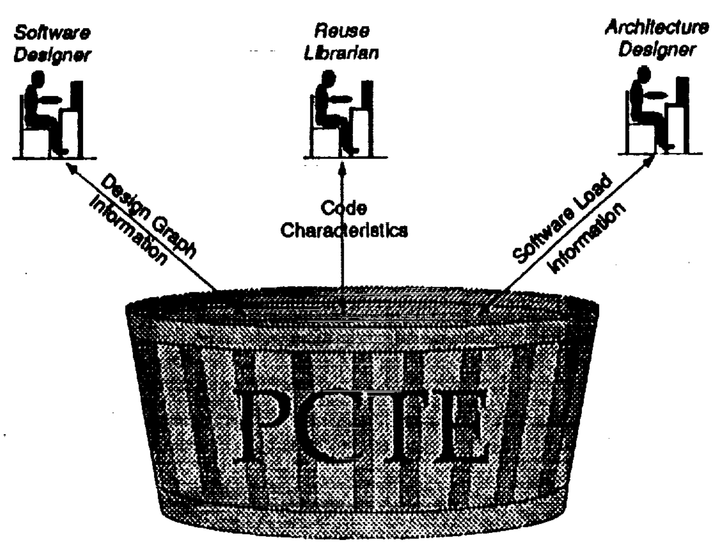
In order to support ADT, a project was initiated to construct and evaluate an open environment software infrastructure as the framework for this design technology. The environment was based on the Integrated Project Support Environment model of software integration, where a complete infrastructure is build in which software tools are embedded. Further, the environment was built in accordance with the Portable Common Tool Environment standard of IPSE systems. The main advantages of using PCTE are many; the biggest advantages are (1) a common data infrastructure were all data is viewed as objects and resources are provided to all program in the environment to manipulate those objects, and (2) all objects are highly organized by relationships to each other, thus enabling easy reference and access to any object in the system.

The project, shown in Figure 1, was undertaken to show the advantages of PCTE in practical terms. In this scenario, we have a three engineers working in a PCTE environment. The software engineer is designing software, which is being cataloged by the reuse librarian and being executed on a system designed by the architecture engineer. The software engineer sees her software in terms of control and data flow graph information; the reuse librarian see coding characteristics; and the architecture designer sees the load information the software will put on the hardware he is designing. Each engineer has a perspective of the software being design; it is the software infrastructure that allows these perspectives to be integrated into one software model. Our scenario combined three "real" programs jointly developed with NASA LaRC: CASE for software design, InQuisiX for the reuse librarian, and ADAS for the hardware design tool.

PCTE allows objects and their manipulation to be hidden from the user and her software. Each user's software accesses what it should in the correct format and translations or information derivation is under the surface of the IPSE.

It is hoped that the construction and demonstration of this software infrastructure will inspire others to use an IPSE to design and implement their software systems. Examples are numerous: different, off-the-shelf geographic modelling programs implementing their own GIS models as *perspectives* of some common geographic object; spreadsheets from different vendors on different computers sharing complex information on mission launches as if they were in the same format; database systems accessing each others information.

Figure 1: The PCTE-based Demonstration Environment



N93-16775

VIRTUAL REALITY SYSTEMS

Virtual: "being in essence or effect, but not in fact"
Reality: "a real event, entity, or state of affairs"
-Webster's Dictionary

David W. Johnson, ASEE Fellow
At Langley Research Center, Virginia
July 31, 1992

The essence of reality is, of course, one of the largest questions to entertain man's mind and has been sought in physics and the sister sciences,[1] metaphysics, philosophy and religion. A construct of man's imagination to the semiologist,[2] it is intrinsically cultural and specific to the anthropologist. Fascinating too is how man's mind created image-based media that bring to life both "old" and "new" realities for both "re-creation" and "recreation." [3] Now man's mind has invented computer enhanced artificial or virtual reality (VR) systems. These let users' minds participate in the those abstract spaces where the physical viewer does not exist.

THE ISSUE OF CONTROL IN THE HCI

Virtual realities are a type of human-computer interface (HCI) and as such may be understood from a historical perspective. In the earliest era, the computer was a very simple, straightforward machine. Interaction was human manipulation of an inanimate object, little more than the provision of an explicit instruction set to be carried out without deviation. In short, control resided with the user.

In the second era of human computer interface, some level of intelligence and control was imparted to the system to enable a dialogue with the user. Simple context sensitive help systems are early examples, while more sophisticated expert system designs typify this era. Control was shared more equally.

In this, our third era of the human-computer interface, the constructed system emulates a particular environment, constructed with rules and knowledge about "reality." Control is, in part, outside the realm of the human-computer dialogue. For instance, currently the predominate metaphor is that a desktop with rules that emulate a paper handling system; unlike a real paper handling system, the electronic one will not let the user place his only copy of an electronic document in TRASH without some ability to retrieve it later in spite of his intention in putting it there originally.

Perhaps the ultimate of this level of human-computer interaction might be that depicted by the Holodeck simulations from the television series *Star Trek: The Next Generation*. Here the system views the user as only one data source. The user retains command override, but is not the dominate force in the control of the developed interaction.

From this brief, broad historical perspective, one can classify VR as a form of human-computer interface characterized by an environmental simulation that is controlled only in part by the user, a natural evolution of interface design with increasing control placed with the computer.[4]

VR SYSTEMS-A CONTINUUM

In addition, VR systems may be characterized by the nature of the realities depicted on a continuum.

> Remotely controlling machines such as wind tunnels and robots provide computer mediated reality.
>
> Moving along the continuum, there are efforts that have a data source based in reality. Meaning can be extracted from ever larger databases (such as from wind tunnel simulations and remote sensing of planet earth) by visualization.
>
> Moving further, some CAM/CAD and other design systems allow for the user to be exposed to a possible but not actual constructed reality (e.g., the UNC architecture simulations).

Finally, at the far extreme of this continuum are microworlds such as learning environments in which the laws of the known universe may be modified, suspended, or contradicted, potentially under the control of the user.

NATURALNESS OF USER INVOLVEMENT

Usefulness in any tool is enhanced by naturalness in its user's involvement. The mind of man can now conceive of Cyberspaces, such as the Holodeck of the *USS Star Ship Enterprize* that are indistinguishable from reality. For now, our devices can only approximate these effects. Clearly, experiments with Eyephones and DataGloves do allow for a far greater degree of natural user involvement than do CRT-based realities such as those based on menu selections or those in which the user imagines cursor or mouse movements to be the equivalent of other bodily movements.

DEMONSTRATION PROJECTS ARE NEEDED

Specific developments are needed for more realistic VR systems: VR for multiple users, enhanced graphic resolution, user interface standards, data communication standards, and increased CPU power. While important challenges, there are from the perspective of an information scientist even more need to develop VR systems. Arching over the future of all HCI are: the huge volume of data and information we are now capable of gathering; the wide variety of types of data and information we seek; and the to discover the relationships in these data and information. Thus, projects that include a VR component are needed to develop enabling technologies in signal acquisition, digitization, mediation and presentation.[5]

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THE DAMPER PLACEMENT PROBLEM FOR LARGE FLEXIBLE SPACE STRUCTURES

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ABSTRACT

The damper placement problem for large flexible space truss structures is formulated as a combinatorial optimization problem. The objective is to determine the p truss members of the structure to replace with active (or passive) dampers so that the modal damping ratio is as large as possible for all significant modes of vibration. Equivalently, given a strain energy matrix with rows indexed on the modes and the columns indexed on the truss members we seek to find the set of p columns such that the smallest row sum, over the p columns, is maximized. We develop a tabu search heuristic for the damper placement problems on the CSI Phase I Evolutionary Model (10 modes and 1507 truss memebers). The resulting solutions are shown to be of high quality.

1. INTRODUCTION

The demand for larger sized space structures with lower mass has led to the development of highly flexible structures where, in effect, every point can move relative to the next. Traditionally, structural motion is viewed more simply in terms of a sum of several dozen or more independent motions called ***natural motions***. The problem of controlling the motion of a flexible structure is then reduced to controlling the natural motions. Associated with each natural motion are three parameters: a ***mode*** which is a natural spatial shape, a ***natural frequency*** which expresses the rate of oscillation, and a ***natural decay rate*** which is a measure of the time required for the motion to decay. The contribution of each natural motion to the overall motion depends on the degree to which it is excited by external forces.

The overall structural motion of a flexible truss structure can be reduced by the use of structural dampers that both sense and dissipate vibrations. We focus on where to locate these dampers so that vibrations arising from the control or operation of the structure and its payloads or by cyclic thermal expansion and contraction of the space structure can be damped as effectively as possible. There are several mechanisms available for vibrational damping. We consider the replacement of some of the truss members by active dampers which sense axial displacement (strain) and induce a compensating displacement. (A related option is to replace some of the truss members with passive dampers which dissipate strain energy due to their material properties.) Each of these techniques for damping increases the weight and cost of the truss structure. Hence, structural designers are required to locate as few dampers as possible and still maintain an appopriate level of vibrational damping.

2. FORMULATION

The CSI Phase I Evolutionary Design (see Figure 1) is an example of a large flexible space truss structure. A normal modes analysis of a finite element model of this structure yielded a 10 (***nmodes***) by 1507 (***nmembs***) modal strain energy matrix. Let D_N denote this matrix with row index set I and column index set J. The entries in the matrix have been normalized so that each d_{ij} denotes the percentage of the total modal strain energy imparted in mode i to truss member j.

The goal of the damper placement problem is to select p truss members to be replaced by active (passive) dampers so that the ***modal damping ratio*** is maximized for all significant modes. Maximizing the modal damping ratio is a widely accepted goal in damper placement problems (see Anderson et al. 1991). However, the modal damping ratio is difficult to determine explicitly and, consequently, the placement of active (or passive) dampers has proved difficult (cf. Padula and Sandridge 1992 and Preumont et al. 1991). Both active and passive dampers dissipate forces which are internal to the structure and are most effective replacing truss members with maximum extension or compression. The truss elements with maximum internal displacement are those with the largest strain energy over all modes. Given a finite element model and the results of a normal modes analysis the modal strain energy in each candidate location (truss member) for each significant normal vibration mode can be estimated quite accurately. The damping achieved with active dampers depends on the properties of the damper and the control law that is implemented. Following Padula and Sandridge (1992) we use a force-feedback control law (cf. Preumont et al. (1991)) yielding damping ratios that are directly proportional to the fraction of modal strain energy. Hence, the maximization of the modal damping ratio for all modes can be accomplished by selecting the p damper locations that maximize the minimum sum of modal strain energy over the p chosen locations. Padula and Sandridge (1992) formulate this problem as a mixed 0/1 integer linear program (MILP).

Alternatively, the damper placement problem may be formulated as a combinatorial opimization problem. That is, given D_N we seek to find the *nmodes* by p submatrix whose smallest row sum is as large as possible. Let $Z(X) = min_{i \in I} \sum_{j \in X} d_{ij}$. Then the damper placement problem becomes

$$max_{X \subseteq J} Z(X)$$

$$\text{subject to } |X| = p.$$

3. COMPUTATIONAL RESULTS

There are several ways in which tabu search (and many other heuristic search strategies) can be of use. First, it can simply be used to generate solutions to the damper placement problem. However, tabu search by itself provides no information about the quality of the solution found. Solving the linear programing (LP) relaxation of the MILP mentioned above is one way to get a good upper bound. Solving the MILP with a branch and bound code will provide even better upper bounds as well as a lower bound (the MILP solution). Table 1 compares the quality of solutions generated by the MILP formulation (solved by LINDO with a limit of 10,000 iterations) and tabu search. Secondly, tabu search can be used to try and improve upon the MILP solution or the LP relaxation of MILP. In the latter case fractional solutions will be present and a mechanism for choosing a subset of the optimal decision variables must be found. We picked the p (where $p = 8$, 16, or 32) decision variables with largest value (closest to one). For example, when $p = 8$ the LP solution had 12 non-zero decision variables in the optimal solution. Of these 12 five had a value of one. When $p = 32$ there are even fewer choices to be made. The LP optimal solution had only 35 non-zero decision variables of which 29 had a value of one. Table 2 summarizes the performance of tabu search under three different initial solutions—random, MILP solution, and LP relaxation. Reported timings are for a 16 MHz 386-class micro-computer. The solutions generated by LINDO for the MILP formulation were computed on a CONVEX computer in about 4 minutes, this corresponds to approximately 200 hours of computational effort on the 386 micro-computer.

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P	LP	U. Bnd	IP/BB	% UB	Tabu	% UB
8	1.6144	1.6131	1.3211	81.9	1.4291	88.6
16	3.1629	3.1110	2.7778	89.3	2.9647	95.3
32	5.8867	5.8838	5.6745	96.4	5.7943	98.5

Table 1. Best objective function value comparisons

P	Random	Time	IP/BB	Time	LP	Time
8	1.4291	8 min	1.3662	1 min.	1.4291	1 min
16	2.9647	210 min	2.8881	3 min	2.9332	1 min
32	5.7762	270 min	5.7635	50 min	5.7943	7 min

Table 2. Tabu Search results from different initial solutions

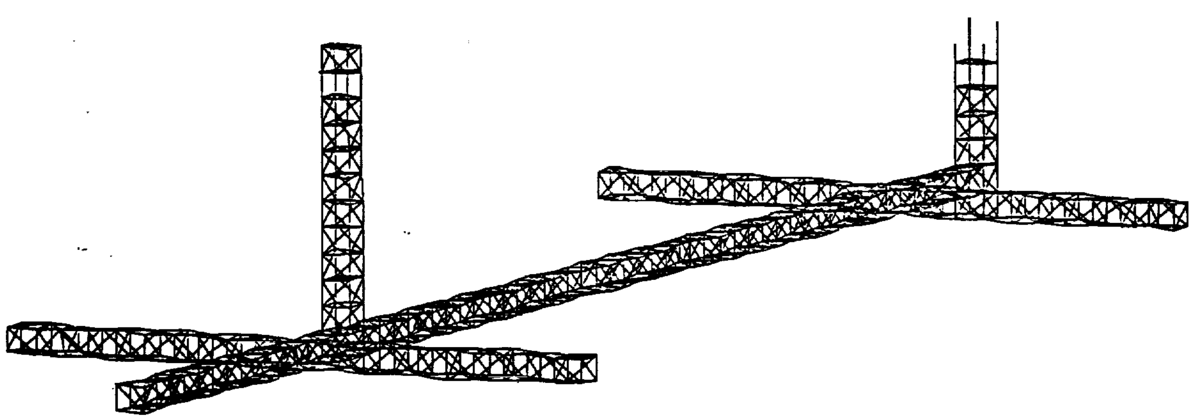

Figure 1. CSI Phase I Evolutionary Design

N93-16777 1

QUANTIFYING PARAMETERS FOR BAYESIAN PRIOR ASSUMPTIONS WHEN ESTIMATING THE PROBABILITY OF FAILURE OF SOFTWARE

by
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Software reliability has become increasingly important, especially in life-critical situations. The ability to measure the results of testing and to quantify software reliability is needed. If this is accomplished, a certain minimum "amount" of reliability for a piece of software can be specified, and testing and/or other analysis may be done until that minimum number has been attained.

There are many models for estimating software reliability. The accuracy of these models has been challenged and many revisions for the models and recalibration techniques have been devised. Of particular interest is the method of estimating the probability of failure of software when no failures have yet occurred in its current version as described by Miller et al[3]. This model uses black box testing with formulae based on Bayesian estimation. The focus is on three interrelated issues: estimating the probability of failure when testing has revealed no errors; modifying this estimation when the input use distribution does not match the test distribution; and combining the results from random testing with other relevant information to obtain a possibly more accurate estimate of the probability of failure. My research relates directly to the third issue, obtaining relevant information about the software and combining the results for a better estimate for the Miller et al. model.

The Miller et al. method is based on Bayesian estimation using a *Beta(a,b)* distribution in which *a* and *b* represent prior assumptions based on some information about the software or its development. To continue the efforts of estimating the probability of failure as described by Miller et al., it is necessary to quantify techniques used to improve software during development, testing, and maintenance. The specific problem is using these quantifications to establish the *a* and *b* parameters for the *Beta* distribution.

An extensive search of the literature on white box software analysis techniques is being done. From those models studied, several methods that are believed to give quantitative estimates concerning probability of failure are being selected. Attempts to model the outcome of these analyses using *Beta* functions will be done. In some cases attempts will be made to experimentally determine whether or not these predictions have statistical validity.

There are three areas already targeted as being a source for reliable quantifiable estimates. Munson and Khoshgoftaar[4] have developed a method of using software metrics to determine fault prone programs. These complexity metrics are statistically analyzed and used to create a predictive model for assigning programs to one of two groups. One group is predicted to have a very low fault rate and the other a very high fault rate. They have devised a method for representing most of the program complexity information as a single value called the relative complexity. A method for using this relative complexity value will be attempted to be derived and used for forming the prior parameters for Bayesian estimation in the Miller et al. model.

Reliability growth models for software have been in use for decades. Applying these models during the development of software can determine predictions of the probability of failure during future tests. From these predictions a mean and a variance can be calculated and used to obtain an a and b to produce a *Beta* distribution having the same mean and variance. Thus, there is a quantifiable source for determining the Bayesian priors.

The Littlewood-Verrall and the Jelinski-Moranda models[2] are well known models that are frequently used in reliability discussions today. Basically, these models make a prediction on the i th version of the software based on the previous 1 through i-1 observations of software failures during execution. Data obtained from these models during the development of the software can be used to develop values for a and b.

The model described by Becker and Camarinopoulos[1] is unlike other models discussed in that this model will indicate the possibility that no more errors exist in the software. This method will be analyzed and hopefully incorporated into the determination of the a and b parameters so that the probability of failure equal to zero is represented by the Miller et al. model.

There are several areas currently being considered for further research as far as expanding the techniques for determining the a and b parameters. Continuation of this research will result in several ways for quantifying parameters for Bayesian prior assumptions when estimating the probability of failure of software.

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VARIATIONAL DERIVATION OF EQUATION FOR GENERALIZED PAIR CORRELATION FUNCTION

by

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Abstract

The wavefunction of a system is explicitly written down in a fully anti-symmetric way between a fermion pair and a medium, and the equations for each one of them are derived from the variation of total energy for bound systems and by forming appropriate scalar products for continuum states.

High-energy particles, such as protons, electrons, and nuclei impinging upon spacecraft, produce secondary radiations. In order to protect the internal environment of spacecraft from these radiations, their intensities are determined in many instances theoretically, and an appropriate program has been developed in the High Energy Science Branch [1]. The purpose of this research is to investigate the problem of indistinguishability of an incident projectile with one of the same in a target. For example, when a high-energy incident proton interacts directly with a target proton embedded in a medium, an appropriate scheme must be developed to incorporate the Pauli principle between the two colliding protons, as well as among all the protons in the medium. The natural scheme for this purpose is to partition the total wavefunction ψ (1 . . . . n), into an anti-symmetrized, two-proton wavefunction, ϕ_α (ij) and an anti-symmetric target wavefunction ψ_β. A completely anti-symmetric wavefunction under this partitioning scheme may be obtained by generalizing the work of references [2, 3],

$$\Psi(12\cdots ij\cdots n)=\sum_{\alpha\beta}\sum_{\substack{ij\\ j=i+1}}(-1)^{i+j}\phi_\alpha(ij)\psi_\beta(\bar{i}\,\bar{j}) \quad (1)$$

In equation (2), (1, 2 . . . n) represents coordinates of n-particles, α and β label all quantum numbers needed to define an infinity of states, and $\psi_\beta(\bar{i}\,\bar{j})$ is a function of all but the ith and jth coordinates. The expansion above forms a complete set and normally $\psi_\beta(\bar{i}\,\bar{j})$ would refer to all the states of the target Hamiltonian $H_T(\bar{i}\,\bar{j})$. the function Ψ is completely anti-symmetric if ϕ_α and ψ_β are anti-symmetric with respect to interchange of two adjacent coordinates.

For bound states, the equations for ϕ_α and ψ_β have been derived using the variation of total energy of the system with auxiliary conditions of orthornormality and anti-symmeterization. These are coupled sets of integro-differential equations.

For continuum states of ϕ_α, the appropriate equations are obtained by evaluating the scalar product $\left(\psi_\beta, (H-E)\Psi\right)=0$. The structure of the equation for the continuum states of ϕ_α is the same as the one for bound states, but now the modulation of ψ_β due to ϕ_α is neglected.

The expansion (1) provides a complete description of pairs in a state α and is an alternative to Jastrow's ansatz [4], which assumes the correlated part of the wavefunction to be state independent. One may, however, generalize the Jastrow ansatz making the correlation state dependent by multiplying the right-hand side of (1) with symmetric, correlated functions, g (ij). Thus, the generalized Jastrow function is

$$\Psi(12\cdots n) = \Sigma_{\alpha\beta}\,\Sigma_{ij}\,(-1)^{i+j}\,\phi_\alpha(ij)\prod_{k,l} g(il)\,g(kj)\,\psi_\beta(\bar{i}\,\bar{j})\,\Pi\, g(kl) \tag{2}$$

Although equation (2) may be more convenient to deal with potentials with hard cores, its completeness property needs further investigation.

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N93-16779

FUZZY SET APPROACH TO QUALITY FUNCTION DEPLOYMENT: AN INVESTIGATION

by

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ABSTRACT

This is the final report of the 1992 NASA/ASEE Summer Faculty Fellowship at the Space Exploration Initiative Office (SEIO) in Langley Research Center.

Quality Function Deployment (QFD) is a process, focused on facilitating the integration of the customer's voice in the design and development of a product or service. Various input, in the form of judgements and evaluations, are required during the QFD analyses. All the input variables in these analyses are treated as numeric variables. The purpose of the research reported here was to investigate how QFD analyses can be performed when some or all of the input variables are treated as linguistic variables with values expressed as fuzzy numbers. The reason for this consideration is that human judgement, perception and cognition are often ambiguous and are better represented as fuzzy numbers.

Two approaches for using fuzzy sets in QFD have been proposed. In both cases, all the input variables are considered as linguistic variables with values indicated as linguistic expressions. These expressions are then converted to fuzzy numbers. The difference between the two approaches is due to how the QFD computations are performed with these fuzzy numbers. In Approach I, the fuzzy numbers are first converted to their equivalent crisp scores and then the QFD computations are performed using these crisp scores. As a result, the output of this approach are crisp numbers, similar to those in traditional QFD. In Approach II, all the QFD computations are performed with the fuzzy numbers and the output are fuzzy numbers also. Both the approaches have been explained with the help of illustrative examples of QFD application. Approach II has also been applied in a QFD application exercise in SEIO, involving a 'mini moon rover' design. The mini moon rover is a proposed tele-operated vehicle that will traverse and perform various tasks, including autonomous operations, on the moon surface. The output of the moon rover application exercise is a ranking of the rover functions so that a subset of these functions can be targeted for design improvement.

The illustrative examples and the mini rover application exercise confirm that the proposed approaches for using fuzzy sets in QFD are viable. However, further research is needed to study the various issues involved and to verify/validate the methods proposed.

N93-16780

PREDICTION OF THERMAL CYCLING INDUCED MATRIX CRACKING

by

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Abstract

Thermal fatigue has been observed to cause matrix cracking in laminated composite materials. A method is presented to predict transverse matrix cracks in composite laminates subjected to cyclic thermal load. Shear lag stress approximations and a simple energy-based fracture criteria are used to predict crack densities as a function of temperature. Prediction of crack densities as a function of thermal cycling is accomplished by assuming that fatigue degrades the material's inherent resistance to cracking. The method is implemented as a computer program. A simple experiment provides data on progressive cracking of a laminate with decreasing temperature. Existing data on thermal fatigue is also used. Correlations of the analytical predictions to the data are very good. A parametric study using the analytical method is presented which provides insight into material behavior under cyclical thermal loads.

Background

Unprotected structure in space goes through wide, cyclical swings in temperature. These cycles are severe (+/- 150 °F in LEO, +/- 250 °F in GEO) and a long-life structure such as the Space Station must withstand up to 175,000 cycles in a lifetime. Advance composite materials are widely and successfully used for space structure, but transverse cracks in the plies of composite structures have been observed to form under thermal cycling loads. In some critical applications, this cracking may degrade performance, and even threaten the integrity of the space structure. Greater understanding of this phenomena is necessary to predict, avoid, and/or live with transverse cracking in composite materials.

Approach

Given appropriate material properties, the layup and geometry of a composite laminate, and a thermal loading history, we will predict the resulting distribution of matrix cracks, and the resulting degraded laminate properties. An analytical model is implemented as a computer program to provide the predictions. It is verified by correlation with experiments, some performed as part of this effort and some garnered from the literature.

Analytical Model Thermal or mechanical loading stores energy in the laminate. Some of this energy is released by the formation of a transverse crack. Typically, these cracks appear suddenly across the full height and width of a ply, parallel to the fibers. The amount of energy released can be approximated by a shear lag solution of the stresses in the vicinity of the crack (Figure 1) and a simple energy method- if the energy released ΔG is greater than the energy necessary to form the crack G_c, the crack will form (see, for example, [1]). Multiple cracks are handled by predicting a crack density ρ, which is the inverse of the average crack spacing (Figure 2). Predictions based on a single parameter ρ assume an unrealistically even crack spacing, but can be used to calculate either the maximum possible crack density, or the minimum density. To provide an idea of the true crack density, a direct Monti-Carlo simulation of crack accumulation is performed, assuming cracks initiate at random locations in the material. Fatigue is accounted for by assuming that cyclic loading decreases the material toughness factor G_c [2].

Computer Program The method was implemented as a FORTRAN computer code that runs on Macintosh or other computers. It requires layup geometry and material properties as inputs, an will solve for crack density and degraded material properties at a given temperature, or provide plotable tables of crack density and material properties as functions of either decreasing temperature, or number of thermal fatigue cycles at a constant minimum temperature.

Experiments A simple experiment was performed to measure crack density as a function of decreasing temperature. P75-934 laminates with a layup of $[0_2/90_2]s$ were cooled to progressively lower temperatures in an environmental chamber, and matrix cracks counted under an optical microscope. Available thermal fatigue data on a variety of materials and layups was also used [3,4].

Correlations The measured crack density as a function of temperature followed the lower bound predicted by the analysis (Figure 3). It was determined, by comparing the measured crack distributions to predicted distributions, that this was due to (unmodeled) macroscopic irregularities in the strength of the plies. Use of the minimum crack density prediction, as well as the values of some geometric and material parameters that were not available, were set by this correlation. Then the code was used in predictive mode (with no adjustment of parameters) to correlate fatigue data. A typical result is shown in Figure 4. The correlations are excellent.

Parametric Studies The code was used to study the effects of material properties, ply thicknesses, and layups on the cracking of laminates under both progressively dropping temperatures and thermal cycling. It was found that colder temperature and/or fatigue caused increasing cracking, with no true "saturation" level ever being reached (although variations in crack densities did become very small under some circumstances). Increasing material toughness G_c delayed the appearance of the first crack and lowered crack densities. Using thinner plies delayed the appearance of the first crack, but resulted in more cracking later. Cracking in thin plies also had much less effect on laminate properties than cracking in thick plies. The layup had a complex, non-intuitive effect on the cracking behavior of the laminate.

Conclusions and Recommendations

The technique developed here looks very promising, both as a design and analysis tool, and as a way to increase understanding of the phenomena of transverse crack formation. More data is needed, notably G_c of materials as functions of both temperature and number of thermal cycles. More direct correlation testing would be interesting, particularly comparing the results of mechanical vs. thermal loads. More analytical work is needed in the areas of damage initiation modeling (i.e. how do cracks form?), crack distribution modeling (where do they go?), and links to delamination and laminate failure. Success would lead to an accurate analytical tool for the design of reliable composite space structure.

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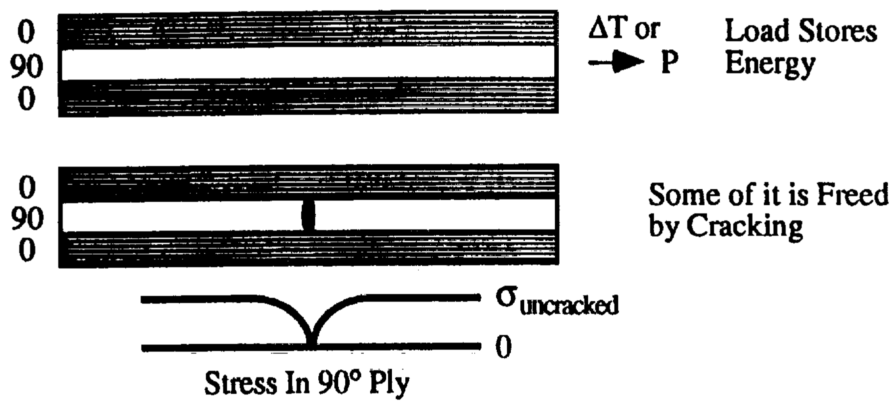

Figure 1. Energy stored in a laminate is freed by the appearance of a crack. Shown is an edge-on view of a laminate. The crack is assumed to extend through the 90° ply to the other edge.

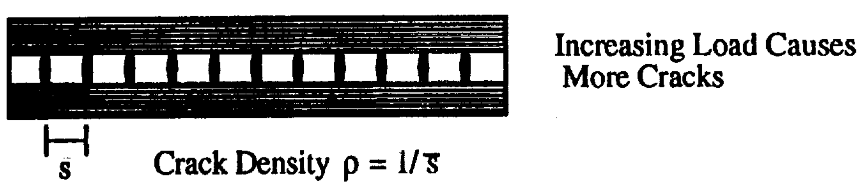

Figure 2. Progressive cracking measured by crack density ρ.

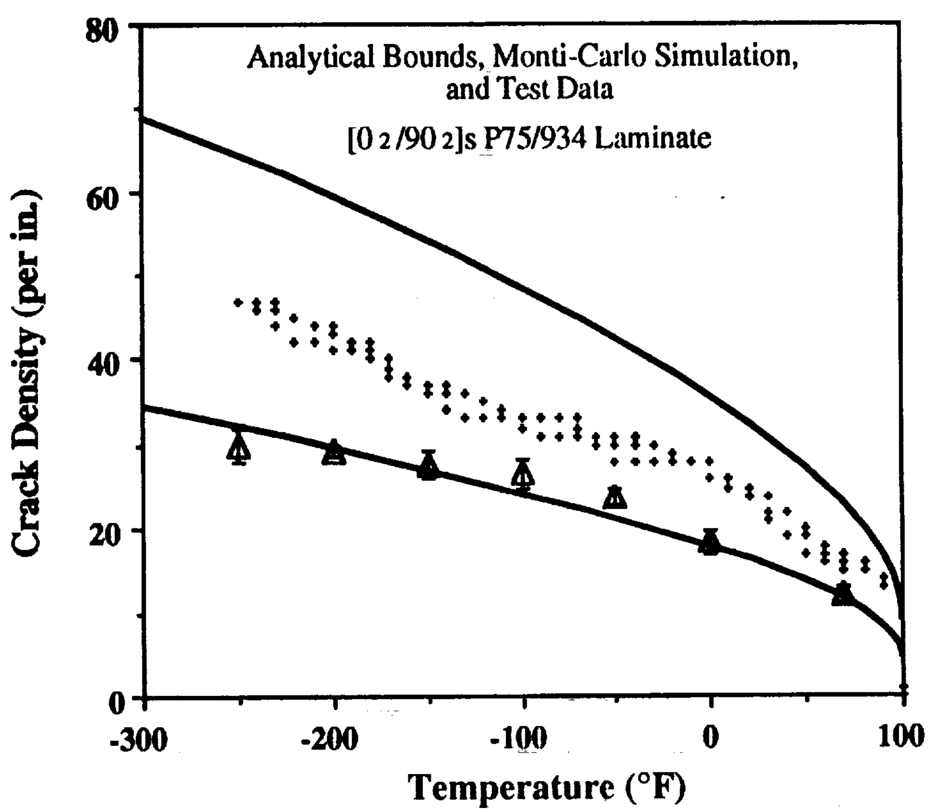

Figure 3. Predicted upper and lower bounds of crack density (solid lines), Monti-Carlo model predictions (dots) and test data (triangles, with bars showing range of three specimens).

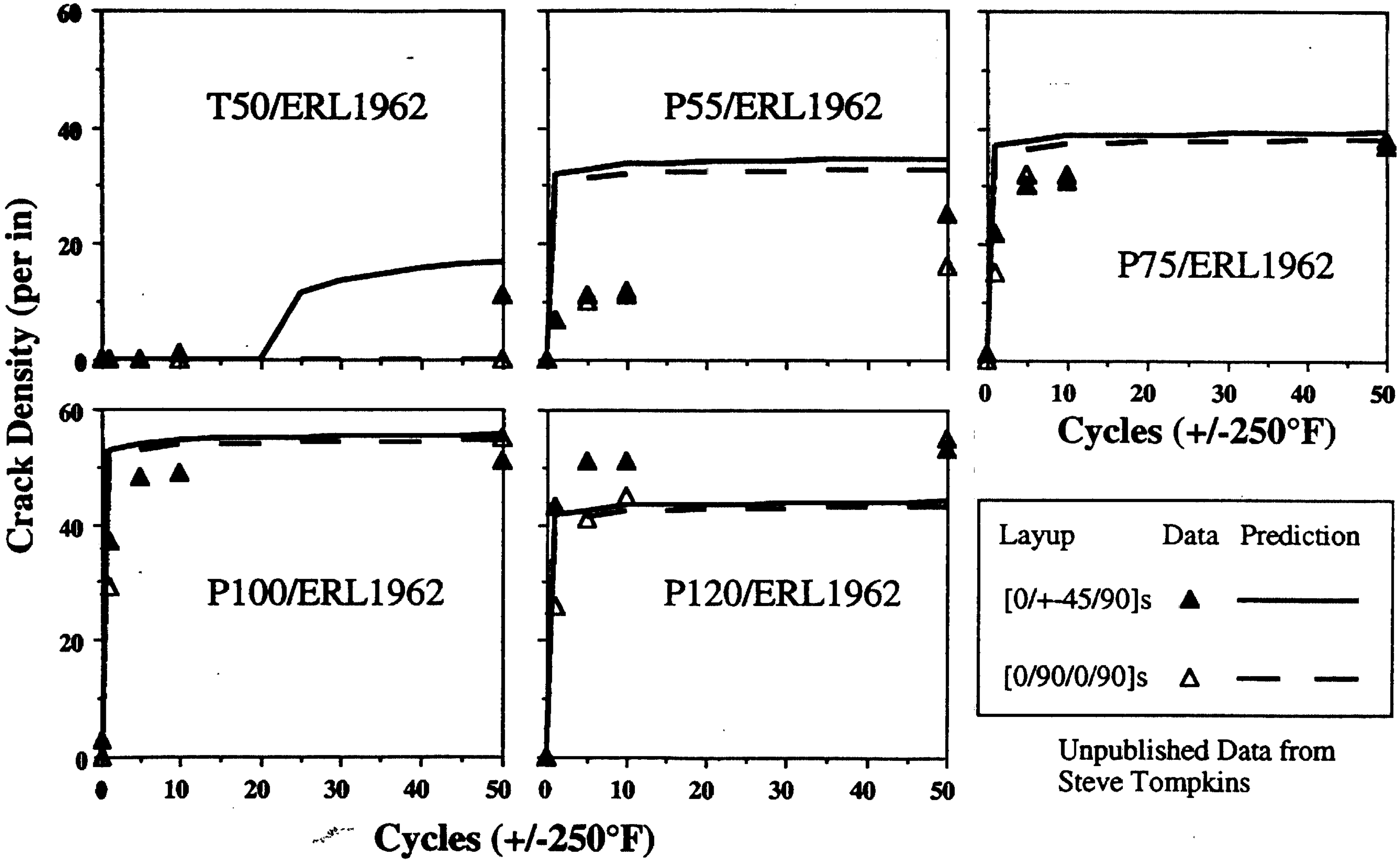

Figure 4. Correlation of analytical predictions with experimental thermal fatigue data for five different materials and two layups.

N93-16781

Diode Injection - Seeded, 940 nanometer(nm), Titanium - Sapphire Laser for H_2O DIAL, (Differential Absorption Lidar), Measurements

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Differential absorption of laser radiation by various molecular species represents both a selective and a sensitive method of measuring specific atmospheric constituents[1]. DIAL measurements can be carried out via two different means. Both involve using two laser pulses with slightly different wavelengths(λ), (one λ at a strong absorption line of the molecule of interest, the other detuned into the wing of the line), and comparing the attenuation of the pulses. One approach relies on scattering of the radiation from some conveniently located topographical target. In the other technique elastic scattering from atmospheric aerosols and particulates is used to return the radiation to the lidar receiver system. This case is refered to as the differential absorption and scattering technique, and is the technique we are interested in to measure water vapor at 940nm. The 940nm wavelength is extremely desirable to atmospheric scientist interested in accurate DIAL measurements of H_2O in the upper and lower troposphere. This is illustrated in figures 1 - 3 which show simulated measurements using ~940nm and 815nm lasers at a range of altitudes and experimental conditions. By offering access to larger absorption cross - sections, injected seeded, 940nm DIAL laser transmitters would allow for more accurate water profile measurements at altitudes from 6 to 16km than is currently possible with 730nm and 815nm DIAL laser transmitters[2].

We have demonstrated the operation of an injected seeded titanium - sapphire (TS) laser operating at ~940nm with an energy of more than 90mJ per pulse. The TS laser is pumped by a commercial, 600mJ, 532nm, 10Hz Nd:YAG laser. Figure 4 shows the slope efficiency of the laser using a flat 50% R output coupler and a 10m end - mirror. The laser was injected seeded with a cw, AlGaAs, semiconductor diode laser which had an output of

83mW. The cw diode seed beam was introduced into the TS laser cavity through a HR end - mirror. When the diode beam is aligned to the TS resonator, it controls the TS laser output wavelength and its spectral line width with the required resolution for DIAL applications. This work supports the need for the development of 940nm, titanium - sapphire DIAL transmitters[3].

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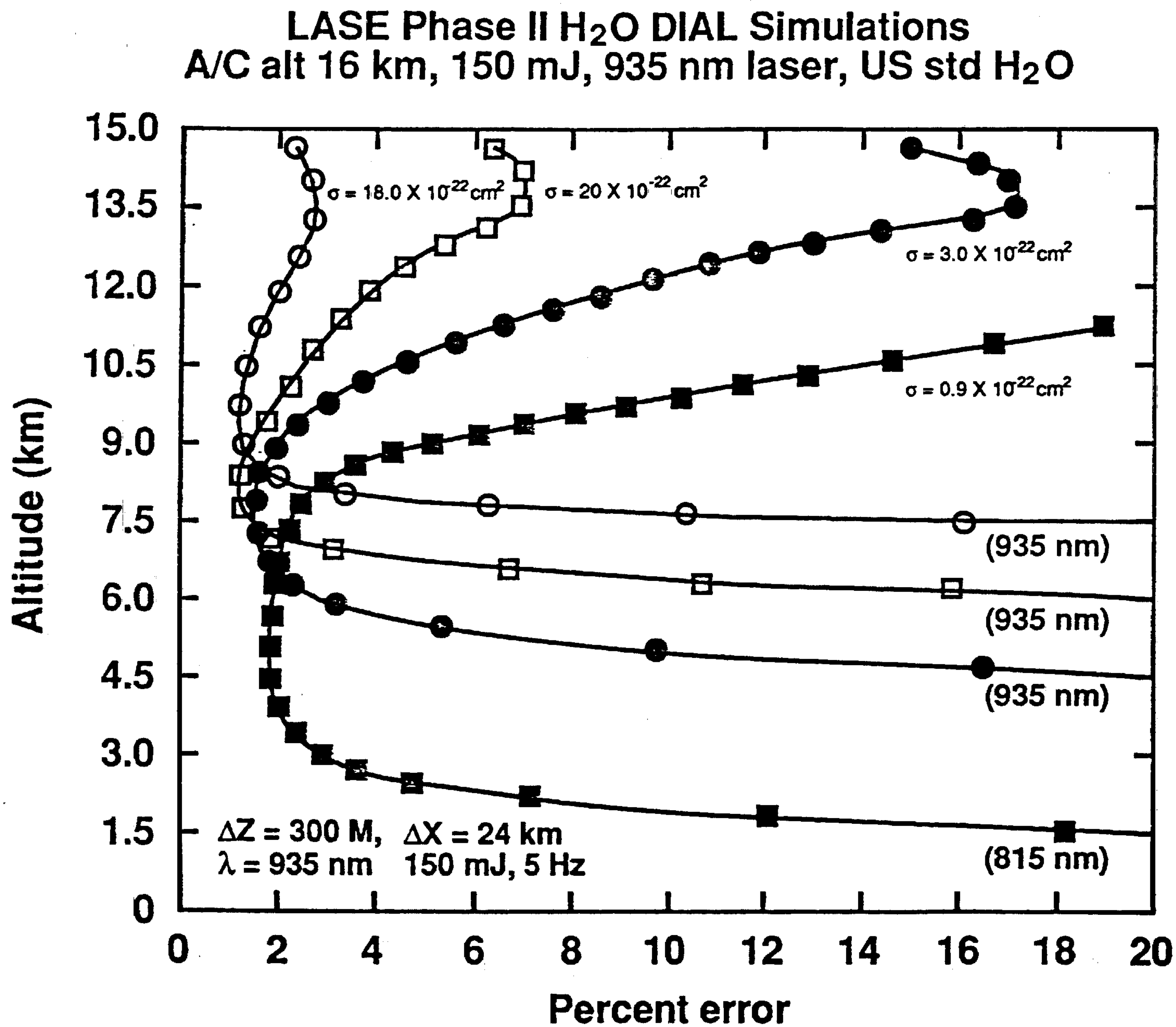

Figure 1. Aircraft altitude is 16 km; Laser energy is 150 mJ @ 935 nm. σ = 0.9 X 10 $^{-22}$ cm2 is the maximum cross-section available in the 730 and 815 nm regions.

jcb 250

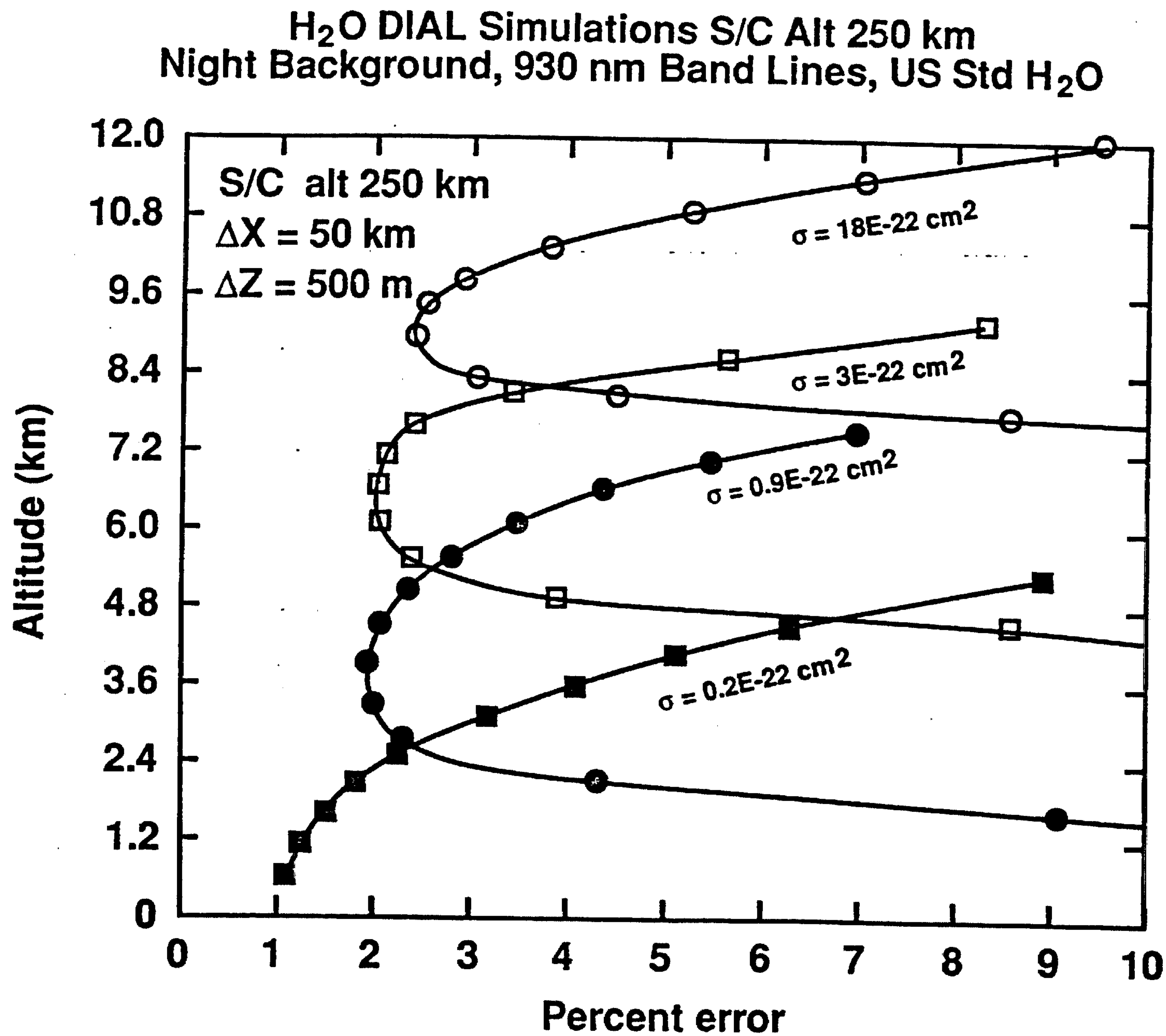

Figure 2. Spacecraftcraft altitude is 250 km; Laser energy is 0.5 J @ 935 nm. $\sigma = 0.9 \times 10^{-22}$ cm^2 is the maximum cross-section available in the 730 and 815 nm regions.

jcb 252

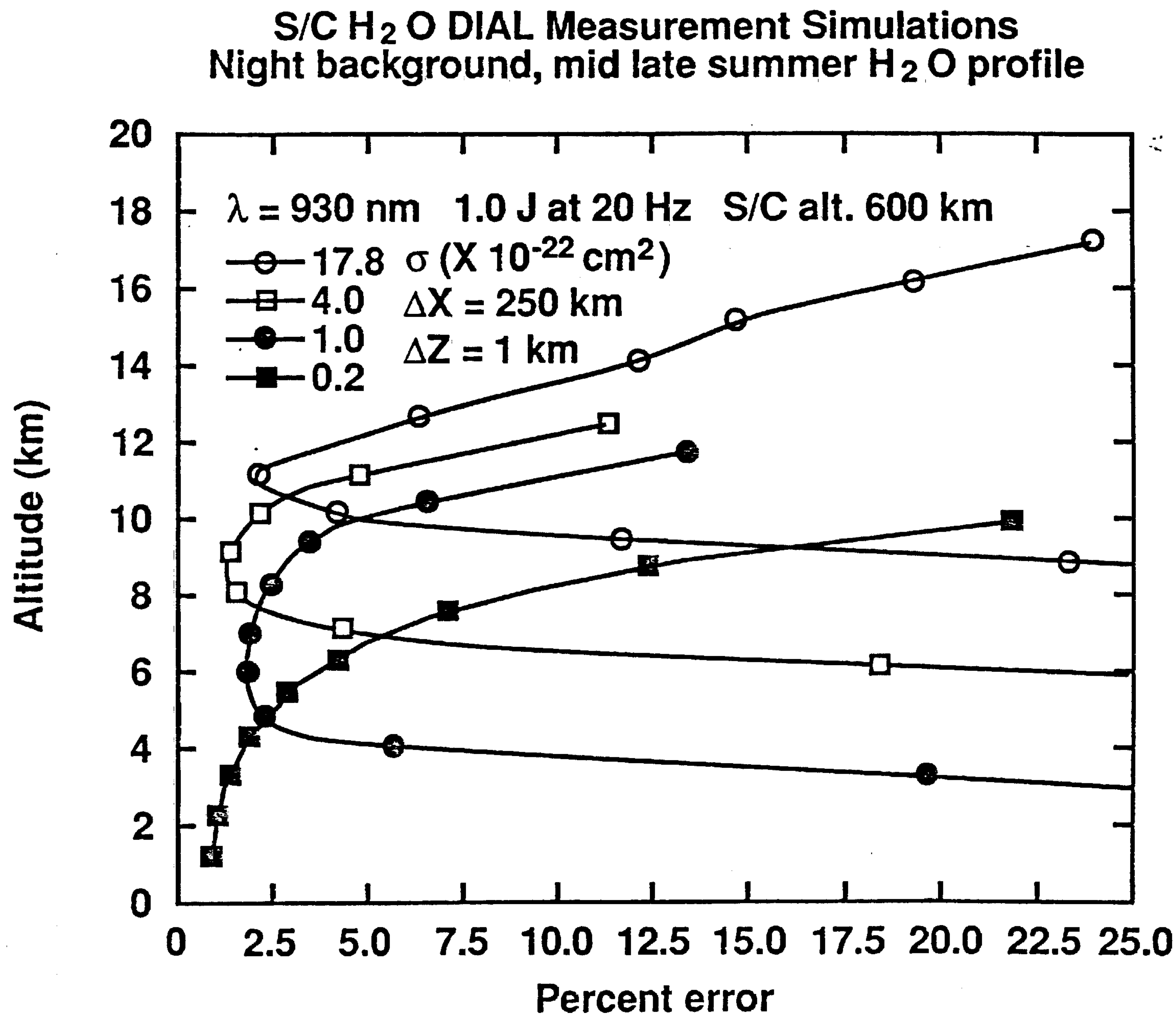

Figure 3. Spacecraft altitude is 600 km; Telescope is 1.25 m. $\sigma = 1.0 \times 10^{-22} cm^2$ is the maximum available cross-section in the 730 and 815 nm regions.

jcb 251

940nm Titanium-Sapphire Laser Demonstration

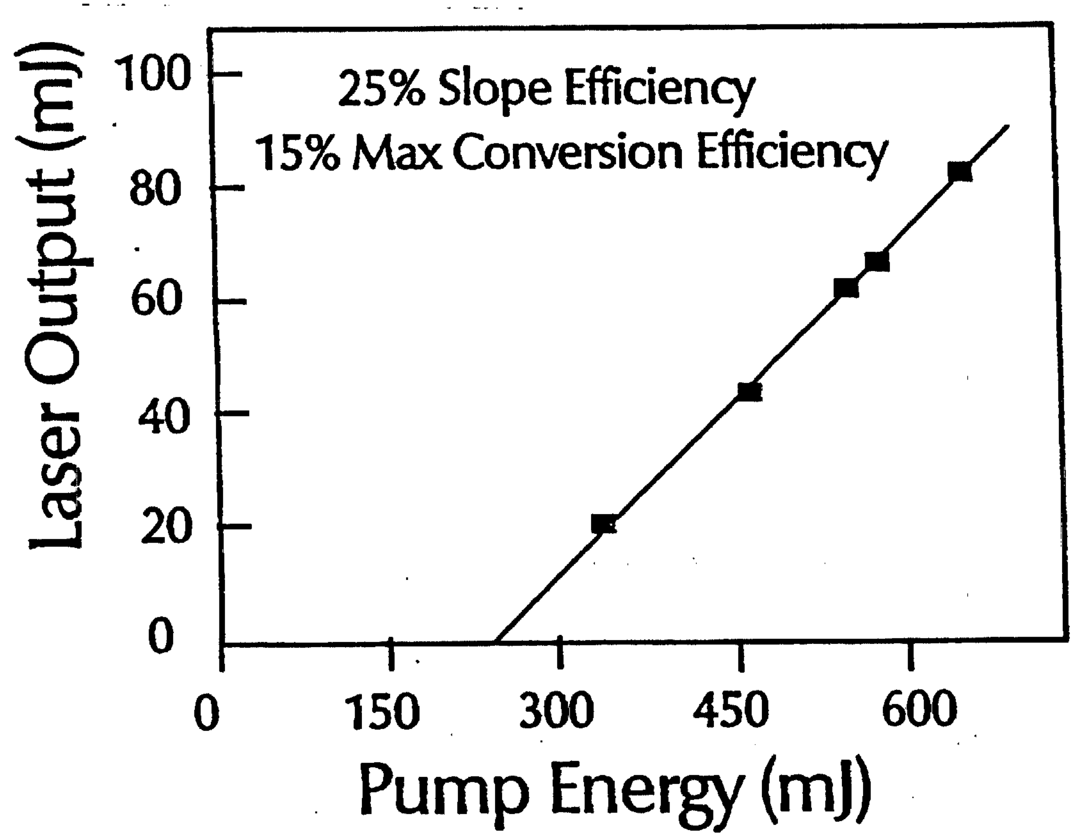

Figure 4. 532 nm pump energy in vs. Ti:Sapphire energy out.

N93-16782

BEAM, PLATE, AND SHELL FINITE ELEMENTS FOR CSI DESIGN CODE

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Abstract

Efficient triangular plate bending finite elements (with 6 degree-of-freedom per node) are surveyed. The most promising element will be selected, coded, and implemented into the current CSI Design Code [1].

Numerical example, v.i.a. CSI Design Code will be conducted to confirm the efficiency and accuracy of the selected plate bending element. Procedures to further enhance the computations of the CSI design code will be recommended.

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N93-16783

Cognitive and Affective Components of Mental Workload: Understanding the Effects of Each on Human Decision Making Behavior

by

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Human factors and ergonomics researchers have recognized for some time the increasing importance of understanding the role of the construct of mental workload in flight research. Current models of mental workload suggest that it is a multidimensional and complex construct, but one that has proved difficult to measure. Because of this difficulty, emphasis has usually been placed on using direct reports through subjective measures such as rating scales to assess levels of mental workload. The NASA Task Load Index (NASA/TLX, Hart and Staveland [1]) has been shown to be a highly reliable and sensitive measure of perceived mental workload. But a problem with measures like TLX is that there is still considerable disagreement as to what it is about mental workload that these subjective measures are actually measuring.

The empirical use of subjective workload measures has largely been to provide estimates of the cognitive components of the actual mental workload required for a task. However, my research suggests that these measures may, in fact, have greater potential in accurately assessing the affective components of workload. That is, for example, TLX may be more likely to assess the positive and negative feelings associated with varying workload levels, which in turn may potentially influence the decision making behavior that directly bears on performance and safety issues. Pilots, for example, are often called upon to complete many complex tasks that are high in mental workload, stress, and frustration, and that have significant dynamic decision making components -- often ones that involve risk as well.

Studying Workload and Dynamic Decision Making. There has been little systematic research investigating the potential relationship between changes in workload and decision making behavior, particularly risk-taking behavior. The major effort of this summer project has been to design laboratory experiments to systematically examine this relationship. If subjective measures of workload actually assess the affective components of workload more so than the cognitive components, then these measures should prove useful in relating workload to risk-taking and risk-avoiding tendencies. TLX, for example, has a frustration/stress dimension that would allow one to measure the affective nature of an individual's subjective experience of workload, either positive or negative.

There is a vast psychological literature that suggests that because we are limited information processors, the cognitive components of decision making are flawed and biased. By far the most significant work is that of Kahneman and Tversky [2] which has shown very dramatically that individuals can make opposite choices between a pair of competing alternative if the situation is merely framed differently. Specifically, when choice alternatives are framed in terms of what could be gained, people are generally risk-averse. That is, they will often choose a sub-optimal sure gain in order to avoid or reduce risk. However, when the same situation is framed in terms of what could be lost, people are often risk-seeking -- that is, willing to take a chance on a sub-optimal gamble in order to avoid a sure loss.

There is also compelling evidence that decision making processes can be influenced by one's affective mood state. For example, Isen, Nygren, and Ashby [3] have shown that a positive mood state can lead decision makers to exhibit conservatism in risky choice situations. They become overly sensitive to potential losses and make decision in such a way as to avoid losses. People in negative moods also exhibit a cautious shift toward risk-aversion in their actual choices, but they do so apparently through a different mechanism. These individuals tend, when evaluating alternatives, to focus on negative outcomes and give them more weight in the decision process.

Clearly, such findings on these decision biases and on mood state are potentially relevant for pilots as they relate to predictions of how risky decisions might be made under varying levels of workload. The goal of this summer research was to design a series of studies using the Multi-Attribute Task Battery (see Arnegard & Comstock [4]). The MAT is a PC-based battery of tasks that incorporates activities analogous to those performed in flight. Figure 1 illustrates the video monitor display of the tasks included in the MAT -- monitoring, tracking, auditory communications, and resource management. Studies will be done using the MAT in an attempt to examine the effects of positive and negative affect or mood on actual MAT performance as well as on perceived performance and workload levels. In particular, we are interested in whether strong differences that have been previously found in more restrictive laboratory settings using simple gambling behavior will generalize to decision strategies used in the dynamic components of the MAT monitoring and decision making tasks.

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Multi-Attribute Task Battery

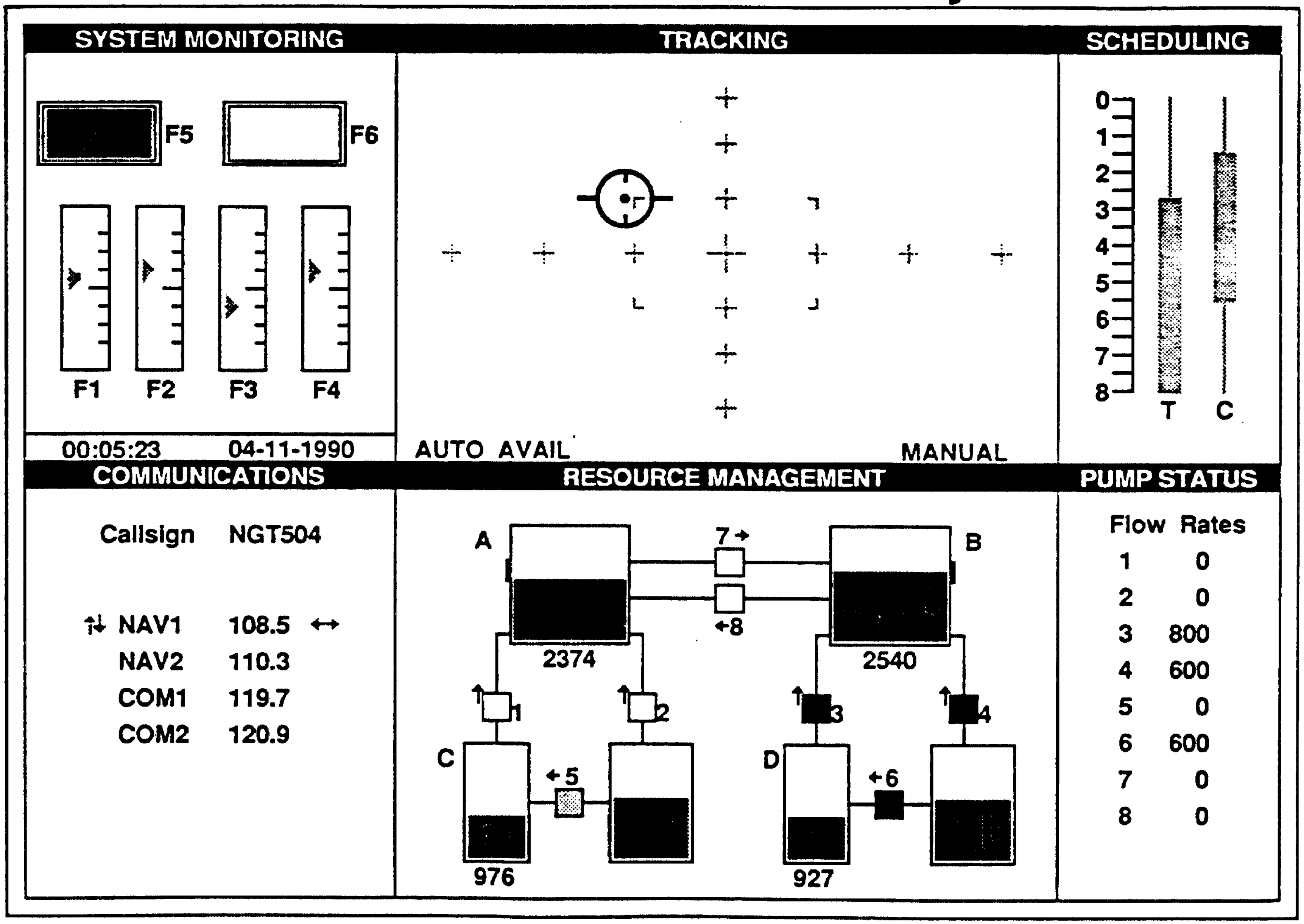

Figure 1

4

N93-16784

Digital Data Acquisition and Preliminary Instrumentation Study for the F-16 Laminar Flow Control Vehicle

by

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Preliminary studies have shown that maintenance of laminar flow through active boundary-layer control is viable. Current research activity at NASA Langely and NASA Dryden is utilizing the F-16XL-1 research vehicle fitted with a laminar-flow suction glove that is connected to a vacuum manifold in order to create and control laminar flow at supersonic flight speeds. This experimental program has been designed to establish the feasibility of obtaining laminar flow at supersonic speeds with highly swept wing and to provide data for CFD code calibration. Flight experiments conducted at supersonic speeds have indicated that it is possible to achieve laminar flow under controlled suction at flight Mach numbers greater than 1. Currently this glove is fitted with a series of pressure belts and flush mounted hot film sensors for the purpose of determining the pressure distribution and the extent of laminar flow region past the stagnation point. The present mode of data acquisition relies on out-dated on board multi-channel FM analogue tape recorder system. At the end of each flight, the analogue data is digitized through a long laborious process and then analyzed. It is proposed to replace this outdated system with an on board state-of-the-art digital data acquisition system capable of a through put rate of up to 1 MegaHertz.

The purpose of this study was three-fold:

- Develop a simple algorithm for acquiring data via 2 analogue-to-digital convertor boards simultaneously (total of 32 channels)
- Interface hot-film/wire anemometry instrumentation with a PCAT type computer
- Characterization of the frequency response of a flush mounted film sensor

A brief description of each of the above tasks along with recommendations are given below.

Part I - Digital Data Acquisition

Hardware Description

The analogue-to-digital boards utilized were manufactured by RC Electronics (Model ISC-16). The ISC-16 board is designed to permit an IBM PC computer to perform as a sophisticated data acquisition laboratory instrument. The ISC-16 consists of a 16-channel analog to digital (A/D) plug-in interface and a BNC termination box. The system is capable of digitizing 16 analog data channels with individual time bases, input at an aggregate sampling rate of up to 1 MHz. When more than 16 input channels are required, it is possible to support multiple boards (up to 4 cards, or 64 channels). Analog to digital conversion is achieved with 12 bit accuracy over a maximum voltage range between ± 10 V. Each data sample is stored in a 16 bit word (two 8 bit bytes).

A 64K sample memory (65,536 words) on the ISC-16 card is used to capture input signals. The memory is sectioned into two buffers, each with 32K sample (32,768) maximum memory. The two buffers are used interchangeably to simultaneously capture the input signal. The buffer size determines the total number of data points that will be collected per channel each time data acquisition is initiated.

A complete mechanization of the ISC-16 hardware is shown in Figure 1. A brief description of some of the key features are summarized below.

- 12 bit 1 usec A/D conversion
- 1 to 16 channel programmable input multiplexer
- 64K sample double buffered memory
- 12 bit trigger threshold DAC output
- trigger any channel or on external input
- trigger slope, level or threshold
- variable trigger delay (1 to 65,384 samples)
- internal clock rate (1 to 65,384 usec)
- external clock input
- 2 digital outputs

Software Description

The software developed for the above ISC-16 board was written in C language. The drivers supplied with this board consist of "outp" calls directed to a given board address. These drivers can only be used with the Microsoft C compiler (ver 6.0 and above) with the small library option. The software written consisted of standard I/O calls and basic calls to the C drivers provided by the manufacturer. Many of these drivers were modified to overcome a hardware interrupt problem that was encountered when other computer peripherals were being used. The A/D boards were supplied with a hardware interupt that was in direct conflict with COM2 port address. This hardware interrupt was used to provide the necessary high signal when the A/D board had completed the data acquisition cycle. Since each board was assigned a unique address location, it was decided to disable (permanently) the hardware interrupt while still being able to read and process the 64K buffer memory (sample and hold).
The software written in C can be used to acquire data from two boards with different base address locations simultaneously. The simultaneous acquisition is only possible if an external trigger signal is used to activate both A/D boards. This was accomplished by sending a positive analogue voltage out via one of the board's digital-to-analogue port during each sample burst. This output signal was then used as trigger signal and was connected to the trigger input of both boards.

Before a sample burst, the software is constantly interrogating the hardware trigger before data acquisition begins. Upon activation of the hardware trigger, the two boards will sample data at the specified rate and the assigned channels. Since two independent calls are made to activate each A/D card, there is a time delay between the start of data acquisition on the first board and the second board. This time delay was estimated to be of the order of 10^{-9} seconds which is 3 orders of magnitude faster than the A/D conversion speed (10^{-6} sec.) between consecutive samples. Hence it was felt that this software delay was insignificant.

In order to acquire data at the fastest possible rate when several channels are to be sampled, it is necessary that all unassigned channel numbers to be multiplexed and looped back. The input multiplexer consists of a 16 to 1 analog data selector controlled by a 16x4 bit RAM. This allows for 16 separate multiplexer selections to be made with each sample pulse causing the multiplexer RAM to cycle to the next multiplexer setting. In this manner, the total number of channels in use can only be 1, 2, 4, 8 or 16 (e.g. 6 would not work). The current software assumes that if two boards are to be used, then both will have exactly the same number of channels and utilizing the same numbering sequence. The latter is not a restriction and can be easily modified to accommodate other arrangement and combinations.

Since the total number of channels that can be connected are restricted to the above combinations, the maximum throughput rates are listed below (based on the Nyquist criteria):

Number of Channels	Maximum Sampling Rate (KHz)
1	500
2	250
4	125
8	62.5
16	31.75

The source code flow diagram is shown in Figure 2.

Part II - Interfacing of Hot-film/wire Anemometry to a PCAT Computer

The basic anemometry system consisted of a TSI-IFA100 system which includes a master module that is used to control 4 channels of a constant temperature anemometer circuitry. The LFC branch has purchased a total of three complete stand-alone system which can provide 12 anemometry channels. Ideally, a single master module should be used to control all three units, via a single RS232 connection to a PCAT type computer. However, the current configuration requires that each of these units to be controlled via a dedicated RS232 connection. Due the severe limitations associated with available number of communication ports in a PCAT, it was recommended that the LFC branch purchase two slave interface cards which replaces the master module cards, allowing control to be passed on to the single master module to control all channels.

The IFA-100 Master boards are designed to accept ascii instructions in determining and setting some of the anemometer reference condition for each channel (e.g. sensor resistance, cable resistance, amplification, filter setting, overheat ratio etc.). However, the control resistor, which determines the overheat ratio (i.e. sensor operating temperature) can only be set by manual means. Hence the only reason for utilizing the computer interface would be to download for each channel, the sensor characteristics which needs to be determined during a calibration procedure and before an actual test run.

The IFA-100 only supports a 2 way communication (pins 2&3 of an RS232) without any handshaking. Unfortunately neither C or Fortran support this mode of communication via a serial port. Hence we are restricted to using "QBASIC" as a means of sending information to the IFA-100 master module. The following statement is required before any communication can be established:

```
OPEN "COM1:1200,N,8,1,CD0,CS0,DS0,OP0,RS,TB2048,RB2048"
```

This particular statement is only supported in Microsoft QBASIC and is not available in GWBASIC.
It is recommended that similar routine be developed in assembly language which can then be linked to C or Fortarn. Further information on the use of IFA-100 can be found in the supplied instruction manual.

Part III - Frequency Response of a Typical Flush-Film Sensor

It is well known that hot wires/films respond quite rapidly to flow transients. This response has been estimated to be in the Khz range, for both type sensors, but have rarely ever been measured in a controlled environment where the fluctuations are known (e.g. 100KHz pulsed flow). As a result most frequency response calibrations are done with an artificially induced square wave amplitude across a constant temperature sensor. The anemometer output is monitored and tweaked to provide the shortest time response, without too much overshoot, to this input pulse. A typical response curve for a square wave input is shown in Figure 3.

For the hot-wire anemometer the pulse response has been investigated in detail by many researchers. Excellent response to velocity steps is achieved if the pulse is short without undershoot and in this case the cutoff frequency, f_{cut}, of the anemometer can be estimated by

$$f_{cut} = 1/1.5\tau$$

where τ is the time from the start of the pulse until the pulse has decayed to 3% of its maximum value. Another complication that occurs for non-cylindrical film sensors (e.g. flush mounted, wedges, cones etc.) is the thermal lag caused by heat loss to areas not covered by the heated film at low speeds. It is believed that this heat loss becomes negligible at high velocities, but this still does not account for thermal loss to the supporting material (substrate), which becomes particularly important when this film will be of the direct deposit type on a lightly coated surface (epoxy based).

Experiments were conducted to determine the electronic frequency response of the system for 3 different type sensors. The following measurements were made for the configurations listed below:

Configuration	Frequency Response (KHz)
Hot-Wire (1210-T1.5, 5 meter cable)	230
Hot-Film (Flush Mounted, 5 meter cable)	120
Hot-Film (Flush Mounted, 15 meter cable)	115

The above results are the "electronic" response" of the sensors in still atmosphere and does not represent the actual thermal response which may be lagging due to other factors. It is recommended that a carefully designed experiment be conducted so that a flush type sensor along with a conventional hot wire sensor be placed at approximately the same position in an axi-symmetric fully developed jet discharging into still atmosphere. Measurements of flow frequencies should be made simultaneously and compared. This should reduce uncertainties associated with frequency response.

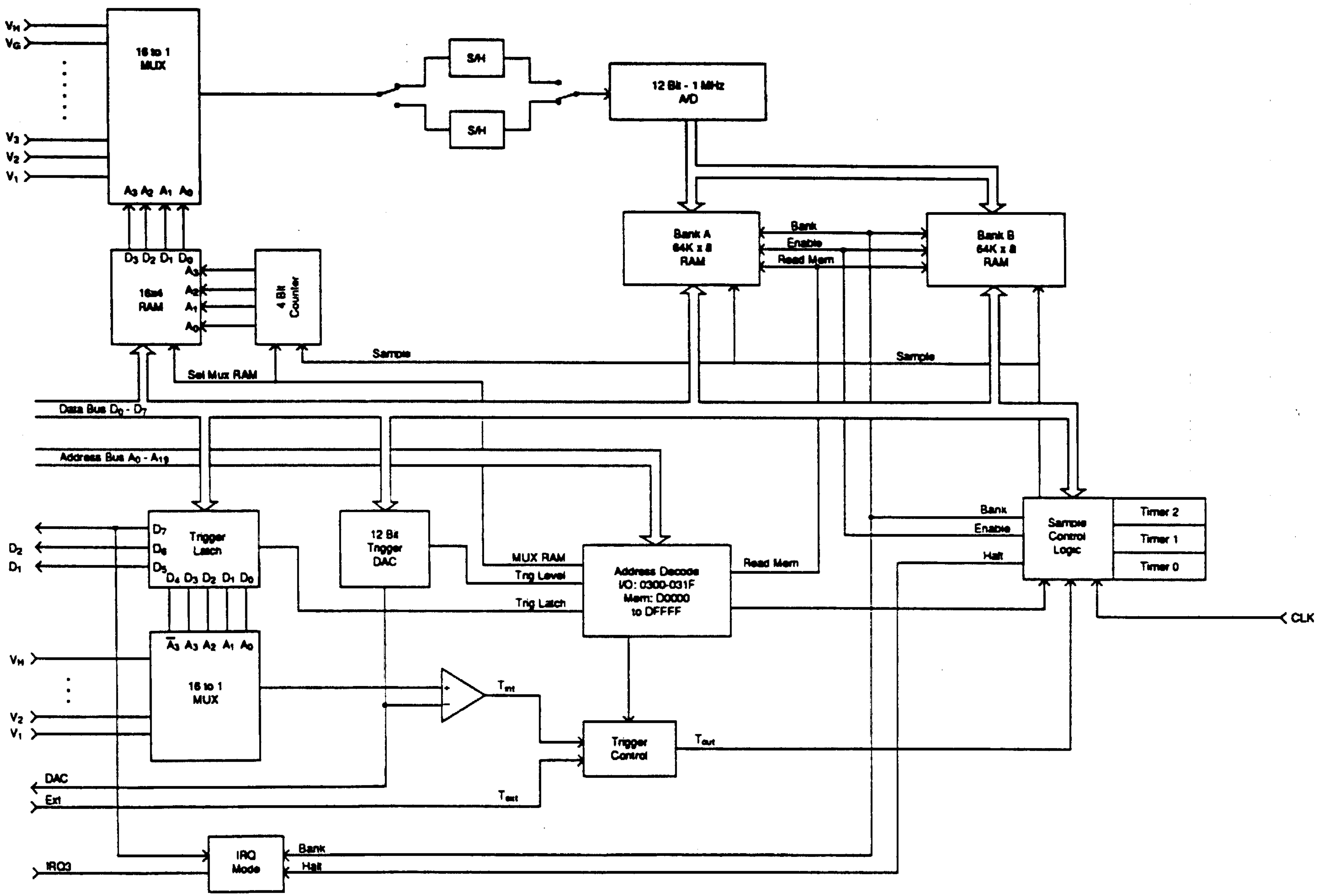

Figure 1 - ISC-16 A/D Board Hardware Schematic

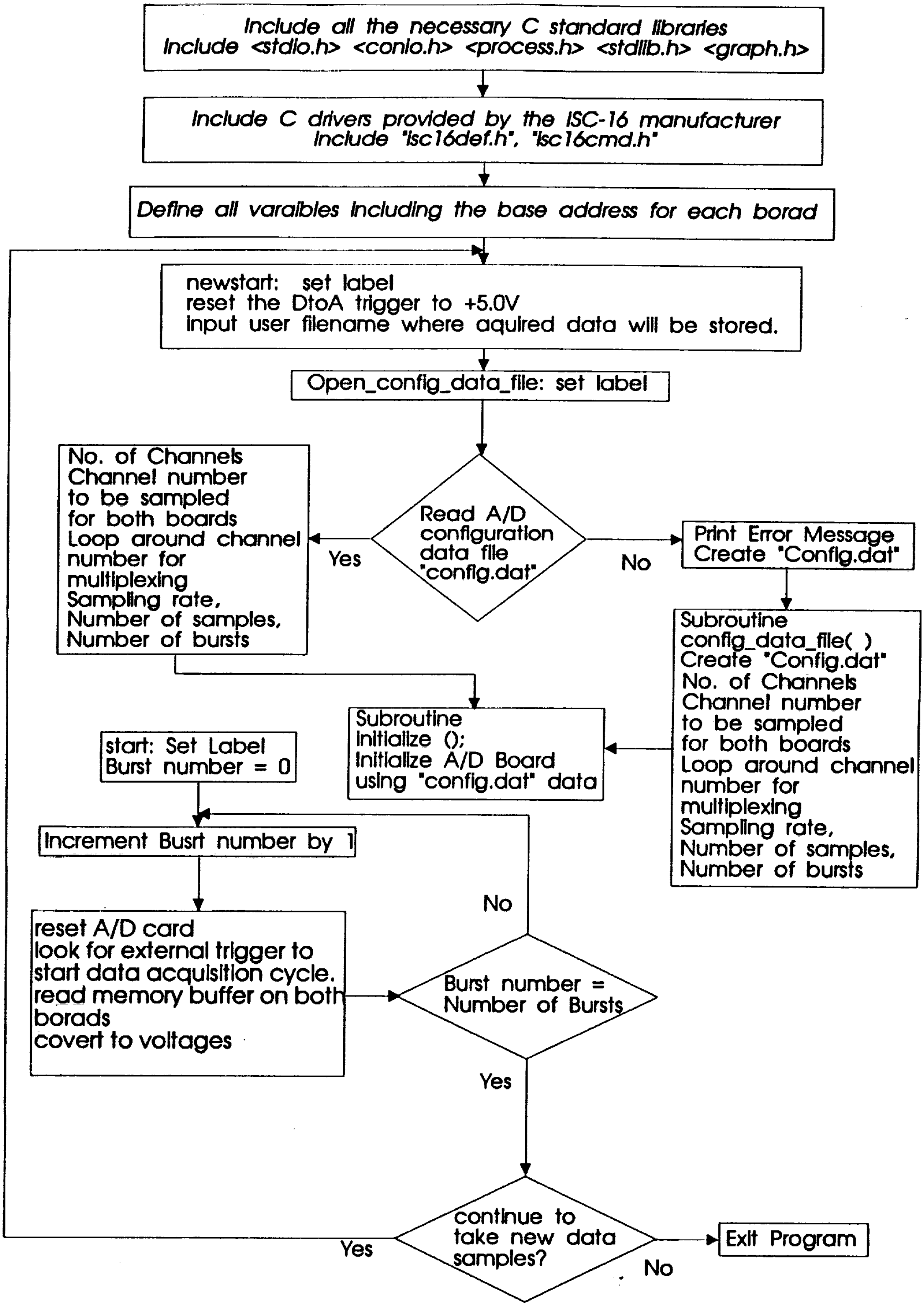

Figure 2 - Data Acquisition Source Code Flow Diagram

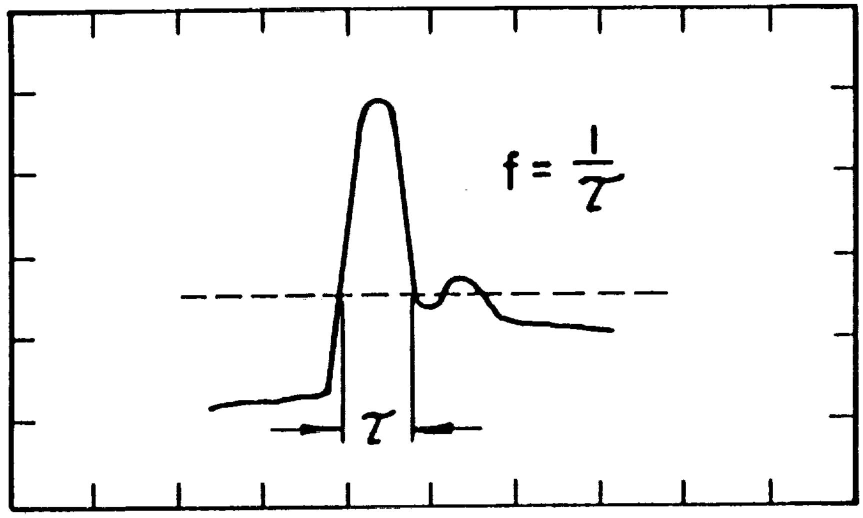

Figure 3a - Square wave test frequency response estimates for film sensors

Curve 1 - ideal response with hot-wire
Curve 2 - ideal response with hot-film
Curve 3 - actual response after tuning

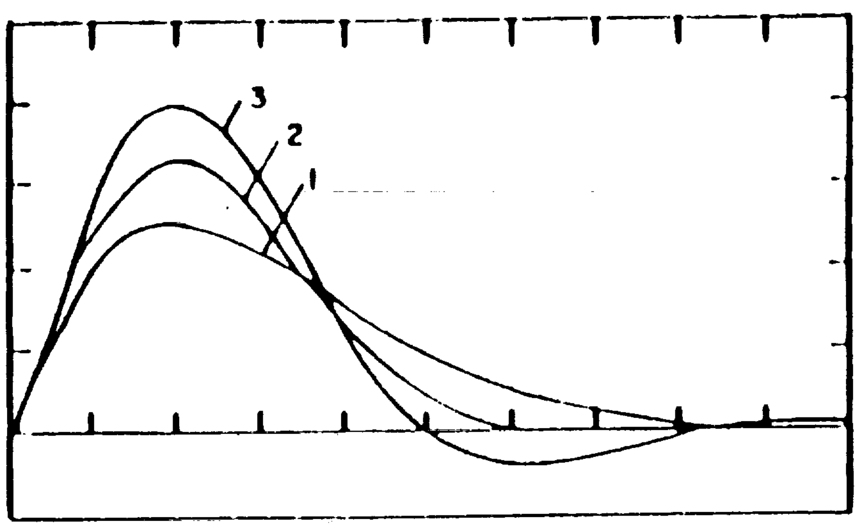

Figure 3b - Pulse shapes in response to a square wave.

A Variational Method for Finite Element Stress Recovery: Applications in One-Dimension

by

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ABSTRACT

It is well-known that stresses (and strains) calculated by a displacement-based finite element analysis are generally not as accurate as the displacements. In addition, the calculated stress field is typically discontinuous at element interfaces. Because the stresses are typically of more interest than the displacements, several procedures have been proposed to obtain a smooth stress field, given the finite element stresses, and to improve the accuracy [1,2]. Hinton and Irons [3] introduced global least squares smoothing of discrete data defined on a plane using a finite element formulation. Tessler and co-workers [4,5] recently developed a conceptually similar formulation for smoothing of two-dimensional data based on a discrete least square approximation with a penalty constraint. The penalty constraint results in a stress field which is C^1-continuous, a result not previously obtained. The approach requires an additional, 'smoothing' finite element analysis and for their two-dimensional application, they used a conforming C^0-continuous triangular finite element based on a conforming plate element [6].

This paper presents the results of a detailed investigation into the application of Tessler's smoothing procedure to the smoothing of finite element stresses from one-dimensional problems. Although the one-dimensional formulation has some practical applicability, such as in truss, beam, axisymmetric mechanics and one-dimensional heat conduction, the primary motivation for developing the one-dimensional smoothing case is to explore the characteristics of the general smoothing strategy. In particular, it is used to describe the behavior of the method and to explore the suitability of criteria proposed for the smoothing analysis. Prior to presenting numerical results, the variational formulation of the smoothing strategy is presented and a criterion for the smoothing analysis is described.

Consider the problem of representing a set of discrete stresses $\hat{\sigma}_p = \hat{\sigma}(\mathbf{x}_p)$, where $\mathbf{x}_p$ is the position vector in a three-dimensional domain Ω, with a smooth, scalar-valued continuous function $\sigma(\mathbf{x})$. The problem may be cast as a minimization of the least-squares/penalty-constraint functional

$$\Phi = \sum_{p=1}^{N} [\hat{\sigma}_p - \sigma(\mathbf{x}_p)]^2 + \lambda \int_\Omega [(\sigma_{,1} - \theta_1)^2 + (\sigma_{,2} - \theta_2)^2 + (\sigma_{,3} - \theta_3)^2] d\Omega \qquad (1)$$

where N is the total number of data points, λ is a large "penalty" number, and θ_1, θ_2, and θ_3 are independent continuous functions . The minimization of Φ is performed with respect to the coefficients in σ and θ_i (i=1,2,3) which serve as the unknowns in this problem. The first term in Eq. (1) represents the *error* in $\hat{\sigma}_p$ as compared with $\sigma(\mathbf{x}_p)$. The second term forces, for large λ, the equivalence of θ_i and the first derivatives of σ.

The finite element method is used to minimize Eq. (1). The domain is discretized by *smoothing* finite elements, each element having a characteristic size h_s. Approximations for the variables σ and θ_i are denoted as σ^{h_s} and $\theta_i^{h_s}$, where the superscript h_s refers to the association of these variables with a smoothing finite element mesh. Since the spatial derivatives of the field variables in Eq. (1) do not exceed order one, only C^0-continuous shape functions need to be adopted for σ^{h_s} and $\theta_i^{h_s}$. While Eq. (1) is written for the general three-dimensional case, the reduction to two- and one-dimensions is trivial: omit terms associated with subscript 3 (2-D) or subscripts 2 and 3 (1-D). The latter is the focus here.

The variational methodology for stress smoothing involves a second finite element analysis, and hence a smoothing finite element mesh is required. A low-order, two-node smoothing element is used here, such that σ^{h_s} is interpolated quadratically and $\theta_1^{h_s}$ linearly [7]. The stresses from the *first* finite element analysis provide the input to the smoothing analysis. These finite element stresses can be written

C-3

in terms of the exact stresses as $\sigma^h = \sigma^{exact} + O(h^m)$, where h represents the finite element size and the exponent m is related to the interpolation order of the finite elements and the definition of stress (assuming no singularity). In elasticity problems, $m = p + 1$, where p is the order of the polynomial in the displacement interpolation. It is argued that the optimum smoothing mesh would result in the same order of accuracy as the original solution. Hence, the smoothing mesh is controlled by the relation $h_s = h^{m/(p_s+1)}$ where p_s is the order of the smoothing element. If the optimal finite element stresses are used as input to the smoothing analysis, then this approach should result in smoothed stresses with optimal accuracy over the entire domain.

A one-dimensional problem defined on the domain (0,1) has been analyzed to evaluate the effectiveness and behavior of the present smoothing method. The problem is analyzed with uniform meshes of 2-, 3-, and 4-node, isoparametric finite elements that use, respectively, linear, quadratic, and cubic interpolation of displacement. The results from the analyses are smoothed using the 2-node smoothing element. The smoothing meshes were based on the above equivalent accuracy criterion.

Figures 1 and 2 show the point-wise and energy convergence of both the finite element and smoothed stresses. It is clear that the smoothed stresses are consistently more accurate than the *raw* finite element stresses, especially for the linear and quadratic finite elements. For the cubic finite element, the results are not as good, which indicates that smoothing elements should be at least as high order as the finite elements whose results they are meant to smooth. Note that the smoothed stresses for the linear and quadratic elements display convergence which is at least one order higher than the finite element stresses. Figure 3 shows the distribution of stress and the error in stress over the entire domain for the case of eight, 2-node finite elements and four, 3-node finite elements. Also shown are the optimal stress points, which were used as input data to the smoothing analysis. It is clear that the smoothing analysis extends the accuracy of the optimal stress points over the entire domain of finite element discretization.

Results indicate that the smoothed stresses are usually at least an order of magnitude more accurate than the original finite element stresses provided interpolation functions for the smoothing element are the same degree or higher than those of the finite element. The accuracy corresponds to a finite element analysis of much higher refinement. Therefore, although an additional, *smoothing* analysis is required, it is much more efficient than refinement of the finite element mesh.

A more detailed explanation of the method and the results can be found in [8]. Application of the smoothing analysis is potentially of use in several areas, including the calculations of transverse shear stresses in plate theory, error estimation based on local equilibrium, and improved potential energy estimation in frequency analysis.

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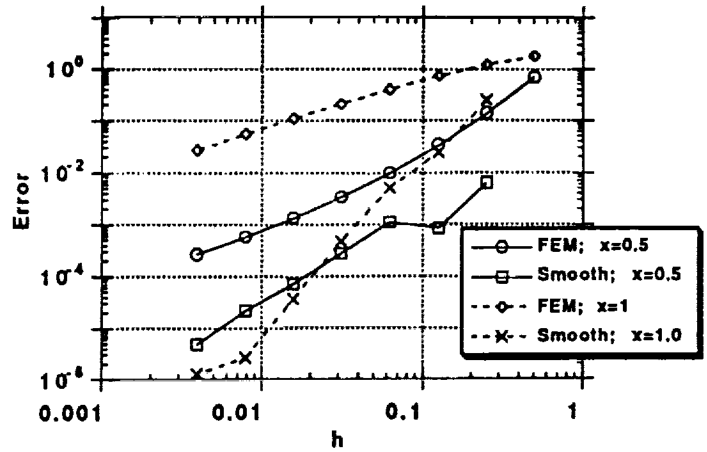
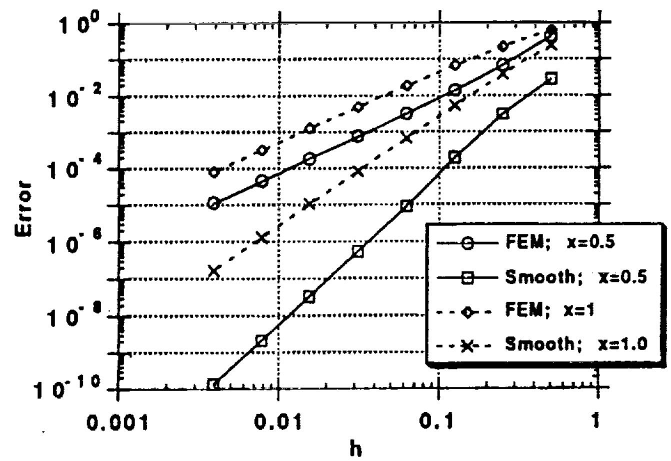


(a)



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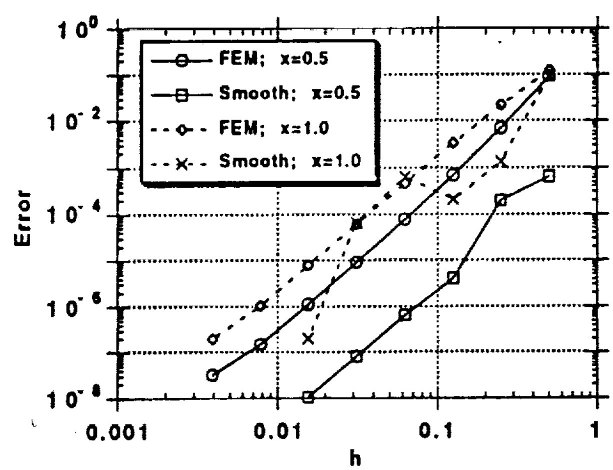
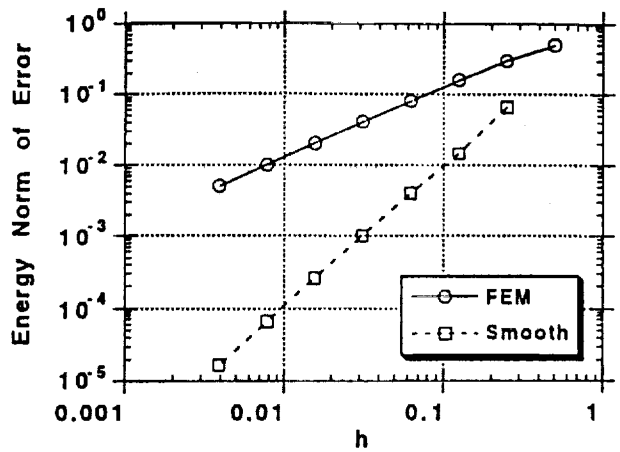


(c)

Figure 1. Error in finite element and smoothed stresses at x = 0.5 and x = 1.0 for (a) linear, (b) quadratic, and (c) cubic finite elements



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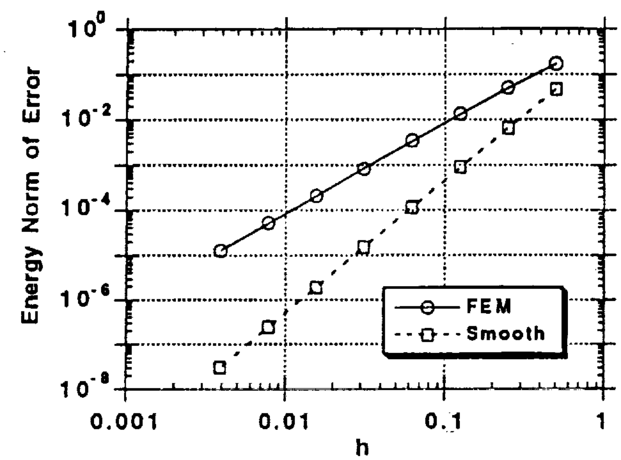
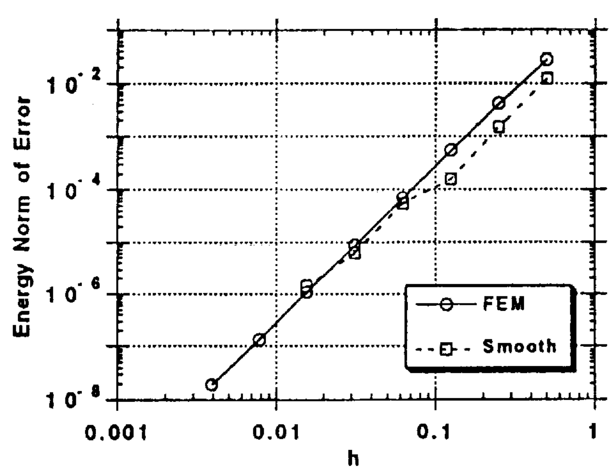


(b)



(c)

Figure 2. Energy norm of error in finite element and smoothed stresses for (a) linear, (b) quadratic, and (c) cubic finite elements

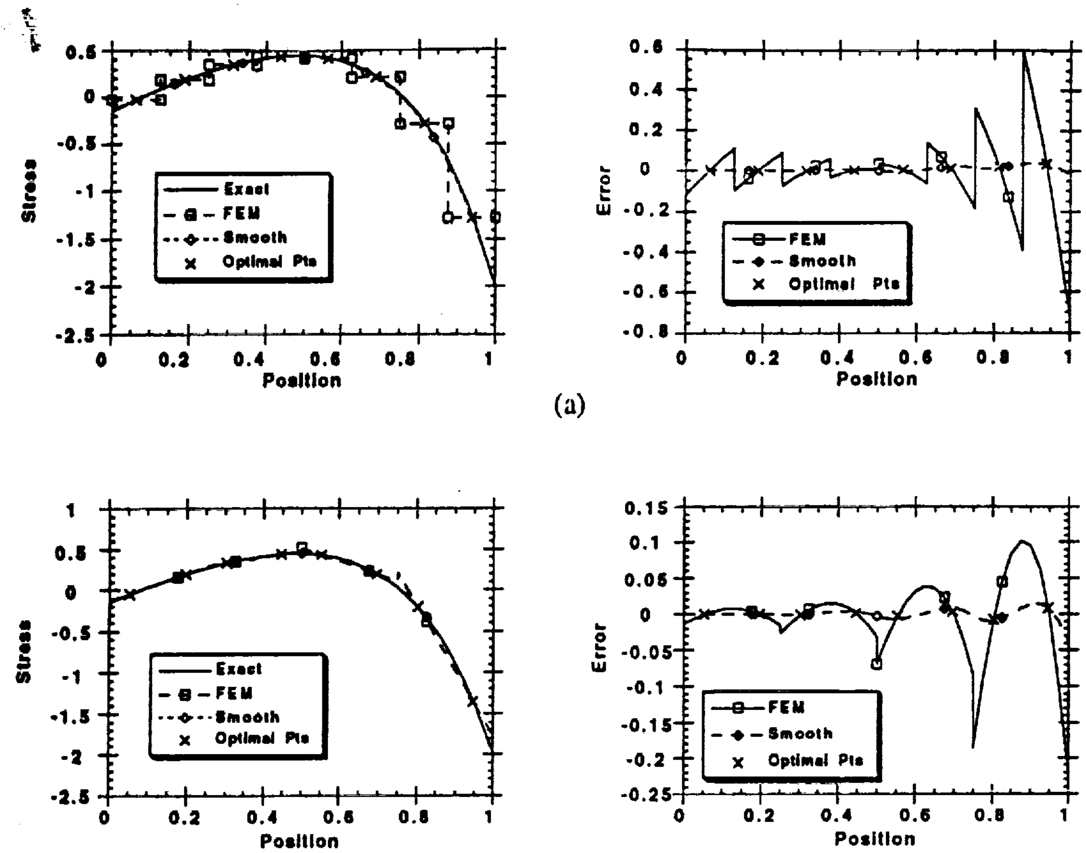


Figure 3. Distribution of stress and stress error for (a) 8 linear and (b) 4 quadratic finite elements

N93-16786

Comparison of Methodologies for Describing Relaxation in Nonequilibrium Gaseous Systems

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abstract

The heat transfer process in hypervelocity vehicles is dominated by nonequilibrium gas dynamics. One model used in CFD codes to predict hypervelocity heat transfer is the "two-temperature" model. An analysis has been made to test the validity of the two-temperature model for predicting another nonequilibrium phenomenon, sound absorption and deviation of signal speed in a high temperature gas. It is found that the two temperature model's prediction capabilities degenerate with increasing temperature. These results are felt to have significance concerning the two-temperature's ability to predict heat transfer in hypervelocity flows.

The goals for future research in space flight include the design of vehicles which can travel through the atmosphere at extremely high velocities. The application for such a requirement include the Mars mission return, the Aeroassisted Orbital Transfer Vehicle, and the National Aerospace Plane. The heat transfer associated with hypervelocity is extreme and must be well understood if adequate designs are to be developed for these applications.

Molecular nonequilibrium dominates physical processes in the transfer of frictional heat developed at hypervelocities. At hypervelocities, the characteristic time scale of the flow is shorter than the time required for energy to equilibrate among the various molecular energy modes. At the shock wave interface, the density gradient of the gas is so great that the gas's kinetic energy is converted almost instantaneously to heat. With the sudden injection of heat energy, the various molecular modes; translation, rotation, vibration, and electronic excitation; are activated at different rates. Heat transfer, therefore, will be due mainly to radiation from a non-equilibrium gas.

Compared to the physics of a gas which is in atomic equilibrium, nonequilibrium gas dynamics historically have not received a great deal of attention. The mechanisms of energy transfer between atomic states is extremely complicated, and few scientific or engineering applications to date have required a knowledge of nonequilibrium gas dynamics; consequently, laws governing nonequilibrium gas dynamics are virtually unknown.

In spite of the fundamental lack of understanding, several models have been proposed for predicting the heat transfer related to nonequilibrium gas dynamics associated with hypervelocity.

One such model, the multi-temperature model, would predict the heat transfer using a modified version of the Navier-Stokes equations in which different temperatures are assigned to different atomic modes. The modal temperatures are coupled to each other through the Landau-Teller terms which include the relaxation time for each mode to reach equilibrium. The concept of modal temperature restricts the population of energy states within those modes to a Boltzmann distribution. We have posed the question as to whether the two temperature model permits the degree of freedom necessary to model the effect of non-equilibrium accurately.

In order to analytically test the validity of the two-temperature model, we considered a sound propagation problem. Sound absorption as well as sound signal speed deviation is controlled by the modal relaxation of translation and vibration. The sound transmission problem has received a great deal of attention from the acoustics community and, therefore, the theory is well understood. Signal frequency in the sound propagation problem is directly analogous to fluid speed in the hypervelocity problem. The problem can be posed in such a way as to be manageable analytically. For frequencies less than 0.1 MHz, the transport terms in the Navier-Stokes equations can be neglected; furthermore, if small signal sound waves are assumed, the equations are linear. The distribution of energy level population among a ground state and two excited states within the vibration mode can be described using rate equations. In the rate equation model, no restriction is made concerning the dynamics of energy level population. The set of equations are solved through the use of successive differentiation and substitution until a wave equation containing the dependant variable of parcel displacement is obtained. A solution in the form of a wave is substituted for this dependant variable. The resulting algebraic equations are solved to obtain an expression for sound absorption and propagation speed.

The figures below illustrate the results for sound absorption. At low temperatures, the lowest excited state is activated relatively infrequently so that sound adsorption is small and the mode's energy is proportional directly to the population of that excited state. Figure 1 shows that, at a low translational mode temperature, 300K, the two temperature model's prediction of sound absorption is identical to the analytical. Figure 2 indicates, however, that, as the temperature is increased, 2000K, the two-temperature model becomes increasingly inaccurate. For the larger temperatures, the second as well as the first excited energy level is populated in a manner not described by a Boltzmann distribution. A given "temperature"; consequently, cannot accurately model vibration mode distribution. Further investigation revealed that when the characteristic time of the sound propagation is low relative to the relaxation time (ie. vibration frequency is large relative to relaxation frequency), the two temperature model predicts sound propagation speed inaccurately regardless of temperature.

Figure 1.
T=300K

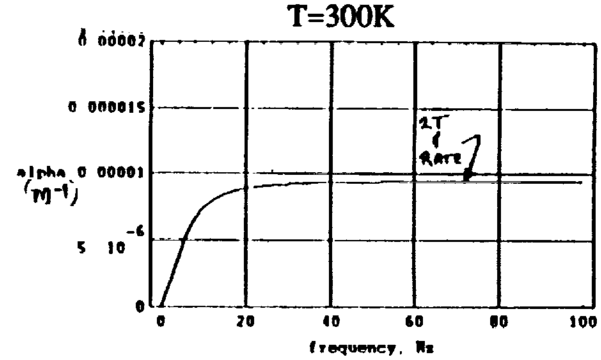
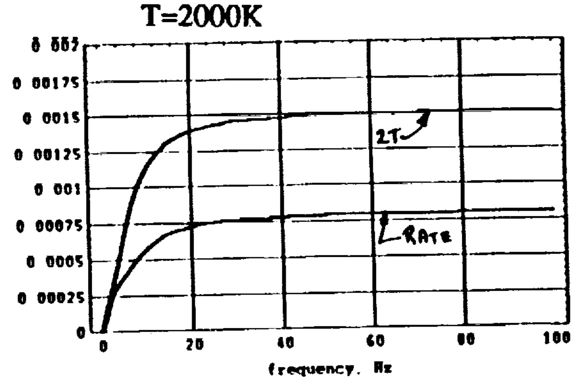


Figure 2.
T=2000K



N93-16787

BOUNDARY-LAYER MEASUREMENTS ON A HIGH REYNOLDS NUMBER THREE-ELEMENT AIRFOIL

by

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Abstract

An experimental investigation is being conducted to evaluate the boundary layer associated with a two-dimensional three-element single-flap airfoil at high Reynolds numbers. The present measurements are being made in the Langley Low-Turbulence (centerline turbulence intensity level is 0.034% at a Mach number of 0.2 and a total pressure of 60 psia) Pressure Tunnel (LTPT). The LTPT is a closed-circuit wind tunnel with a test section which is 3 ft. wide, 7.5 ft. high, and 7.5 ft. long. Operating total pressure for the LTPT varies from 10 atmospheres to near-vacuum conditions. Tests are being conducted at a Mach number of 0.2 and Reynolds numbers (based on chord length) of 5, 9, and 16 million. Measurements include boundary-layer velocity surveys at several chordwise locations and surface skin-friction measurements using Preston tubes.

A sample velocity profile is presented herein for a streamwise location of 0.45 chord lengths, obtained using a Pitot probe. Tunnel conditions included a model angle-of-attack of 4.0 deg., freestream Mach number of 0.2, and chord Reynolds number of 9 million. The velocity profile is presented in terms of nondimensional wall variables, y+ and u+, where $y+=yu_\tau/\nu$, $u+=u/u_\tau$, u_τ=wall-friction velocity= $(\tau_w/\rho)^{1/2}$, ν=kinematic viscosity, and τ_w=wall shear stress. Initially, the data were graphed in the format of a Clauser plot (see Reference 1) to facilitate the determination of the wall shear stress or alternatively, wall skin-friction coefficient, based on a curve-fit to the experimental data in the logarithmic overlap (or log-law) region (up to y+ of approximately 1000). Spalding's composite correlation (applicable to both the wall and log-law regions) was the curve-fit relation used. (see Reference 2) This formula can be written as:

$$y^+ = u^+ + e^{-KB}\left[e^{Ku^+} - 1 - Ku^+ - (Ku^+)^2/2 - (Ku^+)^3/6\right]$$

$K=0.4,\ B=5.5$

The deduced value of the wall skin-friction coefficient from the Clauser plot (0.00263) was then used to define the wall-friction velocity and the values of u+ and y+ for the experimental data. Also shown is an experimental velocity profile based on a value of the wall skin-friction coefficient of 0.00237. This is the value which is obtained from the Newtonian relationship between wall shear stress and wall velocity gradient based on experimental data points close to the wall. It is expected that wall velocity gradients calculated in this manner (at a finite distance above the wall) will result in an underestimation of the wall skin-friction coefficient, since the velocity gradient would be higher at the wall (y+=0).

The deviation of experimental data from the Spalding profile in the region 1000<y+<10000 is due to a jet effect likely caused by induced flow through the slot formed between the slat and the main airfoil element. The change in the slope of the experimental profile at y+>10000 is characteristic of the wake or outer region of the boundary layer.

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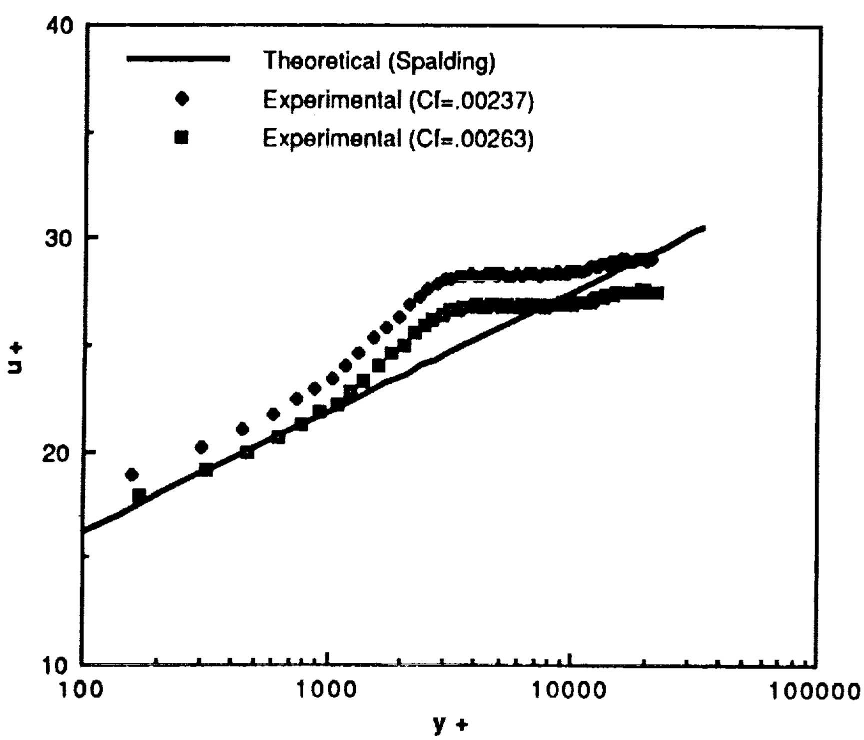
Multielement Airfoil (M=0.2, x/c=0.45)



N93-16788

TOTAL QUALITY MANAGEMENT: STRENGTHS AND BARRIERS TO IMPLEMENTATION AND CULTURAL ADAPTATION

by

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(In collaboration with Michael Glenn, Ed.D., and Louise Hamilton, M.Ed., HRMD/EDB)

NASA/Langley Research Center (LaRC) is in the process of implementing Total Quality Management (TQM) throughout the organization in order to improve productivity and make the Center an even better place to work. The purpose of this project was to determine strengths and barriers to TQM being implemented and becoming a part of the organizational culture of the Human Resources Management Division (HRMD) at Langley. Although there are many definitions of TQM, one that is most comprehensive is contained in the *Draft Department of Defense Total Quality Management Guide* (cited in Saylor, 1992):

> Total Quality Management (TQM) is both a philosophy and a set of guiding principles that are the foundation of a continuously improving organization. TQM is the application of quantitative methods and human resources to improve the material services supplied to an organization, all the processes within the organization, and the degree to which the needs of the customer are met, now and in the future. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach focused on continuous improvement (p.6).

"Corporate culture is the set of formal and informal beliefs, norms, and values that underlie how people in an organization behave and react to change" (Carr & Littman, 1990. p. 181). Carr and Littman (1990) stated that the cultures of traditional organizations generally are not completely supportive of TQM; in fact, some aspects "of the older cultures" can impede quality improvement efforts. On a more positive note, the authors asserted that "executives can learn to treat corporate culture as a manageable variable in the quality equation" (p. 181). However, factors which are causing resistance to TQM must be confronted and conquered in order for a total quality culture to exist (Atkinson, 1991).

Berry (1991) indicated that in order for TQM to succeed, four critical success factors need to exist: (1) top management involvement; (2) a corporate culture that supports the TQM effort; (3) training in TQM tools and techniques; and, (4) customer communications. Dumas described research on TQM efforts which was conducted by Zenger-Miller, management development consultants, based on over 800 organizations. The findings "showed that the majority of ineffective implementations revolved around leadership, skills, strategy, and people issues" (as cited in Clemmer, 1991, p. 40).

The target population for this project was both the supervisory and nonsupervisory staff of the HRMD. In order to generate data on strengths and barriers to TQM implementation and cultural adaptation, a modified nominal group technique was used. Four sessions were held; one with supervisory staff, and three with nonsupervisory staff. A definition of corporate culture was presented to each group before gathering data, to ensure that everyone was operating from a common frame of reference. Two questions were posed to each group, as indicated below:

1. What strengths currently exist to help total quality management be implemented and become a part of the culture of the Human Resources Management Division?

2. What are the barriers to total quality management being implemented and becoming a part of the culture of the Human Resources Management Division?

Supervisors generated 28 strengths and categorized them, in order of importance, beneath the following themes: attitude, HRMD staff, work environment, resources, and interaction. Similarly, 49 barriers were generated and the supervisors categorized them beneath the themes of attitude, work environment, staff, interaction, and resources.

The 30 strengths and 41 barriers produced by nonsupervisors largely paralleled those generated by supervisors. The strengths and barriers were not categorized in order of importance for nonsupervisors, because with three separate sessions, there was not necessarily agreement between the groups. Nonsupervisors categorized the strengths beneath the themes of leadership, employees, communication, center culture, attitude and skills of staff in the Employee Development Branch, and technical support. Barriers were categorized beneath the themes of communication, leadership, training, attitudes, perceptions of center employees, resources, and center culture.

Supervisors and nonsupervisors who participated in the nominal group sessions will review the compiled data for their respective groups. The data will then be fed back to the participants through a series of meetings. Both supervisors and nonsupervisors will be present when data feedback takes place. Participants will be strongly encouraged to own up to, comment on, clarify, or discuss individual items that need to be addressed or debated. With the assistance of this consultant, the data feedback sessions will enable the employees to diagnose the barriers to TQM implementation and cultural adaptation in the HRMD, and to determine organizational development interventions and other strategies that are needed to eliminate these barriers (where feasible). Action plans will be developed and implemented.

Approximately one year from now, an evaluation will be conducted to determine the extent to which the barriers to TQM have been removed and strengths have increased. The evaluation may reveal new barriers that have emerged and need to be addressed. Should the project prove beneficial, it is recommended that the process be be continued throughout LaRC.

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N93-16789

ADVANCED NDE RESEARCH IN ELECTROMAGNETIC, THERMAL, AND COHERENT OPTICS

by
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As a brief acknowledgment, I express my gratefulness to the NASA/ASEE Summer Faculty Fellowship Program and to Dr. Joseph Heyman, Head of the Nondestructive Evaluation Science Branch, for the opportunity of spending an enjoyable, productive and rewarding summer at the Langley Research Center in the technology groups of advanced electromagnetics (Dr. Min Namkung, Group Leader), thermal (Mr. Elliott Cramer, Group Leader), and coherent optics (Dr. Robert Rogowski, Group Leader).

In the electromagnetic group, I investigated a new inspection technology called "Magneto-Optic/Eddy Current Imaging". The magneto-optic imager makes readily visible irregularities and inconsistencies (e.g., rivet holes, fatigue cracks, and subsurface corrosion) in airframe components. A highspeed frame grabber card, image processing solfware (IP Lab/PPG) and an external bias control allow for real-time computer image enhancement. A computer script consisting of background substraction, pixel averaging, histogram equalization, and linear filtering provided excellent real-time computer image enhancement of the anomalies.

Other research I observed in electromagnetics included (1) Disbond Detection Via Resonant Modal Analysis, (2) AC Magnetic Field Frequency Dependence of Magnetoacoustic Emission, and (3) Multi-View Magneto-Optic Imaging. Also while I was in electromagnetics, I had an opportunity to observe an experiment in radiography which involved the identification of various powders and metals via x-ray diffraction.

The thermal group is actively pursuing a number of avenues of research using thermal energy to quantitatively characterize various aerospace structures. Ongoing research I spent time in included: (1) Thermographic detection and characterization of corrosion in aircraft aluminum, (2) A multipurpose infrared imaging system for thermoelastic stress detection. (3) Thermal diffusivity imaging of stress induced damage in composites, and (4) Detection and measurement of ice formation on the Space Shuttle Main Fuel Tank.

The optics group is advancing the state of the art in optical NDE. Current activities of the remote sensing group I observed included: (1) Development of speckle interferometric and shearographic techniques to obtain quantitative strain field images of large surfaces (observed the analysis of subsurface stress on the space station nickel hydrogen batteries via shearography), and (2) Development of fiber optic sensors for the in-situ health monitoring of structures, with emphasis on aircraft and spacecraft structures (the concept of smart structures and skins).

N93-16790

ANTENNA ANALYSIS USING NEURAL NETWORKS

by

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ABSTRACT

Conventional computing schemes have long been used to analyze problems in electromagnetics (EM). The vast majority of EM applications require computationally intensive algorithms involving numerical integration and solutions to large systems of equations. In this study, the feasibility of using neural network computing algorithms for antenna analysis is investigated. The ultimate goal is to use a trained neural network algorithm to reduce the computational demands of existing reflector surface error compensation techniques.

Neural networks are computational algorithms based on neurobiological systems. Neural nets consist of massively parallel interconnected nonlinear computational elements (see Fig. 1). They are often employed in pattern recognition and image processing problems. Recently, neural network analysis has been applied in the electromagnetics area for the design of frequency selective surfaces and beam forming networks.

In this study, the backpropagation training algorithm was employed to simulate classical antenna array synthesis techniques. The Woodward-Lawson (W-L) and Dolph-Chebyshev (D-C) array pattern synthesis techniques were used to train the neural network. The inputs to the network were samples of the desired synthesis pattern. The outputs are the array element excitations required to synthesize the desired pattern. Once trained, the network is used to simulate the W-L or D-C techniques.

Various sector patterns and cosecant-type patterns (27 total) generated using W-L synthesis were used to train the network. Desired pattern samples were then fed to the neural network. The outputs of the network were the simulated W-L excitations. For this part of the study, a 20 element linear array was used. There were 41 input pattern samples with 40 output excitations (20 real parts, 20 imaginary). A comparison between the simulated and actual W-L techniques is shown in Fig. 2 for a triangular-shaped pattern.

Dolph-Chebyshev is a different class of synthesis technique in that D-C is used for side lobe control as opposed to pattern shaping. The interesting thing about D-C synthesis is that the side lobes have the same amplitude. Five-element arrays were used. Again, 41 pattern samples were used for the input. Nine actual D-C patterns ranging from -10 dB to -30dB side lobe levels were used to train the network. Figure 3 shows a comparison between simulated and actual D-C techniques for a pattern with -22 dB side lobe level.

The goal for this research was to evaluate the performance of neural network computing with antennas. Future applications will employ the backpropagation training algorithm to drastically reduce the computational complexity involved in performing EM compensation for surface errors in large space reflector antennas.

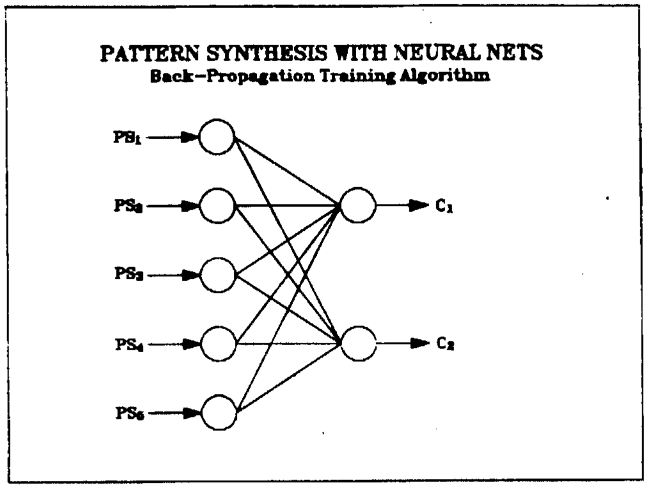

Figure 1. Neural network diagram.

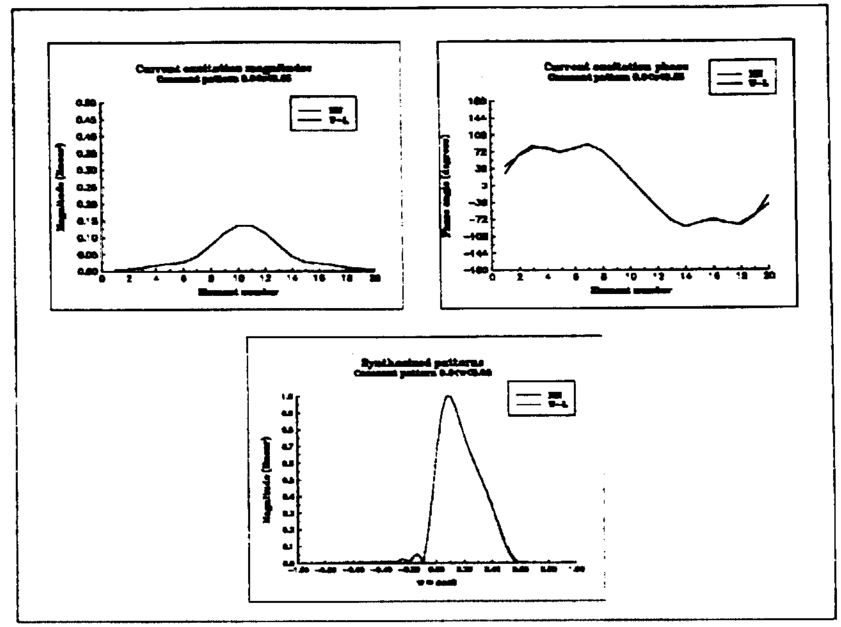

Figure 2. W–L synthesis for a triangular pattern.

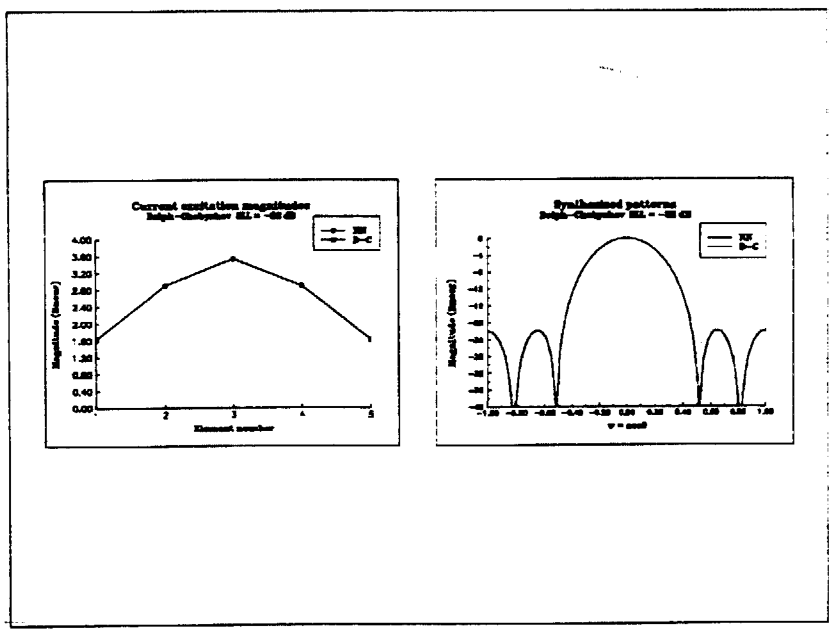

Figure 3. D–C synthesis for a pattern with –22 dB side lobes.

STABILITY OF GENERALLY STIFFENED ANISOTROPIC NONCIRCULAR CYLINDERS

BY

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Continuous filament grid-stiffened structure [1] is a stiffening concept that combines structural efficiency and damage tolerance. However, finite element design of such structures against buckling is expensive due to the complexities of the structure. An analytical model of such a structure is developed using a penalty method (artificial springs) with a First Order Shear Deformation theory. The buckling analysis under combined loading is done using Energy method with a penalty/Rayleigh-Ritz technique. The penalty/Rayleigh-Ritz approach is computationally less demanding when compared to the finite element solution and mesh generation.

Apart from the published research works on buckling of stiffened plates and shells by finite element and finite strips, research works on buckling of stiffened plates and shells utilize three different approaches, smeared, column, and discrete approaches. The discrete approach [2] considers the discrete effects of the stiffeners in the buckling behavior by modeling stiffeners as line of bending (EI) and torsion (GJ) stiffnesses on panel skin. Some local deformations are lost when stiffeners are modeled as (EI) and (GJ) stiffeners. This approach becomes difficult in the case of plate stiffened in more than two directions. Most of the work done using the discrete approach involved the Classical Plate Theory (CLPT) rather than the FSDT. In the remaining part of this abstract we report on our formulation of a discrete approach coupled with a penalty formulation and FSDT.

The displacement field for a cylindrical shell according to First Order Shear Deformation theory (FSDT, also called Reissner-Mindlin Plate Theory) are

$$u = u_0 + z\phi_x, \quad v = v_0 + z\phi_y, \quad w = w_0(x, y)$$

where u_0 is the membrane axial displacement. v_0 is the membrane circumferential displacement. w is the out of plane displacement. ϕ_x, ϕ_y are the cross-sectional rotations.

The critical loading is determined on the basis of the principle that during buckling the elastic strain energy stored in the structure is equal to the work done by the applied loading. The internal strain energy, the external work done and the total potential energies are expressed as

$$U_e = \frac{1}{2}\int_A (N_x\epsilon_x^o + N_y\epsilon_y^0 + N_{xy}\gamma_{xy}^0 + M_x\kappa_x + M_y\kappa_y + M_{xy}\kappa_{xy} + Q_x\gamma_{xz} + Q_y\gamma_{yz})dA$$

$$W_d = \frac{1}{2}\int_A \left(\bar{N}_x\frac{\partial w}{\partial x}\frac{\partial w}{\partial x} + N_y\frac{\partial w}{\partial y}\frac{\partial w}{\partial y} + 2N_{xy}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)dA$$

$$\Pi = U_e + W_d$$

The following approximate representation of the displacement field are used.

$$\{\vec{U}\} = \left\{\begin{array}{c} u \\ v \\ w \\ \phi_x \\ \phi_y \end{array}\right\} = \sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\left\{\begin{array}{c} U_{mn}\cos\frac{m\pi x}{L}\sin\frac{n\pi y}{S} \\ V_{mn}\sin\frac{m\pi x}{L}\cos\frac{n\pi y}{S} \\ W_{mn}\sin\frac{m\pi x}{L}\sin\frac{n\pi y}{S} \\ (\Phi_x)_{mn}\cos\frac{m\pi x}{L}\sin\frac{n\pi y}{S} \\ (\Phi_y)_{mn}\sin\frac{m\pi x}{L}\cos\frac{n\pi y}{S} \end{array}\right\}$$

The approximating functions satisfy simply supported boundary conditions. General boundary conditions are realized by introducing a low order global finite element shape functions.

The discrete form of the internal elastic energy and external work done are expressed as

$$U_e = \frac{1}{2}\left(\frac{LS}{4}\right)\sum_{m=1}^{\infty}\sum_{n=1}^{\infty} \mathbf{U}_A^T\mathbf{K}_{mn}\mathbf{U}_A$$

$$W_d = \frac{1}{2}\left(\frac{LS}{4}\right)\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\left[\hat{N}_x\left(\frac{m\pi}{L}\right)^2 + \hat{N}_y\left(\frac{n\pi}{S}\right)^2\right]\mathbf{U}_A^T\Delta_{(3,3)}\mathbf{U}_A$$

$$+ \quad \mathbf{U}_A^T\sum_{m=1}^{\infty}\sum_{n=1}^{\infty}\sum_{p=1}^{\infty}\sum_{q=1}^{\infty}\hat{N}_{xy}\left(\frac{LS}{4}\right)I_{mnpq}\mathbf{U}_A^T\Delta_{(3,3)}\mathbf{U}_B$$

$$I_{mnpq} = \begin{cases} \frac{32}{LS}\frac{mnpq}{(p^2-m^2)(q^2-n^2)} & m \pm p, n \pm p \ \ odd \\ 0 & otherwise \end{cases}$$

We verified our curved panel code by analyzing the stability of an anisotropic cylindrical panel. The cylindrical panel is not stiffened. The panel is 30.0 in, long and 28.82 in, wide in the circumferential direction with a radius of 40.0 in. This panel was sized by VICON to carry 1000 labs/in axial load. The analysis of this panel using our code gave a buckling load of 900.12 labs/in while the stability analysis by VICON predicted a 984 lbs/in for the buckling load. Our conservative estimate stems for the fact that we have included shear deformation in out energy formulation above.

We introduce the penalty formulation to connect generally oriented stiffeners to the skin of a given fuselage. The internal elastic energy of each stiffener is added to the internal elastic energy of the skin of the fuselage. The skin and stiffeners compatibility is enforced by using stiff springs (penalty functions). The total potential energy of a generally stiffened structure can be written symbolically as

$$\Pi = \sum \Pi_i + \sum \alpha_i \mathbf{f}_i$$

where Π, Π_i, α_i, and $\mathbf{f}_i$ are the total potential energy, potential energy of each structure, penalty functions (artificial springs), and functional constraints, respectively. The total potential energy is then minimized for a specific value of the α_i's. The approximate stability load is obtained by minimizing the total potential energy after choosing a suitable functional expansion of each component of the displacement field.

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N93-16792

STUDIES ON SPECTRAL ANALYSIS OF RANDOMLY SAMPLED SIGNALS: APPLICATION TO LASER VELOCIMETRY DATA

by

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Abstract

Spectral analysis is very useful in determining the frequency characteristics of many turbulent flows, for example, vortex flows, tail buffeting, and other pulsating flows. It is also used for obtaining turbulence spectra from which the time and length scales associated with the turbulence structure can be estimated. These estimates, in turn, can be helpful for validation of theoretical/numerical flow turbulence models. Laser velocimetry (LV) is being extensively used in the experimental investigation of different types of flows, because of its inherent advantages: nonintrusive probing, high frequency response, no calibration requirements, etc. Typically, the output of an individual realization laser velocimeter is a set of randomly sampled velocity data. Spectral analysis of such data requires special techniques to obtain reliable estimates of correlation and power spectral density functions that describe the flow characteristics.

Standard techniques of spectral analysis used for uniformly sampled (equispaced) signals are not directly applicable to randomly sampled data. Shapiro and Silverman [1] showed, theoretically, that alias-free spectral estimates can be obtained from randomly sampled data if the sampling is Poisson distributed. Based on this theory, Mayo et al [2] developed a correlation-based 'slotting' technique to compute the autocorrelation and power spectrum estimates through use of Fourier transform. Also, Gaster and Roberts [3] developed a direct transform method to compute the power spectrum estimates directly from the randomly sampled data, and, if needed, the autocorrelation estimates can be obtained using inverse Fourier transform. The slotting technique is faster than the direct transform method and has been looked into in detail by Srikantaiah and Coleman [4] to make reliable spectral estimates from randomly sampled laser velocimetry data.

The Experimental Methods Branch of NASA Langley Research Center had expressed a need for research, and development of computer codes, for reliable and improved estimation of turbulence spectra and the associated time and length scales from LV data. During his 1992 NASA/ASEE Summer Fellowship tenure, the author has developed FORTRON codes for obtaining the autocorrelation and power spectral density estimates using the correlation-based

slotting technique. Extensive studies have been conducted on simulated first-order spectrum and sine signals to improve the spectral estimates. A first-order spectrum was chosen because it represents the characteristics of a typical one-dimensional turbulence spectrum. Digital prefiltering techniques, first introduced by Roberts and Ajmani [5], to improve the spectral estimates from randomly sampled data have been applied. Studies show that the spectral estimates can be increased up to about five times the mean sampling rate. Figure 1 illustrates the results of this study on simulated first-order spectrum. The codes are currently being used on LV experimental data from different flow facilities at NASA Langley. Figure 2 shows the turbulence spectra measured at two different locations in the backward-facing step flow facility. These results will be compared with hot-wire measurements. Further improvements and validation of the spectral analysis codes will continue.

Large data sets (of the order of 100,000 points or more), high data rates, and ,of course, Poisson sampling are very important requirements for reliable estimation of turbulence spectra. The Poisson sampling requirement is usually met in carefully conducted LV experiments. But, often, certain flow conditions, depending upon measurement location, flow phenomenon, and particle dynamics, force the sampling process to be non-Poisson. The high data rate requirement may not be achieved. The effect of non-Poisson sampling has also been studied on simulated, as well as, real data. Results show that the estimated spectrum deviates considerably from the true spectrum and that non-Poisson sampling is not amenable to spectral improvements from prefiltering techniques. Further research is required to determine the effects of other influences like particle dynamics, velocity bias, etc. on the accuracy of spectral estimates. Research is also needed to extend the spectral analysis techniques to obtain cross-correlation and cross-power spectral estimates from randomly sampled 2-D/3-D LV experimental data.

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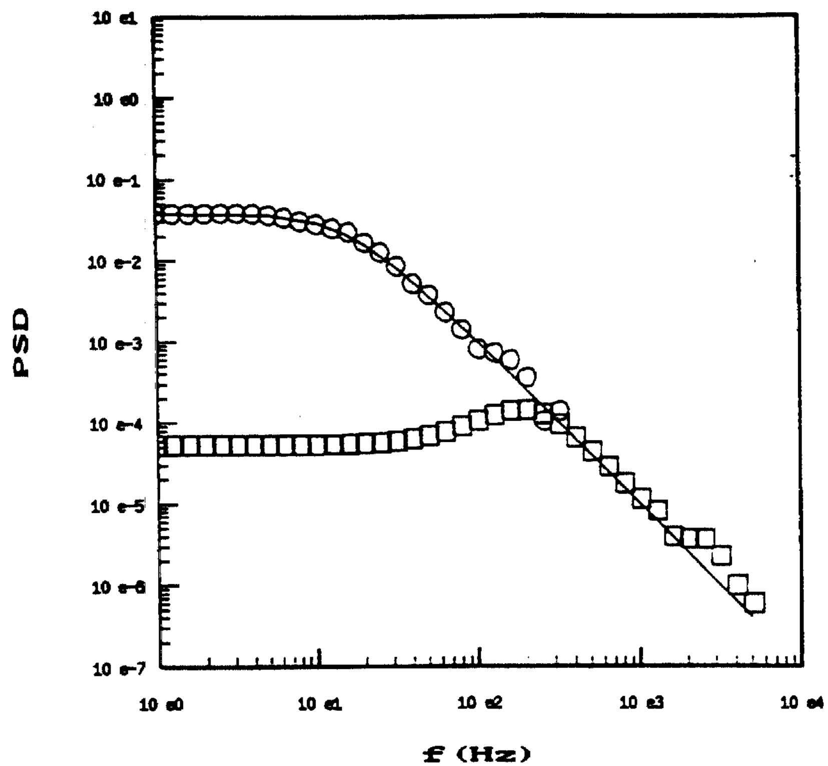

Figure 1: Study on simulated first-order spectrum. Solid line is theoretical spectrum. Circles are estimated values of unfiltered data. Squares are improved values by prefiltering techniques (kind of high-pass filtering) which extend spectral estimates up to about five times data rate (1000/s here). PSD: Power Spectral Density.

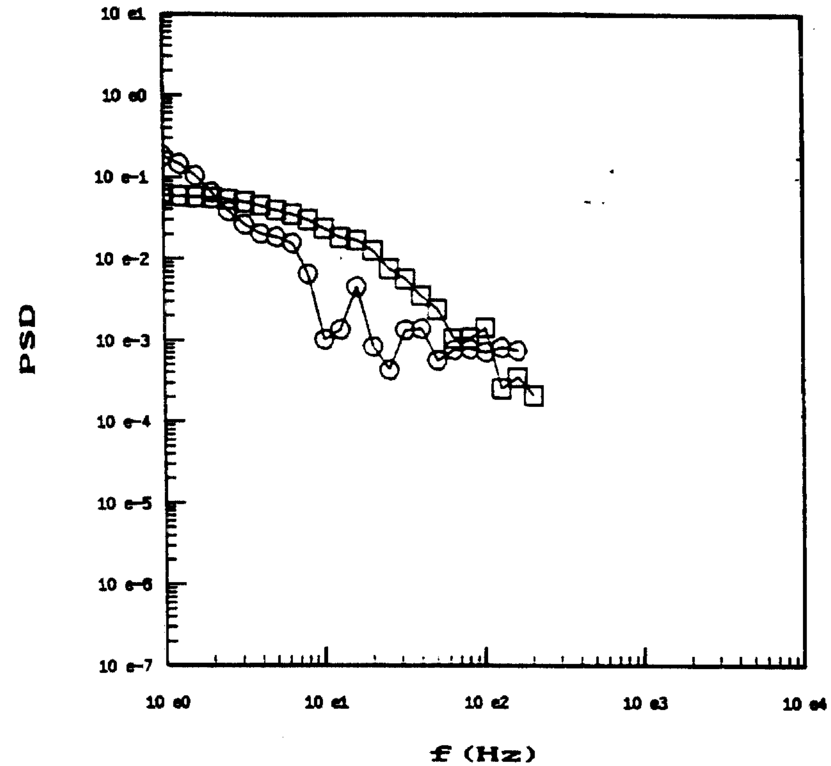

Figure 2: Turbulence spectra from LV measurements at 3" upstream (circles, data rate: 188/s) and 27" downstream (squares, data rate: 96/s) axial locations in backward-facing step flow facility at NASA Langley. Note facility fan frequency of 18.5 Hz (1110 RPM) is detected.

N93-16793

Mode Interaction in Stiffened Composite Shells under Combined Mechanical and Thermal Loadings

by

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Abstract

Stiffened Shells of various configurations, fabricated out of composite materials find extensive applications in aircraft structures. Two distinctive modes of buckling dominate structural response of stiffened panels, viz. the short-wave local mode in which the shell skin buckles essentially between the stiffeners and the and the long-wave overall mode in which the shell skin buckles carrying the stiffeners with it. In optimized designs, the critical stresses corresponding to these modes of buckling would be close to each other. This leads to a nonlinear mode interaction which is recognized to be the principal cause of the failure of stiffened structures. If the structure is subjected to through-the-thickness thermal gradients, then large-wave bending effects would begin to occur well below the overall critical load and these would play the role of overall imperfections. The load carrying capacity would be significantly diminished as a result of interaction of local buckling with overall thermal distortions. The analysis of this problem using standard finite element techniques can be shown to be prohibitively expensive for design iterations.

In this research a novel concept which would greatly facilitate the analysis of mode interaction is advanced. We note that the local buckling occurs in a more or less periodic pattern in a structure having regular spacings of stiffeners. Thus it is a relatively simple matter to analyze the local buckling and the second order effects (which are essential for modelling postbuckling phenomena) using a unit cell of the structure. Once analyzed, these deformations are embedded in a shell element. Thus a shell element could span several half-waves of local buckling and still be able to depict local buckling effects with requisite accuracy. A major consequence of the interaction of overall buckling/bending is the slow variation of the local buckling amplitude across the structure - the phenomenon of "amplitude modulation" - and this is accounted for in the present model by letting the scaling parameter of the local mode vary according to a "slowly varying" function.

The construction of the analytical model involves essentially two stages and these are described briefly in the sequel.

Stage I: In this stage, the local buckling problem is first solved, thus obtaining the buckling mode and the associated second order field. This problem is solved "locally" for the given state of stress without reference to the boundary conditions of the structure and taking advantage of symmetry/periodicity of the arrangement of the stiffeners. For example, in the case of stringer stiffened shells, a finite strip technique with the displacements characterized by appropriate trigonometric functions is employed. The second order field is produced using an asymptotic procedure.

Stage II : The displacement at any point can be viewed as the sum of local and overall contributions. Thus :

$$\{u\} = \{u_{ov}\} + \xi_i f_i \{u_1\} + \xi_i \xi_j f_i f_j \{u_2\}$$

where u_{ov} , u_1 and u_2 stand respectively for the overall displacement field, the local buckling mode, and the associated second order field; ξ_i and f_i are respectively the degrees of freedom (d.o.f.) and functions representing the amplitude modulation. A finite element is constructed to describe the overall displacement variations and the amplitude modulation in terms of appropriate number of d.o.f. For a stringer-stiffened shell, the element would span from stiffener to stiffener and cover several half-waves of buckle in the longitudinal direction.Drastic simplifications arise in setting up the tangent stiffness matrix and the unbalanced load vector at any stage in the loading history, by the recognition of the "slowly varying" nature of the overall displacement and amplitude modulating functions in contrast to the local buckling functions.

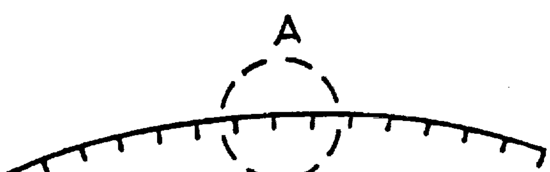
Current status :

Stage I, which comprises of local and postlocal buckling analysis is complete. Stringer-stiffened shells were considered, with appropriate trigonometric functions characterizing the displacement variations in the longitudinal direction and p-version type polynomials in the transverse direction. The advantages of p-version finite strips are the absence of shear-locking and the rapid rate of convergence of the solutions.

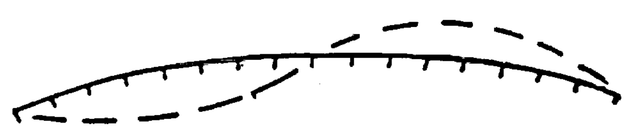
Work on Stage II is currently under way. p-version finite elements have been employed to perform full range nonlinear analysis. An arc-length scheme has been implemented to negotiate the limit points. Several bench mark problems were studied with the object of assessing the performance of the elements in highly nonlinear situations. Local buckling displacement fields were embedded in the elements in terms of the scaling factor of the buckling mode, which is given freedom to vary spatially. Preliminary results on panels having blade-stiffeners are found to closely agree with the established results in the field.

Future Work :

The next phase of the study will focus on modal interaction in the context of combined mechanical and thermal loading of composite stiffened plate and shell structures.

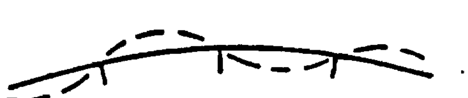


(a)



(b)

Cross-section of a Stiffened Shell
and the Modes of Buckling :
(a) The local mode (b) The overall mode



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N93-16794

CHARACTERIZATION OF RADIATION-INDUCED DAMAGE IN HIGH PERFORMANCE POLYMERS BY ELECTRON PARAMAGNETIC RESONANCE IMAGING SPECTROSCOPY

by

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At present, the potential for long-term human activity beyond the Earth's protective magnetosphere is limited in part by the lack of detailed information on the effectiveness and performance of existing structural materials to shield the crew and spacecraft from highly penetrating space radiations. The two radiations of greatest concern are high energy protons emitted during solar flares and galactic cosmic rays which are energetic ions ranging from protons to highly oxidized iron [1-3].

Although the interactions of such high-energy radiations with matter are not completely understood at this time, the effects of the incident radiation are clearly expected to include the formation of paramagnetic spin centers via ionization and bond-scission reactions in the molecular matrices of structural materials. Since this type of radiation damage is readily characterized by Electron Paramagnetic Resonance (EPR) spectroscopy [4], the NASA Langley Research Center EPR system was repaired and brought on-line during the 1991 ASEE term.

A major goal of the 1992 ASEE term was to adapt the existing core of the LaRC EPR system to meet the requirements for EPR Imaging--a powerful new technique which provides detailed information on the internal structure of materials by mapping the spatial distribution of unpaired spin density in bulk media [5,6]. Major impetus for this adaptation arises from the fact that information derived from EPRI complements other methods such as scanning electron microscopy which primarily characterize surface phenomena.

The modification of the EPR system has been initiated by the construction of specially designed, counterwound Helmholtz coils which will be mounted on the main EPR electromagnet. The specifications of the coils have been set to achieve a static linear magnetic field gradient of 10 gauss/mm/amp along the principal (Z) axis of the Zeeman field.

Construction is also in progress of a paramagnetic standard in which the spin distribution is known in all three dimensions. This sample will be used to assess the linearity of the magnetic field gradient and to ensure authentic image reconstruction.

A second major task was to secure the computer capability to enable image reconstruction from projection data generated by the magnetic field gradients. To this end, commercially available and public domain software packages which perform inverse Fourier Transform and convoluted (filtered) back projection functions are being integrated into the existing EPR data processing system.

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N93-16795

Desktop Computing Integration Project

by

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Project Overview - The Desktop Computing Integration Project for the Human Resources Management Division of LaRC was designed to help division personnel use personal computing resources to perform job tasks. The three goals of the project were to involve HRMD personnel in desktop computing, link mainframe data to desktop capabilities, and to estimate training needs for the division. The project resulted in increased usage of personal computers by Awards specialists, an increased awareness of LaRC resources to help perform tasks, and personal computer output that was used in presentation of information to center personnel. In addition, the necessary skills for HRMD personal computer users were identified. The Awards Office was chosen for the project because of the consistency of their data requests and the desire of employees in that area to use the personal computer.

Involve HRMD Personnel in Desktop Computing - Involving the Awards Office in personal computing required studying available desktop computing applications, identifying current projects where Macintosh productivity software would be helpful, and using the programs to complete a job task. We found that the most readily available programs were Microsoft Works and EXCEL. In addition, there was access to other programs, such as Delta Graph, FoxBase and FileMaker Pro. As we were looking at software packages, a project started that was tailor made for EXCEL. We developed a data set for the exercise, including several graphs and data charts. We identified and used resources around LaRC that allowed printing of the graphs in color. Finally, HRMD Awards personnel documented how the task was done for future reference. This project represented a new area of accomplishment for the Awards staff.

Link Mainframe Data to Desktop Capabilities - Our work began with a brief study of data analysis, capabilities and design. We were interested in presenting the concepts of data management for HRMD personnel so they could use those skills in developing solutions using Macintosh application software. Our target software product for the study was Microsoft Works. This was chosen because of its broad availability throughout the division. We learned about the program through individualized study materials available in the Learning Center. Much of the material presented was review, but some details were important new skills.

After we learned about Macintosh applications, we studied the data that was available on the mainframe system. Our goal in this study was to specify the data necessary for a download session. By examining many reports, along with recent special studies, we identified the content of a proper download from the mainframe database for Awards. This content was translated to specific database elements by searching the database dictionary and examining existing NATURAL programs. This became our specification for a download program, which will require a NATURAL program be written to download the data from the mainframe to the Macintosh. The program will most likely use the linking facility named NATURAL CONNECTION, which allows the mainframe NATURAL database to be easily linked to personal computer applications, processes and files. The downloaded data will then be loaded into an application such as Works.

With the download program specified, we developed a practice data set using a representative report and optical character reading (OCR) technology. This sample data set allowed personnel to practice the skills necessary to be successful after data is downloaded. We practiced importing data, setting the database format, generating reports, sorting, selection and printing. In addition, we studied how to automate the data import and transformation process by using a macro. This allows automatic, consistent setup of a downloaded set of data.

Estimate Training Needs for the Division - There are three types of skills that users need to be successful in downloading data. These are personal computing basics, data abstraction and data related problem solving. The personal computing basics that are required of the user are working with diskettes, proper use of folders, use of the mouse and desktop, and knowledge of a productivity program. Data abstraction is representing an activity in terms of data. This skill is necessary in personal computer exercises where the user must decide upon content. Data abstraction also requires an understanding of the types of data that are reasonable, such as number, character and date formats. Data related problem solving is applying the personal computer skills, data abstraction and an understanding of data meanings to solve a new problem.

Resources for the Job - There are many resources available at LaRC. Three particular areas that helped us in our personal computing project were the Evaluation and Information Center (EIC), Technical Library and the Learning Center. As an ASEE fellow, I found the NASA Publications such as Spinoff and TECH Briefs to be a great source of information, as well as the Teacher Resource Center and the COSMIC database resource.

The Evaluation and Information Center (EIC) provides technical information to the center and keeps current on hardware and software capabilities. The EIC has many resources available for evaluation and use, such as different hardware platforms, software, scanners and color printers. In addition, the EIC has reviews on products in both magazine and database form, and runs a bulletin board service to provide information and software items. We used EIC hardware and software not available in our division to help us get the job done.

The Technical Library is a comprehensive engineering and scientific library. There are a number of books available on personal computing software. This resource is valuable to the user seeking information on different programs. The on-line catalog, STILAS (Scientific and Technical Information Library Automation System), provides a quick search capability to the volumes on hand. Also, the CD-ROM journal collections allow searching of journals for information, including some full text options for various collections. We used the library as a reference to desktop applications as questions came up.

The Learning Center offers individualized courses in many topics, including personal computing. Their catalog of offerings lists the available training resources. We used the Microsoft Works introductory course as one of our introductory learning aids.

Concluding Remarks - Desktop computing will become increasingly more important to the Human Resources Management Division. Desktop computing will allow the specialist to present data in ways not otherwise available. Downloading of data from a mainframe to personal computing applications will be a good tool for responding to requests that have historically required either manual processing or user written programs.

N93-16796

MULTIDISCIPLINARY DESIGN OPTIMIZATION USING RESPONSE SURFACE ANALYSIS

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Aerospace conceptual vehicle design is a complex process which involves multidisciplinary studies of configuration and technology options considering many parameters at many values. NASA Langley's Vehicle Analysis Branch (VAB) has detailed computerized analysis capabilities in most of the key disciplines required by advanced vehicle design. Given a configuration, the capability exists to quickly determine its performance and lifecycle cost. The next step in vehicle design is to determine the best settings of design parameters that optimize the performance characteristics. Typical approach to design optimization is experience based, trial and error variation of many parameters one at a time where possible combinations usually numbering in the thousands. However, this approach can either lead to a very long and expensive design process or to a premature termination of the design process due to budget and/or schedule pressures. Furthermore, one variable at a time approach can not account for the interactions that occur among parts of systems and among disciplines. As a result, vehicle design may be far from optimal.

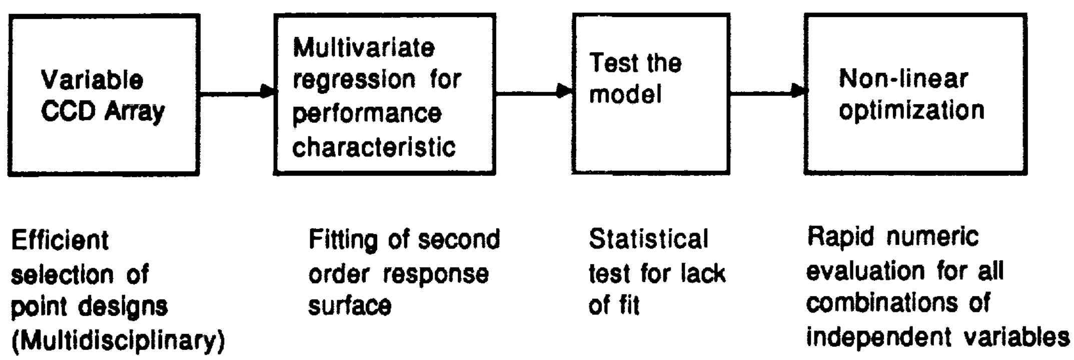
Advanced multidisciplinary design optimization (MDO) methods are needed to direct the search in an efficient and intelligent manner in order to drastically reduce the number of candidate designs to be evaluated. The payoffs in terms of enhanced performance and reduced cost are significant. A literature review yields two such advanced MDO methods used in aerospace design optimization; Taguchi methods and response surface methods.

Taguchi methods provide a systematic and efficient method for design optimization for performance and cost. Using orthogonal arrays (OA) the method explores the entire design space through a significantly small number of point designs than required by a full factorial study. From these data, a first order, linear multiple-regression model representing the performance characteristic in terms of the design parameters is constructed [6]. This linear model is then used to determine parameter sensitivities and predict the best setting of design parameters that optimize the performance characteristic. Taguchi method gains its experimental efficiency by sacrificing some information on parameter interactions. Efficiency diminishes rapidly as more parameter interactions need to be studied.

Taguchi method has been utilized at VAB in structures, propulsion and trajectory analyses [4][5]. In these studies, the Taguchi method provided an efficient, flexible and robust methodology for solving multiparameter vehicle optimization problems. A major advantage of the method is its ability to handle discrete variables. On the limiting side, the Taguchi method locates a near optimum only and must be used repetitively to improve accuracy. It also sacrifices some efficiency when it is necessary to study all interactions. In most vehicle design and analysis problems however, it is very difficult to initially estimate which parameters will tend to interact [4]. Thus, it may become necessary to study all interactions. Finally, the first order linear model may become inadequate as design complexity and response surface non linearity increases.

A more accurate, second order model that can account for all two parameter interactions and capture the curvature (non linearity) on the response surface, could significantly improve the optimization process [1]. A second order model requires that each parameter be studied at three levels (values) as opposed to two [2]. This can not be done efficiently using Taguchi's three-level OA since experimental effort increases exponentially (3^k). However, such a model can be constructed efficiently by using central composite designs (CCD) from design of experiments theory [3]. CCD are first order designs (2^k) augmented by additional points (2k+1) to allow estimation of the coefficients of a second order model [7]. The number of experimental point designs needed for fitting a second order model using CCD is significantly less than required by Taguchi's OA and from full factorial designs. As an example, for a problem involving 5 parameters at three levels and all interactions being considered, CCD requires only 27 experiments, as opposed to 81 required by Taguchi and, 243 required by a full factorial study. Another benefit of CCD is that it can be used sequentially, or "built up" from the first order design.

Response surface method (RSM) leads to a better, more accurate exploration of the parameter space and to estimated optimum conditions with a small expenditure on experimental data. The use of central composite designs, multivariate regression, and a nonlinear optimizer form the basis of response surface methodology. The central composite design element is used to efficiently describe the multivariate combinations needed for analysis. The regression analysis element involves the fitting of multivariate data to create a dependent function of performance characteristics. These generalized estimation equations are then used for rapid multidisciplinary parametric evaluation of the performance characteristics for all combinations of independent variables at system level.



RSM has potential applications at aerospace vehicle design and it can prove to be a very efficient multidisciplinary design optimization tool for systems level design studies.

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NAVIER-STOKES CALCULATION OF TRANSONIC FLOW PAST THE NTF 65-DEGREE DELTA WING

by

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Abstract

This project is a continuation of the research initiated in summer last year. Viscous flow past a wind tunnel model of a 65-degree swept angle Delta wing at transonic speeds is being studied. The model was tested in the 8-foot cryogenic transonic wind tunnel at the National Transonic Facility. Aerodynamic forces and wing surface pressure data were obtained at various angles of attack, Mach numbers and Reynold's numbers for four different leading edges of the wing. The objectives of the present investigation are:

1. To perform numerical modelling of the flow around the wing.
2. To validate the experimental data with a Navier-Stokes computational fluid dynamics code and vice versa.
3. To investigate the effects of the sting mount of the wing.
4. To evaluate the effects of leading edge radius on the flow.
5. To explain the Reynold's number effect as indicated by the test data.

Several computer programs were developed to define the surfaces of the wing, the four leading edges and the sting mount. Based on these geometric databases, the surface grids of a single-block computational domain was generated interactively on the IRIS workstation using the GRIDGEN2D module of GRIDGEN. To refine the grids and to avoid excessive loss of grid points due to collapsed edges, a 9-block computational domain containing approximately 750,000 grid points was developed with the GRIDBLOCK module to replace the single-block grid:

Block No.	Model Surface Contained	Dimension
1	Fore Upper Wing	49x13x65
2	Leading Edge	49x49x65
3	Fore Lower Wing	49x13x65
4	Sting	49x49x65
5	Wing Apex	25x25x65
6	Upper Sting Joint	49x25x65
7	Rear Upper Wing	49x25x65
8	Rear Lower Wing	49x25x65
9	Lower Sting Joint	49x25x65

Fig. 1 shows the wing and sting surfaces, and the block edges near the model, while Fig. 2 shows all the blocks in the entire computational domain encompassing a space of 20 chord lengths from the wing in all directions.

The double-precision version of GRIDGEN2D was then used to generate the surface grids of every block. Grid point-clustering was performed on high-curvature portions of the apex, the leading edge, the trailing edge and the sting joint. To facilitate thin-layer Navier-Stokes calculation at high Reynold's numbers, a very tight spacing of 10-6 was specified on the wing surface. Fig. 3 shows some typical surface grids on the model and the plane of symmetry. Figs. 4 and 5 show some typical 2-D grids on block interfaces. Upon minor modification of the blocks containing the wing apex and the leading edge, the surface grids of these two blocks can be generated for other leading edge profiles without disturbing the other blocks.

Job files and input files were created to read the multiple-block surface grids into the GRIDGEN3D module on the Cray super-computer to generate the internal volume grid of each block. A typical output file summarizing successful generation of satisfactory volume grids is given in Appendix A. The resulting volume grids were finally examined by the GRIDVUE3D module or the FAST software on the IRIS workstation.

The CFL3D computational fluid dynamics code, developed by the Computational Aerodynamics Branch, is to be applied. A typical input file which sets up the code to read the volume grids and specifies the boundary conditions for each block is given in Appendix B. Calculations for both laminar and turbulent flows are being conducted, and preliminary solutions are expected in the immediate future.

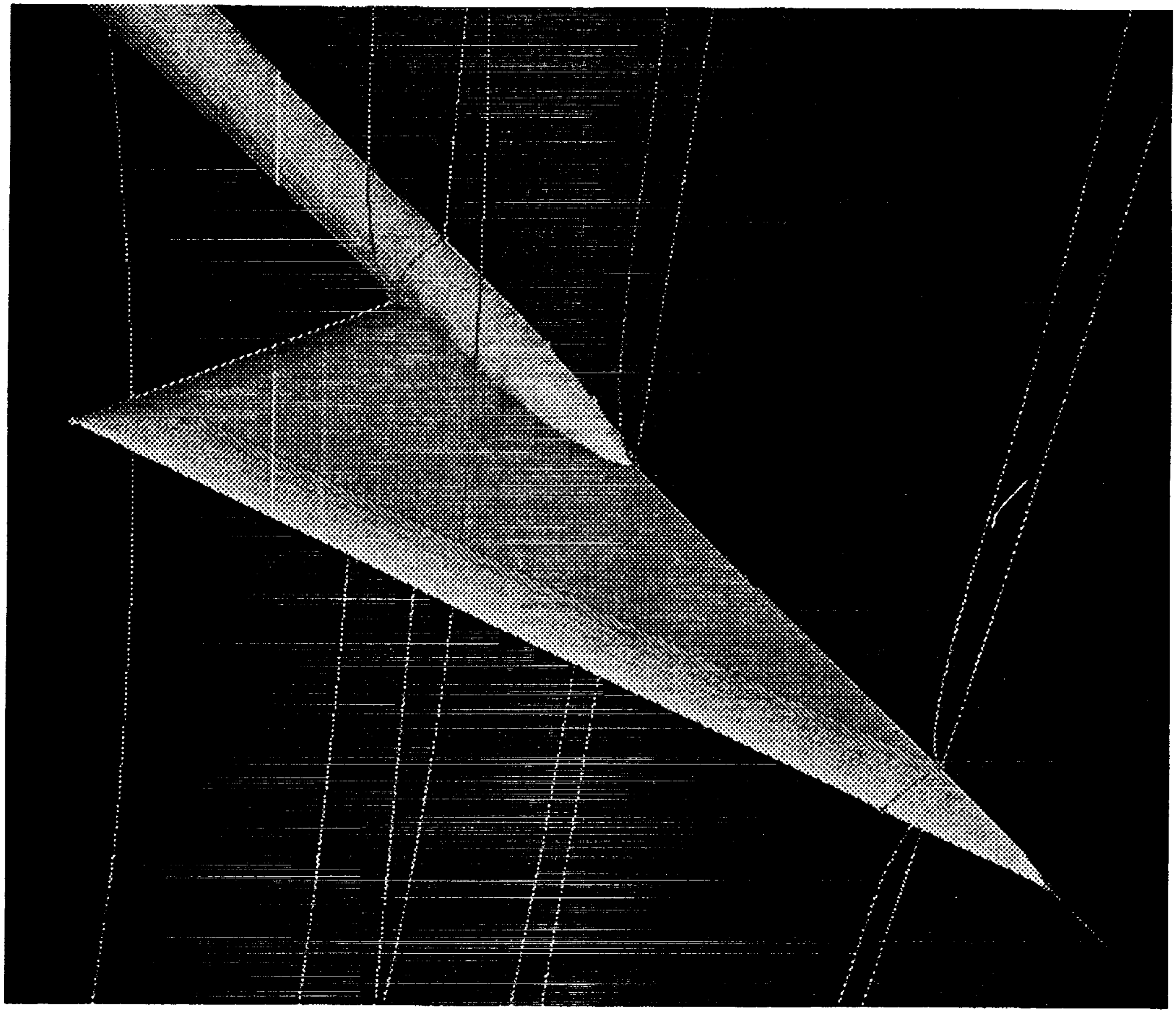

Fig. 1 Wing Model and Block Edges - Near Field

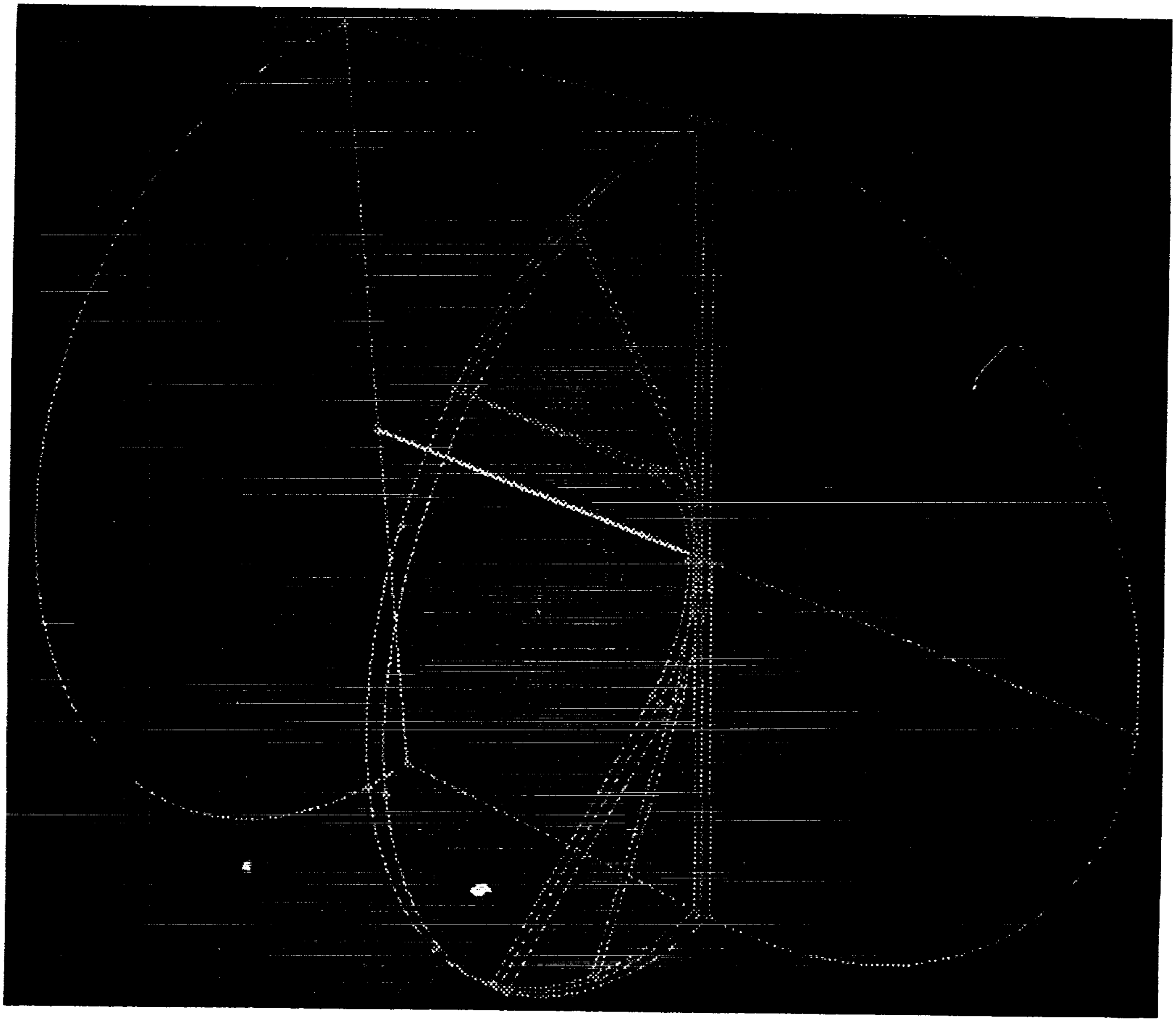

Fig. 2 Block Edges - Far Field

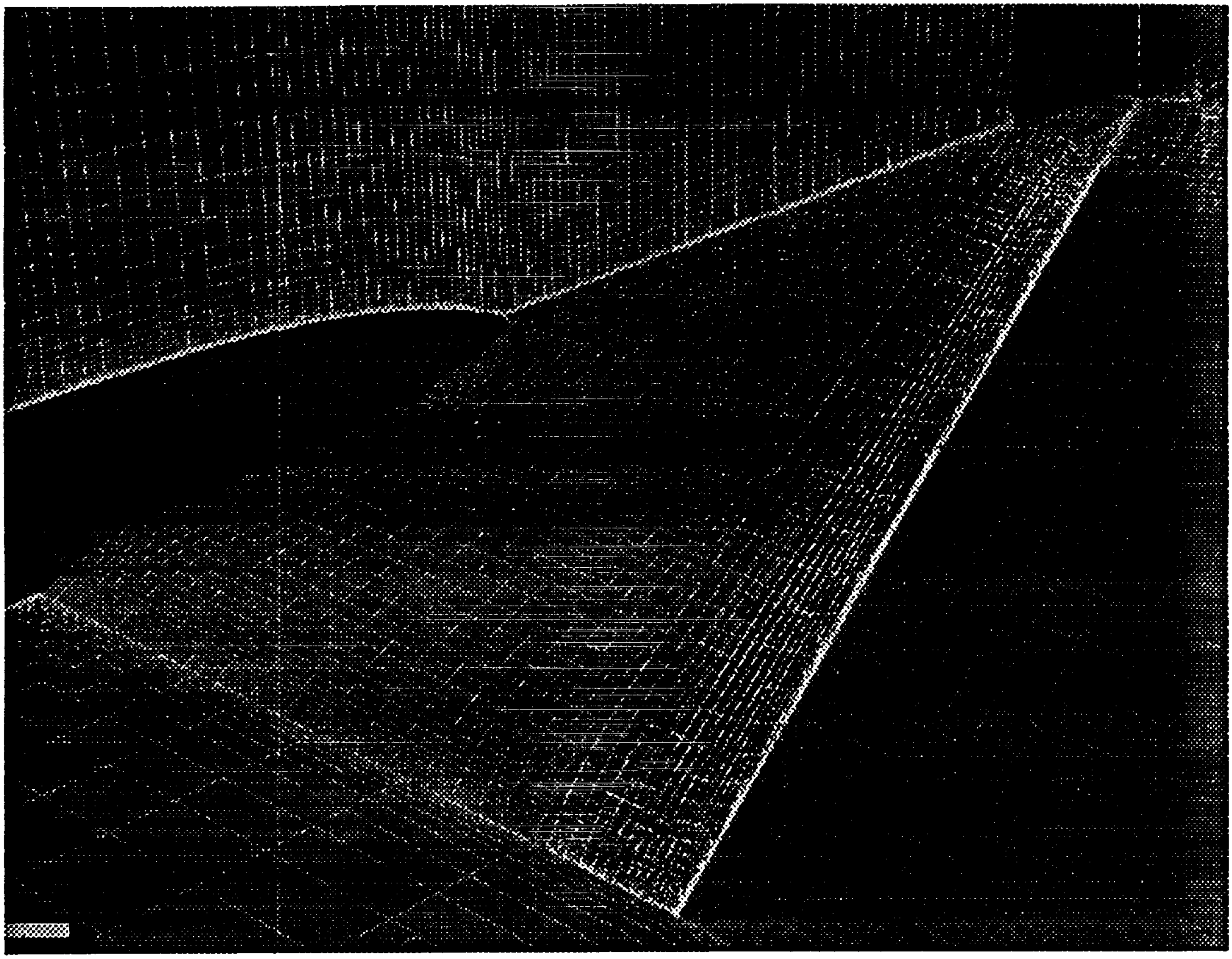

Fig. 3 Surface Grids on the Model and Plane of Symmetry

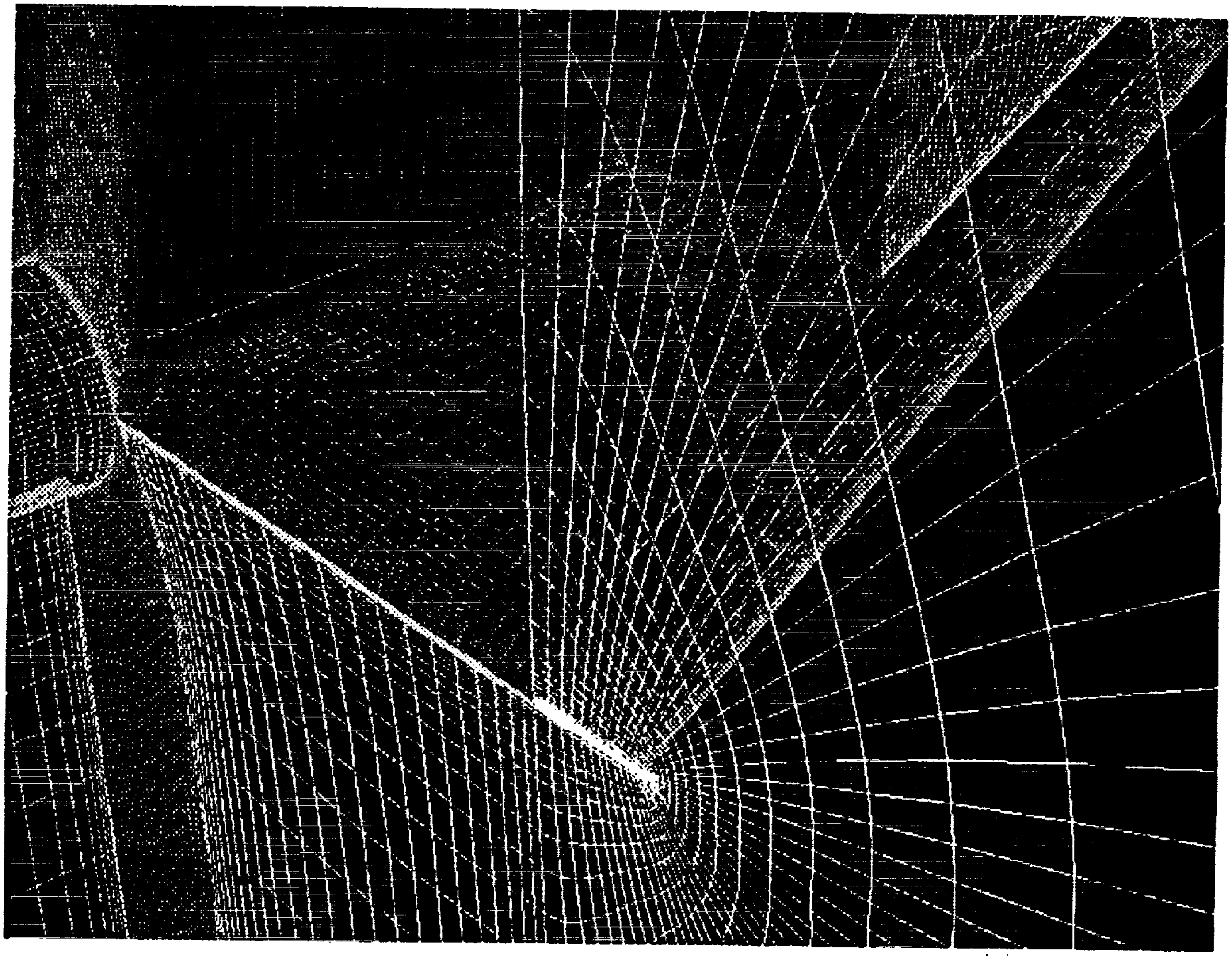

Fig. 4 Surface Grids on Block Interfaces

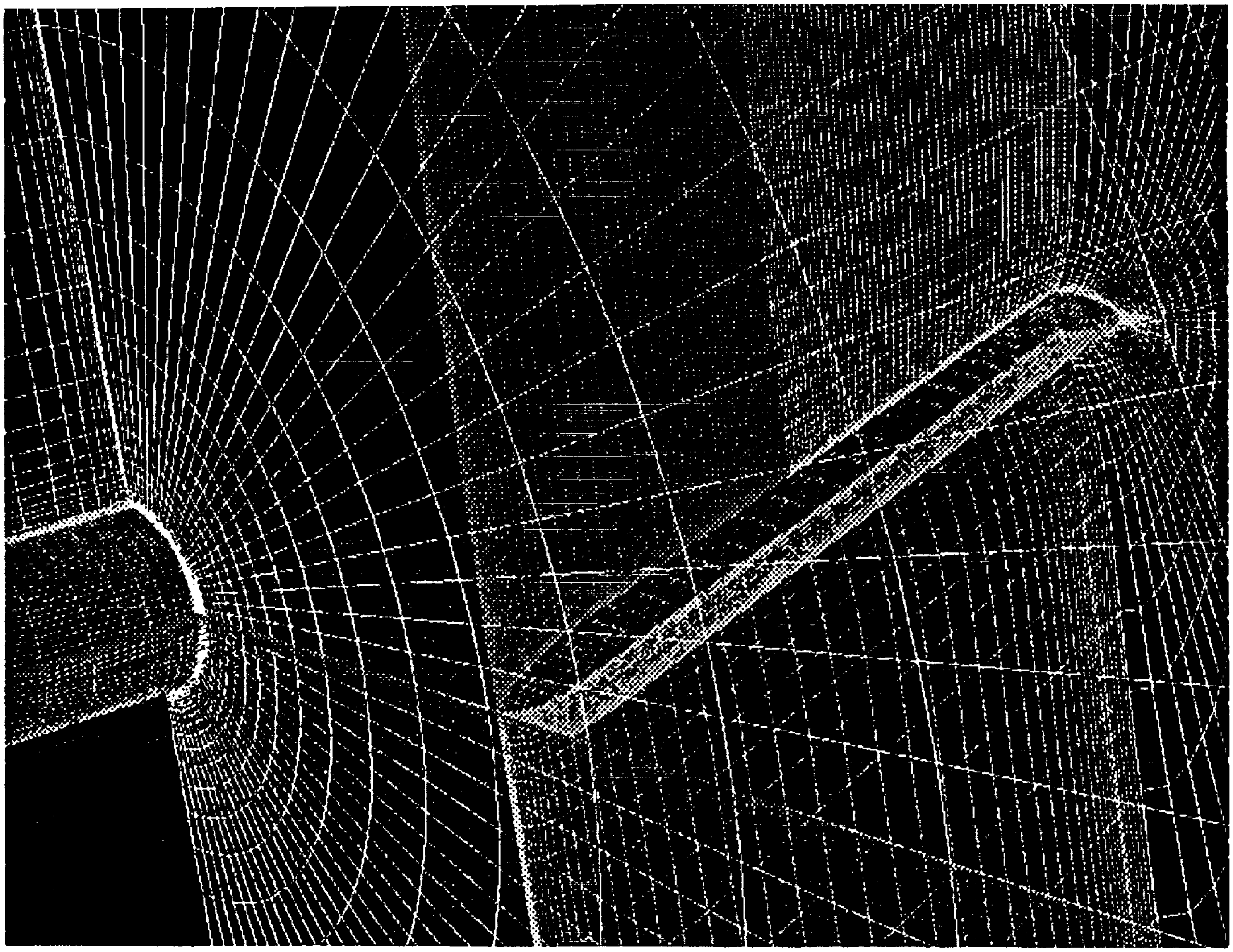

Fig. 5 Surface Grids on Block Interfaces

```
GGGGG  RRRRR  I  DDDDD  GGGGG  EEEEE  N   N  33333  DDDDD
G      R   R  I  D   D  G      E      NN  N      3  D   D
G GGG  RRRRR  I  D   D  G GGG  EEEEE  N N N  33333  D   D
G   G  R  R   I  D   D  G   G  E      N  NN      3  D   D
GGGGG  R   R  I  DDDDD  GGGGG  EEEEE  N   N  33333  DDDDD

                   $Revision: 8.6.3.4 $

               NASA Langley Research Center

                   MDA Engineering, Inc.

*********************************************************************
*****                       I N P U T                          *****
*********************************************************************
&ASSEM  IASSEM = 0, IDEBUG = 0, IFORM = 1, NOBOCON = 0, NBLOCKS = 9, MMII
2*49, 65, 13, 49, 65, 49, 25, 65, 25, 49, 65, 25, 49, 65, 25, 49, 65
 IAUTO = 0, IBPW = 7009149136318496768, FNBOCI = 'interle4.bnda        ', FNSUR
 FNVOLI = 'interle4.vol          ', PATHTMP = '.
     ------------------------------------------------
          Grid contains   9 block(s)
     ------------------------------------------------
        mb      imax      jmax      kmax      name
     ------------------------------------------------
         1       49        65        13       inter2.blk
         2       49        65        49       inter3.blk
         3       49        65        13       inter4.blk
         4       49        65        49       inter7.blk
         5       25        65        25       inter1.blk
         6       49        65        25       upjoint
         7       49        65        25       wingup
         8       49        65        25       winglo
         9       49        65        25       jointlo
     ------------------------------------------------
*********************************************************************
*****              A L G E B R A I C   S O L V E R             *****
*********************************************************************
 &INIT  INITIAL = 9*2, TOLER = 1.E-9, ITSONI = 16, IJACA = 1  &END
     ------------------------------------------------
     Jacobians for block #  1: inter2.blk
       number of positive volumes :  36864 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2, 13) is   0.5158E-12
       maximum volume at ( 17, 65,  7) is   0.8509E-01
     ------------------------------------------------
     Jacobians for block #  2: inter3.blk
       number of positive volumes : 147455 (100.00%)
       number of  skewed  volumes :      1 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at ( 49,  2, 25) is   0.1773E-14
       maximum volume at ( 25, 65, 25) is   0.1046E+00
     ------------------------------------------------
     Jacobians for block #  3: inter4.blk
       number of positive volumes :  36864 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2, 13) is   0.8873E-12
       maximum volume at ( 17, 65,  7) is   0.6504E-01
     ------------------------------------------------
     Jacobians for block #  4: inter7.blk
       number of positive volumes : 147456 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2,  4) is   0.4317E-11
       maximum volume at ( 49, 65, 47) is   0.2896E+02
     ------------------------------------------------
     Jacobians for block #  5: inter1.blk
       number of positive volumes :  36337 ( 98.57%)
       number of  skewed  volumes :    527 (  1.43%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2, 13) is   0.1768E-13
       maximum volume at ( 25, 65,  2) is   0.1002E+02
     ------------------------------------------------
     Jacobians for block #  6: upjoint
       number of positive volumes :  73728 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2,  2) is   0.5358E-12
       maximum volume at ( 31, 65, 25) is   0.2172E-01
     ------------------------------------------------
     Jacobians for block #  7: wingup
       number of positive volumes :  73728 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at ( 49,  2, 25) is   0.2288E-11
       maximum volume at ( 29, 65,  2) is   0.2060E-01
     ------------------------------------------------
     Jacobians for block #  8: winglo
       number of positive volumes :  73728 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at ( 49,  2,  2) is   0.2181E-11
       maximum volume at ( 29, 65, 16) is   0.2763E-01
     ------------------------------------------------
     Jacobians for block #  9: jointlo
       number of positive volumes :  73728 (100.00%)
       number of  skewed  volumes :      0 (  0.00%)
       number of negative volumes :      0 (  0.00%)
       minimum volume at (  2,  2, 25) is   0.4156E-12
       maximum volume at ( 19, 65, 25) is   0.1394E-01
     ------------------------------------------------
     Jacobian summary for entire grid
```

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Appendix A   GRIDGEN3D Output File

```
dspl.g2dgrd
p3dx.d25mac
p3dq.d25mac
d25mac.out
d25mac.plt
d25mac.infc
d25mac.prout
d25mac.press
d25mac.restrt
d25mac.jkturb
65-deg Delta Wing with Sting - Medium Leading Edge
    XMACH     ALPHA      BETA  REUE,MIL   TINF,DR      ISND     C2SPE      IRUN
     0.85      12.3       0.0      9.00     527.0         0      0.00        85
     SREF      CREF      BREF       XMC       YMC       ZMC   XLTRANS   XUTRANS
  0.23315   1.00000    0.9326      0.25      0.00      0.00      0.01      0.01
       DT     IREST   IFLAGTS      FMAX     IUNST     RFREQ    ALPHAU      CLOC
   -1.000        01      0200       07.         0      0.00      0.00    0.0000
    NGRID   NPLOT3D    NPRINT    NWREST      ICHK       I2D     ITURB      CFLG
        9         9         0       100         1         0         0       0.5
      NCG       IEM  IADVANCE    IFORCE     IMESH  IVISC(I)  IVISC(J)  IVISC(K)
        1         0         0         1         1         0         0         1
        1         0         0         1        11         0         0         1
        1         0         0         1         0         0         0         1
        1         0         0        -1        11         0         0         1
        1         0         0         0        11         0         0         1
        1         0         0         0                   0         0         1
        1         0         0         0         0         0         0         1
        1         0         0         0         0         0         0         1
        1         0         0         0                   0         0         1
     IDIM      JDIM      KDIM      ITE1      ITE2      JTE1      JTE2
       49        13       065         1        49         1        13
       49        49       065         1        49         1        49
       49        13       065         1        49         1        13
       49        49       065         1        49         1        49
       25        25       065         1        25         1        25
       49        25       065         1        49         1        25
       49        25       065         1        49         1        25
       49        25       065         1        49         1        25
       49        25       065         1        49         1        25
    INEWG    IGRIDC        IS        JS        KS        IE        JE        KE
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
        0         0         0         0         0         0         0         0
 IDIAG(I)  IDIAG(J)  IDIAG(K)  IFLIM(I)  IFLIM(J)  IFLIM(K)
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
        1         1         1        00        04        04
  IFDS(I)   IFDS(J)   IFDS(K)  RKAP0(I)  RKAP0(J)  RKAP0(K)
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
        1         1         1  -3.00000  0.333333  0.333333
MTYPEI(1) MTYPEI(2) MTYPEJ(1) MTYPEJ(2) MTYPEK(1) MTYPEK(2)
      200       200      1001       200        10      1003
      200       200       200       200        10      1003
      200       200       200      1001        10      1003
      200      1003      1001      1001        10      1003
      703       200      1001      1001        10      1003
      200       200      1001       200        10      1003
      200       200       200       200        10      1003
      200       200       200       200        10      1003
      200       200       200      1001        10      1003
     MSEQ    MGFLAG    ICONSF       MTT      NGAM
        1         1         0         0        01
     ISSC EPSSSC(1) EPSSSC(2) EPSSSC(3)      ISSR EPSSSR(1) EPSSSR(2) EPSSSR(3)
        1       0.3       0.3       0.3         0       0.3       0.3       0.3
     NCYC    MGLEVG     NEMGL     NITFO
     1000        03        00      0000
     MIT1      MIT2      MIT3      MIT4      MIT5      MIT6      MIT7      MIT8
       01        01        01        01
   1-1 BLOCKING DATA:
     NBLI
        0
    NELON   NBLK(1    NBLK(2
LIMBLK(1  LIMBLK(2  LIMBLK(3  LIMBLK(4  LIMBLK(5  LIMBLK(6  ISVA(1,1  ISVA(1,2)
LIMBLK(1  LIMBLK(2  LIMBLK(3  LIMBLK(4  LIMBLK(5  LIMBLK(6  ISVA(2,1  ISVA(2,2)
  PATCH SURFACE DATA:
   NINTER
       26
    IIFIT    LLIMIT    IITMAX     MMCXI    MMCETA
        3         5        20         0         0
        4         5        20         0         0
        3         5        20         0         0
        3         5        20         0         0
        3         5        20         0         0
        4         5        20         0         0
        4         5        20         0         0
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        3         5        20         0         0
        4         5        20         0         0
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IMPROVEMENT IN THE CONTROL ASPECT OF LASER FREQUENCY STABILIZATION FOR SUNLITE PROJECT

ABSTRACT

By
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Flight Electronics Division of Langley Research Center is developing a spaceflight experiment called "Stanford University and NASA Laser In-Space Technology" (SUNILTE). The scientific objective of the project is to explore the fundamental limits on frequency stability using a FM laser locking technique on a Nd:YAG non-planer ring (free-running linewidth of 5 KHz) oscillator in the vibration free, microgravity environment of space. Compact and automated actively stabilized terahertz laser oscillators will operate in space with an expected linewidth of less than 3 Hz.

To implement and verify this experiment, NASA engineers have designed and built a state of the art, space qualified high speed data acquisition system for measuring the linewidth and stability limits of a laser oscillator [1]. In order to achieve greater stability and better performance, an active frequency control scheme requiring the use of a feedback control loop has been applied.

In the summer of 1991, the author had the opportunity to further investigate the application of control theory in active frequency control as a frequency stabilization technique. The results and findings were presented in 1992 American Control Conference in Chicago, and have been published in Conference Proceedings [2].

The main focus of this project was to seek further improvement in the overall performance of the system by replacing the analogue controller found in [2] by a digital algorithm.

DIGITAL VERSUS ANALOGUE CONTROL

Replacement of the analogue controller Gc(S) , by a digital predictor/controller as shown in [2], is certainly an option, specially in the case of the SUNLITE project. Implementation of the control algorithm by the TMS320C30 microprocessor which is being used in the system for data acquisition and measurement purposes, is very much tempting. However, before attempting to design a new digital controller or to replace the existing analogue controller, which is a routine engineering job, it seemed appropriate to obtain an appreciation of the possible effects of the quantization.

It is obvious that the existing analogue controller provide continuous processing of the signal and can be used for very high bandwidth systems. It also gives almost infinite resolution of the signal it is measuring. On the negative side, like any other analogue device, it may suffer from component aging and temperature drift which is particularly important in the case of SUNLITE experiment.

Digital controllers on the other hand, sample the signal at discrete time intervals, this limits the bandwidth (bandwidth is 1/6 to 1/10 sampling rate) that can be handled by the controller. The processing of the signal takes a finite amount of time, adding to phase delay in the system. In addition, the resolution of the signal is limited by the resolution or wordlength of the processor which brings us to the well known quantization problem. Therefor a thorough analysis of finite arithmetic has been conducted to ensure that system performance will not be degraded.
However, it must be reminded that in almost every control application, the inability to place controller poles with perfect precision, due to finite word length of the computer used for implementation, is quite insignificant in the overall design.

In an effort to determine the impact of noise due to quantization,

$$SNR_Q = 10\log_{10}\left(\frac{\sigma_x^2}{\sigma_e^2}\right)$$

the following definition of signal-to-quantization ratio is used It has been shown in [3], that it is directly related to k the AGC constant and b.

$$SNR_Q = 10\log SUB10 \frac{1}{k^2\sigma_e^2} = 6b + 10.8 - 20\log_{10} k$$

$$SNR_Q \approx 6b - 20dB$$

In the case of SUNLITE project assuming a 24 bit ADC, and k = 10, the SNR_Q = 118dB . This indicates that the quantization noise power is approximately 118dB below the signal and background noise power. Therefore, the noise added by the ADC can be considered negligible.
Based on that conclusion, the algorithm for the PID digital controller has been written and will be implemented. For details of the algorithm please see the Appendix. As an alternative, the transfer function of existing analogue compensator has been transformed in to digital, using bilinear (Tustin) transformation method. I it the authors hope that after trying both options the best be used.

REFERENCES

1. SUNLITE project Preliminary Design Review, Electronic Branch, Flight Electronics Division, LaRC, NASA, 1990
2. O. Zia "On the Control Aspect of Laser Frequency Stabilization" Proceedings of 1992 ACC conference. Chicago , Il.
3.David J. Defatta " Digital Signal Processing" 1988, John Wiley.

Appendix A

DIGITAL PREDICTOR CONTROLLER DESIGN

$$e_m(t) = K_p e_1(t) + K_i \int e_1(t)\,dt + K_d \frac{de_1(t)}{dt} \ldots\ldots. (1)$$

$$e_2(nT) = K_p e_1(nT) + K_i \sum_{k=1}^{n} e_1(kT) \frac{K_d}{T} [e_1(nT) - e_1((n-1)T)] \ldots\ldots\ldots\ldots\ldots (2)$$

Where T is the sampling time, K_p , K_i , and K_d are the proportional, integral and differential coefficients of the controller.

$$e_1(nT) = e_1((n-T) + [e_1((n-1)T - e_1((n-T))] \ldots\ldots\ldots. (3)$$

$$e_2(nT) = K_p[2e_1((n-1)T) - ((n-T) + K_i T[\sum_{k=1}^{n-1} e_1(k) + 2e_1((n-1)T) - e_1((n-2)T)] + \frac{K_d}{T}[e_1((n-1)T$$

$$e_2(nT) = [2K_p + 2K_i T + \frac{K_d}{T}] e_1((n-1)T) - [K_p + K_i T + \frac{K_d}{T}] e_1((n-2)T) + [K_i T] e_s((n-1)T)$$

$$e_s((n-1)T) = \sum_{k=1}^{n-1} e_1(k)T \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$e_s((n-1)T) = e_s((n-2)T) + e_1(n-1)T) \ldots\ldots. (7)$$

$$e_2(nT) = k_1 e_1((n-1)T + K_2 e_1((n-2)T) + K_3 e_s((n-1)T) \ldots\ldots\ldots\ldots (8)$$

$$K_1 = 2K_p + 2K_i + \frac{K_d}{T}$$

$$K_2=-K_pK_i-\frac{K_d}{T},\ K_3=K_iT$$

Appendix B

DEVELOPMENT OF DIGITAL COMPENSATOR BASED ON EXISTING ANALOGUE CONTROLLER

The S-Domain transfer function of the analogue compensator has been determined in [2].

$$G(S)=\frac{\frac{R_F}{R_1}\frac{R_F}{R_X}\left(1+\frac{S}{\frac{1}{R_1C_1}}\right)}{\left(1+\frac{S}{\frac{1}{R_FC_F}}\right)\left(1+\frac{S}{\frac{1}{R_FC_F}}\right)}$$

$R_1 = R_F = 1MEG$, $R_X = 100K$, $C_1 = 33pF$, $C_F = 0.0047UF$
Substituting numerical values ,

$$G(S)=\frac{10+(3.3E-5)S}{1+(9.4E-3)S+(2.2E-5)S^2}$$

Using biliear transformation technique, with frequency prewarping before transformation, the following discrete transfer function has been obtained.

$$H(Z)=\frac{0.65E-3+0.56E-3Z^{-1}-0.09E-3Z^{-2}}{1-1.978Z^{-1}+0.9789Z^{-2}}$$

APPENDIX XII

PROGRAM ORIENTATION EVALUATION REPORT

1992
NASA/ASEE/Langley Research Center Summer Faculty Fellowship Research Program

Program Orientation Evaluation Report

Submitted to:

1) **Mr. Edwin Prior**
   Acting University Affairs Officer
   NASA Langley Research Center

2) **Mr. Robert L. Yang**
   Assistant University Affairs Officer
   NASA Langley Research Center

August 20, 1992

Submitted and Prepared by: **John H. Spencer**
1992 NASA/ASEE
Program Co-Director

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PREFACE

The purpose of the 1992 ASEE Program Orientation is to provide ASEE Program participants with pertinent information regarding NASA Langley Research Center (LaRC) to facilitate their 10-week stay at the Center. In order to evaluate the effectiveness of the orientation, the 1992 ASEE Orientation Evaluation was developed to serve as a tool to identify which of the following five areas need closer examination: (1) Overall Organization, (2) Pre-conference Notification, (3) Information and Knowledge Gained at the Orientation, (4) Program Breakout Session, and (5) General Rating of the Orientation. This evaluation is also used as a tool to follow with NASA's goal of "continuous improvement". That is, by critically examining the five aspects of the orientation from an objective viewpoint, the appropriate changes can be implemented or made within the ASEE Program. Following are the results of the 1992 ASEE Program Orientation Evaluation, recommendations for the 1993 ASEE Program Orientation Evaluation, and a summary.

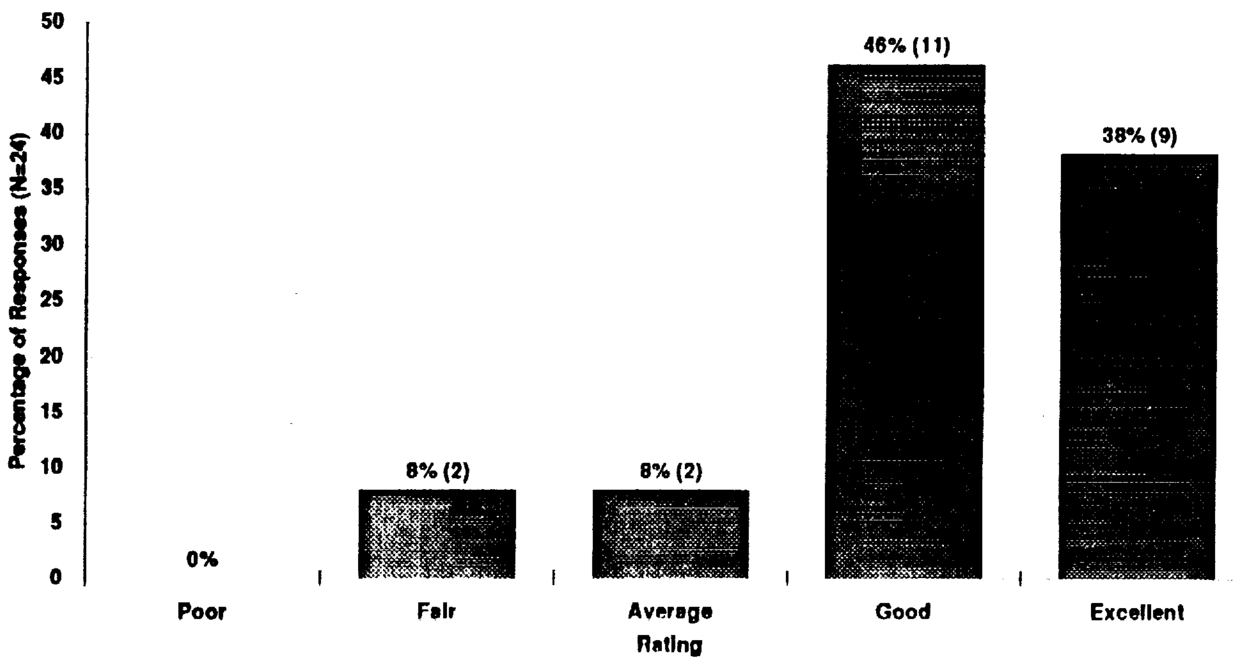
RESULTS

Twenty-four of the 29 surveys distributed on the day of the orientation were returned, thus yielding a return rate of 82.75%. The five areas addressed in the survey are as follows: (1) Overall Organization, (2) Pre-conference Notification, (3) Information and Knowledge Gained at the Orientation, (4) Program Breakout Session, and (5) General Rating of the Orientation.

A. Overall Organization

Eighty-four percent of the respondents rated the overall organization of the orientation as either good (46%) or excellent (38%), while 16% rated it as average (8%) or fair (8%). The comments were as follows: (1) "the Security talk was a bit long", and (2) "too long".

Table 1. Overall Organization

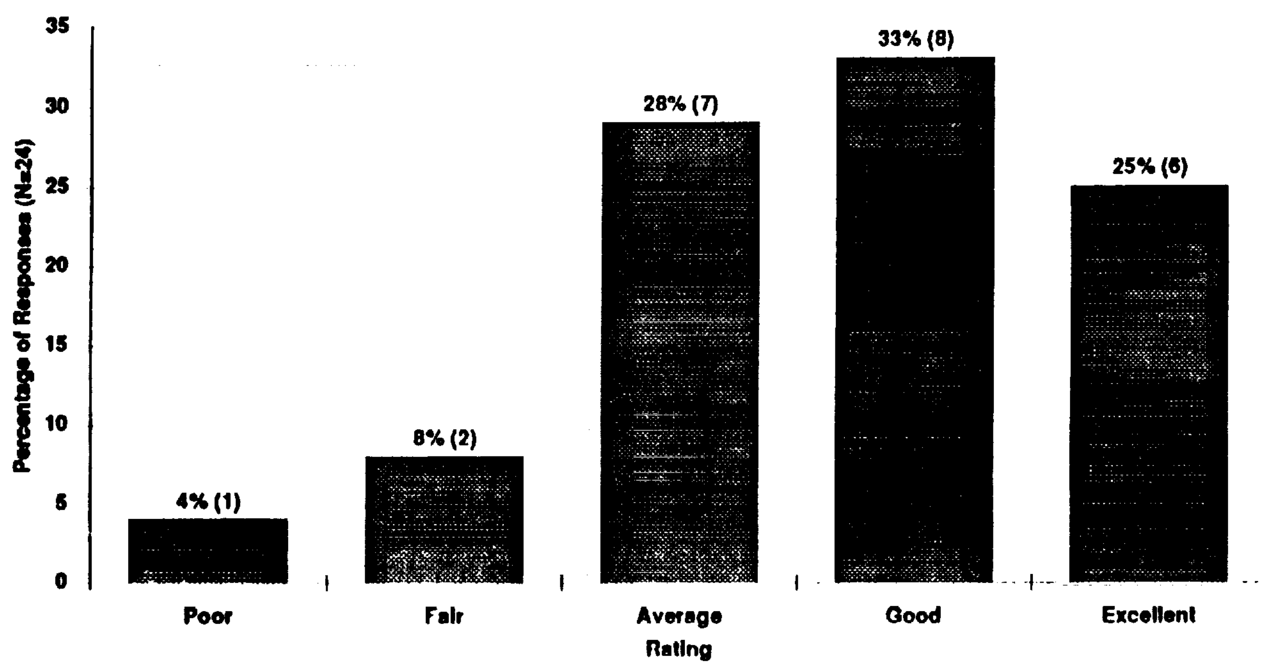


Overall Organization

B. Pre-Conference Notification

Twenty-five percent of the respondents rated the pre-conference notification as excellent. Thirty-three percent gave a rating of good and 29% gave a rating of average. Eight percent rated the pre-conference notification as fair and only four percent rated it as poor. Comments were: (1) "time to show up was ambiguously stated", and (2) "a few of the speakers needed to be more concise". This second comment seems aimed at the question regarding information and knowledge gained.

Table 2. Pre-Conference Notification

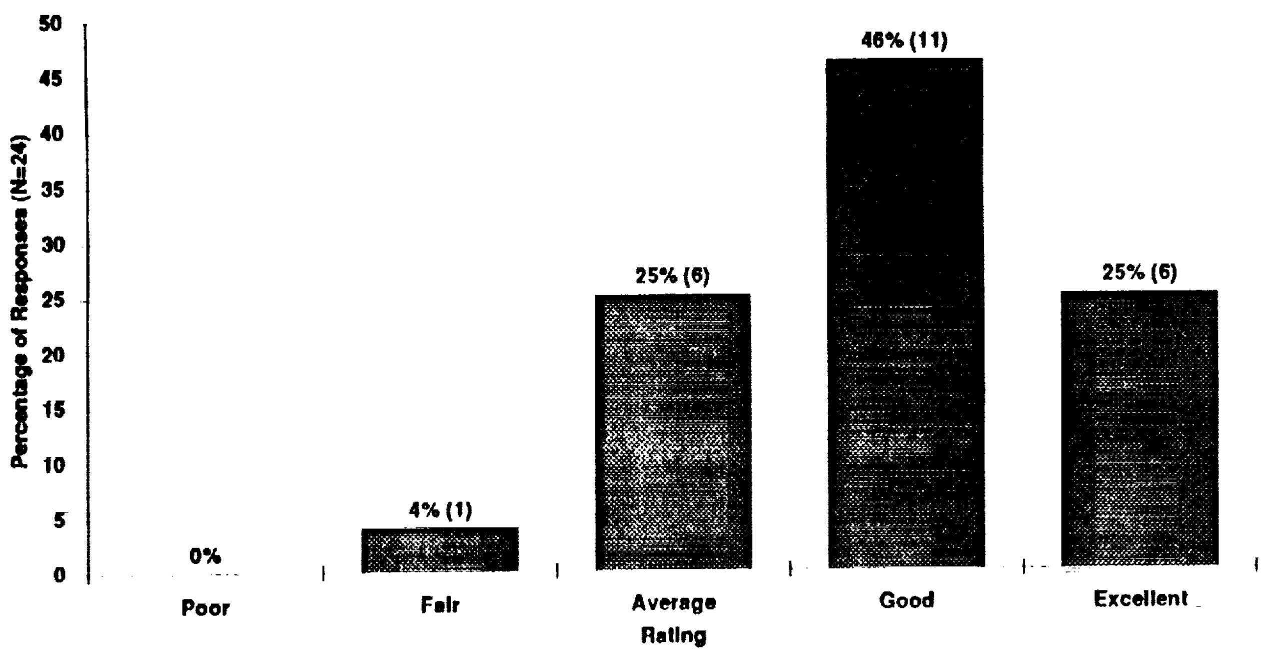


Pre-Conference Notification

C. Information and Knowledge Gained at the Orientation

Seventy-one percent of the respondents rated the information and knowledge gained at this orientation as good (46%) or excellent (25%), while 25% rated it as average and 34% rated it as fair. The following comments were made: (1) "tell the security person to be brief and limit anecdotes", (2) "security presentation long and unorganized", and (3) "quite a bit was unnecessary".

Table 3. Information and Knowledge Gained at the Orientation

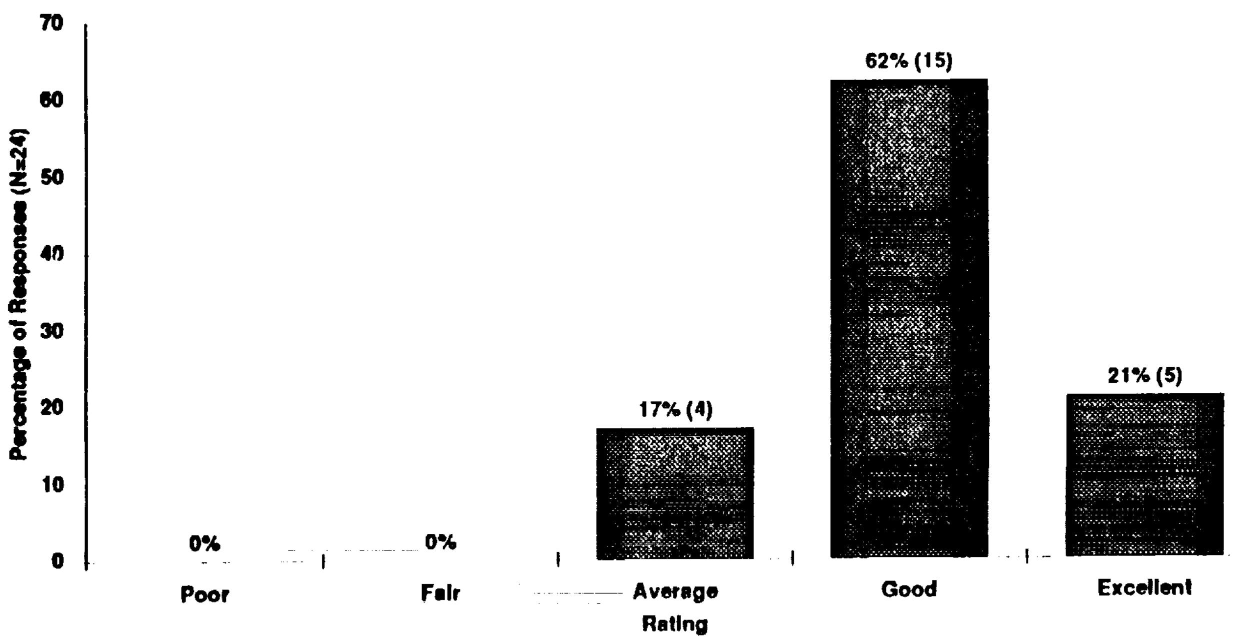


Information and Knowledge Gained

D. Program Breakout Session

Eighty-three percent of the respondents rated the program breakout session as good (62%) to excellent (21%). Seventeen percent of the respondents rated the session as average. None rated the session as fair or poor. There were no comments made about this session.

Table 4. Program Breakout Session



Program Breakout Session

E. General Rating of the Orientation

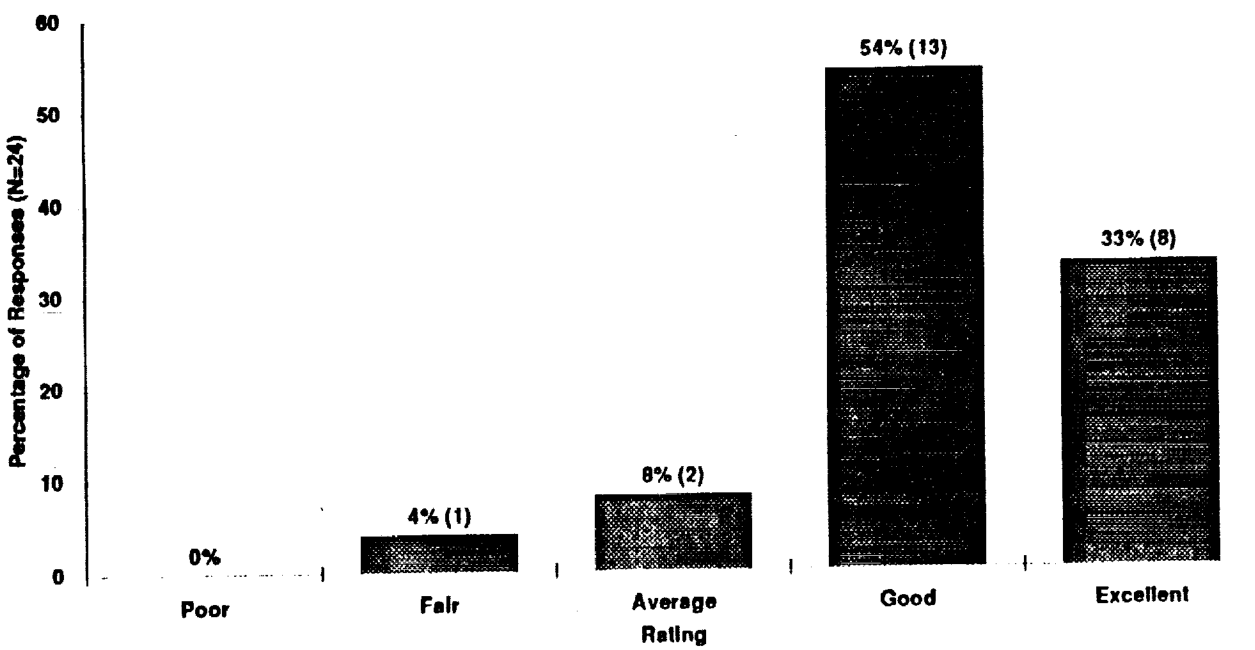
All of the respondents (100%) gave the orientation a positive rating from fair (4%), average (8%), good (54%), to excellent (33%). No respondent gave a poor rating. The following comments were made in terms of the general rating of the orientation: (1) "informative", (2) "registration should be modified to eliminate long lines", (3) "long, slow, scattered", (4) "good food and friendly folks are the high points", (5) Extra stuff (cafeteria manager), security briefing for unsecured people are the low points", and (6) "there really wasn't a need to arrive at 7:30 a.m. for a presentation that started at 9 a.m.".

Overall Comments, Suggested Changes or Improvements:

(1) Eliminate or put a time limit on security.

(2) Traffic threats are not a productive part of the morning.

Table 5. General Rating of the Orientation



General Rating of the Orientation

RECOMMENDATIONS

Based on the results of the 1992 ASEE Orientation Evaluation, the following recommendations are made for the 1993 ASEE Orientation:

(1) Limit presenters time at the orientation to no more than 10 minutes.

(2) Strictly enforce the time limit.

(3) Do not eliminate the so called "extra stuff" presentations, but explain that each presenter has an important role in the NASA Program.

(4) Review all correspondence for possible ambiguities.

(5) Review method of registration to eliminate the waiting in line.

(6) Review time of arrival for Fellows (i.e., Is 7:30 a.m. necessary for a 9 a.m. meeting?).

SUMMARY

Although the ASEE Program has been in operation for twenty-nine years. This is the first year for a written evaluation of the orientation program. The written orientation seems to parallel the oral responses we have received in previous years. Ninety-four percent of the respondents rated the overall organization from average to excellent. Ninety-six percent of the respondents gave a general rating of average to excellent. The pre-conference notification was the only heading that received a poor rating (4%). Comments on the pre-conference notification were positive. One person felt that the time to assemble was ambiguously stated.

The responses indicate that the program orientation was well received and the information and knowledge gained was considered beneficial. While there were no major complaints, we should still review the orientation program for areas of improvement for 1993.

APPENDIX XIII

AGENDA SITE VISIT

NASA HEADQUARTERS/ASEE SITE VISIT
by
Sherri McGee
FEH/Higher Education Program Manager
Education Division

AGENDA

11:00-11:25	Structures Directorate - Structural Dynamics Branch 3 Langley Blvd. - Bldg. 1229, Rooms 212 & 212G Dr. Christina Bloebaum - SUNY at Buffalo Dr. William Carpenter - University of South Florida Dr. Rex Kincaid - College of William & Mary (Ext. 47693)
11:30-11:55	Space Directorate - Space Exploration Initiative Office 1 South Marvin Street - Bldg. 1237T, Room 205 Dr. Abu Masud - Wichita State University (Ext. 48200)
12:00 - 12:55	Group Luncheon - Cafeteria - Private Dining Room Dr. Philip FitzSimons - Michigan State University Dr. William S. Gray (Steve) - Drexel University (PA) Mr. David Johnson - St. Paul's College (VA) Dr. Denise Siegfeldt - Troy State University (VA) Dr. Robert Tureman - Paul D. Camp Community College (VA) Dr. Chivey Wu - California State University, LA Dr. Omar Zia - California Polytechnic State University
1:00 - 1:25	Electronics Directorate - Instrument Research Division 4 Langley Blvd. - Bldg. 1230, Room 290 Dr. Milton Ferguson - Norfolk State University (Ext. 44802)
1:30-1:55	Aeronautics Directorate - Fluid Mechanics Division 18D West Taylor Street - Bldg. 1192D, Room 155 Dr. Mark Glauser - Clarkson University (Ext. 43186)

July 28, 1992

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13. ABSTRACT *(Maximum 200 words)* 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. Objectives: (1) To further the professional knowledge of qualified engineering and science faculty members; (2) To stimulate and exchange ideas between participants and NASA; (3) To enrich and refresh the research and teaching activities of participants' institutions; (4) To contribute to the research objectives of the NASA center. Program Description: College or university faculty members will be appointed as Research Fellows to spend 10 weeks in cooperative research and study at the NASA Langley Research Center. The Fellow will devote approximately 90 percent of the time to a research problem and the remaining time to a study program. The study program will consist of lectures and seminars on topics of interest or that are directly relevant to the Fellow's research topics. The lectures and seminar leaders will be distinguished scientists and engineers from NASA, education, or industry.

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