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NASA/AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) SUMMER FACULTY FELLOWSHIP PROGRAM 1989

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OLD DOMINION UNIVERSITY
Norfolk, Virginia

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SECTION I

ORGANIZATION AND MANAGEMENT

The 1989 Old Dominion University (ODU)-NASA-Langley Research Center (LaRC) Summer Faculty Fellowship Research Program, the twenty-sixth such institute to be held at LaRC was planned by a committee consisting of the University Co-Director, LaRC staff members from the research divisions and the Office of University Affairs. It was conducted under the auspices of the Langley Research Center's Chief Scientist, Dr. Richard W. Barnwell.

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 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. After the applications had been reviewed by the various divisions, a committee consisting of staff members from the various divisions, the University Affairs Officer and the University Co-Director met. At this meeting the representatives from the various divisions indicated those individuals selected by the divisions.

The University Co-Director then contacted each selected Fellow by phone extending the individual the appointment. The University Co-Director also forwarded each selected Fellow a formal letter of appointment confirming the phone call. Individuals were given ten days to respond in writing to the appointment. As letters of acceptance were received, contact was made with each Division Coordinator advising them of their Fellows for the summer program.

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

At the assembly meeting, Dr. Samuel Massenberg, the NASA-LaRC University Affairs Officer introduced, Mr. Richard H. Petersen, Director of the Langley Research Center, who formally welcomed the summer Fellows. Dr. Richard Barnwell, Chief Scientist, presented a Langley overview briefing. Miss Carolyn Floyd from the Technical Library Branch briefed the Fellows on the use of the library. Mr. Richard Weeks, manager of the LaRC cafeteria, briefed the Fellows relevant to the cafeteria policies, hours, etc. Mr. James Harris of the

Computer Management Branch briefed the Fellows on the Computational Facilities. The subject of security at LaRC was discussed by O. J. Cole from the Security Branch. Safety procedures were discussed by Vernon Wessel from the Safety Branch. Patricia Gates presented programs and activities sponsored by the Activities Center. Peter Edgette discussed the Occupational Health Services available through the clinic. Further instructions were given and information disseminated by Dr. Samuel E. Massenberg and Dr. Surendra N. Tiwari, Co-Director, ASEE program.

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. Eleven 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 evaluation of the summer program.

SECTION II

RECRUITMENT AND SELECTION OF FELLOWS

RETURNING FELLOWS

An invitation to apply and participate in the Old Dominion University (ODU)-Langley Research Center (LaRC) Program was extended to those individuals who held 1988 LaRC Fellow appointments. Fourteen individuals responded to the invitation, however, only nine were selected. Thirty-five applications were received from Fellows from previous years or from other programs. Fourteen 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 Dr. Surendra Tiwari of Old Dominion University (ODU) and Professor John Spencer of Hampton University (HU), requesting their assistance in bringing to the attention of their faculties the ODU/HU-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 made site visits to minority schools soliciting applicants, and sent over three hundred letters to deans and department heads. These efforts resulted in a total of ninety-eight formal applications, all indicating the ODU/HU-LaRC Program as their first choice and a total of thirty-one indicating the ODU/HU-LaRC Program as their second choice. The total number of applications received came to one hundred twenty-nine (Table 1).

Forty-one applicants formally accepted the invitation to participate in the program. Eight applicants declined the invitation. Several Fellows delayed their decision 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. Fifteen positions were funded by the LaRC divisions.

The average age of the participants was 43.

TABLE 1

FIRST CHOICE APPLICATIONS

Total	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
98	1	5	10	82	6

SECOND CHOICE APPLICATIONS

Total	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
31	0	1	1	29	0

NASA-LaRC APPLICATIONS

Total	Females		Males		Minority Schools Represented
	Black	NonBlack	Black	NonBlack	
41	0	4	5	32	5

First Year Fellows	Returnees	Number Declined
32	9	8

Positions Funded by NASA	Local Purchases
26	15

SECTION III

STIPEND AND TRAVEL

A ten week stipend of $8,000 was awarded to each Fellow. Although this stipend has improved over previous years, it still falls short (for the majority of Fellows) of matching what they could have earned based on their university academic salaries. This decision on their part does, however, clearly reflect the willingness of the Fellow to make some financial sacrifice in order to participate in the summer program.

Travel expenses incurred by the Fellows from their homes to Hampton, Virginia, and return were reimbursed in accordance with current ODU regulations. A relocation allowance of $500.00 was provided for the Fellows traveling a distance of 50 miles or more.

SECTION IV

LECTURE SERIES, PICNIC AND DINNER

LECTURE SERIES

In response to statements made by the Fellows, the Lecture Series was again arranged around research being done at LaRC and the speakers were LaRC research scientists.

Appendix III contains the agenda for the special ASEE Summer Lecture Series for 1989.

PICNIC AND DINNER

A picnic for the Fellows, their families, and guests was held on June 16, 1989. A seminar/dinner was held on July 24, 1989.

SECTION V

RESEARCH PARTICIPATION

The 1989 ODU-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	Office of the Chief Scientist
1	Analysis and Computational Division
2	Instrument Research Division
4	Flight Electronics Division
2	Structural Mechanics Division
4	Structural Dynamics Division
2	Interdisciplinary Research Division
5	Materials Division
1	Acoustics Division
1	Advanced Vehicles Division
2	Applied Aerodynamics Division
1	Flight Applications Division
3	Fluid Mechanics Division
1	Atmospheric Sciences Division
1	Space Systems Division
1	Information Systems Division
3	Guidance and Control Division
4	Flight Management Division
1	Systems Engineering Division
1	Personnel Division

Thirty-seven (90%) of the participants were holders of the doctorate degree. Four (10%) held the masters degree. The group was a highly diversified one with respect to background. Areas in which the last degree was earned:

Number	Last Degree
2	Aeronautics/Astronautics
3	Aerospace Engineering
1	Applied Mathematics
1	Applied Science
1	Business Administration
1	Chemical Engineering
1	Chemistry
1	Civil Engineering
1	Civil/Environmental Engineering
1	Control Theory
1	Educational Science (Higher Educ.)
1	Electrical Engineering
1	Engineering Management'
4	Engineering Mechanics
2	Engineering Science
1	Linguistics
2	Mathematics
4	Mechanical Engineering
1	Meteorology
1	Occupational Education Admin.
1	Operations Research
2	Psychology
1	Physical Chemistry
3	Physics
1	Statistics
1	Structural Engineering/Mechanics
1	Theoretical Applied Mathematics

EXTENSIONS

A portion of the funds remaining in the travel 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 University Affairs Officer. The following individuals were granted extensions:

Hari Bidasaria	1 Week
Louis Gratzer	1 Week
John Kosmatka	1 Week
Zia Razzaq	1 Week
George Rublein	1 Week
Greg Selby	1 Week
Margaret Manning	2 Weeks

ATTENDANCE AT SHORT COURSES, SEMINARS, AND CONFERENCES

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

Robert Arenburg attended the 3rd Annual Joint ASME/ASCE Mechanics Conference held in San Diego, CA.

Herbert Armstrong attended the FAA DataLine Symposium held at the FAA Technical Center in Atlantic City, NJ.

Hari Bidasaria attended the ACM/SIGGRAPH (special interest group in graphics) Conference in Boston, MA.

Greg Byrd attended the NASA Colloquia by Robert Sheets and Ed Aldrin.

Walter Gerstle attended a short course on Boundary Integral Equations by Dr. F. Erdogan.

Peyman Givi gave a short course on PDF Methods in Turbulent Combustion.

Johnny Houston attended a NASA seminar on Unstructured Finite Element Mesh Generation and Adoptive Procedures for CFD given by Ken Morgan of the United Kingdom. He also attended a short course held at the Research Center for Advanced Scientific Computing, College of Engineering, Mississippi Valley State University entitled "Numerical Grid Generation".

Jeng-Nan Juang attended two seminars. The first was on AFE Plasma Dynamic Effects: Theory and Modelling. The second was on Millimeter Wave Near-Field Measurement Study.

Joseph Keiser attended the Chemically Modified Oxide Surfaces Symposium held in Michigan.

Moira LeMay attended a seminar by W. B. Rouse on Intelligent Cockpit Aids. She also attended a seminar on Vigilance by B. J. Parasuraman.

Mark Mear attended F. Erdogan's short course on Singular Integral Equations.

Sailes Sengupta attended a conference entitled Neural Network for Defense (AI-

Expert) in DC. He also attended the IGARSS/12th Canadian Remote Sensing Conference held in Vancouver.

Suzanne Smith attended an in-house workshop by Richard Pappa entitled "The Eigensystem Realization Algorithm".

Dave Zimmerman attended three seminars. The first was entitled Semi-Infinite Optimization in the Integrated Design of Controlled Flexible Structures. He attended a seminar on the Boeing Evolutionary Model. The last seminar attended was on Parametric Modelling Techniques for CSI Projects.

In addition to the above there was attendance and participation in conferences, seminars, and short courses held at LaRC.

PAPERS PRESENTED

Ground Evaluation of Seeding an In-Flight Wingtip Vortex Using Infrared Imaging Visualization Technique - Ted Akinyanju.

Automatic Speech Recognition in Air Ground Data Line - Herb Armstrong.

Efficient Algorithm for Calculation of Ray-Object Intersections in Ray-Tracing Objects Modelled Through Triangulation - Computer Vision Graphics and Image Processing Journal - Hari Bidasaria.

Animation on Ultra Network - Hari Bidasaria.

From Where They Look to What They Think: Determining Controller Cognitive Strategies from Oculometer Scanning Data - Steven Cushing.

Spectral Methods in Turbulent Combustion - Numerical Modeling in Combustion - Peyman Givi.

An Equivalent Model Force Based Formulation of the Elastostalic Boundary Element Method - Engineering Computations - Walter Gerstle.

Characteristics of Ho:Tm:Cr:YAG Laser - LTAB - George Henderson.

The Implementation of the Graphics of Program EAGLE, A Numerical Grid Generation Code, on the NASA LaRC SNS Computer System - Johnny Houston.

An Analytic Study of Non-Steady Two-Phase Laminar Boundary Layer Around An Airfoil - American Institute of Aeronautics and Astronautics - Yu-Kao Hsu.

AFE Dynamic Effects in Inhomogeneous Plasmas - Jeng-Nan Juang.

Characterization of Surface of a Platinum/Tim Oxide Catalyst by Fourier Transform Infrared Spectroscopy (FTIR), prepared with Billy T. Upchurch - Joseph Keiser.

A User-Friendly, Menu-Driven, Language-Free Laser Characteristics Graphing Program for Desk-Top IBM-PC Compatable Computer - Marvin Klutz.

Dynamic Characteristics of an Advanced Composite Tilt-Roter Blades - Vertica or Journal of the American Helicopter Society - John Kosmatka.

Development of a Figure of Merit for Operator Performance - Eastern Psychological Association - Moira LeMay.

An Investigation of a Mathematical Model of a Ti:Al_2o_3 Laser System, prepared with A. M. Buoncristiani and J. J. Swetits - Journal of Applied Psychology - Lila Roberts.

A Geometric Programming Algorithm for Stable Robustness of Polynominal Polyhedra - IEEE Trans. - George Rublein.

Generation of Circumferential Velocity Contours Associated with Pulsed Point Suction on a Rotating Disk - ASME International Symposium on Nonsteady Fluid Dynamics - Greg Selby.

Textural Characteristics of Cloud and Ice Covered Surfaces in Polar Regions - IEEE/IGARSS Conference - Sailes Sengupta.

Performance of Two Texture Based Classifiers of Cloud Fields Using Spatially Averaged Landsat Data - IEEE/IGARSS - Sailes Senguptal.

A Neural Network Approach to Cloud Classification - Sailes Sengupta.

Simultaneous Expansion and Orthogonalization of Measured Modes for System Identification - 31st Structures Structural Dynamics and Materials Conference - Suzanne Smith.

Problems Associated with Mars Rover Image Understanding - Paul Wang.

Mathematical Analysis of Directional Filters - Paul Wang.

Simultaneous Structure/Control Synthesis with Nonnegligible Actuator Mass - AIAA Structures, Structural Dynamics & Materials Conference - Dave Zimmerman.

ANTICIPATED PAPERS

Evaluation of a Technique to Quantify Microburst Windshear Hazard Potential to Aircraft, prepared with F. H. Proctor, and R. L. Bowles - Journal of Aircraft - Greg Byrd.

Other Fellows are planning publications based on their research but have not solidified their plans at this time.

ANTICIPATED RESEARCH PROPOSALS

Effects of Reynolds Number and Mach Number on Leading-Edge Vortices, Lift and Aerodynamic Forces of Swept Wings at Low and High Angles-of-Attack - to be submitted to NASA Langley - Ted Akinyanju.

Postbuckling Analysis of Composite Structures Including the Effect of Local Material Failures - to be submitted to NASA Langley - Robert Arenburg.

End Effector Joint Conjugates for Robotic Assembly of Large Truss Structures in Space: A Second Generation, 9/89-9/90 - to be submitted to NASA Langley - William Brewer.

Development of a Technique to Estimate Microburst Windshear Hazard Potential from Airborne Forward-Look Sensors - to be submitted to NASA Langley - Greg Byrd.

From Where They Look to What They Think: Determining Controller Cognitive Strategies from Oculometer Scanning Data - to be submitted to NASA Langley - Steven Cushing.

Conceptual Design Methodology for Aerospace Vehicles - to be submitted to NASA Langley - Louis Gratzer.

Development of a Quasi-Three-Dimensional Fracture Mechanics Analysis of a Multiple-Cracked Laminate Subject to Extension, Bending, and Torsion - to be submitted to NASA Langley - Steven Hooper.

Computational Flow Fields of an Airfome Configuration, Using the Numerical Grid Generator, Program Eagle - to be submitted to NASA Langley - Johnny Houston.

AFE Dynamic Effects in Inhomogeneous Plasmas - to be submitted to NASA Langley - Jeng-Nan Juang.

Extension-Bend-Twist Coupling of Advanced Composite Tilt-Rotor Blades - to be submitted to NASA Langley - John Kosmatka.

Multi-Input Multi-Output Alrorithmsfor Stable Robustness - to be submitted to NASA Langley - George Rublein.

Automated Cloud Classification: An Expert System - to be submitted to NASA Langley - Sailes Sengupta.

Inverse Modeling of Turbulence Transition - to be submitted to NASA Langley - Paavo Sepri.

Modeling of Transition and Turbulence Involving Free Stream Turbulence - to be submitted to AFOSR - Paavo Sepri.

Evaluation of Model Data for Optimal-Update Structural Identification - to be submitted in response to a Research Announcement - Controls-Structures Interaction Experiments for Large Space Structures Guest Investigator Program - Suzanne Smith.

Mathematical Analysis of Directional Filters - to be submitted to NASA Langley - Paul Wang.

FUNDED RESEARCH PROPOSALS

Air Traffic Control Simulation - NASA Langley - Herb Armstrong.

NSF Graphics Equipment Grant - Hari Bidasaria.

End-Effector-Joint Conjugates for Robotic Assembly of Large Truss Structures in Space - NASA Langley, 9/88-9/89 - William Brewer.

Thermal Expansion of Solid State Laser Materials - NASA Langley - George Henderson.

FIRE - NASA Langley - Sailes Sengupta.

Cloud Flux Project - NSF - Sailes Sengupta.

Neural Network and Tactile Sensors - LORD Corporation - Paul Wang.

Sensor/Actuator Dynamics in the Active Control of Flexible Structures - NASA Langley - Dave Zimmerman.

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 V 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 17 (44%)
Somewhat 22 (56%)
Minimally 0

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

Very much so 38 (97%)
Somewhat 1 (3%)
Minimally 0

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 27 (69%)
Somewhat 9 (23%)
Minimally 2 (5%)
Don't Know 1 (3%)

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

Yes 27 (69%) No 12 (31%)

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 38 (97%)
Somewhat 1 (3%)
Minimally 0

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 17 (44%)
Redirected 9 (23%)
Advanced 27 (69%)
Just maintained 2 (5%)
Unaffected 2 (5%)

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 27 (69%)
Positively 12 (31%)
Without enthusiasm 0
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 31 (79%)
By starting new courses 7 (18%)
By sharing research experience 32 (82%)
By revealing opportunities for future employment in government agencies 28 (72%)
By deepening your own grasp and enthusiasm 23 (59%)
Will affect my teaching little, if at all 1 (3%)

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 26 (67%) No 11 (28%)
Don't Know 2 (5%)

C. Administration

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

(41%) 16 Received announcement in the mail.
(8%) 3 Read about it in a professional publication.
(31%) 12 Heard about it from colleague.
(28%) 11 Other (explain).

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

Yes 15 (38%) No 21 (54%)

1 DOE
12 Another NASA Center
4 Air Force
3 Army
3 Navy

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

Army - 2 Airforce - 0 Navy - 1 NASA - 3

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

Many 5 (13%)
A few 30 (77%)
None 4 (10%)

5. Would the amount of the stipend ($800) be a factor in your returning as an ASEE Fellow next summer?

Yes 22 (56%)
No 17 (44%)
If not, why Stipend low but adequate - Experience outweighs money - Research opportunities with NASA sicentists great

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

Yes 16 (41%) No 23 (59%)

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

Yes 34 (87%) No 3 (8%) NA 2 (5%)

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

Yes 37 (95%) No 1 (3%)

9. How do you rate the seminar program?

Excellent 12 (31%)
Very good 22 (56%)
Good 2 (5%)
Fair 2 (5%)
Poor 1 (3%)

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	10
Lectures	25	0	5	6
Tours	19	12	1	2
Social/Recreational	21	11	1	3
Meetings	19	5	3	8

11. What is your overall evaluation of the program?

Excellent 24 (62%)
Very good 8 (21%)
Good 2 (5%)
Fair 1 (3%)
Poor 0

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 for improving the second year.

D. <u>Stipend</u>

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

   $__________ per __________.

   Salary average was approximately $46,100.00 for the academic year.

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

   Yes 3 (8%) No 24 (62%) In part 11 (28%)

3. What, in your opinion, is an adequate stipend for the ten-week program during the summer of 1990?

   800 - 1 (3%) 1000 - 26 (67%) 1200 - 4 (10%)
   900 - 4 (10%) 1100 - 1 (3%) 1200 - 1500 - 1 (3%)

E. <u>American Society for Engineering Education (ASEE) Membership Information</u>

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

   Yes 9 (23%) No 29 (74%)

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

   Yes 23 (59%) No 9 (23%)

Percentages have been rounded off to next whole number.

Where percentage figures do not equal 100 there was a response missing.

Ninety-seven percent of the Fellows responding felt that their research was of importance to the center (LaRC) and to NASA.

Sixty-nine percent of the Fellows responding felt that their research capabilities had been advanced as a result of the summer experience.

One hundred percent of those responding would strongly recommend the program to faculty colleagues.

Sixty-two percent of the Fellows responding indicated that salary was not the primary motivation to participation in the program.

Seventy-four percent of the Fellows responding indicated that they <u>are not</u> currently members of the American Society for Engineering Education. Fifty-nine percent of these persons are first year Fellows.

Thirteen percent indicated a stipend range from \$8,000 to \$9,000 for the ten weeks as satisfactory.

Sixty-seven percent indicated a stipend of \$10,000 for the ten weeks would be satisfactory.

FELLOW'S COMMENTS

The comments were as follows: Activities are well balanced, more activities would not be desirable; the Lecture Series conflicted with experiments; end of budget year restricts equipment purchases; I was disappointed that there was no money to exploit the ideas I had been asked to develop; Langley facilities are excellent - support people are knowledgeable and helpful; a program extended through a one or two year time line sponsored or supported by organizations such as ASEE/NASA could provide research experiences for academic faculty; I consider the ASEE/NASA program to be a great asset for getting researchers and NASA together for continuing research. Also the effect in the classroom has been positive; I have also received two one year research cooperative agreements through my NASA contacts; The program is excellent, it gives a rare opportunity to interact with authorities in respective fields - the atmosphere is conducive to productive work; a stipend of $9,000 represents 2/9 of an academic year salary of about $40,000 (probably close to average salary of all Fellows). If increasing the stipend means a reduction in numbers, I am opposed to the reduction, the experience is too valuable! The relocation allowance was a step in the right direction; amount of relocation allowance and travel funds should be increased.

FELLOW'S RECOMMENDATIONS

Recommendations included the following: Change the evaluation forms for the seminars - leave room for comments; extend the program into the academic year to allow for research opportunities for teaching faculty; extend program to twelve or fifteen weeks; have a program match the three month (12 weeks) apartment lease period; the presentations (lectures) were given at a level beyond many in the audience (especially LARSS), suggest use of more lay terms; distribute guidelines of policies regarding work hours, etc.; finance a pre-visit; reimburse full costs of travel; influence housing agents to give short term leases; allocate a portion of the stipend to reimbursement of expenses, not as income; reinstate the tour of the facilities for new Fellows; alternate Research Associate's are needed especially if the advisor takes an extended trip or vacation; provide opportunities for more interaction between Fellows and among Fellows and Research Associates (informal luncheon and other social get togethers); provide better physical facilities (desk, chair, telephone, work station) and extend library hours.

RESEARCH ASSOCIATES' SURVEY

Ninety-five percent of the responses indicated that the Fellows were adequately prepared for their research assignments. Some Fellows brought their own computer hardware, shipped data to the Research Associate prior to arrival, and visited the base for information. The one negative response was due to the lateness of identifying the assignment and the participant.

All Research Associates responding indicated satisfaction with the diligence, interest and enthusiasm of the Research Fellow. Some comments: Enthusiastic, energetic with broad interests; highly motivated; unusual insight and professionalism.

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

All Research Associates responding expressed an interest in have the Fellow, if eligible, return for a second year.

RESEARCH ASSOCIATES' COMMENTS

Why limit participation to two years?

These summer experiences have b een helpful to our programs and overall understanding of specific topics.

-------is making a valuable contribution to our branch research this summer because we do not have experts in his discipline. His research experiences is helping us develop a research program.

Ten weeks is too short------extend the program to twelve weeks.

The program has been very important to our research efforts.

Research Fellows bring in a different perspective, a welcome change from our own approaches. Sometimes, a different viewpoint provides more fruitful views.

The opportunity to work and exchange ideas with individuals in the academic community------is beneficial and rewarding.

RESEARCH ASSOCIATES' RECOMMENDATIONS

Increase stipend.

Provide a senior position.

Extend program to twelve weeks.

SECTION VII

CONCLUSIONS AND RECOMMENDATION

CONCLUSIONS

Comments from the Research Fellows and from the Research Associates indicate continued satisfaction with the program. The Fellows feel their research activities to be important to them in terms of professional growth and important to the center and NASA.

The Research Fellows all stated that they would strongly recommend the program to faculty colleagues.

There is some indication of a need for improved communications between the Fellow and the Associate prior to arrival.

There is an indication of a need for more formal information regarding submission of research proposals.

More housing information is needed and sent out earlier to the Fellows.

The stipend is considered adequate. It is not the prime consideration when accepting the appointment.

RECOMMENDATIONS

Urge increased contact by the Research Associate prior to arrival. Increase pre-visit consultations.

Send housing information as soon as possible even if it requires several mailings.

APPENDIX I

PARTICIPANTS - ASEE/NASA LANGLEY SUMMER FACULTY RESEARCH PROGRAM

RETURNEES

1989 NASA-ASEE-ODU FELLOWS

RETURNEES

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOCIATE
Dr. Brewer, William V. Associate Professor Technology Jackson State University Jackson, MS 39217	50	Structural Mechanics Division	Marvin D. Rhodes Building 1148 Mail Stop 190 Tel. 864-3121
Dr. Byrd, Gregory P. Assistant Professor Earth Sciences SUNY-Brockport Brockport, NY 14420	32	Flight Management Division	Roland L. Bowles Building 1168 Mail Stop 156A Tel. 864-2035
Dr. Gratzer, Louis B. Associate Professor Aeronautics and Astronautics University of Washington-Seattle Seattle, WA 98195	68	Advanced Vehicles Division	Samuel E. Dollyhigh Building 1251 Mail Stop 406 Tel. 864-5975
Dr. Green, Terry J. Assistant Professor Chemistry Bethune-Cookman College Daytona Beach, FL 32015	36	Instrument Research Division	Donald H. Phillips Building 1230 Mail Stop 234 Tel. 864-4777
Dr. Hafele, Joseph C. Assistant Professor Mathematics and Physics Eureka College Eureka, IL 61530	55	Flight Electronics Division	Arthur L. Newcomb, Jr. Building 1202 Mail Stop 486 Tel. 864-1740
Dr. Hansen, Marion G. Associate Professor Chemical Engineering University of Tennessee Knoxville, TN 37996-2200	43	Materials Division	Ruth H. Pater Building 1293A Mail Stop 226 Tel. 864-4277

FELLOW	AGE	ASSIGNED TO	RESEARCH ASSOCIATE
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APPENDIX II

PARTICIPANTS - ASEE/NASA LANGLEY

SUMMER FACULTY RESEARCH PROGRAM

FIRST YEAR

1989 NASA-ASEE ODU FELLOWS

FIRST YEAR

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APPENDIX III

LECTURE SERIES

PRESENTATIONS BY RESEARCH FELLOWS

1989
ASEE/NASA
Old Dominion University - Langley Research Center

LECTURE SERIES

Location: Activities Center Auditorium, Bldg. 1222
Time: 9:00 a.m. to 10:30 a.m.

DATE	TOPIC	SPEAKER
June 5	Langley Overview and Orientation	Dr. Richard Barnwell Chief Scientist
June 13	Global Atmospheric Change: An Uncontrolled Experiment	Dr. Joel Levine Atmospheric Sciences
June 20	Space Station Freedom	Lenwood Clark Space Station Office
June 27	National Aerospace Plane	Allan Whitehead Hypersonic Tech Office
July 6	Aircraft Fault Monitoring and Diagnosis (AI)	Kathy Abbott Flight Management Division
July 11	Artificial Intelligence Techniques for Aircraft Controls	Richard Hueschen Guidance and Control Division
July 18	Automation and Robotics	Al Meintel ISD-Automation Technology Branch
Aug. 1	Aircraft Drag Reduction	Dennis Bushnell Fluid Mechanics Division

Schedule of Final Presentations by Faculty Fellows

Location: Bldg. 1212, Room 200
Date: August 10, 1989
Time: 9:00 a.m. to 4:30 p.m.

NAME/DIVISION/BRANCH	TOPIC
Peyman Givi Fluid Mechanics Div./ Computational Methods Br.	Large Eddy Simulations and Direct Numerical Simulations of High Speed Turbulen Reacting Flows
Rex Kincaid Interdisciplinary Research Office	Minimizing Distortion in Truss Structures Via Simulated Annealing
Robert Arenburg Structural Mechanics Div./ Structural Mechanics Br.	Incorporation of a Progressive Failure Analysis in the CSM Testbed Software System
William Brewer Structural Mechanics Div./ Structural Concepts Br.	Joints for the Assembly of Truss Structures
Zia Razzaq Acoustics Division	Flexural Fatigue Life Prediction of Closed Hat-Section Using Materially Nonlinear Axial Fatigue Characteristics
Louis Gratzer Advanced Vehicles Div./ Vehicle Integration Br.	Conceptual Design of Aerospace Vehicles
Ted Akinyanju Flight Applications Div./ Flight Research Br.	Ground Evaluation of Seeding An In-Flight Wingtip Vortex Using Infrared Imaging Flow Visualization Technique
Joseph Keiser Instrument Research Div./ General Research Instrumentation Br.	Characterization of the Surfaces of Pt/SnO_2-Based Catalysts by FTIR
Resit Unal Systems Engineering Div./ Cost Estimating Office	Operations and Support COst Modeling Using Markov Chains
Steven Cushing Flight Mechanics Div./ Vehicle Operations Research Branch	From Where They Look to What They Think: Determining Controller Cognitive Strategies from Oculometer Scanning Data

NAME/DIVISION/BRANCH	TOPIC
Joseph Hafele Flight Electronics Div./ Advanced Sensors Program Office	Stability of Laser Oscillator Systems
Mark Mear Material Div./ Mechanics of Materials Br.	Modeling Growth of Fatigue Cracks Which Originate at Rivet Holes
Hari Bidasaria Analysis & Computation Div./ Flight Software & Graphics Br.	A Few Modeling and Rendering Techniques for Computer Graphics and Their Implementation Ultra Hardware
Dave Zimmerman Guidance & Control Div./ Spacecraft Controls Br.	Simultaneous Structure/Control Synthesis with Nonnegligible Actuator Mass

APPENDIX IV

ABSTRACTS

RESEARCH FELLOWS

N90-25035

GROUND EVALUATION OF SEEDING AN IN-FLIGHT WINGTIP VORTEX USING INFRARED IMAGING FLOW VISUALIZATION TECHNIQUE

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ABSTRACT

An experimental simulation of an in-flight wingtip vortical ~~vorticity~~ flow visualization technique uses infrared imaging to observe strong and concentrated vortices. This experiment is phase I of a two-phase infrared evaluation program. The system includes a Vortex Generator (Model 320 Vortec Vortex Tube) which generates the required vortex. The mouth of the unit is mounted close to the free end of a half-inch diameter, sixteen and a half foot long stainless steel tubing (sized after tubing currently installed in the wings of an experimental Beechcraft Sundowner 180 aircraft).

Dichlorodifluoromethane (Freon-12) is entrained into the generated vortex. A breakdown of the vortices is indicated by the rapid diffusion and the resulting pattern is tracked using the infrared imager and video systems. Flow rates (volume and mass) are estimated at the laboratory and proposed flight conditions. The nominal flight altitude is expected to be 2500 feet.

NOMENCLATURE

A tube cross-section area

k specific heat ratio (c_p/c_v)

P pressure

ρ_o absoulute density

$\dot{m}$ mass flow rate

$\dot{V}$ volume flow rate

$\bar{V}$ discharge velocity

τ_e effective transmission

$R_c(\lambda)$ Agema 880 spectral response

$E(\lambda, T)$ Plank constant

$\tau(\lambda, CCl_2F_2\ \%)$ atmospheric/Freon-12 percent transmission at each wavelength

INTRODUCTION

The observation and diagnosis of aircraft off-surface flow fields are traditionally performed in the wind tunnels. But with the present demand for highly maneuverable military aircrafts and high-performance commercial jetliners, the importance of these off-surface flows has greatly increased, and especially the vortical flows. Vortices generated at wingtips and at the side-edges of trailing-edge flaps are typically observed at take-off, landings and during maneuvers at low altitudes.

One of several innovative works in the vortical flow area is the development of the vortex attenuators (spoilers) by NASA. The NASA program concentrated on the axial penetration of vortex wake because it appears the most likely to happen during landings. Strong vortex wakes generated by large transport aircrafts are a potential hazard to smaller aircrafts. Encounters with such wakes could result in loss of altitude/rate of climb, imposed roll and structural load factors. The spoilers alleviate the trailing-edge vortex by injecting turbulence. Other recent efforts to improve performance include aircraft configurations that promote vortex flows which augment lift at high angles of attack.

APPARATUS AND TESTS

A Beechcraft Sundowner wingtip was simulated with a sixteen and a half feet ~~long~~, half-inch diameter stainless steel tubing. A Teledyne Hastings Flow Meter and its laminar flow element were integrated into the line at the 12 foot mark. Freon-12 from a 30 psig cannister was entrained into generated vortex until a maximum

Freon-12 is an odorless and non-toxic gas at room temperature (20% by volume or less). Since the fluid was compressed under its own vapor pressure as a liquified gas, we can apply the principle developed for isentropic flow of an ideal gas relations with possibility of condensation. A discharge velocity of 90.1 mph and a volume flow rate of 11.1 ft/min (CFM) were estimated for the Freon-12 based on its physical properties, tubing size and cannister size. The maximum flow rate obtained during tests was 6.22 CFM. It was observed that a maximum flow rate stayed constant for only 10 to 12 seconds and the gradually dropped as the gas condensed. The rate of flow decrease was about constant for the tests. Table 1. shows values for volume and mass flow rates. (Values expected to be a little higher at 2500 feet altitude.)

	TEST A	TEST B	TEST C
RUN 1	6.22 CFM 1.98 lbm/min	5.12 CFM 1.60 lbm/min	4.60 CFM 1.46 lbm/min
RUN 2	4.84 CFM 1.50 lbm/min	4.07 CFM 1.30 lbm/min	4.14 CFM\ 1.32 lbm/min

IMAGE RECORDING SYSTEM

The infrared measuring technique has become very popular in recent years, especially in flow studies that involve non-intrusive flow measurements. Gases are in many cases transparent to radiation and absorb or radiate either with discrete spectra or spectra in very small regions of wavelengths. In the current experiment radiation is transmitted by the Freon-12 through the atmosphere to the camera. The background against which the gas is visualized also emits radiation. To estimate effective transmission, one has to discriminate the gas from the background.

The infrared image system used in the current experiment (Agema 880) measures the vortex patterns with a field frequency of 25 Hertz. The camera is equipped with a nitrogen-cooled detector

Incorporation of a Progressive Failure Analysis Method in the CSM Testbed Software System

by

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Development of graphite-epoxy composites for aircraft primary structure has been the focus of research for many years. Analysis of the postbuckling behavior of composite shell structures pose many difficult and challenging problems in the field of structural mechanics. Current analysis methods perform well for most cases in predicting the postbuckling response of undamaged components. To predict component behavior accurately at higher load levels, the analysis must include the effects of local material failures. Consider the example in Fig. 1 where the end-shortening results for a blade-stiffened panel with a central cut-out are presented. Good agreement between the test results and the analytical predictions are observed for loads up to the point where local failures were first observed, however, beyond this point the analysis begins to deviate significantly from the experimental data. In order to predict the structural response beyond the point of local material failures, the analysis must reflect the change in stiffness due to local material failures. In response to this need, current research efforts are in progress to incorporate a progressive failure model into the geometrically nonlinear solution procedure in the CSM Testbed software system.

The CSM Testbed software system is a highly modular structural analysis system currently under development at the NASA Langley Research Center[1]. One of the primary goals of the CSM Testbed is to provide a software environment for the development of advanced structural analysis methods and modern numerical methods which will exploit advanced computer architecture such as parallel-vector processors. The CSM Testbed is composed of three major components: functional processors, a command language and a data manager. The fundamental program tasks or functions are organized into independent Fortran programs called processors. Examples of tasks commonly performed by processors include computing stiffness matrices, equation solving and eigenvalue extraction. The command language provides the mechanism for invoking the various processors in order to perform specific analysis tasks. The command language features a high-level, structured programming capability including DO, IF, WHILE and PROCEDURE constructs. Data exchange between functional processors is not performed directly with each other, instead the processors share data stored in a common database under the control of the data manager.

Development of a progressive failure analysis method consists of the design and implementation of a processor which will perform the ply-level progressive failure analysis and the development of a geometrically nonlinear analysis procedure which incorporates the progressive failure processor. An overview of the nonlinear analysis procedure showing a typical load step is presented in Fig. 2. At each load step, after a converged solution is obtained, the progressive failure analysis processor is executed. In the progressive failure analysis processor, all plies within the elements are analyzed for possible failures, see Fig. 3. If a ply failure is detected, as indicated by the failure criteria, the ply properties are then modified according to a particular degradation model. In the event ply failures are detected, the structure is reanalyzed utilizing the modified ply properties at the current load level. This process is continued until either no additional ply failures are detected or additional ply failures continue to progress resulting in total collapse of the structure.

Regarding the development of the progressive failure processor, two components are required: failure criteria and a degradation model. For the initial implementation, the failure criteria of Hashin [2] will be used, see Fig. 4. A major advantage of these criteria is identification of the failure mode which is essential information for the material degradation model. The function of the degradation model is to provide the progressive failure processor with the reduced ply properties in response to the various detected failure modes. For a matrix failure which typically indicates the development of transverse matrix cracks, the ply properties will be degraded following the suggestion of Tsai [3]. Tsai proposed that the properties of the cracked ply should be replaced by material properties of an uncracked material with a reduced matrix modulus. The new ply properties are then easily obtained using micromechanics relations. For a fiber failure, the ply is unable to carry any load, as a result the ply properties are effectively reduced to zero. In the future, it is anticipated that a variety of failure theories and degradation models will be examined. In response to this need provisions have been made in the software design which will allow the incorporation of other models into the progressive failure analysis processor with minimal effort.

Work to date includes the design of the progressive failure analysis processor and initial plans for the controlling geometrically nonlinear analysis procedure. The implementation of the progressive failure analysis has begun. Access to the model database and the Hashin failure criteria have been completed. Work is in progress on the input/output operations for the processor related data and the finite element model updating procedures. In total the progressive failure processor is approximately one-third complete.

References

1. Knight, N. F., Jr., Gillian, R. E., McCleary, S. L., Lotts, C. G., Poole, E. L., Overman, A. L., and Macy, S.C., "CSM Testbed Development and Large-Scale Structural Applications", NASA TM-4072, April, 1989.
2. Hashin, Z., "Failure Criteria for Unidirectional Fiber Composites", J. Appl. Mech., Vol. 47, 1980, pp. 329-334.
3. Tsai, S. W., Composites Design, 3rd edition, Think Composites, Dayton, Ohio, 1987.

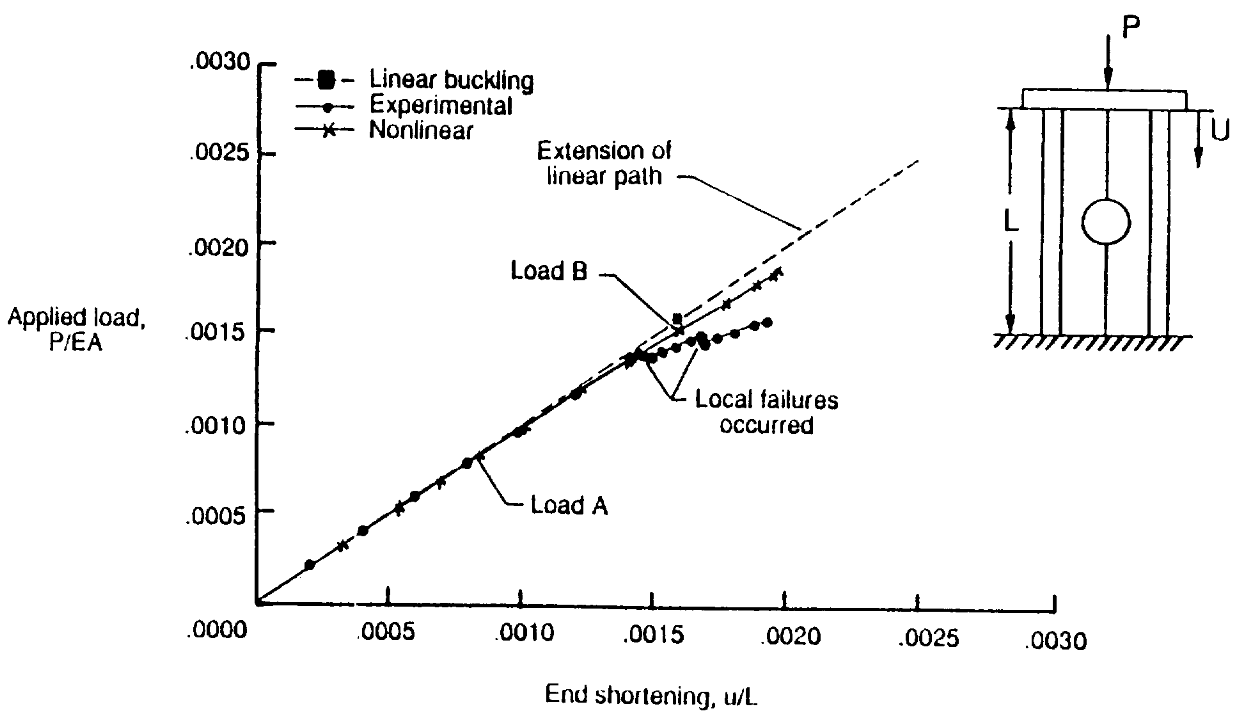

Figure 1. Blade-Stiffened Panel with Discontinuous Stiffener

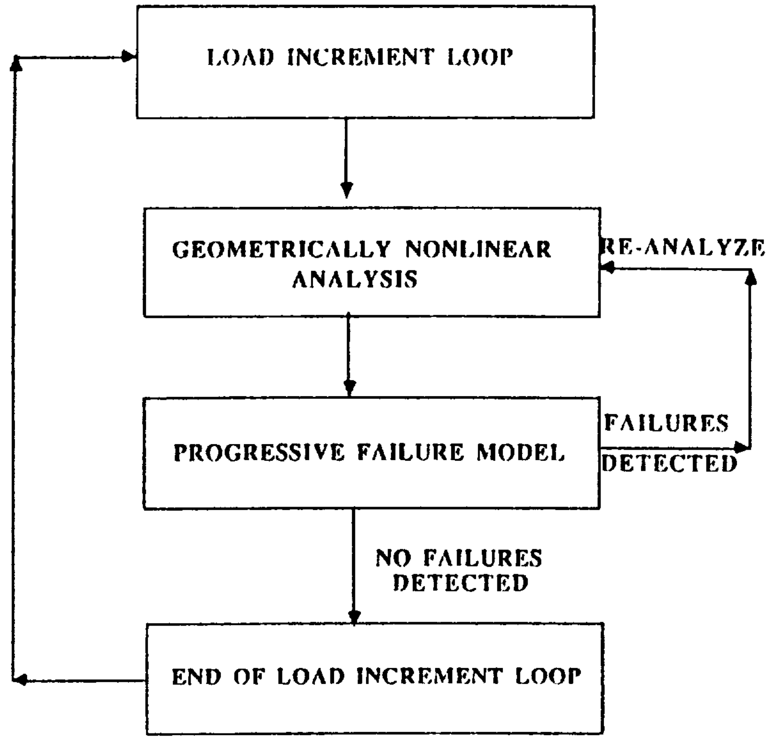

Figure 2. Progressive Failure Analysis Solution Procedure

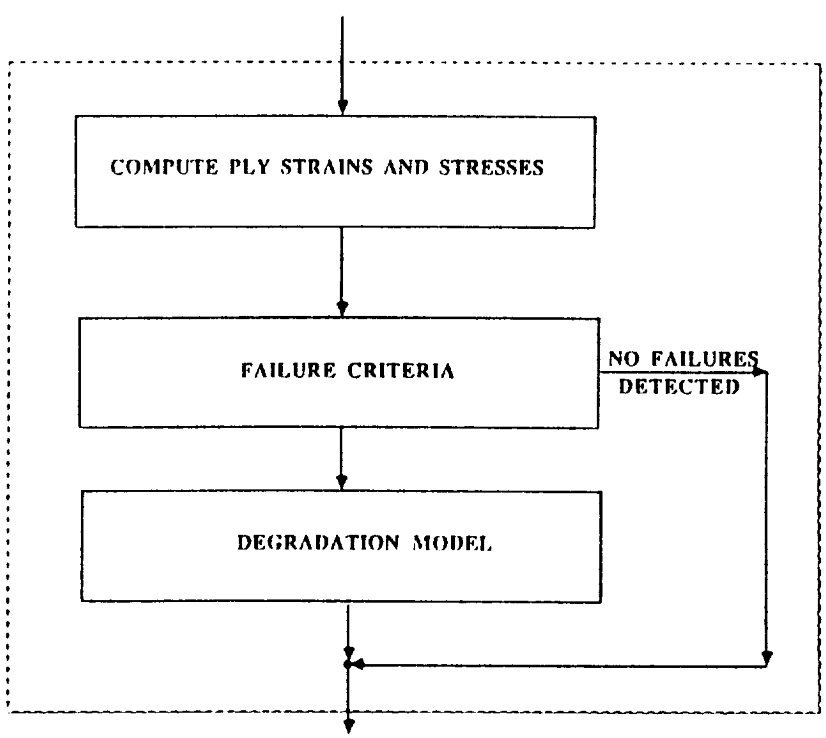

Figure 3. Progressive Failure Analysis Processor

- Tensile Matrix Failure, $\sigma_{22} + \sigma_{33} > 0$

$$\left(\frac{\sigma_{22} + \sigma_{33}}{Y_T}\right)^2 + \frac{1}{S_{23}^2}\left(\sigma_{23}^2 - \sigma_{22}\sigma_{33}\right) + \frac{1}{S_{12}^2}\left(\sigma_{12}^2 + \sigma_{13}^2\right) = 1$$

- Compressive Matrix Failure, $\sigma_{22} + \sigma_{33} < 0$

$$\begin{aligned}\frac{1}{Y_c}\left[\left(\frac{Y_c}{2S_{23}}\right)^2 - 1\right](\sigma_{22} + \sigma_{33}) + \frac{1}{4S_{23}^2}(\sigma_{22} + \sigma_{33})^2 \\ + \frac{1}{S_{23}^2}(\sigma_{23}^2 - \sigma_{22}\sigma_{33}) + \frac{1}{S_{12}^2}(\sigma_{12}^2 + \sigma_{13}^2) = 1\end{aligned}$$

- Tensile Fiber Failure, $\sigma_{11} > 0$

$$\left(\frac{\sigma_{11}}{X_T}\right)^2 + \frac{1}{S_{12}^2}\left(\sigma_{12}^2 + \sigma_{13}^2\right) = 1$$

- Compressive Fiber Failure, $\sigma_{11} < 0$

$$\frac{\sigma_{11}}{X_c} = 1$$

Figure 4. Hashin Failure Criteria

N90-25037

AUTOMATIC SPEECH RECOGNITION IN AIR-GROUND DATA LINK

by

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Abstract

In the present air traffic system, information presented to the transport aircraft cockpit crew may originate from a variety of sources -- the airline company, weather service, or air traffic control -- and may be presented to the crew in visual or aural form, either through cockpit instrument displays or, most often, through voice communication. But voice radio communications are the most error prone method for air-ground data link. Voice messages can be misstated or misunderstood and radio frequency congestion can delay or obscure important messages.

The data link of the future will offer more options for presentation of information and probably less reliance on voice communication. Discrete electronic addressing of data will allow information to be fed directly into the aircraft's flight management system. This could lead to a proliferation of output devices in the cockpit, each competing for the attention of the crew and presenting distractions during periods of workload variability.

To prevent this proliferation, a multiplexed data link display can be designed to present information from multiple data link sources on a shared cockpit display unit (CDU) or multi-function display (MFD) or some future combination of flight management and data link information. Furthermore, the data link interface will have the capacity to store messages that can be called up by the crew or presented automatically during periods of lower workload or during the appropriate phase of flight. In this way, critical information will be presented immediately, while lower priority information will be stored until needed or wanted.

An aural data link which incorporates an automatic speech recognition (ASR) system for crew response offers several advantages over visual displays. First, an aural system eliminates the need for a separate display unit. Information can be presented visually on the CDU or MFD when requested by the crew, thus limiting the time sharing of the unit to periods when it least interferes with flight management functions. Second, the presentation of information in more than one media, visual and aural, is likely to increase retention and recall. Also, the aural presentation is more likely to get the crew's attention during

periods of high workload while ASR input leaves the crew's eyes and hands free to complete other tasks. Finally, aural presentation with ASR input is more natural and offers the least variation from the present environment.

A variation on this approach is an interface which can present information in various formats (aural, visual, or printed) as appropriate to the crew workload. Thus, during a period when the crew's visual workload is already high (e.g. scanning instruments during a critical phase of flight) high priority information might be presented aurally and stored so the crew can call it up visually later when desired. Lower priority information is stored and presented when appropriate, so as not to overload the crew with information at critical times. Such a system requires some means for the interface to measure and determine the crew's current workload -- perhaps by "listening in" on radio transmissions, monitoring TCAS or control movements, or monitoring crew activity in some way. The interface computer then decides whether to store or present the information and the most appropriate medium for presentation.

A number of questions exist about the efficiency of a computer mediated aural/ASR system. What indicators of workload should be used and how should the computer decide presentation media? What is the effect of inconsistency in the form in which information is presented? Would the system reduce or increase crew data entry errors? Is speech input faster and more accurate than manual entry? Would the system improve or degrade information retention and recall? How will information priorities be set? How well will crews accept the system? These and other issues require further research.

The purpose of this summer's work was to begin an investigation of the possibility of applying ASR to the air-ground data link. The first step has been to review current efforts in ASR applications in the cockpit and in air traffic control and evaluate their possible data link application. Next, a series of preliminary research questions is to be developed for possible future collaboration.

N90-25038

A FEW MODELING AND RENDERING TECHNIQUES FOR COMPUTER GRAPHICS AND THEIR IMPLEMENTATION ON ULTRA HARDWARE

by

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Abstract

Ultra network is a recently installed very high speed graphics hardware at NASA Langley Research Center. The Ultra Network interfaced to Voyager through its HSX channel is capable of transmitting up to 800 Million bits of information per second. It is capable of displaying fifteen to twenty frames of precomputed images of size 1024 x 2368 with 24 bits of color information per pixel per second. I have been working towards the development of few modeling and rendering techniques in computer graphics and their implementation on Ultra hardware.

Since sometime, I have been working on the modeling and rendering images of three dimensional objects through the use of generalized cylinders. A generalized cylinder is defined as a surface generated by a sweeping cross-section along a given trajectory. The sweeping cross-section undergoes, in general a continuous transformation in shape, size, position, and orientation as a function of the location along the trajectory. The sweeping cross-section by itself may or may not be intersected by the trajectory for the part or all of the way. The generalized cylinders make a powerful tool for the modeling of variety of three dimensional objects like screws, spirals, twisted rods etc., and various aircraft and space vehicle's parts. In ray-tracing (in computer graphics), for an object modelled through the use of a generalized cylinder, problem of finding the point of intersection of the ray with the surface of the generalized cylinder and the normal to the surface may become complex depending upon the type of the surface generated. I have been working towards reducing this problem to that of finding the point of intersection between two curves in a plane. Using this method, I have modelled and displayed several images on the Ultra Network Graphics system on the Voyager.

Presently the method of stochastic fractal geometry has been gaining popularity for the modeling of natural objects like trees, mountains, fern etc. I have been actively involved in the research in this area. An object defined by fractal geometry, the details of the structure of an object remain the same (or similar) as one zooms in more and more on the object. I have been developing models and code for the modeling and rendering of such objects on the Ultra Network. I have developed methods and code for the generation of impressive looking images of

botanical trees and mountains on the Ultra Network. I have also successfully developed a tree animation on the Ultra Network.

I have been also working on the development of the ray-tracer in use here at Flight Software and Graphics branch. The ray-tracer was not compatible with the voyager system. I have made the necessary changes in the ray-tracer and now it works well on the Voyager. I have modified it substantially, particularly the modeling through triangulation component of it, to make it more efficient. In fact, I have used this feature of the ray-tracer for the first time here at this branch and I have successfully animated an F-16 fighter plane (using the triangulation data available in the branch). I have made the program run faster by at least two orders of magnitude with the changes I have made to it for better efficiency. I am working towards further modifying the ray-tracer for multi-tasking on the Voyager so that four frames of images can be generated simultaneously for animation purposes.

N90-25039

STRUT - NODE JOINT CONJUGATES FOR THE ASSEMBLY OF SEMI-PERMANENT OR REUSABLE TRUSS STRUCTURES

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ABSTRACT

INTRODUCTION

When strut and node components are used for truss construction an assembly problem occurs if a strut must be fitted between nodes whose separation distance is either closer or farther than the design intended. This condition is the result of normal dimensional variations that occur in any manufacturing process. In such circumstances two actions would permit continued assembly:

1. Change the effective strut length.
2. Move the nodes.

Assuming continued assembly is the most attractive alternative, attention is focused on accomplishing these actions as part of the assembly process.

DISCUSSION

Existing strut-node systems solve the assembly problem in a variety of ways. Manufacturing accuracy and material elasticity minimize the problem, especially for small manually assembled truss structures where necessary forces and reactions can be applied by hand. Large and (or) rigid structures require mechanisms to assist in accomplishing one of the two necessary actions. A common method depends on lateral forces applied to "ramp" the strut axis into position between nodes [ref. 3]. When sufficient lateral force is difficult to apply or react, a variable length strut can be used to fit between nodes or apply axial force. This approach permits a choice of several mechanisms that can transmit force and energy to actuate axial displacement. Such systems are available commercially [ref 1]. Others have been designed for special applications [references 2 thru 6].

Dimensional integrity is a necessary requirement of a truss in most applications. Variable length struts are usually preloaded at the joints against a reference length in an attempt to maintain the desired dimension. As a byproduct they can pull the nodes together or push them apart but most cannot do both.

DEFINITIONS

Double action shall be taken to mean the ability of a variable length strut to fit between nodes spaced either too close together (push) or too far apart (pull) and preload against a reference length in both cases [references 2 & 5].

Single action provides the same capability if nodes are too close together or too far apart but not both [ref 1,3,4 & 6].

DESCRIPTION

Three concepts have been pursued to a point where "Invention Disclosures" were submitted to the LaRC Patent Office:

1. SIMPLIFIED DOUBLE ACTION MECHANISM TO PRELOAD STRUT AND NODE JOINTS IN THE ROBOTIC ASSEMBLY OF TRUSS STRUCTURES (Figure 1).

   Objective - preload mechanism for strut-node truss joints that:

   a) allows parametric variation over a wide range of envelope configurations, preload forces, and preload displacements,
   b) provides for double action (both push and pull) from a single drive interface to facilitate automated assembly,
   c) has simple easily manufactured cylindrically shaped components to reduce production costs,
   d) is compatible with currently available knob-end and pocket-scar joint conjugates.

2. SLOTTED NODE & T-BAR JOINT FOR ASSEMBLY OF TRUSS STRUCTURES submitted with M. D. Rhodes (Figure 2).

   Objective - node and conjugate strut ends that:

   a) are compact having a high packaged density for shipping,
   b) will work with double or single action push/pull mechanisms,
   c) allow each attachment site to be approached from two sides,
   d) guide an approaching strut end toward capture of the node,
   e) locate strut axis on node center when the preload is applied,
   f) prevent rotation about any axis.

3. SIMPLIFIED DOUBLE ACTION TRUSS STRUT JOINT (Figure 3).

   Objective - double action strut ends that:

   a) are simple to use and inexpensive to manufacture,
   b) can be used in architectual and structural applications,
   c) will extend to allow automated assembly possibilities.

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Double Action
Preload Mechanism:

TURNBUCKLE

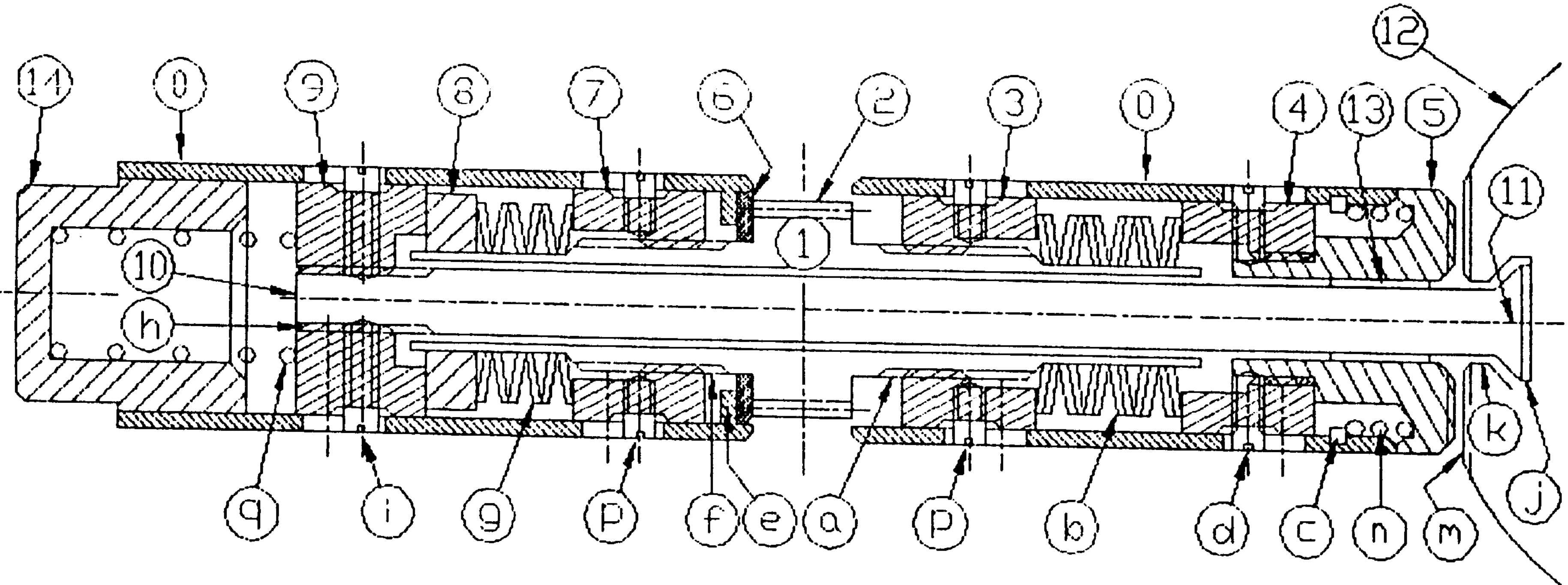

Figure 1

Slotted Node & T-Bar

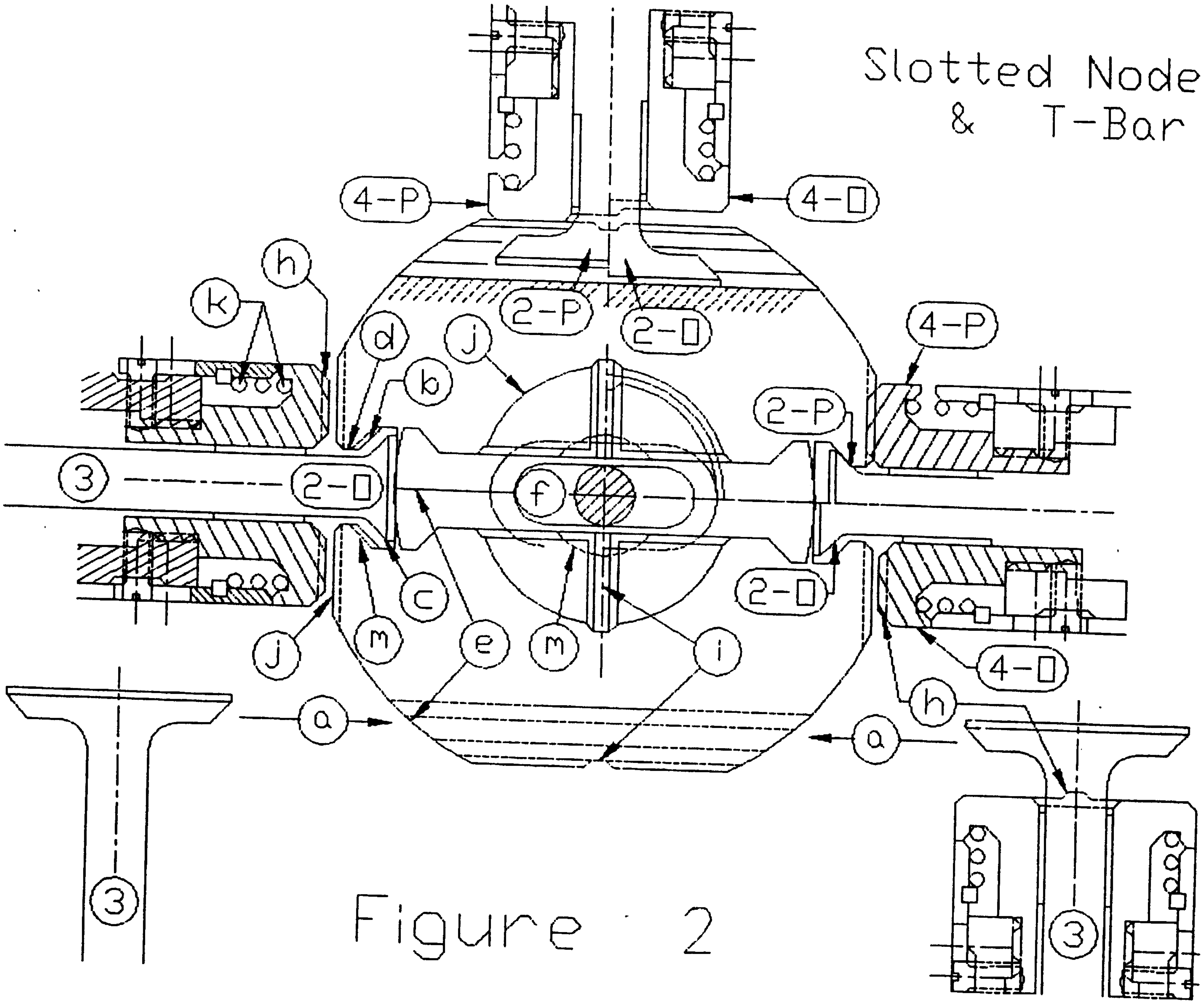

Figure 2

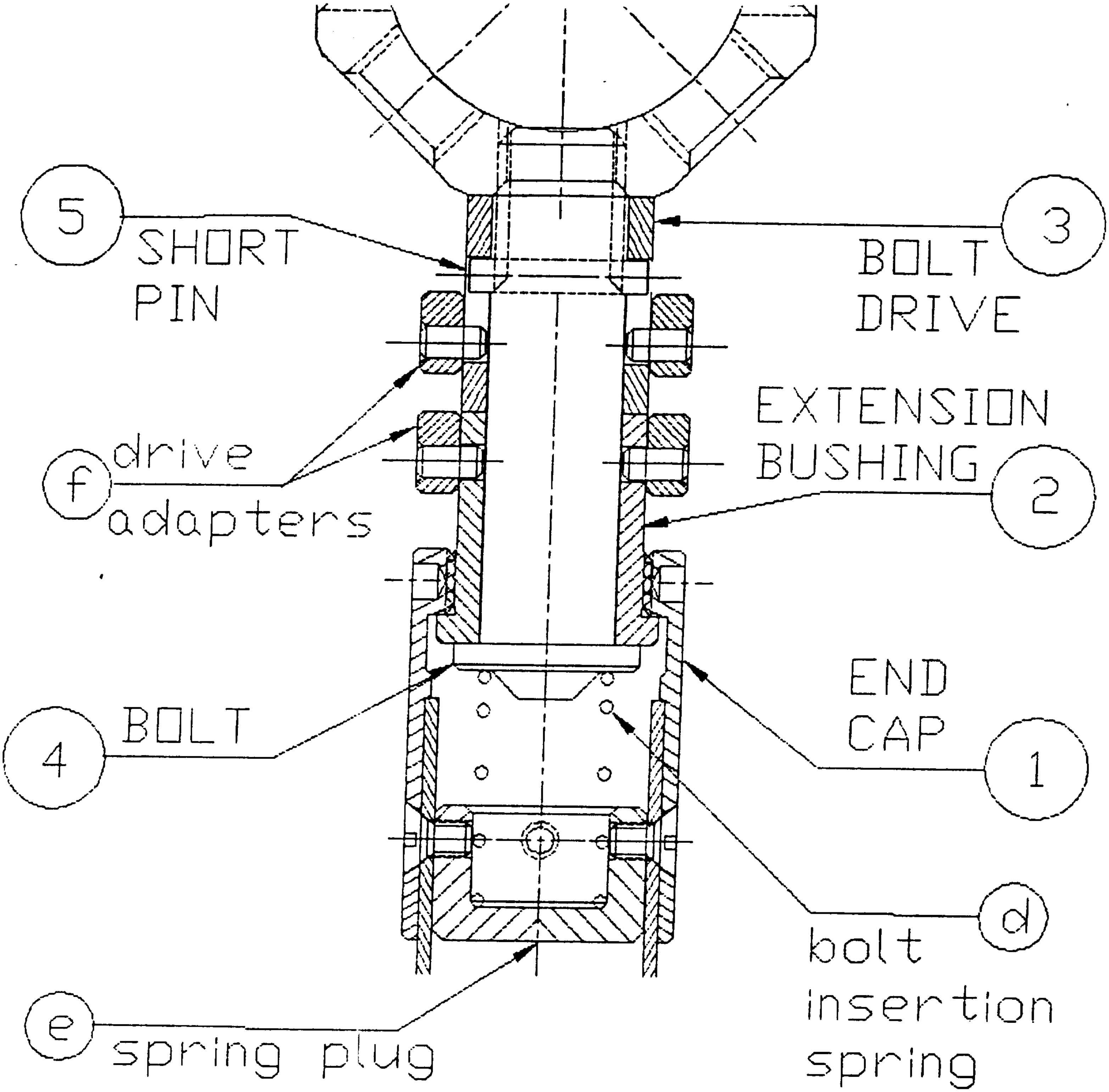

figure 3 - with Adaptive Collars

N90-25040

A QUANTITATIVE TECHNIQUE TO ESTIMATE MICROBURST WIND SHEAR HAZARD TO AIRCRAFT

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Low-altitude microburst wind shear encounters can significantly affect aircraft performance during approach or takeoff. Over the past 25 years, hazardous wind shear has been a contributing factor in over two dozen commercial airline accidents in which there were over 500 fatalities. In response to the wind shear problem, a number of agencies including NASA, the FAA and the National Center for Atmospheric Research have been involved in the design and testing of various sensors to detect the hazard. Among the sensors being tested are the ground-based Terminal Doppler Weather Radar (TDWR) and airborne Doppler radar and LIDAR systems. While these sensor systems do measure horizontal wind shear, they do not adequately account for the vertical wind, which is a key component of the microburst hazard to aircraft. This study defines a technique to estimate aircraft hazard from the combined effects of horizontal and vertical winds, given only horizontal wind information.

The wind shear hazard potential to aircraft performance may be quantified in terms of the Bowles F-factor (Bowles and Targ 1988):

$$F = \frac{W_x}{g} - \frac{W_h}{V} \qquad (1)$$

where W_x is the substantial derivative of the horizontal wind along the flight path, W_h is the vertical wind and V is the airspeed of the plane. Term A in Eq. 1 is represents the effect of horizontal wind shear (e.g. headwind loss, tailwind gain) on aircraft performance, while term B constitutes the effect of vertical wind (e.g. downdraft). The effect of the two components is illustrated in a schematic view of an aircraft microburst encounter on approach shown in Fig. 1. The more positive the value for F-factor, the greater the detriment to aircraft performance, with an F-factor in excess of 0.1 considered as hazardous.

F-factors for this study were computed from model simulations using the Terminal Area Simulation System (TASS) convective cloud model developed by Proctor (1987a,b; 1988, 1989). The TASS has been used extensively to produce realistic simulations of numerous microburst environments. Fig. 2 shows that for a composite of nine TASS model simulations, the horizontal shear contribution to the F-factor decreases rapidly with height , to less than 50 percent at altitudes above about 200 meters (650 feet). Therefore, Doppler radar and LIDAR systems will seriously underestimate the total hazard by not taking into account the vertical wind effects.

A method to estimate the total F-factor, given only the horizontal wind information has been developed, based on mass continuity. Assuming an axisymmetric cylindrical microburst, the horizontal divergence is related to the vertical velocity by an altitude-dependent scale factor:

$$\text{scale factor (SF)} = \frac{\text{vertical velocity}}{\text{horizontal divergence}} = \frac{W_h}{\frac{\partial W_x}{\partial X} + \frac{W_h}{R}} \qquad (2)$$

The F-factor may then be evaluated according to:

$$\text{FDERIVED} = g^{-1}V\frac{\partial W_x}{\partial X} - \frac{SF*[\partial W_x/\partial X + W_x/R]}{V} \qquad (3)$$

where R is distance from the center of the microburst. Fig. 3 shows the quadratic curve fit for scale factor versus altitude, based on 9 TASS microburst simulations. The scale factor increases due to the increasing importance of the vertical wind and smaller horizontal divergence at higher altitudes Tests on independent cases reveal that the F-factor estimation technique (FDERIVED) shows good agreement with TASS simulated F-factors (FMODEL). Fig. 4 shows the remarkable agreement of FMODEL and FDERIVED at an altitude of 240 meters (790 feet) for the Dallas-Fort Worth microburst of 2 August 1985 for the time of the Delta flight 191 accident. At the same time, the F-factor due to horizontal shear (FHORIZ) significantly underestimated the hazard, failing to reach the critical F-factor of 0.1. Temporal (Fig. 5) and altitude (Fig. 6) analyses also show good agreement between FDERIVED and FMODEL, with serious underestimation of the hazard by FHORIZ at altitudes of greater than 120 meters.

The method presented here shows promise in that it provides a reliable estimate of aircraft performance hazard given only horizontal wind information. It is a simple, straight forward technique which can be easilty integrated with Doppler radar and LIDAR sensing systems. At present, it is limited in that it does not work reliably for very narrow microbursts and has only been tested on axisymmetric microburst cases. Future work will include technique refinement using both two- and three-dimensional versions of TASS. Specifics to be addressed are flight paths which are not through the center of microbursts and axisymmetric microbursts. Also, the technique resolution problem will be looked at in regards to its inadequate treatment of narrow microbursts.

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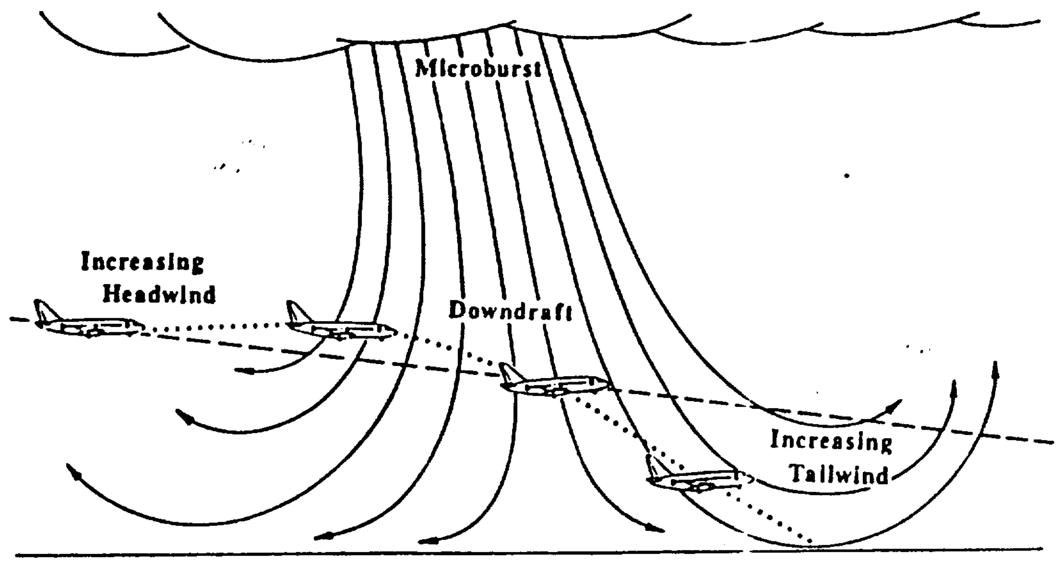

Fig.1: Schematic of an aircraft microburst encounter on approach.

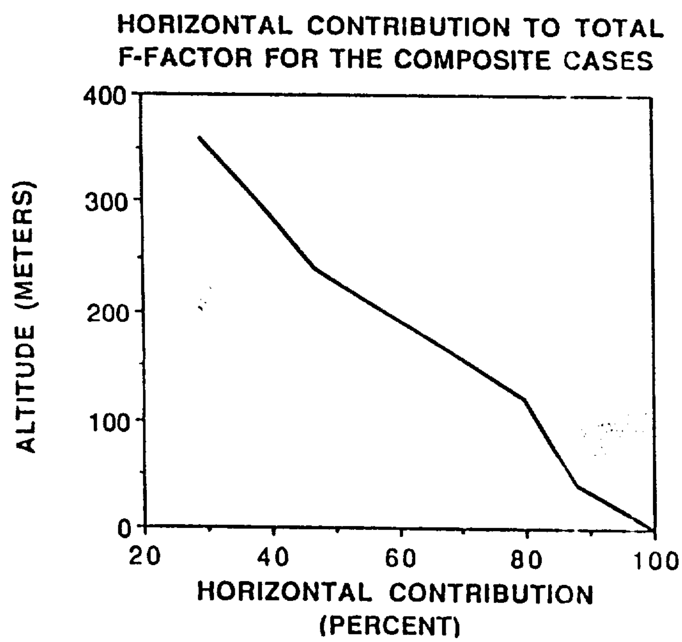

Fig. 2: Horizontal contribution (W_x/g) to the total F-factor for a composite of 9 TASS model simulations.

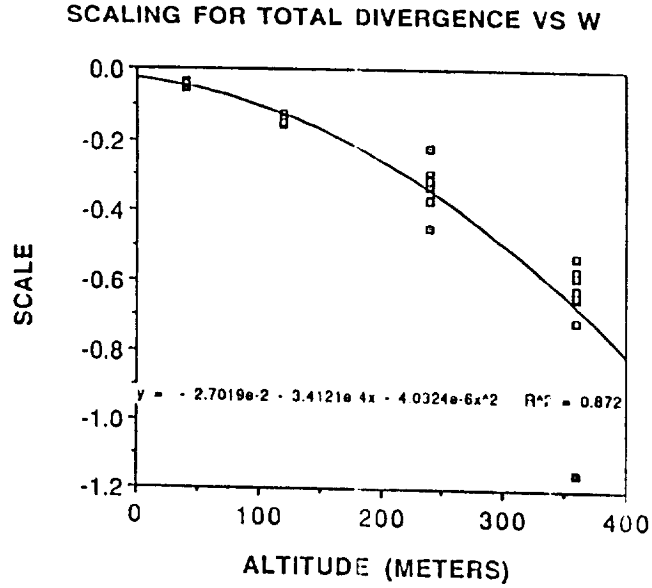

Fig. 3: Quadratic curve fit of scale factor versus altitude.

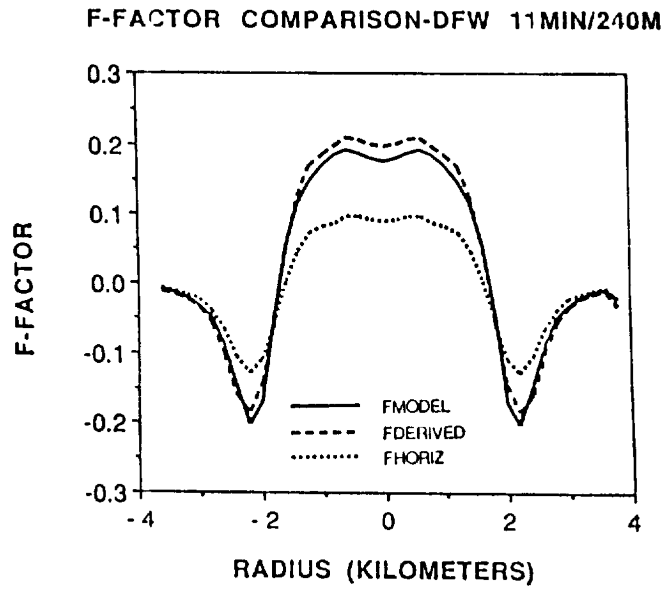

Fig. 4: F-factor comparison for DFW case of 2 August 1985 at an altitude of 240 meters near Delta accident time.

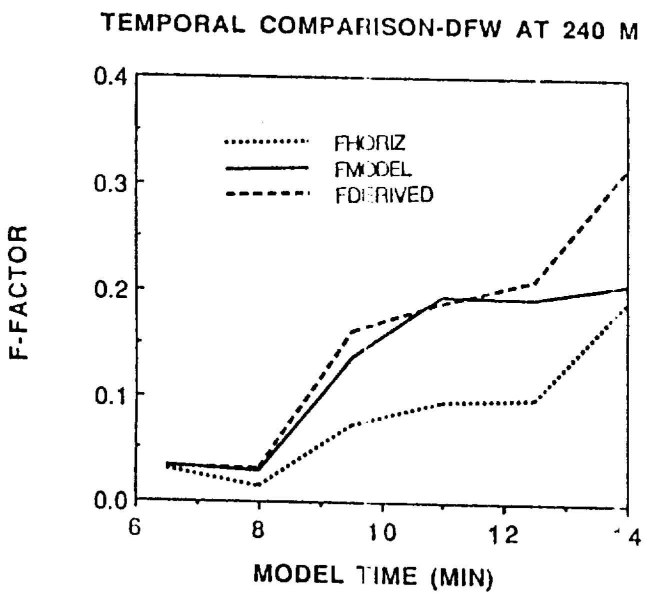

Fig. 5: Temporal plot of maximum F-factor for DFW case at an altitude of 240m.

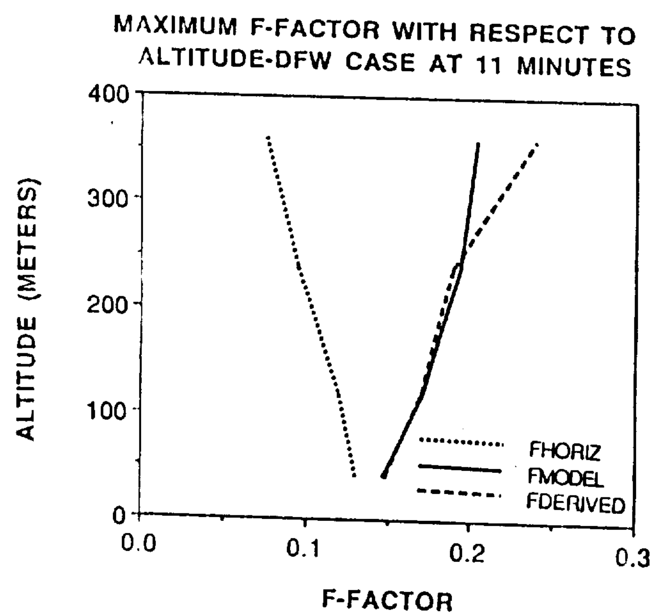

Fig 6: Plot of maximum F-factor versus altitude

N90-25041

FROM *WHERE THEY LOOK* TO *WHAT THEY THINK:* DETERMINING CONTROLLER COGNITIVE STRATEGIES FROM OCULOMETER SCANNING DATA

by

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My work this summer has been a real team effort, with initial impetus from Hugh Bergeron of FltMD/VORB and a lot of assistance from fellow ASEE Fellow Herb Armstrong. My task has been to determine what might be learned about the behavior and cognition of air traffic controllers from oculometer scanning data that had already been obtained for another purpose. There has been very little work done to develop models of air traffic controllers, much of what has been done having been done here at Langley. One aim of developing such models is to use them as the basis of decision-support or expert-systems tools to assist controllers in their tasks. Such tools are more likely to be effective if they incorporate the strategies that controllers actually use, rather than steering them in what might be felt to be unnatural directions.

One simple model of controller activity is that of Carlson and Rhodes (Figure 1), in which some of the basic steps of detecting and resolving aircraft conflicts are spelled out in their natural sequence. A more detailed model has been developed by Lohr (Figure 2). Harris and Bonadies have derived some nice quantitative results specifically from scanning data (Figure 3), and Roske-Hofstrand has made some initial efforts toward basing a model on such data (Figure 4). My own impressions as to controller strategy, based on viewing videotapes of the simulation sessions in which the oculometer data were obtained are summarized in an internal report.

In summary, I suggest the following initial hypotheses as to controller strategy:

(1) Controllers formulate and modify their plans in terms of *clusters* of aircraft, rather than *individual* aircraft.

(2) Controllers cluster aircraft based on *closeness in an abstract cognitive space*, rather than simple *separation in physical space.*

(3) Controllers segment their work temporally and dynamically into (*sometimes overlapping*) *episodes* and *subepisodes* defined in terms of the interactions of aircraft clusters.

(4) Controllers *prioritize* the subtasks within their episodes, with different strategies for different subtasks.

(5) Controllers change plans *consequent upon* changes in perceived clustering: *deliberate* cognitive acts are triggered by *presented* changes in conceptualization.

Hypotheses (1)-(3) are illustrated in the report As an example of hypothesis (4), a controller checks that separation of aircraft is adequate both before and after doing an artificial "side-task" consisting of reading extraneous information about the weather or the like, but he is less thorough in checking before scanning to accept a flashing hand–off aircraft, thereby suggesting that he considers the latter task more important and in need of more immediate attention when it arises. Hypothesis (5) has implications for tool development, in that it suggests limits on the extent to which automated aids should be allowed to deviate from actual controller practice.

In consequence, I suggest the following directions for further investigation:

(1) Determine the *geometry* of the controller's *cognitive space*, i.e., its *dimensions* and *topology* and the *metric* that is used to measure *"closeness"* (i.e., *relevant relatedness*) in that space, *as distinct from separation in physical space.* For example, are clusters determined solely by arrival sequence or do other factors also play a role?

(2) Determine the *metric* that is used to *prioritize* subtasks and the extent of *look-ahead* that is used for *planning* those subtasks. For example, does the controller check aircraft separation *in preparation* for doing the "side-task," or does he do the "side-task" *after having checked* separation?

(3) Determine the range of episode *types* and the extent of episode *nesting* and *overlap*. For example, to what extent does the controller maintain separation *of clusters*, and to what extent is he willing to *shuffle* (i.e., modify and mix) them?

(4) Determine the relative extent and cognitive significance of *intra*- and *inter*-cluster scanning. For example, how often and why does the controller scan *back* to aircraft that are *already* lined up on the localizer, while focusing primarily on a *later* cluster; how often and why does he scan to *outliers* beginning a *new* cluster, while focusing primarily on an *earlier* one?

I hope to help substantially with further investigations of these questions.

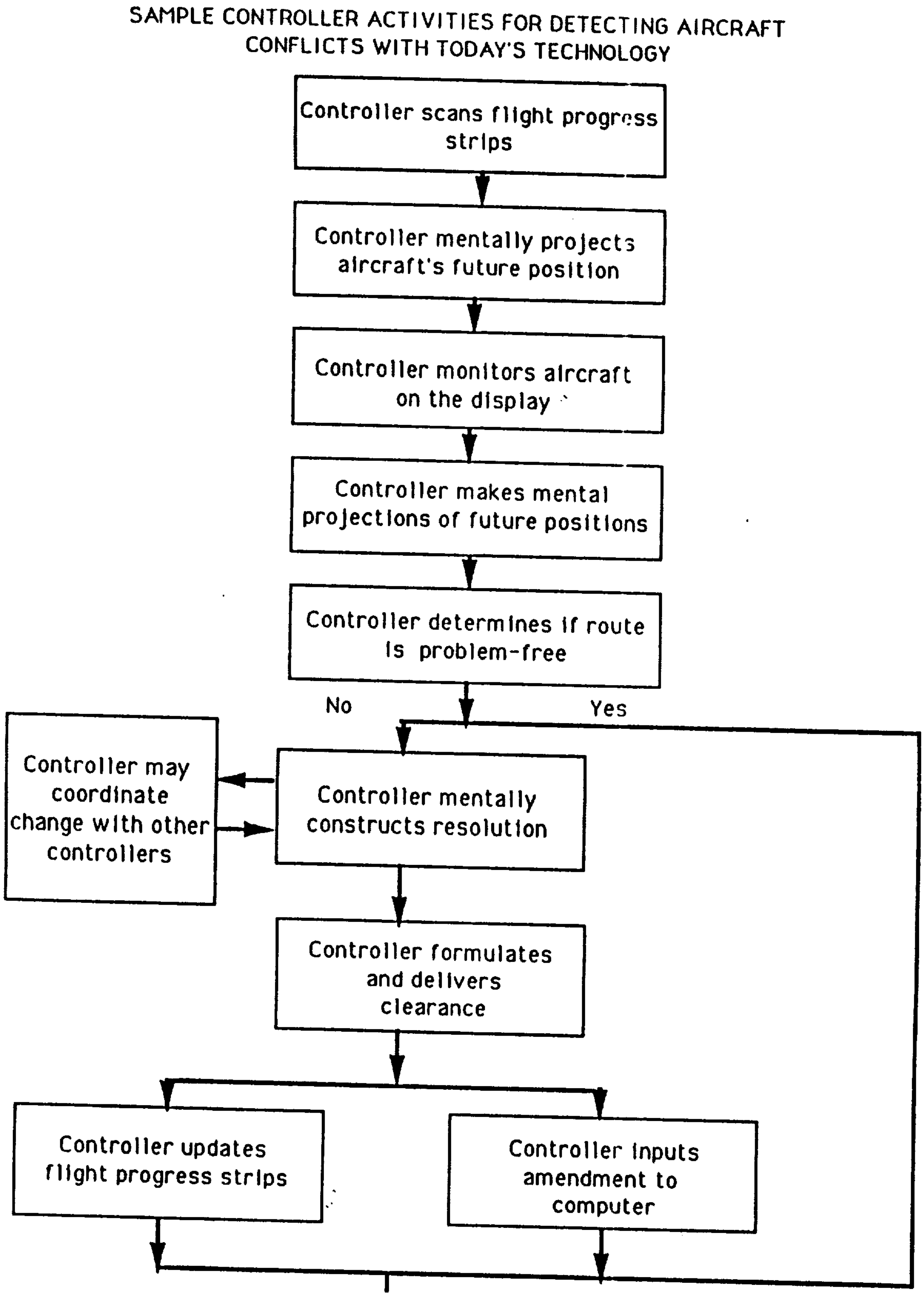

Figure 1: The Carlson/Rhoades model.

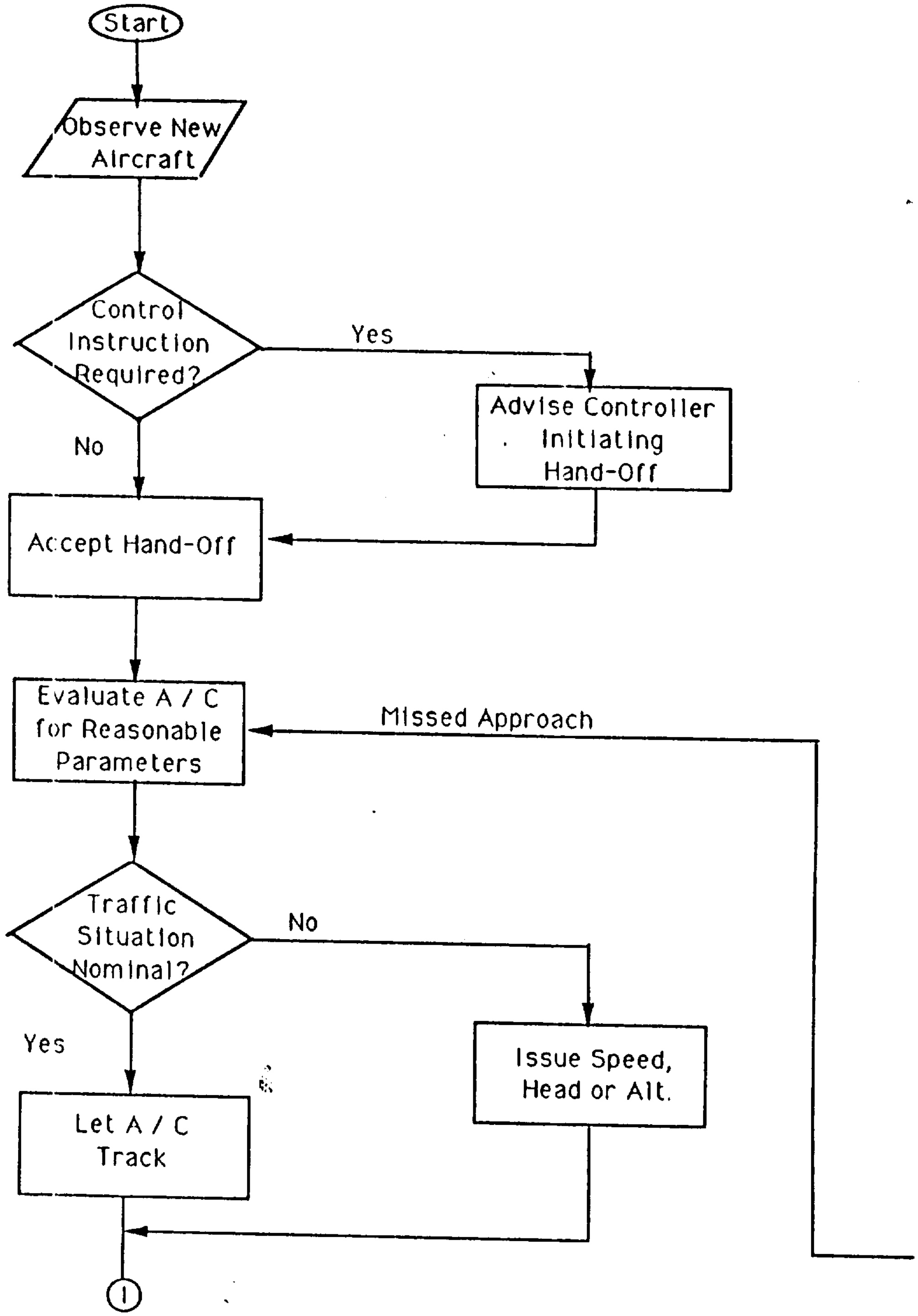

Figure 2: The Lohr model.

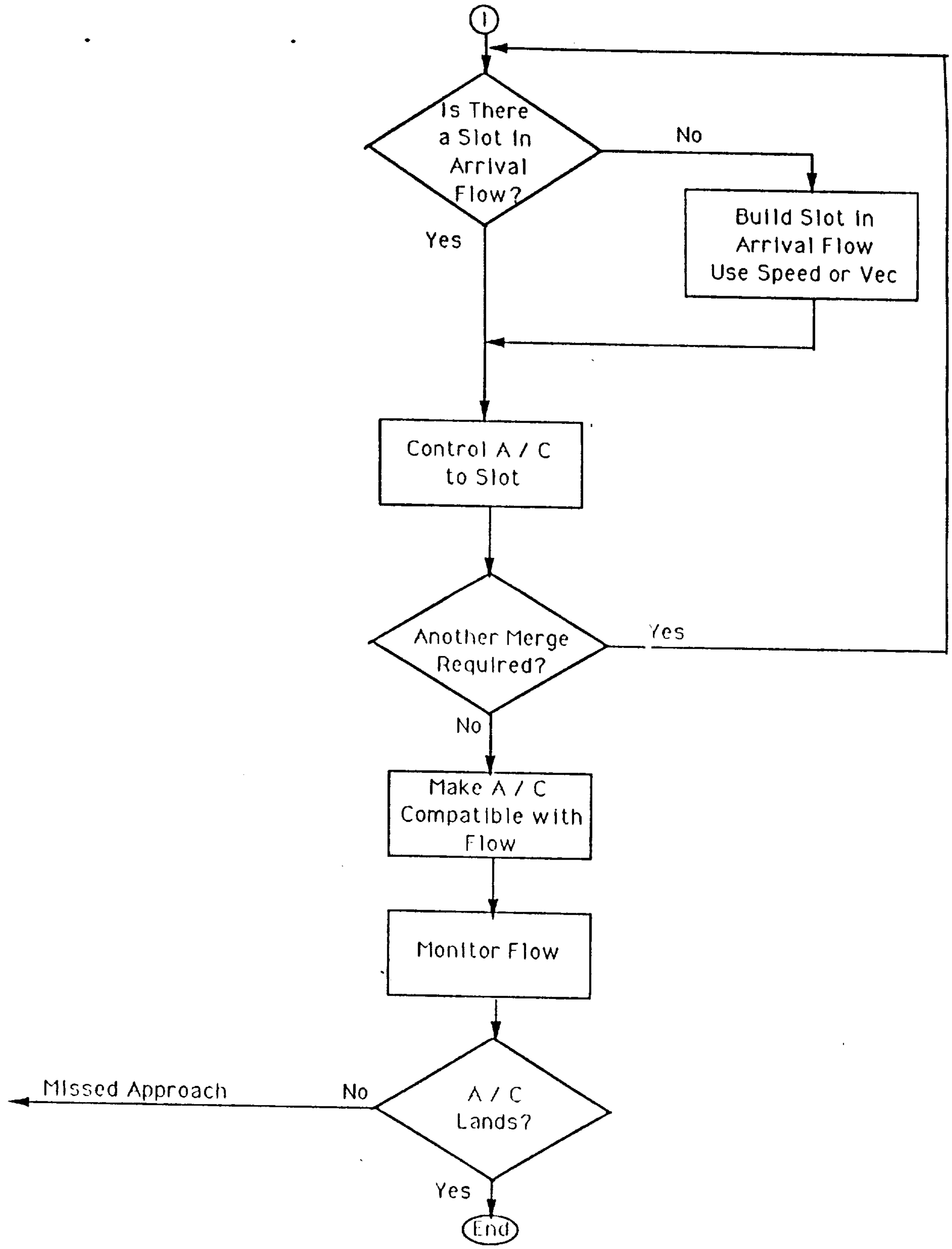

Figure 2 (cont.): The Lohr model.

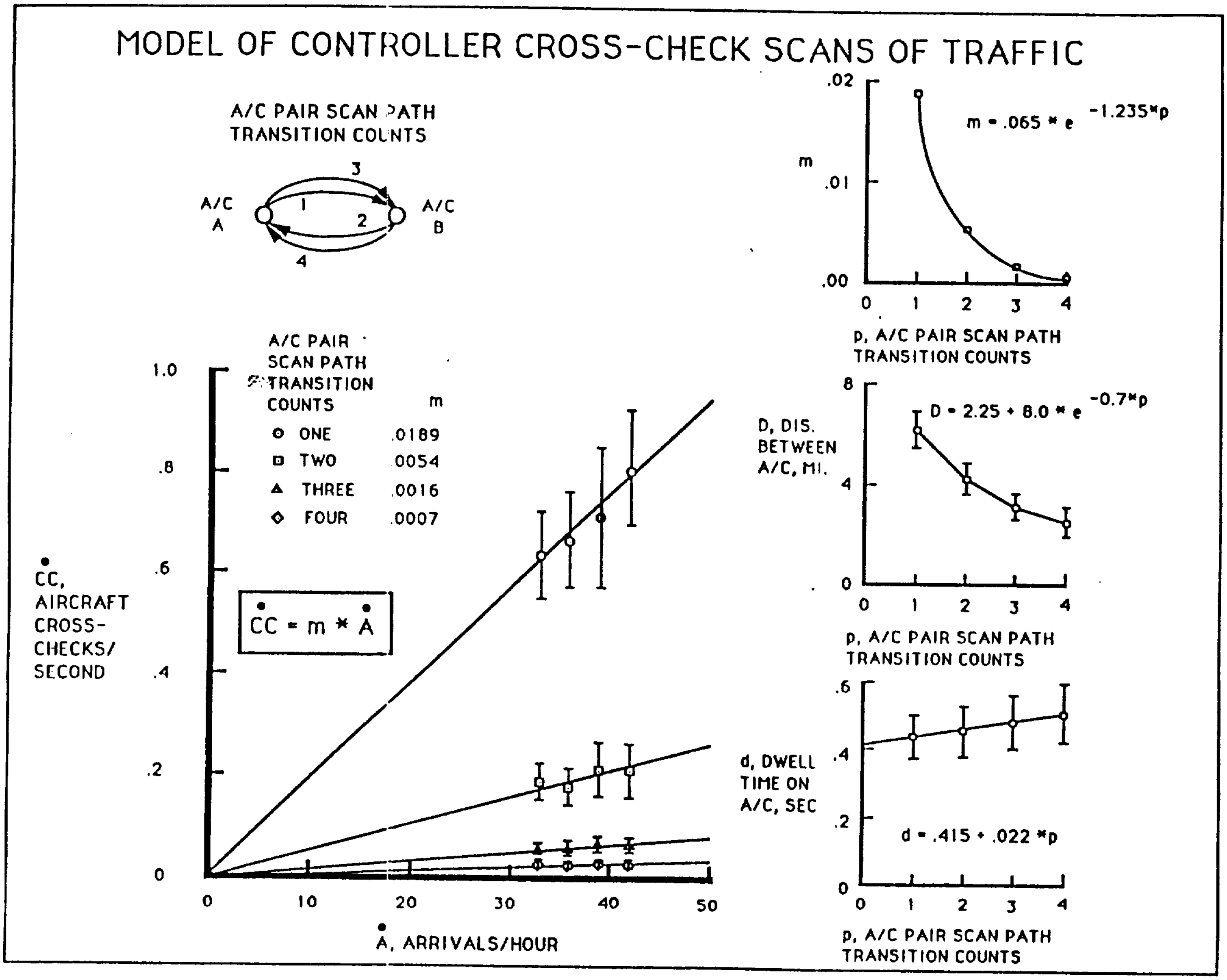

Figure 3: The Harris/Bonadies model.

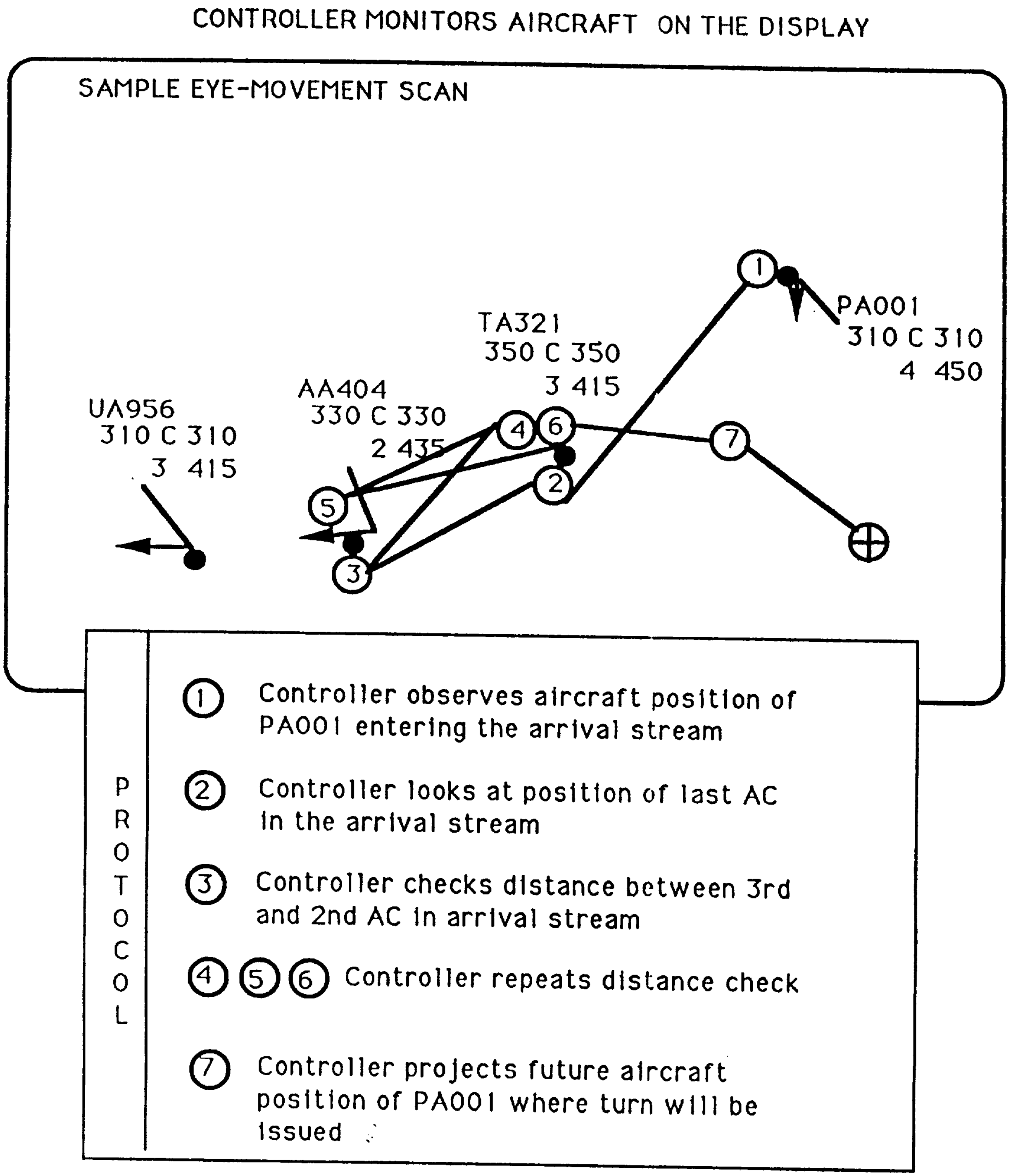

Figure 4: The Roske-Hofstrand model.

N90-25042

Structural Zooming Research and Development of an Interactive Computer Graphical Interface for Stress Analysis of Cracks

by

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Structural Zooming Research

Engineering problems sometimes involve the numerical solution of boundary value problems over domains containing geometric features with widely varying scales. Often, a detailed solution is required at one or more of these features. Small details (for example, cracks and flaws) in large structures may have profound effects upon global performance. Conversely, large-scale conditions may effect local performance (for example, tectonic stresses may cause rock failures near tunnels). Many man-hours and CPU-hours are currently spent in modeling such problems. With the structural zooming technique, it is now possible to design an integrated program which allows the analyst to interactively focus upon a small region of interest, to modify the local geometry, and then to obtain highly accurate responses in that region which reflect both the properties of the overall structure and the local detail.

The structural zooming technique is a general technique that can be applied to the numerical solution of a set of partial differential equations. It can be applied to problems in computational structural mechanics, fluid mechanics, geomechanics, fracture mechanics, and electromagnetics. Problems with widely varying geometric scales of interest exist in each of these areas. The use of the structural zooming technique could result in more accurate analyses at specific regions of interest at a lower cost.

I have interacted with the Computational Structural Mechanics Division in developing ideas in the area of structural zooming, and in learning about their work in global-local analysis and coupling of multidomain problems.

Development of an Interactive Computer Graphical Interface for Stress Analysis of Cracks

A boundary integral equation analysis program, called BOAST, for the stress analysis of cracks has recently been developed by P.C. Tan, J.C. Newman, and I.S. Raju at NASA Langley Research Center. This program can accurately analyze two-dimensional linear elastic fracture mechanics problems with far less computational effort than existing finite element codes. To make the program easy to use, it was decided that one of my tasks while at NASA

Langley Research Center this summer would be to write an interactive computer graphical interface to BOAST.

The graphical interface would have several requirements:

(1) It would be menu-driven, with mouse input, in such a way that anybody could use BOAST with minimal training.

(2) All aspects of input would be entered graphically - geometrical description of the problem, application of boundary conditions, and definition of material properties would all be entered graphically.

(3) The results of a BOAST analysis would be displayed pictorially but also the user would be able to probe interactively to get numerical values of displacement and stress at desired locations within the analysis domain.

(4) The entire procedure would be integrated into a single, easy to use, package.

(5) It would be written using calls to the graphics package called HOOPS, provided by Ithaca Software. Graphics would be in color.

The program as of July 24, 1989, is nearing completion. All of the preprocessing features are working satisfactorily, and have been debugged. The postprocessing features are under development, and rudimentary postprocessing should be available by the end of the summer. The program has been developed and runs on a VAX workstation, and must be ported to the SUN workstation in the Materials Branch of the Materials Division. This activity is currently underway.

In addition to the development of a useful tool, it is hoped that this activity will be useful to the materials division as an introduction to the development of computer graphical programs, an essential activity for the effective numerical analysis of complex materials.

Large Eddy Simulations and Direct Numerical Simulations of High Speed Turbulent Reacting Flows

by

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ABSTRACT

Despite the capabilities of present day supercomputers in allowing calculations with more than one million grid points, the range of length and time scales that can be resolved by Direct Numerical Simulations (*DNS*) of turbulent reacting flows is notoriously limited (Givi, 1989). In previous works in metereological studies and non-reacting turbulence simulations, a remedy for this problem has been sought so that with a given spatial resolution (determined by the computer), the phenomena occurring at scales smaller than those resolved, are treated separately. The large scale behavior is simulated directly, whereas the small scales phenomena are modeled by means of subgrid scale closures. This approach has been termed Large Eddy Simulations (*LES*), and in comparison with *DNS* it allows the simulations of flows with practical physical parameters. The disadvantage is that some modeling is required for the closure of the subgird scales. The tradeoff in the selection between *DNS* and *LES* is dependent on the type of flow being considered, and also on the range of physical parameteres that characterize the turbulent field. Regardless of the methodology, it is now widely accepted that in order to establish a better understanding of the detailed rudiments of reacting turbulence, and to apply the state-of-the-art direct methods to the problems of fundamental and practical interest, there is a crucial need to extend the capabilities of both *DNS* and *LES* for the analysis of such phenomena.

My efforts during the summer tenure at the ASEE program have been concentrated on the implementation and utilizations of *DNS* and *LES* in turbulent reacting flows. The flows considered are high speed and chemically reacting, compatible with those under previous and ongoing investigations at the computational methods branch at NASA Langley (Drummond, 1989). These efforts can be categorized into one primary task, and three secondary tasks. The primary task, which was the main goal of the activities initiated during the program, involves the development and implementations of *LES* in compressible reacting flows. The secondary tasks, which were motivated because of the mutual interests between myself and NASA scientists, are: (1) Initiation of research on direct numerical simulations of temporally developing reacting mixing layers, (2) Completion of a tutorial chapter on "spectral methods in turbulent combustion" for a textbook in numerical methods in combustion, and (3) Developments and offering of a short course on "Probability Density Function (*PDF*) methods in turbulent combustion" presented at the computational methods branch. Below, a summary of the accomplishments in each of these tasks are provided.

<u>Large Eddy Simulations of Reacting Turbulent Flows:</u> Our major goal in this effort is to initiate a program to extend the capabilities of *LES* for the treatment of chemically reacting flows. Despite the success of *LES* for the treatment of both incompressible and compressible nonreacting flows, they have never been employed for the calculations of reacting fields. In this program, we plan to employ a *PDF* model to construct a closure for the fluctuations of the scalar quantities within the subgrid in large eddy simulations. We have already modified the computer codes developed by Erlebacher *et al.* (1987) to

include a second order, single step reaction of the type $A + B \rightarrow Product$ in a homogeneous compressible reacting field with decaying turbulence. We are presently performing some *a priori* tests to examine the behavior of the scalar field at the subgrid, similar to those performed by Erlebacher *et al.* (1987) in non-reacting case. Our future efforts will involve the implementations of the *PDF* methods as a means of providing a subgrid closure.

Direct Numerical Simulations of High Speed Reacting Mixing Layers: In previous works, we have investigated the mechanism of flame extinction in parallel shear flows by means of direct numerical simulations (Givi *et al.*, 1987; Givi and Jou, 1989, Givi, 1989b). In these works, the compositional structure of the flame near quenching were the main subject under investigation, and we were able to address some of the interesting characteristics of the convoluted stretched flame in parallel shear flows. These flows, however were assumed incompressible, in which the effects of density variations were not taken into account. During the ASEE program, we initiated a study to examine the behavior of the flame extinction in supersonic reacting flow fields. For this purpose, we simplified the SPARK computer code (Drummond, 1989; Carpenter, 1989) to simulate a temporally developing mixing layer under the influence of an Arrhenius binary reaction. The primary stages of code modifications have been completed, and the results of initial simulations in capturing the developments of the vortical structures in non-reacting flows are encouraging. The utilizations of this code for the direct numerical simulations of reacting shear flows are the subject of our future investigations.

Completion of a Chapter on Spectral Methods in Turbulent Combustion: During my stay at NASA, I was also able to complete my contribution for a textbook on numerical combustion (Givi, 1990). This book is to be published by Hemisphere publishing company and includes contributions from six scientists on various numerical methods currently in use in the field of combustion. My contribution includes a tutorial discussion on spectral methods and a review of the state-of-the-art accomplishments based on these methods in turbulent combustion. I am grateful for the useful comments of NASA scientists on the preliminary version of the manuscript.

Development of a Short Course on *PDF* Methods in Turbulent Combustion: Due to interest of the research scientists at the computational methods branch at NASA Langley, I prepared and presented a short course on the fundamental of *PDF* methods and their implication and predictive capabilities in turbulent combustion. This course was offered as a lecture series within the branch.

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N90-25043

CONCEPTUAL DESIGN FOR AEROSPACE VEHICLES

By

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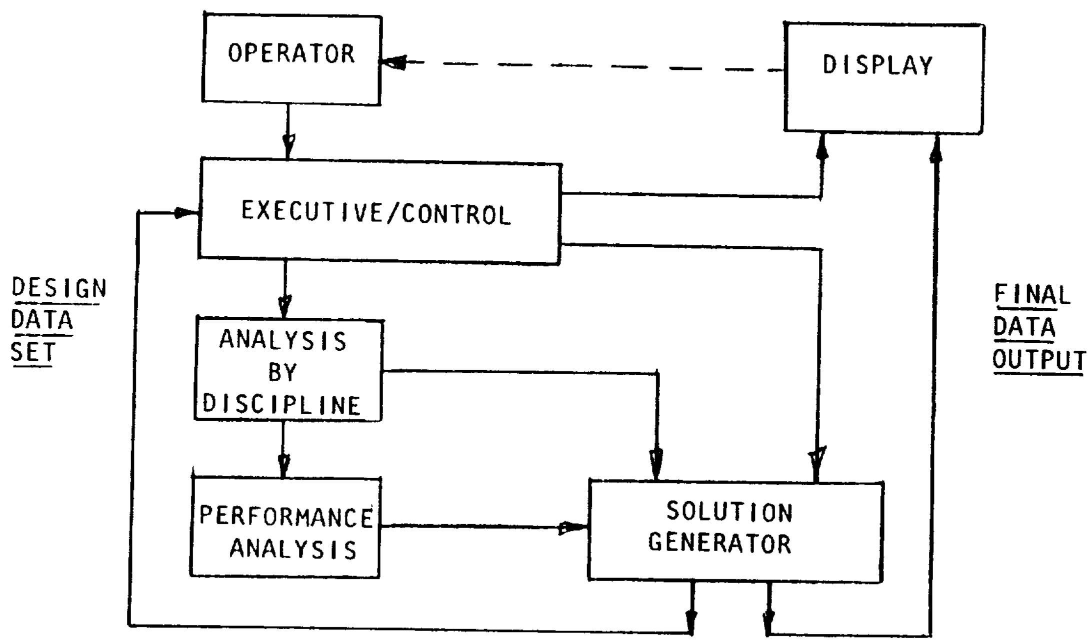
The designers of aircraft and more recently, aerospace vehicles have always struggled with the problems of evolving their designs to produce a machine which would perform its assigned task(s) in some optimum fashion. Almost invariably this involved dealing with more variables and constraints than could be handled in any computationally feasible way. Of necessity, therefore, the design approach was usually limited to consideration of only the most obviously important variables which were known from experience to have significant effects on the performance and mission effectiveness of the vehicle. The focus on design constraints was similarly limited so that the overall design process tended to be decoupled and result in solutions which could only be characterized as sub-optimal.

With the advent of the electronic digital computer, the possibilities for introducing more variables and constraints into the initial design process led to greater expectations for improvement in vehicle (system) efficiency. This was chiefly because of the capability thought to be implicit in computer based methods to allow a closer approach to true optimization, i.e., selection of the vehicle geometry to achieve the best possible result within imposed limits. Unquestionably, better aircraft have resulted from the implementation of computer-aided conceptual design programs. However, the creation of the large scale systems necessary to achieve optimum designs has, for many reasons, proven to be difficult. From a technical standpoint, significant problems arise in the development of satisfactory algorithms for processing of data from the various technical disciplines in a way that would be compatible with the complex optimization function. Also, the creation of effective optimization routines for multi-variable and constraint situations which could lead to consistent results has lagged.

The purpose of the assignment this summer was to evaluate the current capability for carrying out the conceptual design of aircraft on an interdisciplinary basis, to determine the need for extending this capability, and if necessary, to recommend means by which this could be carried out. Based on a review of available documentation and individual consultations it appears that there is extensive interest at Langley Research Center as well as in the aerospace community in providing a higher level of capability that meets the technical challenges indicated above. By implication, the current design capability is inadequate and it does not operate in a way that allows the various technical disciplines to participate and cooperatively interact in the design process. Moreover it does not appear that any significant concensus has yet emerged as to how this can be accomplished.

Based on the above assessment, it has been concluded that substantial effort should be devoted to developing a computer-based conceptual design system that would provide the capability needed for the near-term as well as a framework for development of more advanced methods to serve future needs. A preliminary plan has been outlined which would address the problems of coping with a matrix of variables and constraints in an efficient optimization scheme leading to a true conceptual design capability.

The block diagram shown below suggests a program architecture which could meet the basic objectives and allow the technical disciplines to contribute individually and collectively to the system development.



CONCEPTUAL DESIGN SYSTEM

The most critical elements involve the creation of the sections titled Analysis by Discipline and Solution Generator and are expected to require the greatest expenditure of time and resources. As implied by the flow diagram, progress to a final solution is iterative as required to carry out the complex optimization process. The final data output results from the completion of this process. Multi media presentation of results to the designer may be in the form of printed data, graphics display or continuously by film or tape. A capability for tradeoff analysis is contemplated by which the desirability of relaxing certain constraints or revising design concept features, etc., can be studied. This would allow the designer to more nearly approach important design goals not explicitly included in the conceptual design process due to difficulty of precise formulation or changing the requirements.

It has been recommended that the feasibility of such a system be explored at a modest level without excessive focus on technical detail and using only those variables and constraints which would contribute directly to better design optimization. Nevertheless, the product of this effort should represent a significant improvement over today's capability. It can also be expected to provide the prototype of the more sophisticated conceptual design system of the future.

N90-25044

A 3D VISUALIZATION SYSTEM FOR MOLECULAR STRUCTURES

by

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The properties of molecules derive in part from their structures. Because of the importance of understanding molecular structures various methodologies, ranging from first principles to empirical technique, have been developed for computing the structure of molecules. For large molecules such as polymer model compounds, the structural information is difficult to comprehend by examining tabulated data. Therefore, a molecular graphics display system, called MOLDS, was developed to help interpret the data.

MOLDS is a menu driven program developed to run on the LaRC SNS computer systems (CRAY-2 and CONVEX 210 super computers). This program can read a data file generated by the modeling programs or data can be entered using the keyboard. MOLDS has the following capabilities:

-Draws the 3D representation of a molecule using stick, ball and stick, or space filled model from Cartesian coordinates.

-Draws different perpective views of the molecule.

-Rotates the molecule on the X, Y, Z axis or about some arbitrary line in space.

-Zooms in on a small area of the molecule in order to obtain a better view of a specific region.

-Make hard copy representation of molecules on a graphics printer.

Inaddition, MOLDS can be easily updated and readily adapted to run on most computer systems.

N90-25045

STABILITY OF LASER OSCILLATOR SYSTEMS

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One of the goals of the Stanford-University-Nasa-Laser-In-space-Technology Experiment (SUNLITE) program is to develop ultrastable optical frequency oscillators that can lead to high resolution time standards and ultimately standard clocks. During the past year or two there has been remarkable progress towards achieving in the laboratory the fundamental quantum limits for the frequency stability of nonplanar ring oscillator (NPRO) lasers. This work reviews the quantum theoretical limits for laser oscillator stability, compares measured stability levels, and suggests some applications of such ultrastable laser oscillator systems.

If a collimated beam from a light source with a linecenter frequency f_0 is passed through an optical spectrometer (say a prism or high resolution grating), the different frequencies (wavelengths) in the beam would be dispersed about the linecenter f_0 into a band of width Δf. If the bandwidth (linewidth) is very small compared to the linecenter frequency, the linewidth provides a specification of the frequency stability, either in terms of Δf (in Hz) or the unitless ratio $\Delta f/f_0$. In work sponsored by SUNLITE, linewidths for **free running** solid state NPRO lasers with $f_0 = 2.83\text{X}10^{14}$ Hz ($\lambda = 1.06\ \mu$m) were measured at $\Delta f \sim 1$ kHz, which gives a linewidth ratio $\Delta f/f_0 \sim 4\text{X}10^{-12}$. It is useful to compare such measured linewidths with theoretical limits.

The theoretical limit for a free-running laser was first stated by Schawlow and Townes in their prize winning paper in 1958. The Schawlow-Townes linewidth limit can be put in terms of the frequency **noise** (or angular phase jitter) caused by out-of-phase spontaneous emission in the laser oscillator cavity. If S_f (in Hz^2/Hz) is the spectral distribution of frequency noise, the Schawlow-Townes effect causes a constant ("white" in noise parlance) noise distribution $S_{fST} = 2\Delta f_L{}^2 hf_0/P$, where Δf_L is the laser cavity linewidth, h is Plank's constant, and P is the laser output power. The theory states that Δf is related to S_f by $\Delta f = \pi S_f$, which gives a Schawlow-Townes limit of $\Delta f \sim 1$ Hz for the NPRO lasers referred to above. One of the original goals of the SUNLITE program was to achieve the Schawlow-Townes limit with a free-running laser, but that goal has been considerably lowered because of remarkably low linewidths achieved with frequency stabilized (servocontrolled) laser oscillator systems.

Recently linewidths well below the Schawlow-Townes limit (namely, at the millihertz level!) have been achieved at NIST (formerly the Bureau of Standards) using two HeNe gas lasers individually phase-locked to a reference cavity through a servo control loop. The NIST and other work has shown that the theoretical limit to the linewidth for a phase-locked system is related to the frequency noise of the servo feedback loop. In this case, $S_{fFB} = 2\Delta f_R{}^2 hf_0/P$, where Δf_R is the reference cavity linewidth. For one report, $S_{fFB} \sim 10^{-5}$ Hz^2/Hz was observed, and so linewidths $\Delta f \sim 6$ mHz and ratios $\Delta f/f_0 \sim 2\text{X}10^{-17}$ seem feasible. A linewidth ratio at this level would be completely unprecedented! It exceeds the ratio for cesium atomic standards by about 4 orders of magnitude.

For applications in spectroscopy, the linewidth Δf of the light source is very important, because Δf limits the resolution of spectrometers. Moreover, spectroscopy usually involves measurement times τ less than about 1 sec. However, for applications in metrology, measurements involving reference to absolute time and length standards, the stability of the linecenter frequency f_0 is of paramourt importance. For this case, the standard measure of oscillator quality is the Allan Variance, $\sigma^2(\tau)$, which gives the variation in the linecenter frequency $f_0(t)$ for measurement times τ that can be much greater than 1 sec. **Linewidth** provides a measure of the short term frequency stability, while **Allan Standard Deviation** ($\sigma(\tau) = \sqrt{\sigma^2(\tau)}$) defines the long term linecenter frequency stability. For many years, Cesium beam and Hydrogen maser clocks have been characterized by $\sigma(\tau)$, in particular, by the "flicker floor" that is usually evident in a graph of $\sigma(\tau)$ for $\tau > 1$ sec. In fact, the flicker floor is used to identify the long term stability of ultrastable oscillators. (In noise parlance, flicker means that $S_f = k/f$, where $k =$ const.) The following table lists $\sigma(\tau)$ flicker floor values for various high quality oscillators.

LONG TERM STABILITY OF VARIOUS OSCILLATORS

Oscillator	Stabilizer	Flicker Floor
HeNe	I_2	1×10^{-12}
CO_2	SF_6	5×10^{-13}
HeNe	CH_4	2×10^{-14}
Cs		1×10^{-14}
H		2×10^{-15}
NPRO	(no long term stabilizer)	4×10^{-13}

For applications that require longer term stability, such as for standard optical oscillators and clocks, a long term stabilizer (Iodine cell or trapped ion) will be included in the NPRO oscillator servo control system. The very narrow short term linewidth will be important for probing very narrow (long lifetime) states of any stabilizer atom. The potential for achieving a flicker floor of 10^{-17} to 10^{-18} seems not unrealistic.

Clock quality oscillators invariably pass into a measurement time domain called "frequency random walk." For Cs beam atomic clocks, random walk frequency changes start for τ values greater than several days. Some Cs clocks have been known to go several weeks or months without a frequency change. Nevertheless, the effects of frequency random walk on a time base can be virtually eliminated by a pairwise intercomparison of clock readings in an ensemble of three or more clocks. The intercomparison (cross correlation) data permit identification of the specific clocks that have suffered from a random walk frequency change. Thus identified frequency changes can be folded into the ensemble average, which permits a very accurate recording of the ensemble time base. At least three clocks are required to identify the specific member of the ensemble that changed frequency.

The actual detection of gravity waves would be the ultimate achievement of an ultrastable laser oscillator clock system. If NPRO laser oscillators can be long term stabilized and space qualified, they could be used on the new space station freedom for applications from time base management to intersatellite communications, and even to detect differences in the dc gravitational potential and eventually gravity waves.

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ASEE-NASALangley
Aug 1989

N90-25046

]Morphological Control

of

Inter-Penetrating Polymer Networks

by

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Synthetic organic polymer chemistry has been successful in producing composition of matter with thermal oxidative stability and progressively higher glass transition temperatures. In part, this has been done by increasing the steric-hindrance of moieties in the chain of a macromolecule. The resulting polymers are usually quite insoluble and also produce molten polymers of very high viscosities. Thus, these types of polymers are not easily processed into graphite fiber prepregs by melt or solution impregnation methods. Hence, a technological need exist to produce new knowledge of how to produce polymer-fiber composites from this class of polymers.

The concept of freeze drying amic-acid prepolymers with reactive thermoplastic was proposed as a research topic for the ASEE/NASA Summer Faculty Program of 1989 as a means of producing polymer-fiber composites. This process scheme has the thermodynamic attribute that the magnitude of phase separation do to differences of solubility of two organic constituents in solution will be greatly reduce by removing a solvent not by evaporation but by sublimation.

Progress to date on evaluating this polymer processing concept has produced the following results:

1) Discovery of a solvent which dissolves both an imide thermoset oligermer and a thermoplastic polyimide in the amic-acid form giving a clear solution,
2) Solvent has a melting point above room temperature,
3) Solvent has a high vapor pressure and can be sublimed a room temperature,
4) Hot polymer solution can be used in existing prepreging equipment,
5) Solvent can be sublimed from graphite fiber prepreg,
6) Subsequent B-staged prepreg produce excellent wetting of resin to graphite fibers relative to control system using traditional solution processing methods,
7) A 12-ply void-free composite has been produced.

Further evaluation of the concept is now in progress during the eight week of this program.

N90-25047

Characterization of a Ho:Tm:Cr:YAG Laser With a Cr:GSAG Laser as Pumping Source

by

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Rare earth lasers have been in existance since the first laser was developed. The primary lasing elements for the class of lasers in the infrared has been neodymium and chromium. However, the need for eye safe lasers in the mid infrared range has prompted an enomous amount of research to the use of other elements. Holmium has been investigated extensively as the source of infrared radiation for atmospheric research as well as medical research.

The holmium transistion $^5I_7$ to $^5I_8$ transition produces a photon of wavelength 2.1 μ which is in the desired region for use in the above applications. Most holmium research has been done at liquid nitrogen temperatures using flashlights and low power diodes laser as pumping sources.

In order to obtain lasing at room temperature with holmium, thulium has to serve as an intermediary. The pumping source of around 785 nm pumps thulium to the $^3H_4$ it subsequently decays to the $^3F_4$ of thulium and simultaneously excites a photon from the ground state of thulium by a cross relaxation process the two photons then populate the holmium $^5I_7$ state and lasing occurs in the transition to the $^5I_8$ state. The wavelength of the laser beam is 2.1 microns.

In was was desired to similate the pumping effect of a high power diode laser in order to produce a holmium 2.1 micron laser with relatively high power. At room temperatures previous researchers have been able to obtain power only in the milliwatt region. The Cr:GSAG laser was constructed and used because its wavelength is in the region of 785 nm and its power output is sufficiently high for the investigation. The Cr:GSAG laser has been profiled and found to be ideal for this investigation. Preliminary experiments on the holmium laser crystal, consisting of .36 atomic percent of holmium, .85 atomic percent of chromium and 5.9 atomic percent of thulium in a yttrium aluminum garnet has revealed promising information.

The results of the experiments performed indicates that high power can be obtained from a holmium laser in the 2.1 micron region. Powers in the neighborhood of 10 or more watts have been obtained from the holmium crystal. This represents several orders of magnitude of the power obtained by other researchers. Work is continuing on the complete characterization of the laser. A Q-switched experiment is planned.

N90-25048

DYNAMIC ANALYSIS OF FLEXIBLE MULTIBODY STRUCTURES

by

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A system composed of several interconnected elastic components that may experience large angular motion relative to each other during operation is referred to as a flexible multibody structure. Examples of such systems are space lattice structures which are composed of truss-like members connected by hinge joints which allow for the large relative rotation of components of the structure as the structure goes from it's packaged to it's deployed state; the controlled slewing of large flexible antenna-structure systems; and robotic manipulations.

Several formulations havbe been proposed for the determination of the dynamic response of controlled flexible multibody structures. In general, these formulations consist of superposing elastic deformations of the component body (generally specified in terms of assumed deformed shapes, i.e. mode shapes) onto the large rigid body motion of the component. It has been shown that this particular methodology for combining linear structural deformations with nonlinear kinematics can lead to erroneous response predictions when either the beam member is very flexible or the rotational speed is high[1]. In addition, previous formulations introduce constraint equations to define the interrelations among system components. This approach increases the number of equations that must be solved, and may result in constraint violation when numerical error accumulates during the integration process.

In order to overcome the above difficulties, a new approach has been suggested[2]. The approach is essentially a finite element formulation which takes advantage of the fact that many multibody structures are joint dominated. A three dimensional code which implements the new methodology (Large Angle Transient Dynamic Analysis - LATDYN) is currently being developed at NASA Langley.

The purpose of the research this summer is to critically evaluate the LATDYN program for: 1) clarity of documentation, 2) ease of use, 3) "user friendliness", 4) modelling generality, and 5) accuracy of results. This required gaining a working familiarity with the code and performing several case studies, detailed below.

Case Study I modeled a rigid two dimensional slider-crank with a linear spring driving mechanism. Favorable comparison with a rigid body 2-D mechanism code (DADS[3]) was obtained. The system was also intentionally overconstrained to verify that redundant constraints are properly treated by the code.

Case Study II entailed the inverse and forward dynamic analysis of a rigid and flexible space crane currently under investigation at several NASA centers.

Case Study III investigated the in-plane dynamic response of a flexible structure attached to the interior of a rigid ring that is rotating with constant angular velocity. Modelling difficulties were encountered when attempts were made to compare the LATDYN response to the stability results of a simplified SDOF rotating structure[4]. These difficulties were attributed to the simplified nature of the SDOF model. Reasonable LATDYN results were obtained for the continuous structure that was well removed from a stability boundary predicted by linear eigen-theory. An area of future research is the development of stability results, through Lyapunov and other analytical methods, for the general nonlinear dynamics of the continuous rotating structure and subsequent comparison to LATDYN predictions.

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N90-25049

DEVELOPMENT OF A FINITE ELEMENT BASED DELAMINATION ANALYSIS FOR LAMINATES SUBJECT TO EXTENSION, BENDING, AND TORSION

BY

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Delamination is a common failure mode of laminated composite materials. This type of failure frequently occurs at the free edges of laminates where singular interlaminar stresses are developed due to the difference in Poisson's ratios between adjacent plies. Typically the delaminations develop between 90 degree plies and adjacent angle plies.

Edge delamination has been studied by several investigators using a variety of techniques. Pipes, et. al. [1,2] first identified this problem when they predicted the interlaminar stresses in a laminate loaded in tension. O'Brien [3], Raju and Whitcomb [4] analyzed this problem using a quasi-three-dimensional finite element technique. They calculated the fracture toughness of the laminate in addition to calculating the interlaminar stress distributions. Armanios and Rehfield [5] employed an approximate elasticity solution to solve this problem.

Recently, Chan and Ochoa [6] applied the quasi-three-dimensional finite element model to the analysis of a laminate subject to bending, extension, and torsion. This problem is of particular significance relative to the structural integrity of composite helicopter rotors. Such a test would employ a servo-hydraulic tension/torsion machine to apply a twisting moment to O'Brien's EDT specimen [7].

The task undertaken this summer was to incorporate Chan and Ochoa's formulation into Raju's Q3DG program [8]. The resulting program will be capable of modeling extension, bending, and torsional mechanical loadings as well as thermal and hygroscopic loadings. The addition of the torsional and bending loading capability will provide the capability to perform a delamination analysis of a general unsymmetric laminate containing four cracks, each of a different length.

The solutions obtained using this program will be evaluated by comparing them with solutions from a full three-dimensional finite element solution. This comparison will facilitate the assesment of three-dimensional affects such as the warping constraint imposed by the load frame grips. It will also facilitate the evaluation of the external load representation employed in the Q3D formulation. The external loads are formulated in terms of the twisting curvatures and laminate theory. The resulting load vector in laminate theory is dominated by the twisting moment term. This term appears to violate the natural boundary condition at the free edge of the laminate. This is of particular interest, since these edges contain the cracks, and thus it is this area where stresses must be most accurately modeled. Finally, strain energy release rates computed from the three-dimensional results will be compared with those predicted using the quasi-three-dimensional formulation.

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THE IMPLEMENTATATION OF THE GRAPHICS OF PROGRAM EAGLE A NUMERICAL GRID GENERATION CODE ON NASA LANGLEY SNS COMPUTER SYSTEM

N90-25050

Summer Research Activities
of
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ABSTRACT:

Program EAGLE (Eglin Arbitrary Geometry Implicit Euler) --- Numerical Grid Generation System is a composite (multi-block), algebraic or elliptic grid generation system designed to discretize the domain in and/or around any arbitrarily shaped three dimensional region. This system combines a boundary conforming surface generation scheme and includes plotting routines designed to take full advantage of the DISSPLA Graphics Package (Version 9.0) developed by ISSCO which is supported by Cray machines; currently being supported by the Cray X-MP at NASA Ames Research Center.

Program EAGLE is written to compile and execute efficiently on any Cray machine with or without Solid State Disk (SSD) devices. Also, the code uses namelist inputs which are supported by all Cray machines using the FORTRAN Compiler CFT77. The namelist inputs makes it easier for the user to understand the inputs and operation of Program EAGLE. EAGLE's numerical grid generator is constructed in the following form:

Main Program (EGG) ----------Executive Routine
  Subroutine SURFAC ---------Surface generation Routine
  Subroutine GRID ---------- Grid Generation Routine
  Subroutine GRDPLOT ------- Grid Plotting Routines

Program EAGLE --- Numerical Grid Generation System was jointly developed by the Air Force Armament Laboratory's (AFATL) Aerodynamics Branch (FXA) (Eglin AFB, Florida) and Mississippi State University's (MSU) Dept. of Areospace Engineering. The developers documented Program EAGLE in three(3) volumes of documentation as follows:

Volume I ------------ Executive and Plotting Routines
Volume II ----------- Surface Generation Routine
Volume III ----------- Grid Generation Routine.

Jack Tseng, a doctoral student in the Dept. of Aerospace Engineering, University of Kansas and in conjunction with the Applied Aerodynamics Division/Propulsion Aerodynamics Branch of NASA-LaRC modified Program EAGLE's code to make operational:

Main Program (EGG)
  Subroutine SURFAC
  Subroutine GRID

on the NASA-LaRC SNS Computer (Cray 2S) System. During the modification of EAGLE by Jack Tseng, Subroutine GRDPLOT was deleted from the code by comments. Thus the code (subroutine Grid) could produce output data (coordinates) but could not implement its internal graphics subroutine. More specifically, the output data could only be displayed, graphically, in two environments:

* on NASA Ames Cray X-MP, using the Plot3D graphics package or

* on an Iris workstation at NASA LaRc, using the Plot3D graphics package (after conversion of data to acceptable form).

Jack Tseng departed NASA LaRC on June 20, 1989, leaving the EAGLE code as indicated. Johnny Houston then began working with the code. It then became the responsibility of this ASEE 89 Faculty Fellow:

A. To develop a conversion program for the output data of EAGLE's subroutine Grid to permit the data to be graphically displayed by Iris workstations at NASA LaRc, using Plot3D;

B1. To modify the code of program EAGLE to make operational subroutine Gridplot (using DI- 3000 Graphics Software Packages) on the NASA LaRC SNS Computer System

Or

B2. To determine how to implement, graphically, the output data of subroutine Grid on any NASA LaRC graphics terminal that has access to the SNS Computer System's DI-3000 Graphics Software Packages;

C. To develop a Quick Reference User Guide for the use of program EAGLE on the NASA LaRC SNS Computer System; and

D. To illustrate (inputs/visual graphics/hardcopy) one or more application program(s), using Program EAGLE on the NASA LaRC SNS Computer System, with emphasis on graphics illustrations.

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All of the items (A thru D) have been or will be accomplished by the end of the tenure of the Faculty Fellow's 1989 summer activities.

N90-25051

AN ANALYTIC STUDY OF NONSTEADY TWO-PHASE LAMINAR BOUNDARY LAYER AROUND AN AIRFOIL

by

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Recently, NASA, FAA, and other organizations have focused their attention upon the possible effects of rain on airfoil performance. Rhode[1] carried out early experiments and concluded that the rain impacting the aircraft increased the drag. Bergrum[2] made numerical calculation for the rain effects on airfoil. He claimed that thin airfoils of different sections having the same exposed frontal areas, will have approximately the same rates of water-drop impingement at high speeds, but the distribution of water-drop impingement will be different for each section. Luers and Haines[3] did analytic investigation and found that heavy rain induces severe aerodynamic penalties including both momentum penalty due to the impact of the rain and a drag and lift penalty due to rain roughening of the airfoil and fuselage. More recently, Hansman and Barsotti[4] performed experiments and declared that performance degradation of an airfoil in heavy rain is due to the effective roughening of the surface by the water layer. Hansman and Craig[5] did further experimental research at low Reynolds number. They concluded that the initial effect of rain is to cause premature boundary layer transition near the leading edge.

E. Dunham[6] made critical review for the potential influence of rain on airfoil performance. Dunham[7] et al. carried out experiments for the transport type airfoil and concluded that there is a reduction of maximum lift capability with increase in drag. There is a scarcity of published literature in analytic research of two-phase boundary layer around an airfoil. Although Henry[8] et al. presented a technical paper entitled "A Von Karman Integral Approach to a Two-Phase Boundary Layer", yet their main assumption that the existence of zero shear stress at the wall and on the interface is not physically realistic. Most recently Bilanin[9] attempted an analytic investigation.

He assumed that the ejacta layer thickness is constant in his preliminary report. This assumption is quite doubtful. The present author attempts to improve the analytic research. The following assumptions are made:

1. The fluid flow is non-steady, viscous, and incompressible.

2. The airfoil is represented by a two-dimensional flat plate.

3. There is only laminary boundary layer throughout the flow region.

Under the usual boundary layer approximation, there obtains, Under the usual boundary layer approximation, there obtains,

For the liquid:
Eq. of continuity

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = \alpha . \frac{V_i}{\delta} \sin\beta \qquad (1)$$

Eq. of momentum

$$\frac{\partial u}{\partial \tau} + u\frac{\partial u}{\partial x} + V\frac{\partial u}{\partial y} = \frac{1}{(R_e)_\ell}\frac{\partial^2 u}{\partial y^2} + \alpha\frac{V_i^2 \sin\beta\cos\beta}{\delta} \qquad (2)$$

Where $(R_e)_e = \dfrac{P_w V_c L}{\mu}$ = Reynolds number of the liquid water

$\alpha = \dfrac{W_L}{P_w}$ = ration of liquid water content to water density

$\delta = 5\sqrt{V_x/U_\infty}/L$

For the fog:

Equation of continuity

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad (3)$$

Equation of momentum

$$\frac{\partial u}{\partial \tau} + u\frac{\partial u}{\partial x} + V\frac{\partial u}{\partial y} = \frac{1}{(R_e)_\ell}\frac{\partial^2 u}{\partial y^2} \qquad (4)$$

The initial and boundary conditions are:

at $\tau = 0$ $\quad u = U(x,0) \quad V=0$

for the liquid phase, at $y=0$, $u=v=0$ (No slip condition)

at the interface $y=\delta$

$$(u)_\ell = (u)_f$$

$$(V)_\ell = (V)_f$$

$$\left(\mu\frac{\partial u}{\partial y}\right)_\ell = \left(\mu\frac{\partial u}{\partial y}\right)_f$$

as $y \longrightarrow \infty$, $\quad u = U(x,\tau)$

The above set of partial differential equations is non-linear in nature. An exact solution is not possible. The said set of partial differential equations is transformed into a set of finite difference equations. Using fortran language. An numerical solution is expected.

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FATIGUE ANALYSIS
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MINI-MAST SPACE TRUSS

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The functional, structural adequacy of a 20-meter-long generic space truss (Mini-Mast), subjected to fatigue loading, has been examined with respect to the failure modes which are most likely to occur during services. The space truss is made of thin-walled tubes having unidirectional, zero degree layups of Celanese G50 Graphite fibers/Narmco 5217 Epoxy composite. There is an additional one 5.5 mil, 90 degree E-Glass fiberglass wrap placed in the mid-wall as a strengthening mechanism in the tube circumferential direction. The delta shape truss beam contains eighteen bays, each of which consists of three parallel chords (longerons) with web members (diagonals and battens) in five planes connecting the chords. Such an assemblage of truss members forms a self-stabilizing structure.

In this study, the approach used to investigate the most probable failure mode of the truss under fatigue loading is to determine the stress level, including the types of stress, in the member first, then followed by failure mode analysis based on the stress level just determined. To begin, an approximate beam-parameter truss (BPT) model is analyzed first, followed by a detailed analysis of the truss using a finite element model (FEM) run with NASTRAN code. The BPT model assumes that the longerons are designed as tension or compression members to resist bending moment, the web diagonal members also as tension or compression members to resist shear force, and the remaining web batten members as lateral bracing for stability. The advantage of investigating the BPT model first enables one to assess the relative importance of each parameter, such as damping, natural and forcing frequencies, modes, and types and locations of loads, on the truss dynamical responses in terms of stresses and displacements. Additionally, the response results of the BPT model can also be used to compare FEM results and to check any major deviation of trend derived from the FEM. Once the dynamical stress level and types of stress are determined, the next step is to assess whether any truss member will perform adequately under the most likely failure mode caused by the stress level.

It is important that any structure of composite material under cyclic load needs to include fatigue strength as one of primary design criteria. Stress analysis of the truss shows that the predominant stresses in the truss members are the bending-action induced axial tension or compression stresses in longerons and the shear-force induced axial tension or compression stresses in diagonals. Torsionally induced shear stresses in longerons are found to be negligibly small.

In composite material, initial damage usually appears very early in the fatigue life. Its propagation may be arrested by the internal structure of the composite. The initial and the subsequent damages are evidenced by the continuing loss of stiffness. This could eventually lead to its structural failure such as excessive deformation. In critical application, fatigue failure criterion would be defined by the loss of a predetermined percent of the original stiffness rather than by a complete separation of a member. The loss of stiffness in a member could be caused by many different damage mechanisms, among them the most likely one to occur may be fiber buckling in extensional mode or in shear mode. It may also be possible that a truss member is not failed by fatigue, but by the buckling of compression member itself.

Data for fatigue properties, such as reduced stiffness versus cycles, for a unidirectional composite of zero degree layups thin-walled tube are very limited. Among the few available, the fatigue properties are largely derived from the flat specimen tests. At present, it has not been able to find fatigue test data for thin-walled tubes made of same graphite/epoxy composite and having the zero degree layups. Based on the stress analysis of the truss and the few available fatigue data for tubes of not exactly same composite, the fatigue life for the truss member is estimated. It is found that buckling failure in a compression member precedes fatigue failure of other truss members.

The purpose of the work this summer was to search available fatigue data of the tube material, to conduct approximate dynamical stress analysis of BPT model, to run detailed dynamical stress analysis of FEM model using NASTRAN code, and to predict fatigue life of truss member based on limited fatigue data.

Any space truss under dynamical load needs to include fatigue as one of the design criteria. To this end, there are few areas which need to be addressed. First, it is necessary to compile as complete as possible the fatigue data of the composite tube. Secondly, torsional buckling analysis for a unidirectional composite of zero degree layups thin-walled tube needs to be investigated if the torsionally induced shear stresses are not negligibly small. Third, it may be necessary to include geometric nonlinearity in the analysis unless the deformation can be intentionally kept small and within elastic range.

N90-25053

AFE DYNAMIC EFFECTS IN INHOMOGENEOUS PLASMAS

by

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The Microwave Reflectometer Ionization Sensor (**MRIS**) is an instrument on the Aeroassist Flight Experiment (**AFE**) satellite which will be deployed from the space shuttle.

The flow characteristic around a hypersonic bluff reentry vehicle will be measured by the **AFE**. The general mission of the **MRIS** is to measure the electron density within the range from 10^{12} to 10^{15} electrons per cm^3 and determine the distance to the location of each measured density from the surface of aerobrake. These measurements will be compared with prior aerothermodynamic computer code predictions. Since a knowledge of plasma dynamic effects is important for **MRIS** design and post-flight analysis, it is of interest to consider any possibility of plasma dynamic effects and especially in inhomogeneous plasmas.

Of particular interest is the need to study plasma dynamic effects that may emerge from a flow field stationary state that has been determined without regard to electric or magnetic fields. Such a flow field state will not in general be stationary with respect to electric and magnetic effects. One must, therefore, start any plasma stability analysis from a slightly different starting point, namely are that is modified from the given stationary state in such a way as to remove the most rapidly changing electric effects. Some of the plasma effects to be considered are as follows. A nonuniform system has a natural tendency to release this extra amount of free energy to approach a uniform state of thermodynamic equilibrium. Applying the magnetic field to the plasma places certain constraints on the motion of charged particles. Ordinary relaxation processes through collisions may not have an effective mechanism to approach equilibrium. The onset of an instability may be an alternative avenue relaxations would, thereby, result in the plasma. The effects of force fields upon the motion of charged particles also must to be considered in many cases. Such forces include gravity, electric field, and centrifugal force due to the curvature of the magnetic lines of force. These force fields or inhomogeneities acting together with the magnetic field then produce various drift motions of charged particles. Such particle drifts are essential to the understanding of various instabilities in inhomogeneous plasmas.

The neutral gas will not allow a common drift velocity of ions and electrons (**W_D**) to be attained in electric and magnetic fields. Therefore, there will be a residual electric field which attempts to drive a current and build up a space charge. This charge tends to redrive the electric field and produces a magnetic force (**JxB**). This force tends to increase drift velocity (**W_D**). The space charge must exist only at the boundaries and will be established on a time scale commensurate with the propagation of an electrostatic wave (i.e., the electron thermal velocity).

Any initial values involving **VxB** must first allow the space charge sheath to form so the $\mathbf{V_0 x B}$ term is removed from the problem and the space charge sheath will adjust itself as nearly as possible which tends to cause the residual **VxB** to be reduced throughout the flow field. This of course proceeds on the same fast time scale. At this point, the local electric field will not be totally zero since the velocity field, the temperature, and density fields are also arbitrary. Therefore, the medium has electric stresses that can only be relieved by readjustment of the velocity, temperature, and density fields. This readjustment must pass through a phase in which the Navier-Stokes equation is not strictly valid (or for which the effective transport coefficients cannot be known). The gas still moves under pressure and density gradients, but with higher ordered terms present.

Only after all the readjustments have occurred will there be an "equilibrium" state whose stability can be examined to see where and if electron density fluctuations occur. The purpose of the present research is to investigate some generic flow field density and velocity profiles to approximate this "equilibrium" state.

N90-25054

CHARACTERIZATION OF THE SURFACES OF PLATINUM/TIN OXIDE BASED CATALYSTS BY FOURIER TRANSFORM SPECTROSCOPY (FTIR)

by

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The Laser Atmospheric Wind Sounder (LAWS) Program has as one of its goals the development of a satellite based carbon dioxide laser for making wind velocity measurements. The specifications for this laser include the requirement that the laser operate at a repetition rate of 10 Hertz continuously for three years. This technology does not currently exist. Earth-based carbon dioxide lasers can operate for only a short time on a single charge of gas because the lasing action causes the CO_2 to break down to CO and O_2. Therefore, earth-based CO_2 lasers are generally operated in a "flow through" mode in which the spent gas is continually exhausted and fresh gas is continually added. For a satellite based system, however, a recirculator system is desired because it is not practical to send up extra tanks of CO_2. One of the projects in the Instrument Research Division of NASA, therefore, is to develop a catalyst which could enable a recirculating CO_2 laser to function continuously for three years.

In the development of a catalyst system there are many variables, such as the choice of the metal, the choice of the support, the weight ratio of the metal to the support, and the effect of the pretreatment conditions. Obviously, not all possible formulations can be tested for three years. In fact, it is unlikely that <u>any</u> formulation will be tested for a full three years. Therefore, an accurate model which is based on the reaction mechanism is needed.

The construction of a multistep reaction mechanism is similar to the construction of a jig saw puzzle. Different techniques each supply a piece of the puzzle and the researcher must put the pieces together. Transmission infrared spectroscopy has been shown to be very useful in supplying some of the information needed to elucidate reaction mechanisms. Some of the advantages of the infrared method are:

a) surfaces may be probed in-situ; i.e., while the gas is being passed over the surface and while the surface is being heated
b) chemical (not just atomic) information is supplied.

The main disadvantages of this approach is that infrared absorption spectroscopy is not as sensitive as the ultra high vacuum surface analytical techniques such as Auger or ESCA. Another disadvantage is that the exact assignment of the bands observed by infrared spectroscopy may be difficult.

This purpose of this work was to see what kind of information might be obtained about the NASA catalyst using infrared absorption spectroscopy. Approximately 200 infrared spectra of the prototype Pt/tin oxide catalyst and its precursor components under a variety of different conditions. The most significant observations are summarized below:

1. A number of impurity bands were observed in the catalyst starting materials. These may or may not have an effect on the catalyst activity but efforts are underway to further identify and track these species.
2. Significant amounts of water and hydroxyl groups were observed in the NASA catalyst under almost all of the conditions tested. This is particularly important to note because both of these species are included in the current version of the proposed mechanism.
3. CO chemisorbed onto platinum can be observed in-situ on the prototype NASA catalyst. The CO was observed to absorb in an an "atop" configuration and the saturation coverage was logarithmic versus the gas phase CO pressure. Also, the adsorption appeared to be an activated process since more CO adsorbed at higher temperatures. The absorbed CO could be pumped off at room temperature although sometimes this took a period of hours.
4. NASA researchers were particularly interested to see if carbonate or bicarbonate species could be detected. This is because these species are believed to be involved in the catalyst degradation mechanism. Although no direct observation of carbonate/bicarbonate was made, it was observed that when tin oxide samples which had been exposed to CO and CO_2 were heated in the presence of H_2, CO was predominantly released along with some CO_2 and water vapor.

In summary, this work has broken new ground by demonstrating the usefulness of the infrared approach for the specific catalyst of interest in the LAWS project. Currently several other NASA projects involving infrared spectroscopy have been initiated and these will be able to build on the results obtained by this project.

N90-25055

Minimizing Distortion and Internal Forces in Truss Structures by Simulated Annealing

by
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Inacuracies in the length of members and the diameters of joints of large truss reflector backup structures may produce unacceptable levels of surface distortion and member forces. However, if the member lengths and joint diameters can be measured accurately it is possible to configure the members and joints so that root-mean-square (rms) surface error and/or rms member forces is minimized.

Following Greene and Haftka (1989) we assume that the force vector $\mathbf{f}$ is linearly proportional to the member length errors $\mathbf{e}_M$ of dimension NMEMB (the number of members) and joint errors $\mathbf{e}_J$ of dimension NJOINT (the number of joints), and that the best-fit displacement vector $\mathbf{d}$ is a linear function of $\mathbf{f}$. Let NNODES denote the number of positions on the surface of the truss where error influences are measured. Let $\mathbf{U}_M$ (NNODES x NMEMB) and $\mathbf{U}_J$ (NNODES x NJOINT) denote the matrices of influence coefficients. Then $\mathbf{d} = \mathbf{U}_M\mathbf{e}_M + \mathbf{U}_J\mathbf{e}_J$. Concatenating $\mathbf{e}_M$ with $\mathbf{e}_J$ and $\mathbf{U}_M$ with $\mathbf{U}_J$ yields $\mathbf{d} = \mathbf{Ue}$.

Let $\mathbf{D}$ be a positive semidefinite weighting matrix (in our computational experiments we let D be an identity matrix) denoting the relative importance of the surface nodes where distortion is measured. The mean-squared displacement error can then be written as

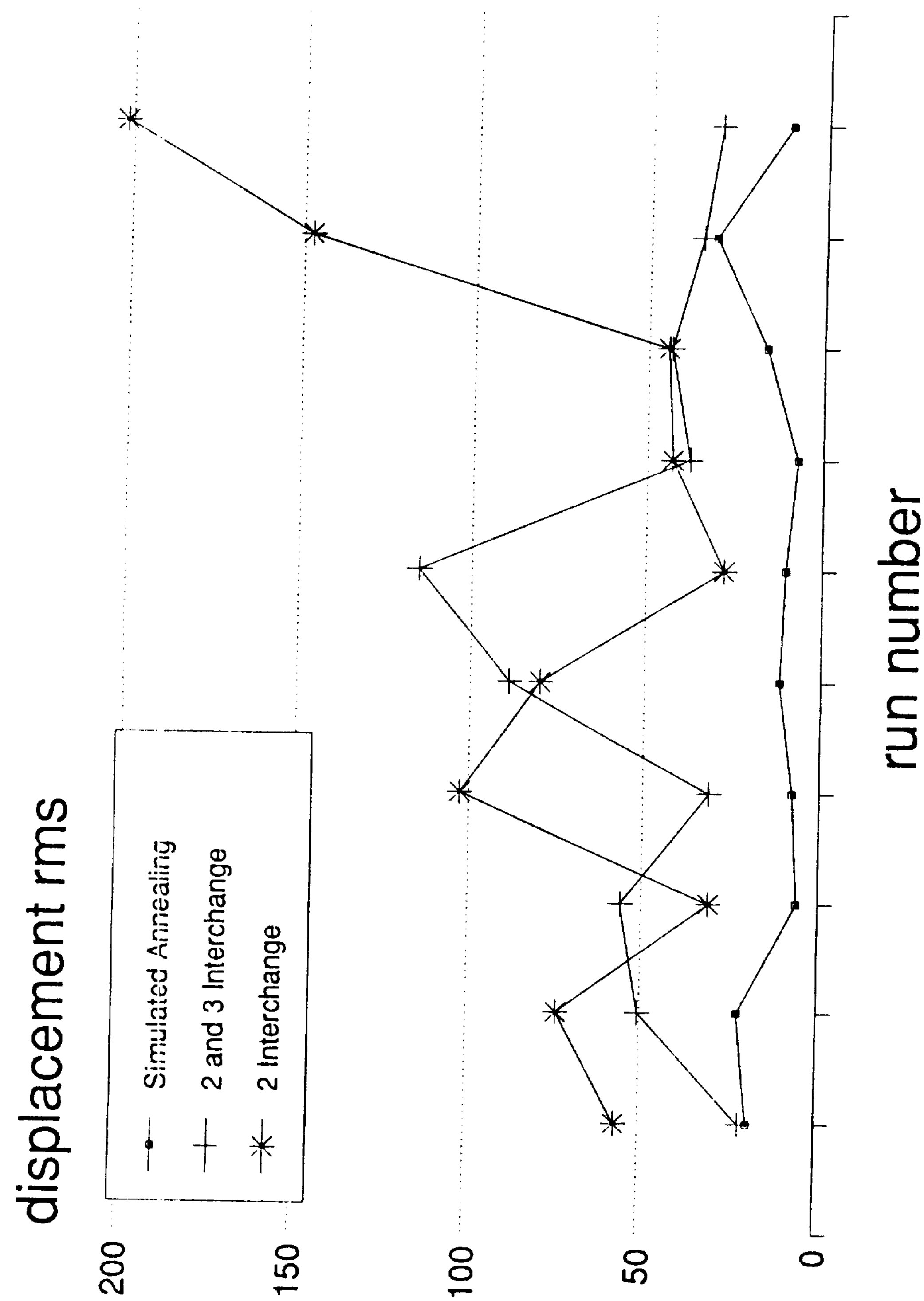
$$\mathbf{d}^2_{rms} = \mathbf{e}^T\mathbf{U}^T\mathbf{DUe} = \mathbf{e}^T\mathbf{He}.$$

A similar construction can be derived for mean-squared member force error, $\mathbf{s}^2_{rms}$ (see Greene and Haftka (1989)). Minimizing $\mathbf{d}^2_{rms}$ (or $\mathbf{s}^2_{rms}$) can be formulated as a combinatorial optimization problem. That is, finding the permutation of the components of $\mathbf{e}_M$ and $\mathbf{e}_J$ that minimizes $\mathbf{d}^2_{rms}$ (or $\mathbf{s}^2_{rms}$) is equivalent to minimizing $\mathbf{d}^2_{rms}$ (or $\mathbf{s}^2_{rms}$) directly. Unfortunately there (NMEMB!)*(NJOINT!) possiblities to consider. Hence, an enumeration scheme is out of the question. However there are many combinatorial optimization problems with exponentially large solution spaces that can be solved by algorithms whose time complexity is bounded by a polynomial function of the problem parameters.

To classify this problem we compare it to a similar combinatorial optimization problem. In particular, when only the member length errors are considered, minimizing $\mathbf{d}^2_{rms}$ is equivalent to the quadratic assignment problem. The quadratic assignment problem is a well known NP-complete problem in the operations research literature. Hence, minimizing $\mathbf{d}^2_{rms}$ is also an NP-complete problem. Moreover, if a problem is NP-complete it is highly unlikely that an algorithm exists which can determine an optimal solution in polynomial time and, therefore, (polynomial time) heuristic solution techniques should be employed. Greene and Haftka (1989) tested two heuristics of the same type. They use pairwise interchange and triple interchange of the members and joints to reduce $\mathbf{d}^2_{rms}$. The focus of our research has been the development of a simulated annealing algorithm to reduce $\mathbf{d}^2_{rms}$. The plausibilty of this technique has been its recent success on a variety of NP-complete combinatorial optimization problems including the quadratic assignment problem.

Simulated annealing was first proposed and used in statistical mechanics in the early 1950's (see Metropolis et al. (1953)). However, not until Cerny (1982) was simulated annealing used to solve a NP-complete combinatorial optimization problem--the traveling salesman problem. A physical analogy for simulated annealing is the way liquids freeze and crystallize. As the liquid is cooled slowly the atoms line themselves up and form a pure crystal that is completed ordered. The pure crystal is the minimum energy for this system. The basic procedure consists of a loop over a random displacement generator that produces changes in the objective function value. If this change is negative the displacement is accepted and the objective function is reduced. If this change is non-negative the displacement is accepted probabalistically. That is, uphill climbs are accepted with some positive probability which decreases as the temperature decreases. Simulated annealing must be used with some care. In addition to determining how to generate random displacements, one must also pick a starting temperature T, a cooling rate TFACTR, and a stopping temperature T_f. If these parameters are not chosen appropriately simulated annealing may produce poor results and/or run for an exponential amount of time.

Figure 1 is a graph of the objective function value ($\mathbf{d}^2_{rms}$) for ten random starting arrangements of the components of **e** for three different heuristics. All computational experiments were done on a MicroVAX. The two interchange heuristic is very fast (an average cpu time of 1.1 minutes per run) but produces widely varying results. The two and three interchange heuristic provides less variability in the final objective function values but runs much more slowly (an average cpu time of 68 minutes per run). Simulated annealing produced the best objective function values for every starting configuration and was faster than the two and three interchange heuristic (an average cpu time of 42 minutes per run).


displacement rms
200
150
100
50
0
Simulated Annealing
2 and 3 Interchange
2 Interchange
run number

```
C
C*********** MAIN PROGRAM *************
C
      INTEGER NMEMB,NJOINT,NROW
      PARAMETER (NMEMB=102,NJOINT=31,NROW=NMEMB+NJOINT,NW=19)
      INTEGER IORDER(NROW),NDIM
      DOUBLE PRECISION H,M,ZQAP,T,TFACTR,ZCHK,PSUM,TSUM
      DIMENSION H(NROW,NROW),M(NROW),PSUM(NROW)
     $,DFDE(NW,NROW),DWDE(NW,NROW)
      CHARACTER*35 MSG
      REAL TIM(20)
      OPEN(UNIT=5,FILE='QAP2.IN',STATUS='OLD')
      OPEN (UNIT=6,FILE='QAPJNT.OUT',STATUS='UNKNOWN')
      OPEN (UNIT=7,FILE='MTEN.DAT',STATUS='OLD')
C
C**********************************************************************
C
C     Read in input data. Influence matrix H=UDU, member
C     length errors M, joint diameter errors M, displacement
C     derivatives DWDE, force derivatives DFDE, and initial
C     objective function value ZQAP.  The input file QAP.IN
C     is created by GENQAP.FOR.
C
C**********************************************************************
C
      DO 21 I=1,NROW
         READ(5,901)  (H(I,J),J=1,NROW)
21    CONTINUE
      DO 20 I=1,NMEMB
         READ(5,901)  (DFDE(I,J),J=1,NROW)
20    CONTINUE
      DO 22 I=1,NW
         READ(5,901)  (DWDE(I,J),J=1,NROW)
22    CONTINUE
      DO 2400 J=1,3
         DO 17 I=1,NROW
            IORDER(I)=I
17       CONTINUE
         READ(7,901)  (M(I),I=1,NROW)
C
         READ(7,902) ZQAP
C
         READ(7,900) MSG
C
C**********************************************************************
C
C     Use the largest eigenvalue of H to provide a bound on
C     the difference between the largest and smallest objective
C     function values.  For this H, 9.779335 is the appropriate
C     eigenvalue.
C
C**********************************************************************
C
         T=0.0
         DO 79 I=1,NROW
            T=T+M(I)*M(I)
79       CONTINUE
         T=T*10*9.779335
         TFACTR=0.96
900      FORMAT(1X,A)
901      FORMAT(1X,5E16.12)
902      FORMAT(1X,E16.12)
C
C
C********* End initialization and echo results
C
C
         WRITE(6,*) 'ITERATION ',J
         WRITE(6,*) 'Start Temperature= ',T,TFACTR
         WRITE(6,*) 'Starting ZQAP=',ZQAP
         CALL SECOND(TIM(J))
C
         CALL ANNEAL(M,H,IORDER,NMEMB,NROW,TFACTR,ZQAP,T)
C
         CALL SECOND(TIM(10+J))
         WRITE(6,*) 'Execution time ',TIM(10+J)-TIM(J)
         WRITE(6,*) 'Final annealing objective value ',ZQAP
C
         CALL OBJCHK(M,IORDER,H,PSUM,NROW,ZCHK)
C
```

```
                WRITE(6,*) 'Obj. value check ',ZCHK
                WRITE(6,*) (IORDER(I),I=1,NROW)
                WRITE(6,*) 'Final temperature ',T
2400    CONTINUE
        STOP
        END
C
C
C
        SUBROUTINE  ANNEAL(M,H,IORDER,NMEMB,NROW,TFACTR,ZQAP,T)
C
C
C**********************************************************************
C
C       This algorithm finds the permutation of the components
C       of the vector M that minimizes the product MHM for any
C       real symmetric positive definite matrix H.  There are
C       NROW (NMEMB+NJOINT) components of M and H is NROW by NROW.
C       The array IORDER(I) specifies the permutation of M.  On
C       input, the elements of IORDER may be set to any permutation
C       of the numbers 1 to NROW.  This routine will return the best
C       alternative permutation it can find.
C
C       T is the current temparture.
C       NOVER is the max number of swaps tried at any temperature T.
C       NLIMIT is the max number of successful swaps before continuing.
C       TFACTR is the annealing schedule, Tnew=Told*TFACTR.
C       ZQAP denotes the objective function value at any time T.
C       DE denotes the change in ZQAP when two components are swapped.
C
C**********************************************************************
C
C
        INTEGER NMEMB,IORDER(NROW),N(2),NOVER,NLIMIT,IDUM
        DOUBLE PRECISION M,H,TFACTR,ZQAP,DE,T,TSUM
        DIMENSION M(NROW),H(NROW,NROW)
        LOGICAL ANS
        NOVER=10*NROW
        NLIMIT=1*NROW
        IDUM=-1
        NSUCC=1
        NCNT=0
        NJOINT=NROW-NMEMB
C
C******* Loop until temperature is too small or NSUCC=0.
C
        DO WHILE (NCNT.LT.600.AND.NSUCC.GT.0)
                NCNT=NCNT+1
                NSUCC=0
C
C******* Local search of neighbors of current assignment
C
                DO 12 K=1,NOVER
C
C******* N(1) and N(2) are the two components of M to be swapped.
C
                IF (RAN3(IDUM).GT.0.76692) THEN
                        N(2)=1+INT(NJOINT*RAN3(IDUM))
                        N(1)=1+INT((NJOINT-1)*RAN3(IDUM))
                        IF (N(2).EQ.N(1).AND.N(2).EQ.NJOINT) THEN
                                N(1)=N(1)-1
                        ELSE IF (N(2).EQ.N(1)) THEN
                                N(2)=N(2)+1
                        ENDIF
                ELSE
                        N(2)=1+INT(NMEMB*RAN3(IDUM))
                        N(1)=1+INT((NMEMB-1)*RAN3(IDUM))
                        IF (N(2).EQ.N(1).AND.N(2).EQ.NMEMB) THEN
                                N(1)=N(1)-1
                        ELSE IF (N(2).EQ.N(1)) THEN
                                N(2)=N(2)+1
                        ENDIF
                ENDIF
                        CALL SWPCST(M,H,IORDER,NMEMB,NROW,N,DE)
                        CALL METROP(DE,T,ANS)
                                IF (ANS) THEN
                                        NSUCC=NSUCC+1
                                        ZQAP=ZQAP+DE
                                        CALL SWAP(IORDER,NROW,N)
                                ENDIF
```

```
                      IF (NSUCC.GE.NLIMIT) GOTO 2
12              CONTINUE
2               T=T*TFACTR
        END DO
        WRITE(6,*) 'NCNT',NCNT
        RETURN
        END
C
        SUBROUTINE SWPCST(M,H,IORDER,NMEMB,NROW,N,DE)
C
C
C***********************************************************************
C
C       This subroutine returns the value of the change in the
C       objective function for a proposed swap of two positions
C       in the current permutation assignment IORDER.  On output
C       DE is the value of the change (+ or -).
C
C***********************************************************************
C
C
        INTEGER NMEMB,IORDER(NROW),N(2),I1,J1,K,K1,ITMP
        DOUBLE PRECISION M,H,LTSUM,RTSUM,DIFF,DE,SQDIFF
        DIMENSION M(NROW),H(NROW,NROW)
C
C********* initialization
C
        DE=0.0
        RTSUM=0.0
        LTSUM=0.0
        I1=IORDER(N(1))
        J1=IORDER(N(2))
C
C********* put indices of M in ascending order, I1 < J1
C
        IF (I1.GT.J1) THEN
                ITMP=I1
                NTMP=N(1)
                I1=J1
                N(1)=N(2)
                J1=ITMP
                N(2)=NTMP
        ENDIF
C
C***********************************************************************
C
C       This section of the code computes the change in the objective
C       function value, DE, in linear time.  To do this, a pointer array
C       IORDER is used to keep track of the switches in the array M.
C       Since only two components of M are switched at any one time only
C       two rows and two columns of the matrix H need be considered to
C       compute DE.
C
C***********************************************************************
C
        DO 12 K=1,NROW
                K1=IORDER(K)
                IF (K1.EQ.I1.OR.K1.EQ.J1) GOTO 12
                        LTSUM=LTSUM+H(K,N(2))*M(K1)
                        RTSUM=RTSUM+H(K,N(1))*M(K1)
12      CONTINUE
        DIFF=M(J1)-M(I1)
        SQDIFF=(M(J1)**2)-(M(I1)**2)
        DE=(SQDIFF*H(N(1),N(1)))+(2*DIFF*RTSUM)
     $    -(SQDIFF*H(N(2),N(2)))-(2*DIFF*LTSUM)
        RETURN
        END
C
C
        SUBROUTINE SWAP(IORDER,NROW,N)
C
C
C***********************************************************************
C
C       This routine performs the actual swap in IORDER between
C       positions N(1) and N(2).  On output IORDER is modified to
C       reflect this exchange.
C
C***********************************************************************
C
```

```
C
        INTEGER NROW,IORDER(NROW),N(2),ITMP
C
C
        ITMP=IORDER(N(1))
        IORDER(N(1))=IORDER(N(2))
        IORDER(N(2))=ITMP
        RETURN
        END
C
C
        SUBROUTINE METROP(DE,T,ANS)
C
C
C*****************************************************************
C
C       Metropolis algorithm.  ANS is a logical variable which
C       issues a verdict on whether to accept a reconfiguration
C       which leads to a change DE in the objective function E.
C       If DE<0, ANS = .TRUE., while if DE > 0, ANS is only
C       .TRUE. with probability exp(-DE/T), where T is a
C       temperature determined by the annealing schedule.
C
C*****************************************************************
C
C
        DOUBLE PRECISION DE,T
        PARAMETER(JDUM=1)
        LOGICAL ANS
        ANS=(DE.LT.0.0).OR.(RAN3(JDUM).LT.EXP(-DE/T))
        RETURN
        END
CC
C
        FUNCTION RAN3(IDUM)
C
C
C*******************************************************************
C
C       Returns a uniform random deviate between 0.0 and 1.0.
C       Set IDUM to any negative value to initialize or
C       reintialize the sequence. (see Numerical Recipes p. 199)
C
C*******************************************************************
C
C
        PARAMETER (MBIG=1000000000,MSEED=161803398,MZ=0,FAC=1./MBIG)
        DIMENSION MA(55)
        DATA IFF /0/
C
C************Initialization
C
        IF(IDUM.LT.0.OR.IFF.EQ.0)THEN
                IFF=1
                MJ=MSEED-IABS(IDUM)
                MJ=MOD(MJ,MBIG)
                MA(55)=MJ
                MK=1
                DO 11 I=1,54
                        II=MOD(21*I,55)
                        MA(II)=MK
                        MK=MJ-MK
                        IF(MK.LT.MZ)MK=MK+MBIG
                        MJ=MA(II)
11              CONTINUE
                DO 13 K=1,4
                        DO 12 I=1,55
                                MA(I)=MA(I)-MA(1+MOD(I+30,55))
                                IF(MA(I).LT.MZ)MA(I)=MA(I)+MBIG
12                      CONTINUE
13              CONTINUE
                INEXT=0
                INEXTP=31
                IDUM=1
        ENDIF
C
C*********End initialization
C
        INEXT=INEXT+1
        IF(INEXT.EQ.56)INEXT=1
```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OF POOR QUALITY

```
      INEXTP=INEXTP+1
      IF(INEXTP.EQ.56)INEXTP=1
      MJ=MA(INEXT)-MA(INEXTP)
      IF(MJ.LT.MZ)MJ=MJ+MBIG
      MA(INEXT)=MJ
      RAN3=MJ*FAC
      RETURN
      END
C
C
      SUBROUTINE SECOND(TIM)
      TIME0=0.0E+00
      TIM=SECNDS(TIME0)
      RETURN
      END
C
C
C
      SUBROUTINE OBJCHK(M,IORDER,H,PSUM,NROW,ZCHK)
C
      INTEGER NROW,IORDER,I1,J1
      DOUBLE PRECISION ZCHK,M,H,PSUM
      DIMENSION M(NROW),H(NROW,NROW),IORDER(NROW),PSUM(NROW)
C
      ZCHK=0.0
      DO 5 I=1,NROW
              I1=IORDER(I)
              PSUM(I)=0.0
              DO 4 J=1,NROW
                      J1=IORDER(J)
                      PSUM(I)=PSUM(I)+H(I,J)*M(J1)
4             CONTINUE
              ZCHK = ZCHK + PSUM(I)*M(I1)
5     CONTINUE
      RETURN
      END
C
C
```


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N90-25056

A USER-FRIENDLY, MENU-DRIVEN, LANGUAGE-FREE LASER CHARACTERISTICS CURVES GRAPHING PROGRAM FOR DESK-TOP IBM PC COMPATIBLE COMPUTERS

by

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A menu-driven language-free program which graphs the interrelationship of the many physical parameters of lasers and laser materials for use by laser researchers and engineers is an expressed need or requirement of the Environmental Sensors Branch of the Flight Electronics Division, NASA Langley Research Center.

The branch has already established a facility that uses collected data and feeds it into mathematical models that generate improved data arrays by correcting for various losses, base line drift, and conversion to unity scaling. These developed data arrays have headers and other identifying information affixed and are subsequently stored in a Laser Materials and Characteristics data base which is accessible to various users. The two part data base: absorption - emission spectra and tabulated data, is developed around twelve laser models. The tabulated section of the data base is divided into several parts: crystalline, optical, mechanical, and thermal properties; absorption and emission spectra information; chemical name and formulas; and miscellaneous.

This summer's project was to develop a menu-driven, language-free graphing program for use with this data base. The final version of the graphing program will reduce and/or remove the requirement that users become competent FORTRAN programmers and the concomitant requirement that they also spend several days to a few weeks becoming conversant with the GEOGRAF library and sequence of calls and the continual refreshers of both. It is the consensus within the Branch that researchers time is more important being spent in their specific research specialties.

The work this summer included becoming thoroughly conversant with or at least very familiar with GEOGRAF by GEOCOMP Corp. GEOGRAF is a FORTRAN callable graphics library that helps plot to screen, printer, or plotter during execution or to a disk file during execution for actual plotting at a later time. In GEOGRAF the programmer instructs the plot device, be it screen, printer, or plotter, with FORTRAN call statements rather than through the symbolic language required by the graphics device. Learning the FORTRAN language from scratch takes the average person several weeks to a couple of months. Learning to actually run each of the subroutines in the GEOGRAF library takes a good block of time. Also, after learning the FORTRAN language and the subroutines, each time a researcher wanted to graph a new set of data he/she would have to spend a block of time refreshing themselves on both the language and the library routines as well as sequence of calls as has been the experience of this program author.

The development of the graphing program involved trial runs of the various callable library routines on dummy data in order to become familiar with actual implementation and sequencing. This was followed by trial runs with actual data base files and some additional data from current research that was not in the data base but currently needed graphs. These actual runs provided the knowledge as to which actual subroutines would need to be included in the menu-driven program to provide for graphing all files from the data base. After successful runs, with dummy and real data, using actual FORTRAN instructions steps were undertaken to develop the menu-driven language-free implementation of a program which would require that the user only know how to use microcomputers. The user would simply be responding to items displayed on the video screen. To assist the user in arriving at the optimum values needed for a specific graph, a paper and pencil check list was made available to use on trial runs.

Visualizing the various problems that can be encountered by neophyte programmers has proved to be a great challenge to the author of this program. For instance, since FORTRAN programs will crash if alphabetic characters are supplied when numeric data are required, reprogramming was required so that all responses be in character format and the computer then convert to the required numeric data required by the call instruction. Near the end of this summer's tenure, other areas that had not been thoroughly visualized from a beginning programmer's viewpoint began to appear. During the seventh week while talking with various researchers and making special runs on data they had collected, it became evident that methods would need to be incorporated for them to massage data before actual processing by the graphing program. This included the capability to invert the graph, to average groups of points for plotting, or to generate a paralleling array of data to serve as the other axis when their data collection system had only provided for one array of data.

There are several areas that need additional investigation as indicated above. One includes the possibility of a generic program to take any data file whether in the data base or not and the user being able to respond to items which in turn will construct correct call statements. A second option would be to investigate the utilization of the on-order FORTRAN compiler which contains integral plot commands. A third area would be to investigate the possibility of loading these onto a host computer for the Division or even Center wide.

It is expected that this graphing program will provide an added dimension to the research accomplishments of various researchers involved in laser research and that continued efforts on this project can expand its capabilities and maybe even be expanded to different aspects of research underway here at the Center.

N90-25057

Extension-Torsion Coupling Behavior of Advanced Composite Tilt-Rotor Blades

by

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Helicopter and tilt-rotor blade manufacturers are incorporating fibrous composite materials into their current designs as a means of reducing weight, vibrations, and costs and controlling vibrations. In a very general sense, a composite tilt-rotor blade can be described as an elastic beam that exhibits generally anisotropic behavior, where it's outer shape is generated by rotating a nonhomogeneous irregular cross section about an initial twist axis (see Fig. 1). The line of centroids does not lie on this axis, instead it can be a helix. Thus, the application of a simple extension (centrifugal) load can result in bending and either unwinding or further twisting of the blade section depending upon the definition of the material properties, section profile, and the location of the initial twist axis. NASA engineers are currently trying to exploit this characteristic, by designing blades that will deform (bend and twist) into the optimum aerodynamic shape for each operating condition (take-off, hover, cruise, etc.) by simply changing the rotational speed of the rotor (i.e.; change the centrifugal force distribution).

Previous research studies have only investigated isotropic pretwisted bars with simple (circular or elliptical) cross sections and have used either a three-dimensional elasticity approach or have tried to approximate the coupling effects using simple technical beam theories. The elasticity-based solutions clearly show the need for three displacement functions that describe the local in-plane and out-of-plane deformations of the cross section. Numerical results have shown that the application of an extension (centrifugal) force to a pretwisted bar will untwist the bar if the initial twist axis and centroidal axis are aligned, but if the initial twist axis and centroidal axis are not aligned, then the bar may either untwist or further twist depending upon the initial twist axis location, cross section shape, and Poisson's ratio.

The objective of my summer project was to develop an analytical model to study the extension-bend-twist coupling behavior of an advanced composite helicopter or tilt-rotor blade. The outer surface of the blade is defined by rotating an arbitrary cross section about an initial twist axis. The cross section can be nonhomogeneous and composed of generally anisotropic materials. The model is developed based upon a three dimensional elasticity approach that is recast as a coupled two-dimensional boundary value problem defined in a curvilinear coordinate system. Displacement solutions are written in terms of known functions that represent extension, bending, and twisting and unknown functions for local cross section deformations (generalized warping). The unknown local deformation functions are determined by applying the principle of minimum potential energy to the discretized two-dimensional cross section. This is an application of the Ritz method, where the trial function family is the displacement field associated with a finite element (8-node isoparametric quadrilaterals) representation of the section.

A computer program was written where the cross section is discretized into 8-node quadrilateral subregions. The material properties for each subregion can be generally anisotropic or laminated composite. The linear matrix equations for each subregion are assembled into a complete cross section representation and solved using standard finite element procedures. Solutions for the local deformations are determined for each of the load conditions (extension, torsion, bending) separately. The extension-bend-twist coupling constants are calculated by substituting the displacement solutions into the cross section equations of equilibrium, and performing the necessary numerical integration (Gaussian Quadrature) over the cross section.

Initially the program was verified using previously published results (both three-dimensional elasticity and technical beam theory) for pretwisted isotropic bars with an elliptical cross section. The calculated local section deformation distributions of the pretwisted bar are composed of coupled in-plane and out-of-plane behavior described by combined Poisson-type contractions, anticlastic surfaces, and torsion-type warping. The current model is in excellent agreement with the published solutions showing torsion stiffness increases, extension stiffness decreases, and maximum negative extension-torsion coupling for pretwisted bars where the initial twist axis and the centroidal axis are coincident. As the initial twist axis is offset from the centroid, the coupling changes sign from negative to positive thus the bar undergoes further twisting, instead of untwisting, for applied extension.

In addition, solid and thin-wall multi-cell NACA-0012 airfoil sections were analyzed (Fig. 2) to illustrates the pronounced effects that pretwist, initial twist axis location, and spar location has on coupled behavior. For moderate levels of pretwist, a solid section has decreased extension stiffness and increased torsion stiffness, whereas certain thin-wall configurations undergo a reduction in both extension and torsion stiffness due to in-plane section deformations that reduce the section planform (Figs. 3,4). Locating the initial twist axis at the centroid maximizes both the extension stiffness and the negative extension-torsion coupling, whereas locating the axis near the quarter chord eliminates the coupling and locating it outside of this region introduces positive coupling and further reduces the extension stiffness (Figs. 5,6).

Currently, a series of advanced composite airfoils are being modeled in order to assess how the use of laminated composite materials interacts with pretwist to alter the coupling behavior of the blade. These studies will investigate the use of different ply angle orientations and the use of symmetric versus unsymmetric laminates.

Future issues that need to be addressed and can be studied with this current model include: 1.) improvement of existing technical beam theory approaches by including the local coupled in-plane and out-of-plane section deformations, 2.) assessment of the local deformation behavior on the dynamic characteristics (stability) of the blade, and 3.) Structural and aeroelastic "tailoring" of the blade structural geometry (wall, spar and ply thickness and ply orientation) for "zero coupling" for constant speed rotors and "maximum coupling" for variable speed (tilt-rotors).

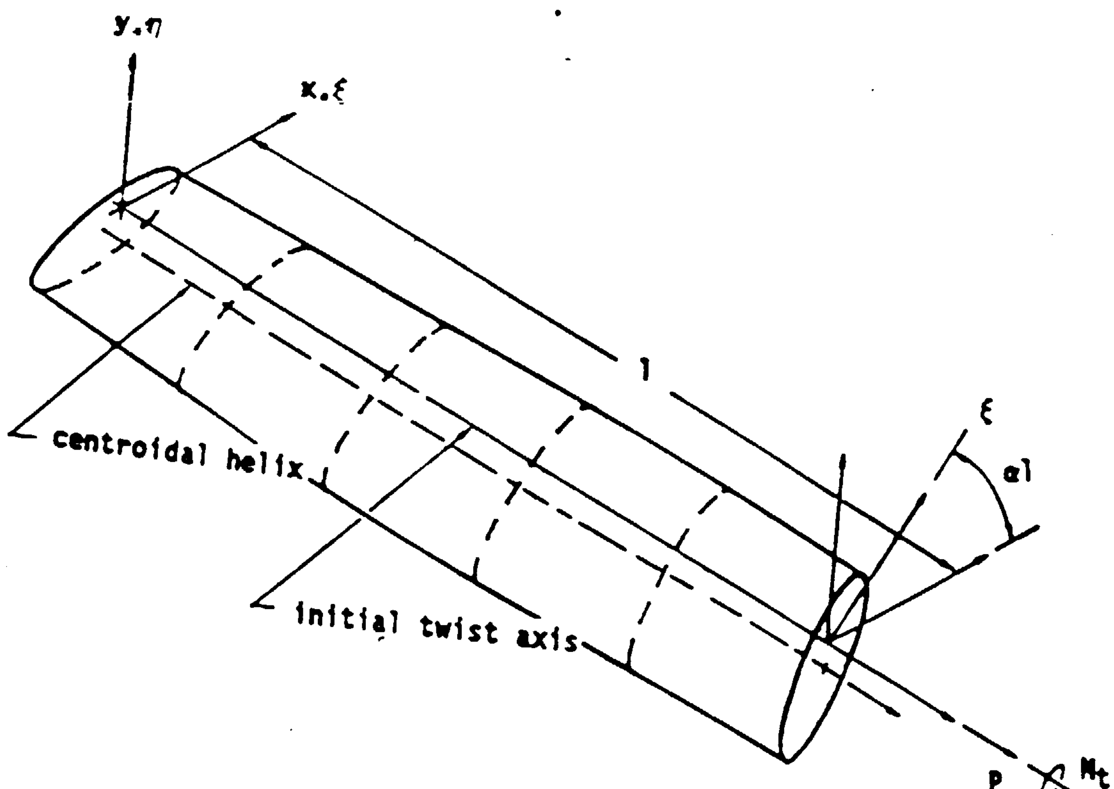

Figure 1 Initially twisted elastic bar with spaced-fixed (x,y,z) and curvilinear (ξ,η,z) coordinate systems and applied extension (P) and torsion (M_t) loads.

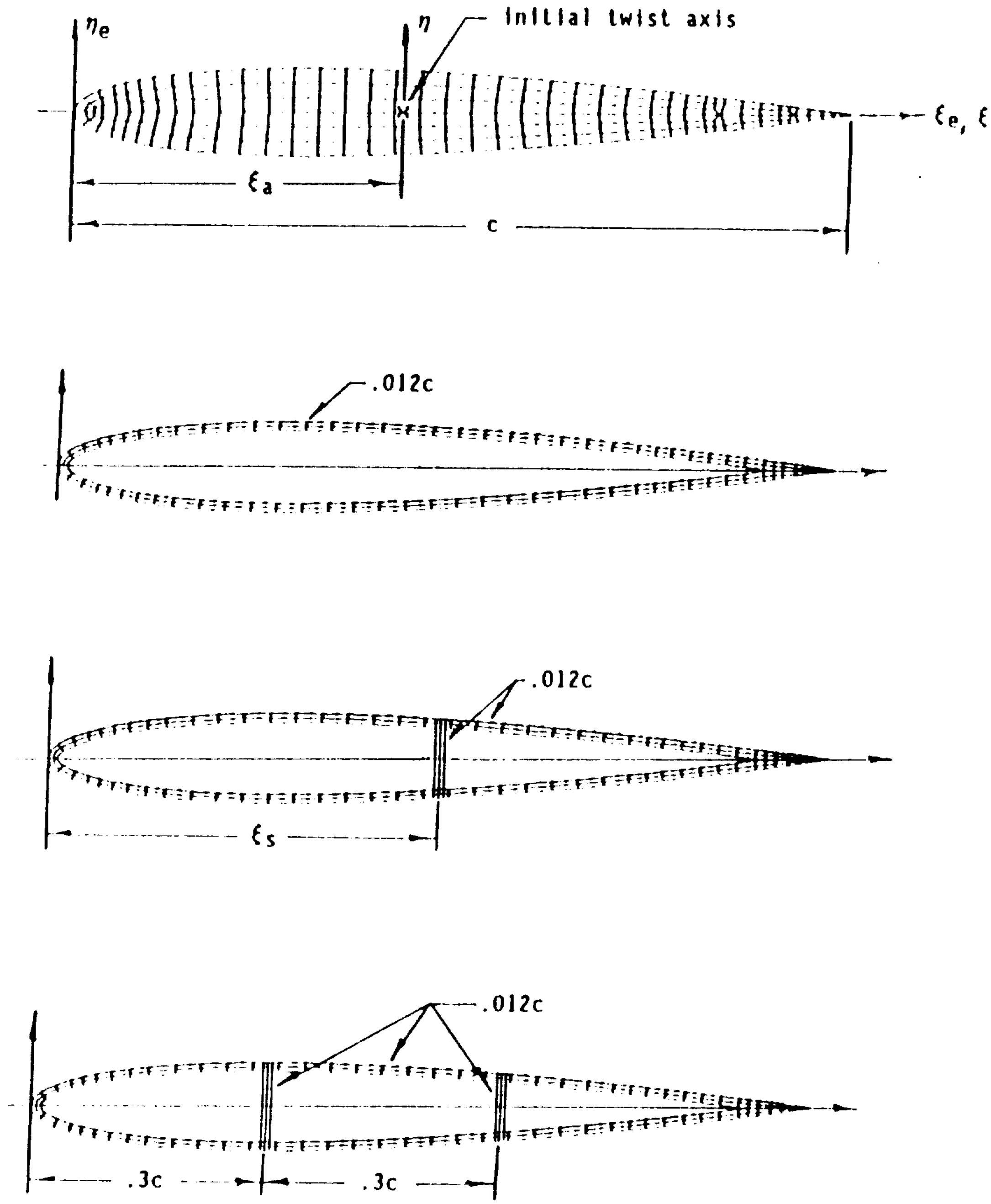

Figure 2 Discretization of four NACA-0012 airfoils with the wall and spar thickness equal to .012c; (a.) solid section using 210 elements, (b.) single cell having 160 elements, (c.) double-cell with 180 elements, and (d.) triple-cell using 200 elements.

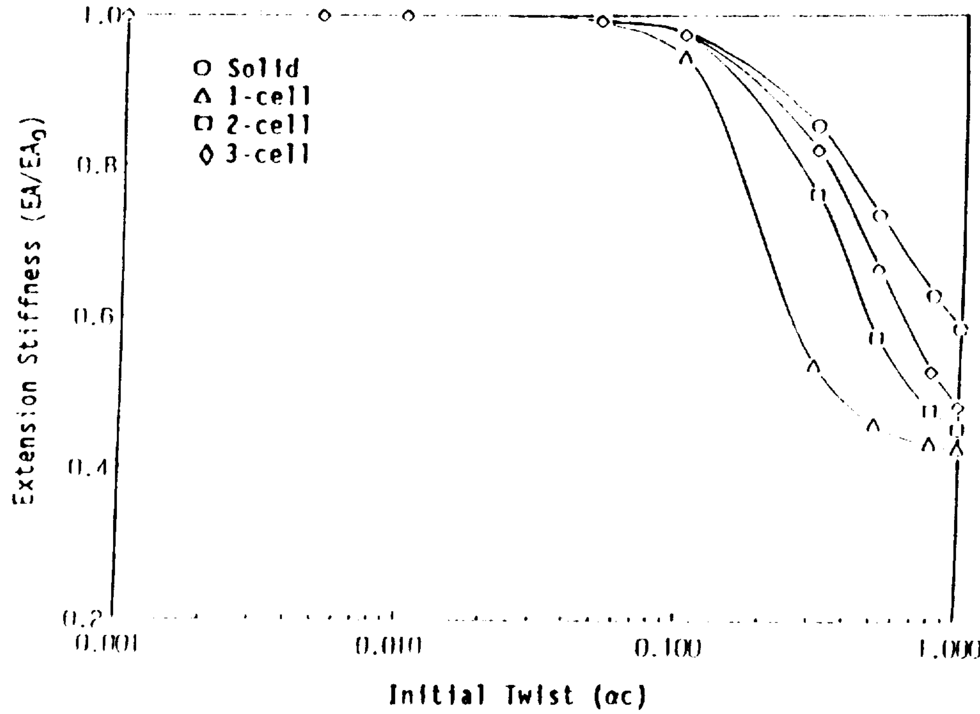

Figure 3 Extension stiffness for pretwisted NACA-0012 airfoil sections with the initial twist axis located at the section centroid.

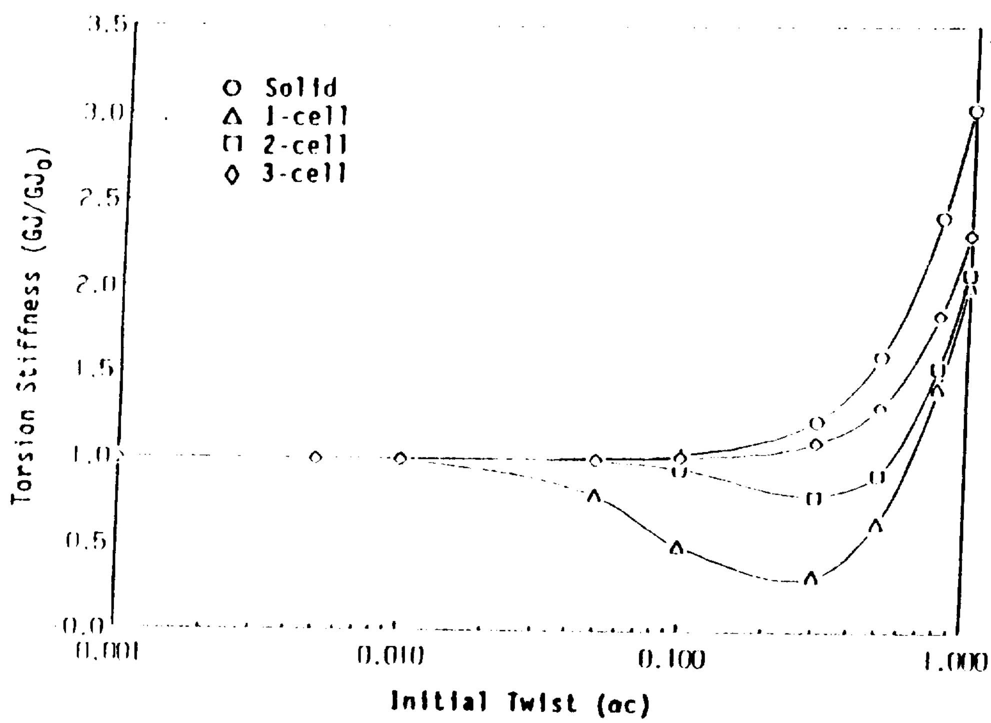

Figure 4 Torsional stiffness for pretwisted NACA-0012 airfoil sections with the initial twist axis located at the section centroid.

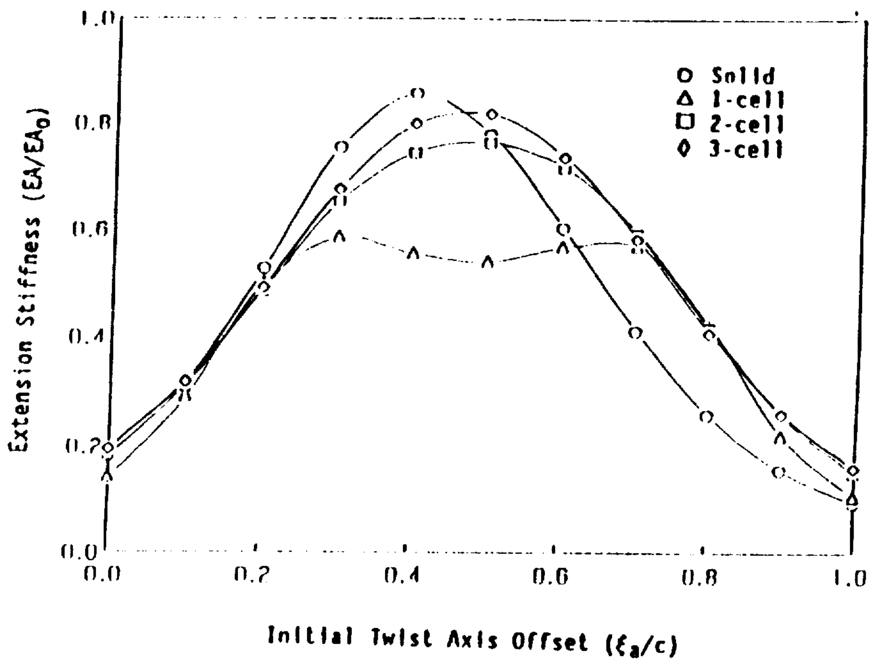

Figure 5 Extension stiffness of a NACA-0012 airfoil section (ac=.30) where the initial twist axis is offset along the chord-wise axis (ξ_a/c).

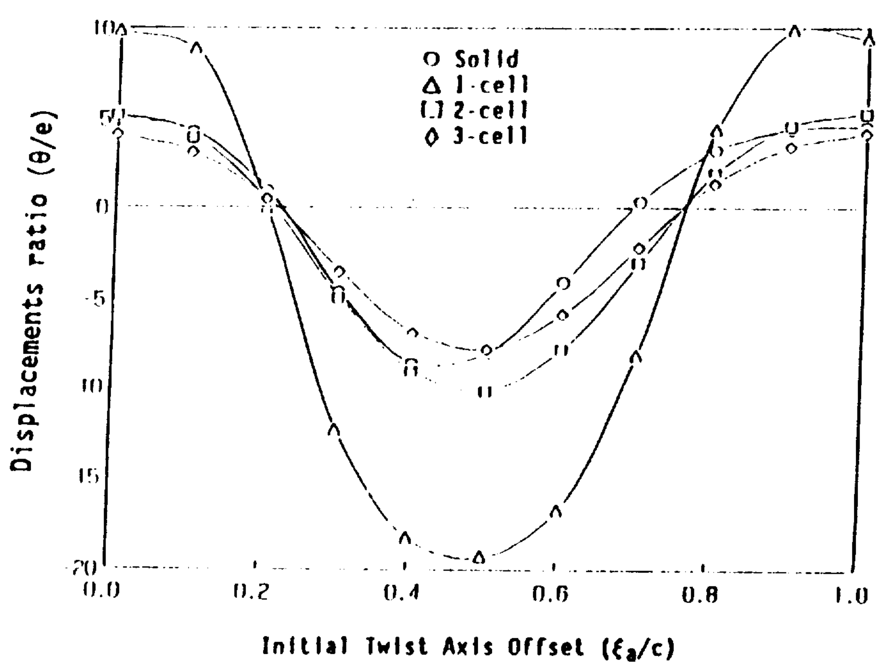

Figure 6 Extension-torsion coupling of a NACA-0012 airfoil section (ac=.30) where the initial twist axis is offset along the chord-wise axis (ξ_a/c).

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N90-25058

AN EMPIRICALLY DERIVED FIGURE OF MERIT FOR THE QUALITY OF OVERALL TASK PERFORMANCE

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The need to develop an operationally relevant figure of merit for the quality of performance of a complex system such as an airplane cockpit stems from a hypothesized dissociation between measures of performance and those of workload (ref. 1). At moderate workload levels, increasing task demands generally leave performance unaffected if operators have sufficient spare capacity. Overload or underload conditions both lead to task performance problems. Reasons for concern with workload measurement include prediction and prevention of system failure and definition of "optimal" workload level which produces smooth system performance. These require a figure of merit to measure overall quality of performance in order to gauge the effect of workload and to signal impending system failure.

Performance can be measured in terms of time, errors, or a combination of these. In most tasks performed by expert operators, errors are relatively rare and often corrected in time to avoid consequences. Moreover, perfect performance is seldom necessary to accomplish a particular task, e.g., a pilot does not need to follow an assigned flight path with zero error and, indeed, does not (ref. 2), but only keeps the craft within certain bounds. Moreover, how well an expert performs a complex task consisting of a series of discrete cognitive tasks superimposed on a continuous task, such as flying an airplane, does not depend on how "well" each discrete task is performed, but on their smooth sequencing. This makes amount of time spent on each subtask of paramount importance in measuring overall performance, since smooth sequencing requires a minimum amount of time spent on each task. Quality consists in getting tasks done within a critical time interval while maintaining acceptable continuous task performance. Thus, a figure of merit for overall quality of performance should be primarily a measure of time to perform discrete subtasks combined with a measure of basic vehicle control.

Acceptable level of performance produces a safe landing. Since most landings are safe, average pilot performance is acceptable. Therefore, it is proposed that deviation from average pilot performance be used as a standard for both continuous and discrete pilot tasks. This allows for a reasonable, rather than absolute, standard and makes it possible to express performance in terms of standard units.

Thus, the proposed figure of merit requires doing a task analysis on a series of performances, or runs, of a particular task, listing each discrete task and its associated time, and calculating the mean and standard deviation of these times, along with the mean and standard deviation of tracking error for the whole task. Since most discrete tasks are cognitive, they are best timed if the pilot indicates the start and end of each task with a keystroke, although other means may be used. Time for each task receives a single standard unit (one unit is one standard deviation above or below the mean). Such a unit can then be combined additively with other standard units for very different tasks. Since a simple addition of equally weighted standard units will not reflect differences in relative contribution of various tasks, the standard unit for each task must be multiplied by the mean time for that task and the tasks added together to obtain a figure of merit. This can be calculated for each new run, which then receives its individual score. Such scores are automatically given in terms of the norm for the whole task.

A set of simulator data on 30 runs of a landing task (ref. 3) has been obtained and a figure of merit will be calculated for each run. On half of the runs, communications with ATC were done with conventional voice radio and on the other half, they were done with a data link ATC message exchange unit. An example of a time line showing timing of discrete and continuous tasks for two runs is illustrated in Figure 1. The figure of merit will be compared for voice and data link, so that the impact of this technology on total crew performance (not just communication performance) can be assessed. The effect of data link communication on other cockpit tasks will also be considered. In this way, it is hoped that the usefulness of the proposed figure of merit as a measure of the impact of technology introduction can be demonstrated.

In addition, a complex task consisting of a number of subtasks is currently being developed in order to study the impact of very low task demands. It will be possible to calculate a more accurate figure of merit for each run of this task, since data collection can be planned in advance. It is hoped that such data will also show appropriate variations in the figure of merit, and the conditions of the study will be reflected in it.

The figure of merit thus developed should then serve as a measure of overall task performance against which variations in workload can be assessed. It should be used to explore the ways in which such task factors as boredom, overload, and their alternation, as measured by traditional workload measures such as physiological variations and subjective impressions, may influence task performance.

References

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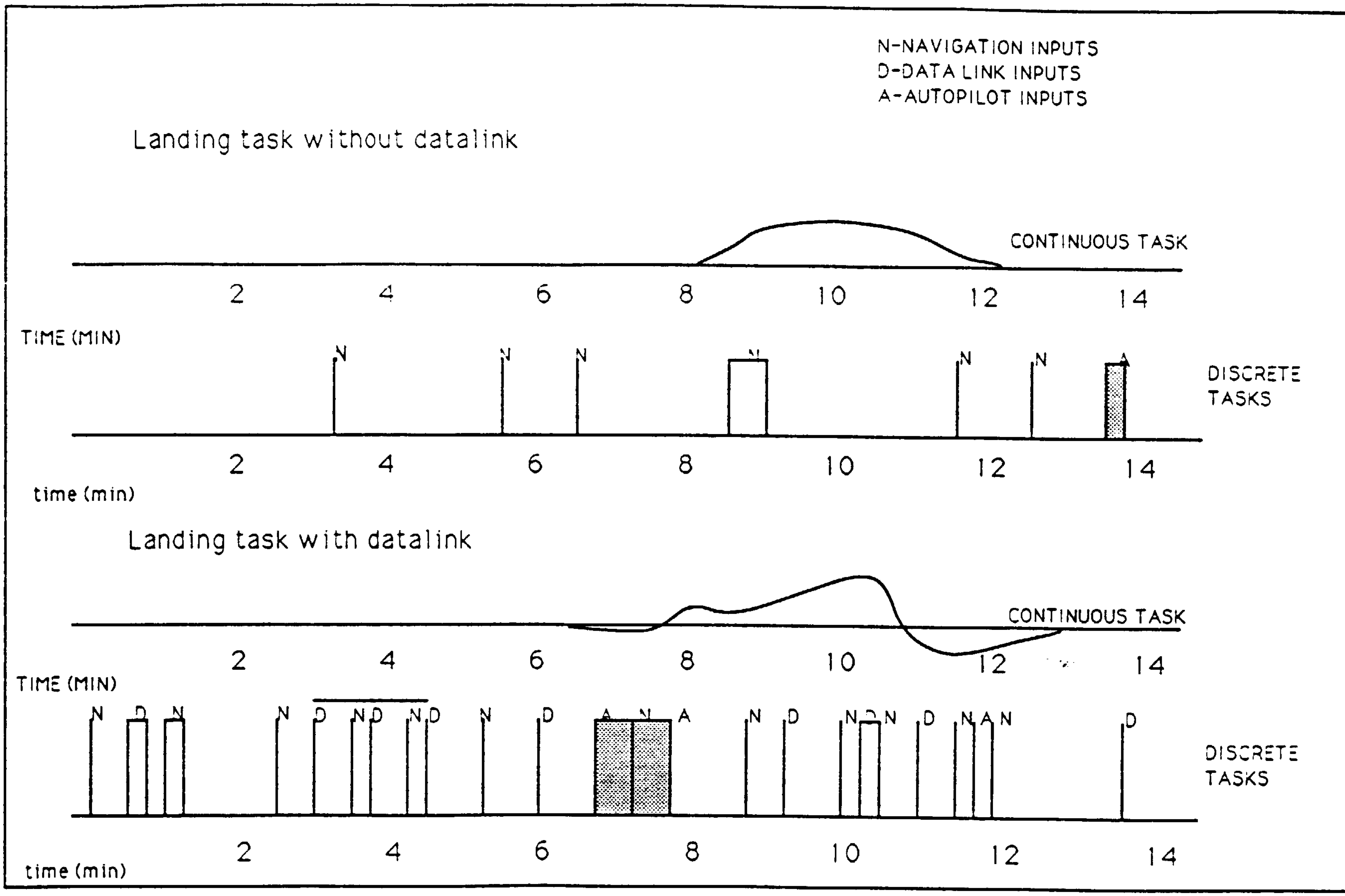

FIGURE 1. Distance from flight path (continuous task) and occurrence of discrete tasks in a simulated landing task.

N90-25059

A SYSTEMATIC APPROACH TO TRAINING: A TRAINING NEEDS ASSESSMENT

by

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In an effort to determine the gap between the actual performance and the necessary performance of employees for the effective and efficient accomplishment of an organization's mission and goals, an organization-wide Training Needs Assessment must be conducted. The first Center-wide Training Needs Assessment Process of this magnitude commenced May 1, 1989.

The purpose of the work this summer was to conduct a training needs analysis and prepare a NASA Langley Catalog of On-Site Training programs. The work included developing a Training Needs Assessment survey (Encl. 1), implementing the survey, analyzing and researching the training needs, identifying the courses to meet the needs, preparing and designing an On-Site Training Catalog.

This needs analysis attempted to identify performance weaknesses and deficits; seek out and provide opportunities for improved performance; anticipate and avoid future problems; enhance and create new strengths. The end product is a "user-friendly" catalog of on-site training available.

The results include:

- Top-down approach to needs assessment
- Improved communication with Training Coordinators
- 98 per cent return rate of Traning Needs Assessment survey
- Complete, newly designed, "user-friendly" catalog
- 167 catalog courses descriptions advertised
- 82 new courses advertised
- Training Logo
- Request for Training Application Form

Once the Training Needs Assessment Survey was initially designed and developed, Administrative Assistants followed by Training Coordinators were briefed on its contents. These meetings resulted in a slightly redesigned survey to meet their concerns. This was distributed to 61 Directorates, Division, or Project Offices Centerwide. Division Chiefs were asked to consult with their Branch Heads, Training Coordinators, and employees to determine their specific training needs according to three skill areas: technical, automated data processing, and human relations.

The following steps were conducted:
- Determined the short-term objectives of the needs analysis
- Developed a Proposed Plan of Action and Milestones (POAM) (Encl. 2)
- Identified the population
- Determined the format for data collection
- Administered the survey through Division Chiefs/ Project Offices
- Designed catalog format
- Enlisted Graphics for cover and spine design
- Researched, analyzed, and compiled data
- Contacted Training Coordinators for clarification of requested needs
- Charted the results Centerwide, by Directorate, by Category, by Function per participant
- Listed training needs and support data
- Identified problem areas
- Developed course descriptions and development strategies
- Prepared the document
- Proofread and edited document
- Prepared Vugraph presentations for each Directorate for course validation of Center-wide and Directorate results
- Presented document to Technical Editing for grammatical corrections
- Presented document to Graphics for layout design and preparation for printer

This effort is the first step in a three year process of an on-going assessment. This process must be continuous and must grow from the initial findings. The Educational Development Specialists must continue consulting with Training Coordinators, Branch Heads, and Section Heads to identify the needs. Some Training Coordinators or supervisors may need to be trained to identify what is or is not a training need. Training must be sensitive to these needs.

As part of this on-going process it appears best to design the needs analysis for administration to different levels. Each level should be approached differently. For upper level management, a one-on-one interview with highly structured questions by an outside consultant who is familiar with the Center's strategies and objectives is recommended. For branch personnel, conduct a needs inventory and one-on-one interviews with a random sampling to clarify findings in the needs inventory.

The success will ultimately be measured by the extent to which management sought to answer the question "What good will training do?" and then by "What good did it do?" A need analysis that does not establish the criteria by which training's success can be measured has not done its job. Once training is accomplished management should assess if training accomplished the desired results.

Proposed Needs Assessment Process - Milestone Chart

Action	May	June	July	August	September	October	November	December	January
Develop survey form	1 ——	1							
Brief Training Coordinators	24								
Survey hand-carried to Program Directors' Administrative Officers		1							
Survey distributed to Division Chiefs from Program Directors		2							
Division Chiefs implement survey and gather input from each Branch Head prior to completing the survey		2-9							
Survey returned to TES (APT Coordinator)		12							
Analyze data from survey		12 ——	7						
Meet by Dir. with Division Chiefs and Training Coordinators			10-14						
Preparation of document			10-21						
Document to printer			21						
Distribute document to each employee				15					
Registration material returned to TES				22					
Complete purge of FY 89 data					15				
Complete data processing of registration requests					15				
Analyze training requests, conduct preliminary market survey, project budget requirements					15-29				
Brief Program Directors/Division Chiefs to prioritize requests within budget parameters						2-13			
Schedule courses, select vendors, award contracts, and develop in-house course curriculum						begin 16	→	→	→
Notification to training coordinators and employees						16	→	→	→
Evaluate FY 90 assessment process							→	→	
Begin development of assessment process for FY 91-92									1990 →

04-24-89

Enclosure (1)

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NASA Langley Research Center

On-Site Training Needs Assessment Survey Form

Fiscal Year 1990

Office of the Director

Signature ______________________ Date ______________________

Karen W. Evans
Extension 46112
Mail Stop 103

Return completed packet to Dr. Mary H. Lewis,
Mail Stop 309, by June 16, 1989.

Enclosure (1)

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Suggested Guidelines for Completion of the On-Site Training Needs Assessment Survey Form

This needs assessment survey packet will be the primary mechanism for identifying on-site training for Fiscal Year 1990. A needs assessment comes at the beginning of any systematic approach to training and development, before anyone is taught anything in any setting or through any technology. During the assessment, the answers to the questions serve as a basis for decisions about the nature of the training to be provided. Naturally, better programs are derived from better assessments.

Our needs assessment is done to gain an understanding about the gap between what is happening and what ought to be happening. Our search is for information about the proficiency, criticality, and frequency of three skill areas: technical, human relations, and automated data processing. Once skill areas have been identified, the training staff will prepare and distribute to each employee a publication outlining courses and providing registration materials for FY 1990.

Answers to the following questions may help you as you consider the three skill areas as they apply to the functional work groups:

1. What do employees need?
2. What do they want?
3. Where are they having problems?
4. Where can we get the most impact for our developmental dollars?
5. What are management priorities for employee growth and development?
6. What are employee priorities? Why?
7. Of all the possible arenas toward which we might direct resources, which ones hold the most promise for the organization and for the employees.

As a result of feedback obtained from the Training Coordinators' briefing on May 24, 1989, a separate form is provided for your convenience for each functional category.

Specific course titles are not necessary; however, if you are familiar with a course, please attach a course description, brochure, or topical outline.

Please complete this packet by June 16, 1989, and return to Dr. Mary H. Lewis, Mail Stop 309.

Suggested Roles and Responsibilities

Training Coordinators

1. Review the entire packet, including enclosures.
2. Distribute copies to branch heads.
3. Consult with branch heads.
4. Survey employees, both civil service and contractor.
5. Review identified needed skill areas with division chiefs/office heads.
6. Complete the survey according to the examples provided.
7. Make sure the packet is returned by **June 16, 1989**, to Dr. Mary H. Lewis, Mail Stop 309.

Branch Heads

1. Consult with training coordinators.
2. Survey employees, both civil service and contractor.
3. Brief division chiefs.

Division Chiefs

1. Give packet to training coordinators.
2. Review data collected by training coordinators and branch heads.
3. Prioritize identified skill areas.
4. Sign the cover sheet and return the packet to Dr. Mary H. Lewis, Mail Stop 309 by **June 16, 1989**.

Employees

Provide input to branch heads, division chiefs, training coordinators, or other designated officials.

If necessary, contact Dr. Mary H. Lewis at extension 42596 for assistance.

Researchers/Engineers

	Number of Employees Targeted	Preferred Length of Instruction	Preferred Training Month(s)
Technical Skills: Specialized knowledge, skills, abilities required Example: Knowledge of Fluid Dynamics	5	32 hours	September
Human Relations: Interpersonal skills Example: Dealing with Difficult People	4	8 hours	Any month except March
Automated Data Processing: Computer-related skills Example: Personal Computer Training (dBase III)	6	12 hours	February

If you are familiar with a course that would meet any of these needs, attach a course description, brochure, or topical outline if available.

Technicians

	Number of Employees Targeted	Preferred Length of Instruction	Preferred Training Month(s)
Technical Skills: Specialized knowledge, skills, abilities required Example: Joining of Metals by Spot Welding	5	30 hours	November
Human Relations: Interpersonal skills Example: Managing Stress	4	16 hours	June
Automated Data Processing: Computer-related skills Example: CAD-CAM Training	6	30 hours	February

If you are familiar with a course that would meet any of these needs, attach a course description, brochure, or topical outline if available.

Administrative Professionals

	Number of Employees Targeted	Preferred Length of Instruction	Preferred Training Month(s)
Technical Skills: Specialized knowledge, skills, abilities required Example: Time Management	5	8 hours	November
Human Relations: Interpersonal skills Example: Listening Skills	4	8 hours	March
Automated Data Processing: Computer-related skills Example: Writing reports using the personal computer	6	12 hours	February

If you are familiar with a course that would meet any of these needs, attach a course description, brochure, or topical outline if available.

Supervisors/Managers/Executives

	Number of Employees Targeted	Preferred Length of Instruction	Preferred Training Month(s)
Technical Skills: Specialized knowledge, skills, abilities required Example: Understanding advanced concepts of project cost planning	5	32 hours	June
Human Relations: Interpersonal skills Example: Interviewing Techniques	4	8 hours	March
Automated Data Processing: Computer-related skills Example: Personal computer (Lotus 1-2-3)	6	32 hours	March-April

If you are familiar with a course that would meet any of these needs, attach a course description, brochure, or topical outline if available.

Secretaries/Clericals

	Number of Employees Targeted	Preferred Length of Instruction	Preferred Training Month(s)
Technical Skills: Specialized knowledge, skills, abilities required Example: Editing and Proofreading Skills	5	16 hours	November
Human Relations: Interpersonal skills Example: Understanding the effects of non-verbal communications or interactions with others	4	24 hours	March
Automated Data Processing: Computer-related skills Example: Macintosh Training - MacWord	6	20 hours	April-May

If you are familiar with a course that would meet any of these needs, attach a course description, brochure, or topical outline if available.

N90-25060

Modeling Growth of Fatigue Cracks Which Originate at Rivet Holes

by

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When a structural component is subjected to repeated stress cycles, it can fail at stresses which are well below the tensile strength of the material. The processes leading to this failure are termed "fatigue".

Instances of fatigue failure in aircraft have become an increasing concern. The cracks leading to failure often originate at rivet holes and then grow in response to stress cycles which occur during operation of the aircraft. A necessary step to preventing failures in todays fleet of ageing aircraft is to increase the frequency and quality of inspections; steps have already been taken in this direction. There is also a need for modeling of fatigue crack growth in aircraft structures so that improvements in design can be established and predictions of the life of components can be made.

The purpose of this study is to provide a method to accurately predict the growth of fatigue cracks and to use this method to make predictions about the life of aircraft structural components. The method relies on the formulation and numerical solution of a singular integral equation(s) for an arbitrarily shaped crack(s) which propagate in response to the applied loading. Of special interest to the ageing aircraft studies are cracks which originate at circular holes (i.e. rivet holes), but other crack geometries can be treated equally as well.

The starting point for the analysis is the fundamental solution for a dislocation in an unbounded medium. The discontinuity in displacements across the crack surface is then represented by a continuous distribution of these dislocations. The dislocation density is determined by requiring the tractions on the crack surfaces to have prescribed (known) values. This results in a singular integral equation for the dislocation density. To render the solution to this equation unique, it is necessary to enforce the condition that the displacements are singled valued everywhere in the cut plane.

To obtain a numerical solution to the integral equation, the crack line is represented by a sequence of piecewise linear segments. The dislocation density at the nodes joining these segments are taken as the unknown quantities, with the density over each element given in terms of these nodal values. Collocation is then used to obtain a system of linear algebraic equations to be solved for the approximate dislocation density.

We have carried out the analysis and developed a code for isolated cracks in unbounded domains and for isolated cracks originating from holes in unbounded domains. Results of several test cases for straight and curved cracks have been compared with known solutions and excellent agreement has been found. Preliminary studies for growing (curving) cracks have also been performed to demonstrate the usefulness of the method. These preliminary results have demonstrated the ease of application of the method and its efficiency.

The next step in the study is to model interacting cracks and cracks in finite domains. To do this we will retain the same modeling scheme for the cracks, and account for the finite domain using standard boundary element techniques. Because the problem is linear, the boundary element method and the distributed dislocation method can be coupled directly using the principle of superposition.

After the development of this capability, the growth of fatique cracks in thin structures will be investigated. As emphasized previously, attention will be given to cracks which originate at rivit holes. The growth of these cracks will be modeled, fully accounting for interactions with other cracks and boundaries. The results of these studies will be used to predict the fatigue life of aircraft structures.

IMPACT OF SUMMER GUEST RESEARCH PERSONNEL ON PRODUCTIVITY AT NASA LANGLEY RESEARCH CENTER

by

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ABSTRACT

During the months of June, July, and August, 1989, NASA Langley Research Center (LaRC) hosted 825 - 850 faculty and students at all levels as part of several regular summer research and training programs. Adding these personnel to a permanent population of approximately 2900 civil service employees and some 2800 private sector contract employees naturally placed increased demands on the Center resources. The goals of the present project were: (1) to assess the impact of the needs of these summer guests on LaRC facilities, personnel, and productivity; and (2) to develop recommendations for future program administration.

Needs Assessment. A questionnaire was distributed to 149 faculty and student participants in current LaRC summer research programs and mailed to 252 university principal investigators with NASA grants at LaRC. Each person was asked to rate and comment on a number of facets of conducting research at LaRC, including an assessment of personal productivity compared to time spent off-Center. A total of 132 completed questionnaires were received, for a 33% return rate. In addition, interviews were conducted with permanent NASA personnel in three categories: current or recent research mentors; the administrators of several programs, branches, divisions, and directorates; and heads or representatives of resource and service agencies (technical library, computing complex, occupational health clinic, security, cafeteria). These individuals were asked to comment on the effect of summer programs on LaRC's mission.

Recommendations. All individuals, permanent and guests, stressed the value and importance of LaRC's continued contribution to the development of motivated researchers in engineering and the

sciences. Generally acknowledged problems of space, equipment, and staffing might be addressed more effectively by treating the summer influx of personnel as a recurring resource to the Center. To that end, the following recommendations were made to the LaRC Senior Staff:

- **Capital Planning.** Construction or renovation of facilities, as well as equipment purchases, should include provision for summer guests, as well as permanent personnel.

- **Annual Planning.** Planning for the accomplishment of the Center's research and development activities should include the extent to which summer personnel, individually or in teams, can be utilized as a resource.

- **Coordination.** Prior to publishing announcements for each year's summer programs, key LaRC personnel should meet to determine the likely collective needs for space, equipment, staffing, and support.

- **Applicant Information.** Program applicants should be informed of specific activities in which they might be involved and asked to describe their needs and particular expertise relative to those activities.

- **Schedule Flexibility.** Alternative scheduling of programs involving faculty and graduate students should be investigated, including fall or winter sabbaticals or leaves, and accredited off-campus research experiences.

- **Information Networking.** Methods should be developed to allow LaRC's distributed computing systems to share information about the arrival, departure, location, and requirements of all personnel, obviating the need for repeated entry of the same information into each specialized system.

- **Feedback Loop.** At or near the end of each summer, key LaRC personnel should meet to review program successes and shortcomings, and develop improved procedures for the next year's programs.

N90-25061

ADVANCED SPACE TRANSPORTATION TECHNOLOGIES

by

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A wide range of propulsion technologies for space transportation has been discussed in the literature [1, 2]. It is clear from the literature review that a single propulsion technology cannot satisfy the many mission needs in space. Space missions may involve the following: (1) seed life and create a limited environment, (2) transport cargo to sustain life in space or on other planets, (3) manned missions from one planet to another, (4) unmanned missions for deep space exploration of our own galaxy and other galaxies, and (5) set up of special purpose industries. There is a broad spectrum of possibilities which could be outlined. However, a national agenda can only determine the long term goals. The time frame to achieve the tasks of the each goal and the financial commitment require not only the scientific and technological commitment but also the public concensus. Is the final goal of space missions to save and preserve the human race from some catastrophic event, to bring more prosperity, or both? If we indeed find life on another planet, how will our long term goals and agenda change?

Many of the technologies tested, proposed, or in experimental stages relate to: (1) chemical and nuclear fuel, (2) radiative and corpuscular external energy source, (3) tethers, (4) cannons, and (5) electromagnetic acceleration. The scope and limitation of these technologies is well tabulated in the literature [1, 2]. Prior experience has shown that an extensive amount of fuel needs to be carried along for the return mission. This requirement puts additional contraints on the lift off rocket technology and limits the payload capacity. Consider the possibility of refueling in space. If the return fuel supply is guaranteed, it will not only be possible to lift off more payload but also to provide security and safety of the mission. Exploration to deep space where solar sails and thermal effects fade would also be possible. Refueling would also facilitate travel on the planet of exploration. This aspect of space transportation prompts the present investigation.

It is known [3] that about one million tons of hydrogen leaves the Sun every second in the highly ionized form of protons and electrons. The protons and electrons stay apart due to the very high temperature. These particles travel at an average speed of 10 to 20 km/sec from the Sun and accelerate up to speeds of 400 to 3000 km/sec with an average density of 5 to 20 particles/cm^3. The density and speed of the particle emission from the Sun's corona are dependent upon the various phenomena taking place at the Sun. These phenomena also determine the activity of the Sun. These phenomena are: sunspots, flares, plages, prominenses, coronal holes, etc. [4].

The speed of the particles from corona to planets is treated as a hydro-dynamic phenomenon by Parker [5], who named the flow solar wind. The flow of solar wind particles to various planets is fluid in nature, and it varies depending upon the atmospheric conditions and magnetic field of the planet. It may be fully absorbed by a body such as the moon, it may be slowed down and deflected by a planet such as the Earth, or it may be partially deflected and partially absorbed by a planet such as Mars. The solar wind will also exert pressure on the planet's atmosphere. The solar wind may get trapped in some parts of space and retained there due to the presence of electric or magnetic fields.

The author proposes to collect the particle emissions from the Sun's corona under three different conditions: (1) in space closer to the Sun, (2) in the Van Allen Belts, and (3) on the moon. The author will propose to convert the particle state into gaseous, liquid, or solid state and store it for refueling space vehicles. These facilities may be called space pump stations and the fuel collected as space fuel. The collected fuel will be approximately 90 percent hydrogen, 9.5 percent helium, and the remaining other elements. The three conditions mentioned above provide the best possible sites for collection of space fuel. The methods of collection and subsequent processing, however, will vary. The author is concentrating his efforts in this direction. Preliminary estimates of fuel collection at all three sites will be made. Future work will continue towards advancing the art of collection rate and design schemes for pumping stations.

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N90-25062

FLEXURAL FATIGUE LIFE PREDICTION OF CLOSED HAT-SECTION USING MATERIALLY NONLINEAR AXIAL FATIGUE CHARACTERISTICS

by

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Straight or curved hat-section members are often used as structural stiffeners in aircraft. For instance, they are employed as stiffeners for the dorsal skin as well as in the aerial refueling adjacent area structure in F106 planes. The flanges of the hat-section are connected to the aircraft skin. Thus, the portion of the skin "closing" the hat-section interacts with the section itself when resisting the stresses due to service loads. The present investigation is circled around an estimation of the flexural fatigue life of such a closed section using materially nonlinear axial fatigue characteristics.

It should be recognized that when a structural shape is subjected to bending, the fatigue life at the neutral axis is infinity since the normal stresses are zero at that location. Implicit in this statement is the assumption that the fatigue failure will not occur due to shear stresses. Conversely, the fatigue life at the extreme fibers where the normal bending stresses are maximum can be expected to be finite. Thus, different fatigue life estimates can be visualized at various distances from the neutral axis. The problem becomes compounded further when significant portions away from the neutral axis are stressed into the plastic range. Furthermore, the fatigue life of a structure is highly material-dependent. Whereas a typical structural component of an aircraft is subjected to a complex state of fluctuating stress, the fatigue characteristics of materials are generally available on miniature specimens under direct tension and compression stresses. The problem posed herein, therefore, can be approximately stated as follows. How can the fatigue life of a closed hat-section be predicted when it is subjected to a cyclic bending moment when the fatigue characteristics of its material are known only under direct axial loading conditions for miniature specimens?

A theoretical analysis of the closed hat-section subjected to flexural cyclic loading is first conducted. The axial fatigue characteristics together with the related axial fatigue life formula and its inverted form given by Manson and Muralidharan are adopted for an aluminum alloy used in aircraft construction. A closed-form expression for predicting the flexural fatigue life is then derived for the closed hat-section including materially nonlinear action. A computer program is written to conduct a study of the variables such as the thicknesses of the hat-section and the skin, and the type of alloy used. The program is first checked by zeroing-in on the S-N curves for a simple solid rectangular section published by Manson and Muralidharan. The program is then used to develop the fatigue life prediction curves for the closed hat-section under investigation. The study has provided a fundamental understanding of the flexural fatigue life characteristics of a practical structural component used in aircraft when materially nonlinear action is present.

N90-25063

An Investigation of a Mathematical Model of an Optically Pumped $Ti^{3+}:Al_2O_3$ Laser System

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Abstract

During the last several years, solid state lasers have been developed that have the potential for meeting rigorous performance requirements for space-based remote sensing of the atmosphere. In order to design a stable and efficient laser and to understand the effect on laser output of changes in the physical and design parameters, an understanding of the development of the dynamical processes of the laser is necessary.

Typically, the dynamical processes in a laser system are investigated via rate equations describing the evolution of the occupancy in the electronic levels and of the photon density in the laser cavity. There are two approaches to this type of study. Most often, for the sake of simplicity, the spatial variations of the dynamic variables in the laser system are disregarded and the mathematical model consists of a system of first order nonlinear ordinary differential equations(ODE). The potential disadvantage of this approach is that the spatial distribution may indeed be important, particularly when experimental techniques such as injection seeding are used in the laser system. In addition, this type of model treats the photon density as a superposition of left and right traveling photons, thus the individual dynamics of the left and right traveling photons are not accessible. The primary advantage to this model is that the rate equations can be solved numerically by readily available ordinary differential equation codes.

The second approach is to take into account both spatial and temporal variations in the dynamic variables in the laser cavity. The resulting model consists of a first order semilinear system of partial differential equations(PDE). Left and right traveling photons are treated separately and their developments in both the cavity and the active medium are described. Effects of the optical elements in the cavity and experimental techniques are taken into account by way of appropriate boundary conditions. The spatial and temporal model also can account for absorption of the pump by the active medium as pumping photons propagate through the material, an aspect which may not adequately be described by the simplified model. While this may be a more realistic approach, the primary disadvantage is that methods for the numerical solutions of systems of partial differential equations are not as easily available as those for ordinary differential equations.In fact, when such methods are available,the large amount of computing time necessary to obtain solutions may make the more complete model impractical.

The model which was studied was generic in the sense that it was a four-level laser system, but the parameters used in the numerical study were specific to Titanium-doped sapphire. For simplicity, a constant, spatially uniform pumping scheme was considered. In addition, a simplification of the model was made so that it treats a single lasing wavelength with a narrow bandwidth. The purpose of the work was to investigate both versions of the mathematical model and to determine whether the numerical solutions are similar both qualitatively and quantitatively.

Reduction of the spatial and temporal model to a temporal model has been treated in the literature a number of ways. First, a spatial average of the dynamic quantities may be taken over the length of the active region. Secondly, a spatial average may be taken over the optical length of the cavity, and finally, an average of the electronic populations over the length of the active medium may be taken and spatial variations in the photon flux are merely disregarded, i.e., the partial derivative of the photon flux with respect to the spatial variable is taken to be zero. The details of each of the above reductions were examined and the resulting systems of ODEs were solved numerically.

The systems of ordinary differential equations were solved numerically using a Runge-Kutta-Fehlberg algorithm which was very efficient for typical values of the physical parameters. A numerical scheme, based on the Modified Euler method, for computing solutions to the system of partial differential equations was developed and implemented. The computer code was written that solves the respective systems for both a Fabry -Perot cavity and a ring cavity configuration. The PDE model was solved numerically at the expense of greatly increased computer time.

Results from numerical computations demonstrate that there are differences in the computed solutions for the PDE and ODE systems. An important parameter which was varied was cavity length. For fixed crystal length and all other physical and design parameters held constant, the cavity length was varied and results for both systems were compared. Each of the ODE systems, except the system obtained from spatially averaging all variables over the length of the active medium, produced numerical results which were similar, qualitatively, to those obtained from the PDE system. However, the quantitative results were different. In the best case, the output predicted by one of the ODE systems was about 28% less than that predicted by the PDE system.

The computer codes for both the ODE and PDE systems have been extended so that output at multiple wavelengths is accessible. In order for the PDE system to be practical for this application, the code should be modified for vector processing. Also, the code to solve the system for an end-pumping scheme has been developed, but a comparison study is incomplete. The primary area in which this study should be extended is to compare the theoretical results to actual experimental data. In addition, there are some qualitative properties of the PDE system which are expected, but have not as yet been proved analytically. An investigation of stability of the PDE system under typical operating parameter values is a theoretical area which could be addressed.

N90-25064

Kharitonov's Theorem: Generalizations and Algorithms

Abstract

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In 1978, the Russian mathematician V. Kharitonov published a remarkably simple necessary and sufficient condition in order that a rectangular parallelpiped of polynomials be a stable set. Here, "stable" is taken to mean that the polynomials have no roots in the closed right-half of the complex plane.

The possibility of generalizing this result has been studied by numerous authors. We are given a set, Q, of polynomials and we seek a necessary and sufficient condition that the set be stable. Perhaps the most general result is due to Barmish who takes for Q a polytope and proceeds to construct a complicated non-linear function, H, of the points in Q. With the notion of stability we have adopted, Barmish asks that we "sweep the boundary" of the closed right-half plane, that is we consider the set $G = \{j\omega \mid -\infty < \omega < \infty\}$, and for each $j\delta \in G$, require $H(\delta) > 0$.

Barmish's scheme has the merit that it describes a true generalization of Kharitonov's theorem. On the other hand, even when Q is a polyhedron, the definition of H requires that one do an optimization over the entire set of vertices, and then a subsequent optimization over an auxiliary parameter.

In the present work, we consider only case where Q is a polyhedron and use the standard definition of stability described above. There are straightforward generalizations of the method to the case of discrete stability or to cases where certain root positions are deemed desirable. The cases where Q is non-polyhderal are less certain as candidates for the method. Essentially, we apply a method of geometric programming to problem of finding maximum and minimum angular displacements of points in the "Nyquist locus", $\{Q(j\omega) \mid -\infty < \omega < \infty\}$. There is an obvious connection here with the boundary sweeping requirement of Barmish.

Presuming that we have a polygonal set of real polynomials, we can begin by looking at {Q(0)}, a line interval, J. Necessary for the stability of Q is that J = [a,b], where a >0. We therefore do the linear programming problems which minimize and maximize Re(Q(0)). (Actually only the minimization would be necessary). Using these points as starting values, we perturb the frequency, say to $\omega = .1$, and look for the vertices in Q whose image under eval($j\omega$) have largest and smallest values. For stability, both must be positive. We can employ an LP-like technique to solve this problem.

Begin, respectively with vertices from the $\omega = 0$ problem for largest and smallest constants. Call these V_1 and V_2. Draw the two vectors in the complex plane from 0 to V_1 and V_2 respectively, and then construct two normals one pointing counterclockwise, and one clockwise. By pulling these two normals back to polynomial space by the transpose of the evaluation matrix,

$$\begin{bmatrix} 1 & 0 & -\omega^2 & 0 & \omega^4 & \dots \\ 0 & \omega & 0 & -\omega^3 & 0 & \dots \end{bmatrix}$$

we can obtain "objective functions" for use in an LP step for, respectively, maximum and minium angle of rotation. Note that the objective function changes from vertex to vertex.

Since the image of the polyhedron changes smoothly as the frequency is swept along the imaginary axis, there should be only occasional changes in vertex, and in general, we should see only single pivots required when there is a vertex change needed. Finally, we simply test for the presence of a "0-penetration" of the convex set Q($j\omega$) by testing the size of the angular opening:

$$\text{Max(angle)} - \text{min(angle)} < \pi$$

is necessary and sufficient for global stability of Q.

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GENERATION OF CIRCUMFERENTIAL VELOCITY CONTOURS ASSOCIATED WITH PULSED POINT SUCTION ON A ROTATING DISK

by

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Numerous experimental studies have been conducted on the steady, three-dimensional boundary layer over a disk rotating at constant angular speed in an otherwise undisturbed fluid. The subject flow geometry is of interest because it provides a relatively simple way to study the cross-flow instability phenomenon which occurs in three-dimensional boundary layers, as on swept wings. This flow instability results in the formation of a stationary spiral vortex flowfield over the disk, as shown by Wilkinson and Malik. Using a hot-wire probe, they mapped out the spatial wave pattern of stationary vortices, which filled the entire circumference of the disk. The subject flow instability caused transition-to-turbulent flow as the periphery of the disk was approached.

The effect on receptivity and transition of discrete disturbance modes, such as three-dimensional roughness elements and acoustic excitation, has been investigated. The present study--an extension of the work of Wilkinson and Malik--is focused on the effect of pulsed point suction on flow instability and transition, and, consequently, on the classical stationary vortical flow pattern.

The rotating-disk apparatus used in conducting the present experiment consisted of an optical-quality flat-glass disk (diameter = 33.0 cm, thickness = 2.8 cm), an air-bearing drive system and a two-axis traverse mechanism with a single-element hot-wire probe. Two diametrically opposed holes (for dynamic balance considerations) were located at a radius of 90 mm; however, only one (at θ = 0 deg., see Fig. 1) was connected to the suction source--an acoustic horn driver. A fluid bath was used to seal the suction path in order to eliminate physical contact between the suction piping and the suction source. The disk/air-bearing drive system was mounted rigidly to the laboratory floor in order to eliminate mechanical vibration of the apparatus. A two-axis traverse mechanism was mounted on a horizontal rail located approximately one disk diameter above the disk. A single, linearized hot wire was used to measure velocity fluctuations in the disk boundary layer. The wire element was oriented parallel to the disk surface and aligned in the radial direction (at z = .86 mm) to facilitate measurement of the circumferential component of velocity.

The present experiment involved operation of the disk at a constant rotational speed of 1193 rpm, with the initiation of the suction pulse (duration of 4 msec) and data acquisition via the hot-wire probe being triggered by a timing pulse from the rotating disk. This allowed synchronization of the suction pulse with the data acquisition period through appropriate delay times and provided for control of the angular region above the disk in which velocity data were acquired. A constant delay time of 43.2 msec between the timing pulse and the start of data acquisition insured that data were acquired over the same angular region above the disk in successive tests (between θ = 54.6 and 320.8 degrees; suction hole position between ϕ = 215.4 and 309.2 degrees). At a fixed value of the radius, 125 time-dependent circumferential velocity measurements were made (beginning at $\theta = 320.8$ deg.) at the rate of 0.3 msec per data point. These 125 measurements are defined as one data record.

The nominal delay time of 18 msec between the disk timing pulse and the initiation of the 4 msec suction pulse was incremented 79 times (each time by 0.3 msec) to provide suction pulse delay times between 18 and 41.7 msec. Thus, at a fixed location (r, θ, z) above the disk within the data acquisition region, 80 measurements of the time-dependent circumferential velocity were recorded, which represented the velocity at that point at 80 discrete times (between the initiation of the suction pulse and when the point in question was spatially coincident with the hot-wire element). The 80 values of velocity at the neighboring point (same r, z; smaller θ) began and ended 0.3 msec later in time. In this manner, 80 data records were acquired at each of 70 values of the radius (between r = 90 and 159 mm) providing a total of 700,000 measurements (125 x 80 x 70) of velocity. These data were acquired by a PC-based data acquisition system, stored in data files, and transferred to a SUN computer system for processing.

Processing of the data involved development and execution of an algorithm which scanned each of the 80 data records (at each radius of interest) to identify and retrieve all velocity data corresponding to a specific elapsed time from the onset of the suction pulse and stored the data in a 80 by 70 array (assuming data at each of the 70 values of the radius were of interest). Three-dimensional graphs (u as a function of r and θ at fixed z and elapsed time) were then constructed (see Fig. 2 for unsmoothed data plots) for specified values of the elapsed time using the PV-WAVE graphics software. Finally, a bicubic spline interpolation technique is to be applied to the data (after appropriate modifications--identified bicubic spline algorithms require rectangular data grids, as compared to the polar grid in the subject data set) in both the r and θ directions in order to obtain smoothness in the data.

Sample unsmoothed circumferential velocity contours are presented in Figure 2 at fixed values of elapsed time (and z). These contours show the outward (in r) and circumferential (toward decreasing θ) convection of the wave packet formed as a result of the present boundary-layer perturbation.

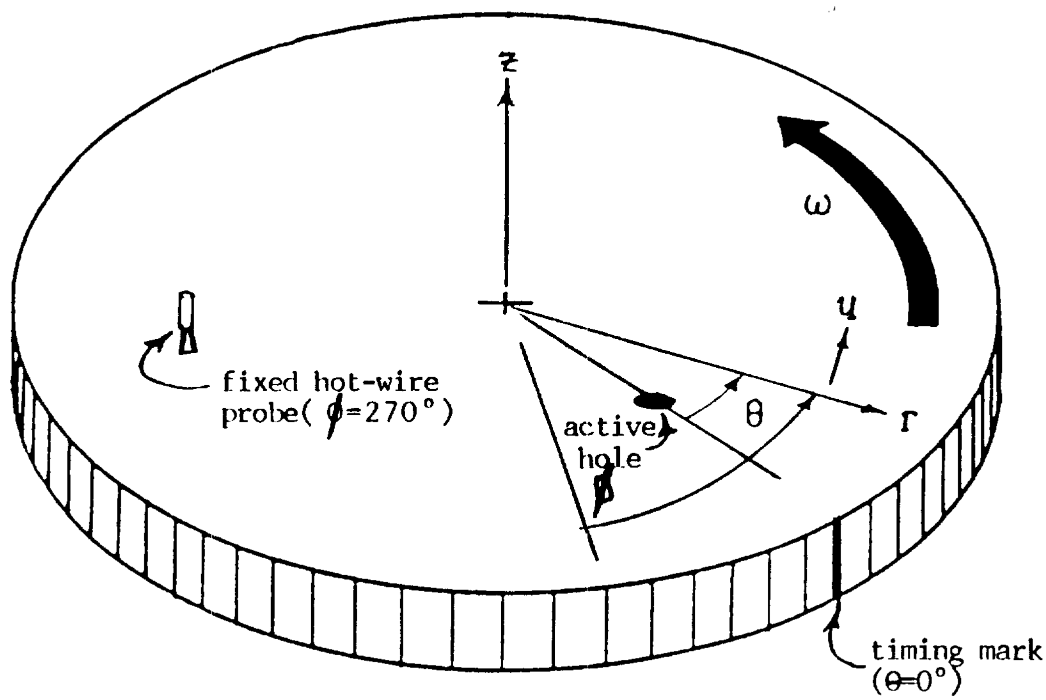
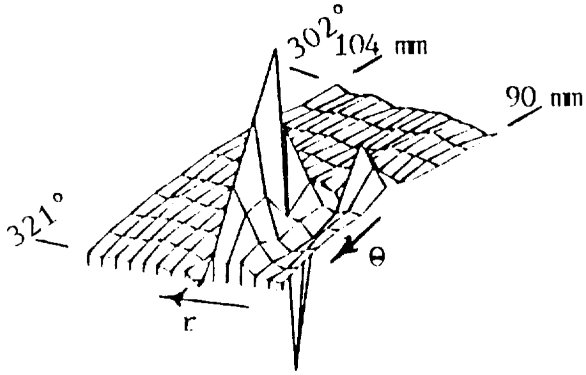
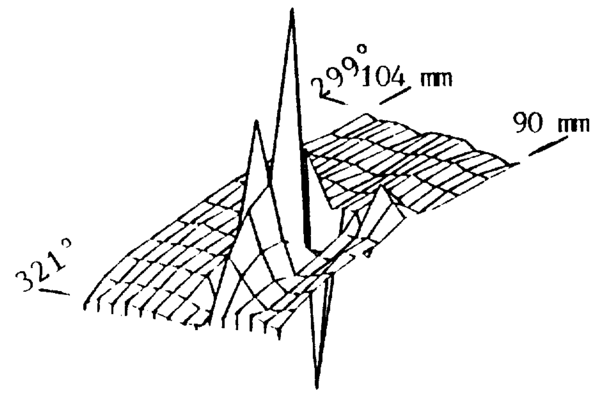


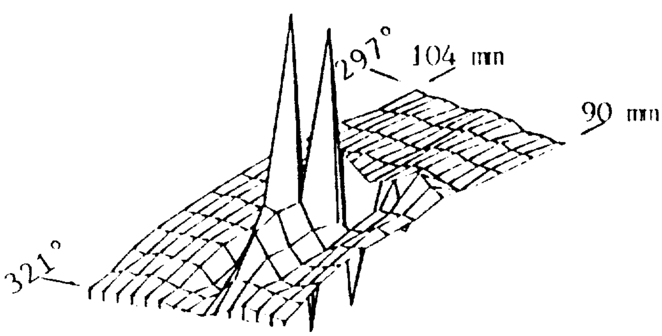
Figure 1. Rotating-Disk Coordinate Systems (θ in rotating system; Ø in laboratory-fixed system)



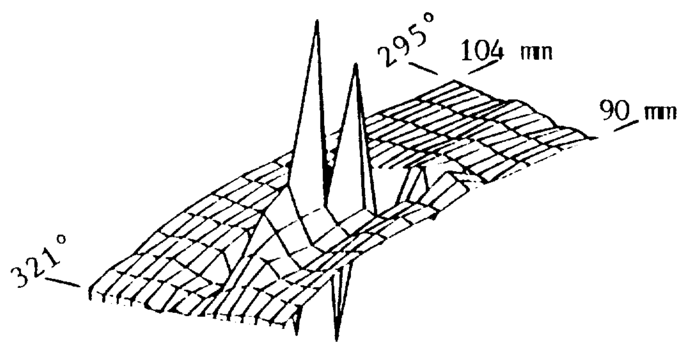
a) t=4.2 ms



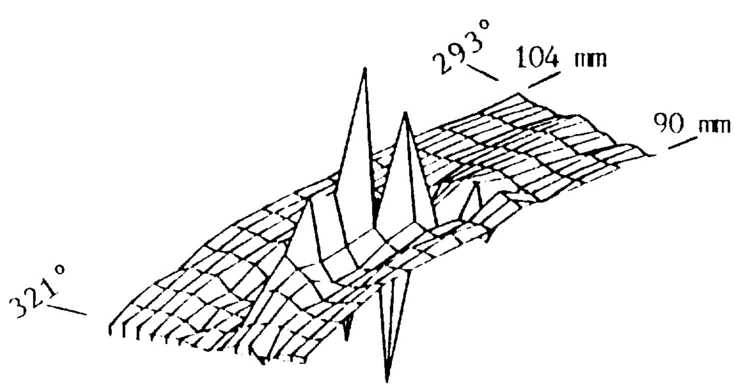
b) t=4.5 ms



c) t=4.8 ms



d) t=5.1 ms



e) t=5.4 ms

Figure 2. Circumferential Velocity Contours at Z=.86 mm and Various Elapsed Times after Initiation of Suction (arbitrary vertical scale; active hole at $\Theta=0°$)

N90-25066

CLOUD FIELD CLASSIFICATION BASED ON TEXTURAL FEATURES

BY

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ABSTRACT

An essential component in global climate research is accurate cloud cover and type determination. The type classification can be done by multispectral/textural methods. Of the two approaches to texture-based classification (statistical and textural), only the former is effective in the classification of natural scenes such as,land, ocean, and atmosphere. The reason lies in the fact that in the latter, visual scenes are analyzed in terms of the organization and relationships among its substructures. These aspects are transparent in man-made objects, but not so in natural scences. In contrast, in the statistical approach that we have adopted, parameters characterizing the stochastic properties of the spatial distribution of grey levels in an image are estimated and then used as features for cloud classification.

Two types of textural measures have been used in this study. One is based on the distribution of the grey level difference vector(GLDV), and the other on a new set of textural features derived from the MaxMin cooccurrence matrix (MMCM).

The GLDV method looks at the difference D of grey levels at pixels separated by a horizontal distance (assuming isotropy) d and computes several statistics based on this distribution. These are then used as features in subsequent classification.

The MaxMin textural features on the other hand are based on the MMCM, a matrix whose (I,J)th entry gives the relative frequency of occurrences of the grey level pair (I,J) that are consecutive and thresholded local extremes (see fig.1) separated by a given pixel distance d. Textural measures are then computed based on this matrix in much the same manner as is done in texture computation using the grey level cooccurrence matrix.

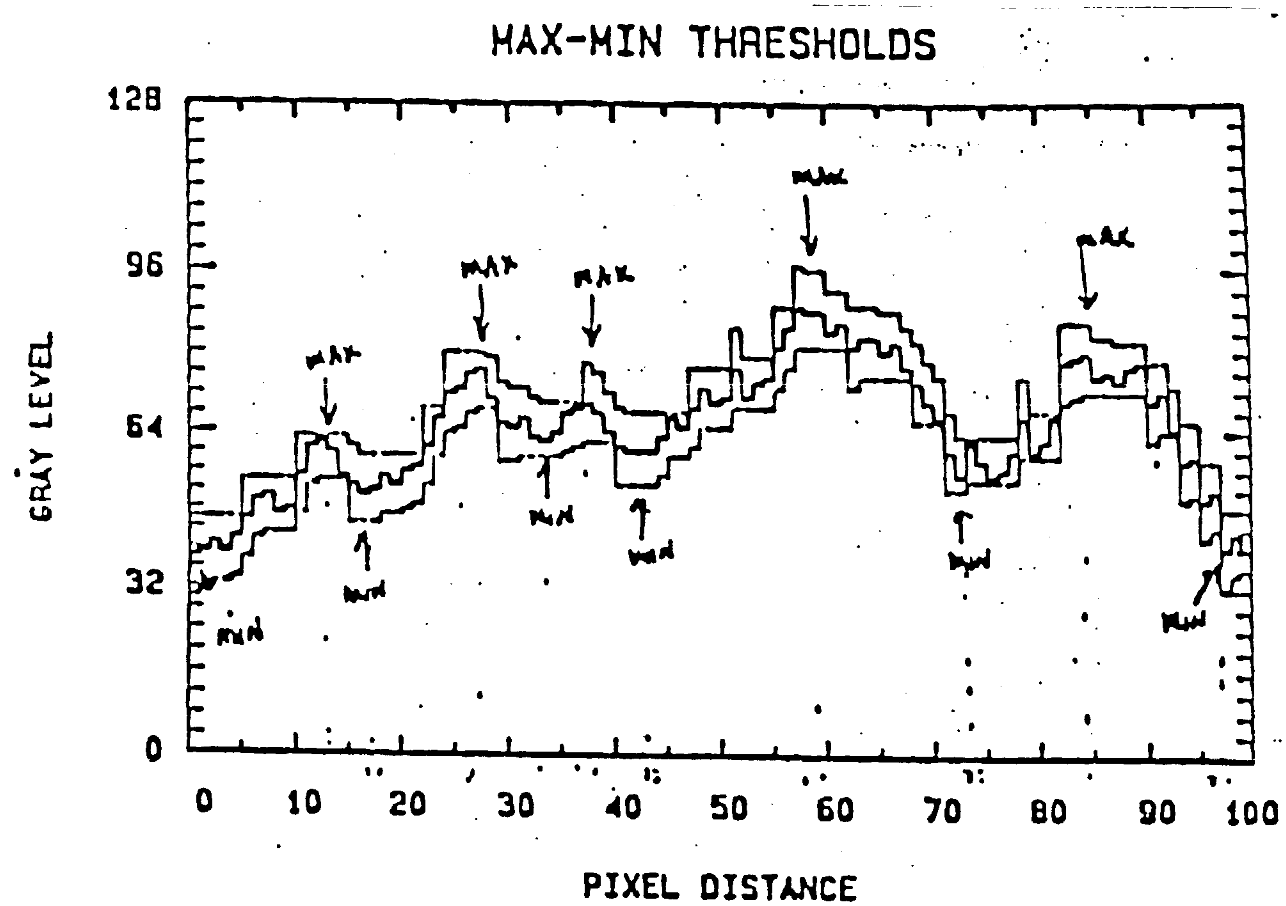
The database consists of 37 cloud field scenes from Landsat imagery using a near IR visible channel. Among these there are 15 stratocumulus, 10 cumulus, and 12 cirrus scenes. Each scene has been subdivided into 20 subregions with each subregion representing a sampling unit. Approximately one third of the scenes chosen at random from each type has been set aside for testing the classification accuracy using a Jackknife validation procedure. The subregions in the remaining scenes of each type have been used for training the two classifiers. The classifiers are based on features computed from the GLDV distribution and from the MMCM distribution respectively. The texture features for each sampling unit have been computed for different horizontal separations d (d = 1,2, .. pixels). The operation has been repeated at different levels of resolution of the scenes, obtained by progressive spatial averaging of 2 x 2, 4 x 4, ... pixels. Features have also been combined by using combinations of the values of d (such as, d=1,2; d= 1,4; d= 1,2,3; ...etc.) providing more features available for use by the classifiers.

The classification algorithm used in this study is the well known Stepwise Discriminant Analysis. This combines the two steps in a classification procedure, feature selection and construction of the linear discriminant functions, into one. The algorithm, although suboptimal, is known to have worked well in various applications. We have implemented this by the BMDP(TM) package using the procedure BMDP7M.

The overall accuracy has been estimated by the percentage of correct classification in each case.

It turns out that both types of classifiers, at their best combination of features, and at any given spatial resolution, give approximately the same classification accuracy, viz. between 84 to 90 per cent. However, at lower spatial resolution, the best performance appears to be slightly better in the case of the MMCM based classifier. (see figs. 2 and 3)

In an ongoing work, we are using a Neural Network based classifier with a feed forward architecture and a back propagation training algorithm to increase the classification accuracy, using these two classes of features. Preliminary results based on GLDV textural features alone look promising in two ways. First, the clssification accuracy has gone up to 93%. Second, the percentage of sampling units needed for training the classifier to attain this level of accuracy is only 20%, compared to 67% of the training samples needed when we use the GLDV based features in our classifier.



<u>Fig. 1</u>: Operation of the MAX-MIN algorithm for a representative cumulus cloud segment.

Classification Accuracy Plot

Maxmin Coocurrence Texture

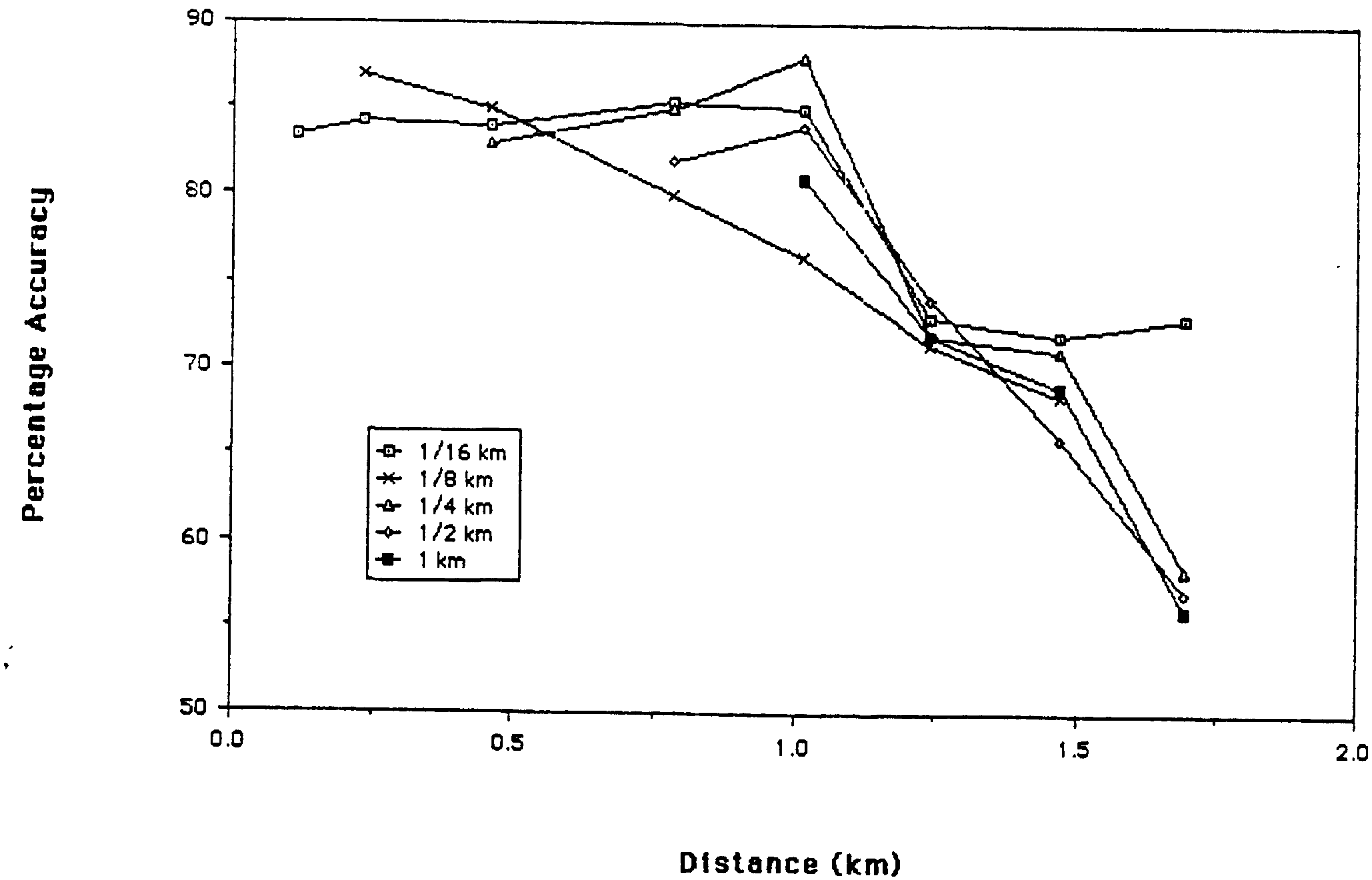


FIG 2

CLASSIFICATION ACCURACY
USING GLDV TEXTURE

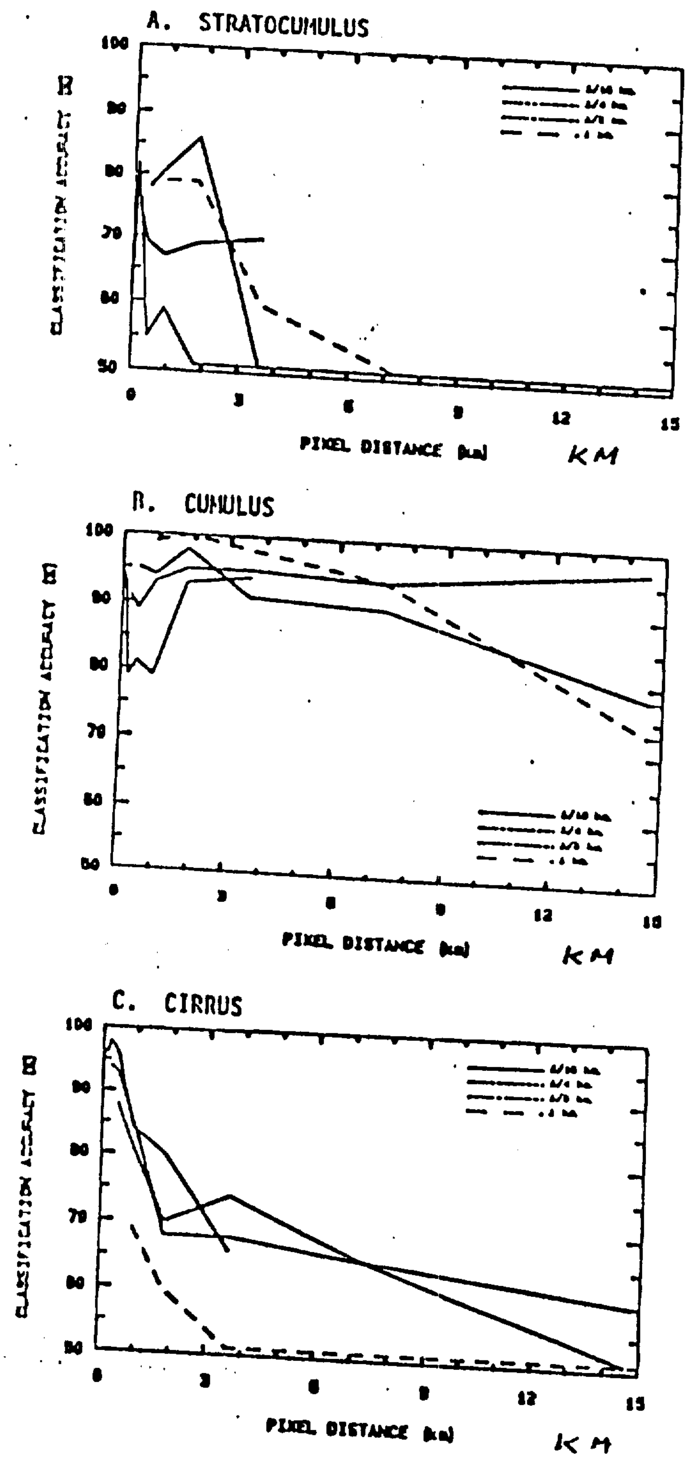


Fig. 3: GLDV classification accuracy for stratocumulus, cumulus, and cirrus as a function of pixel separation and spatial resolution.

N90-25067

COMPUTATIONAL SIMULATION OF TRANSITION TO TURBULENCE THROUGH INVERSE MODELING

by

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The phenomenon of flow transition to turbulence has been intensely studied for several decades owing to its important influences on many practical systems in addition to the intrinsic scientific interest in the subject. Progress in the understanding of this difficult topic during the past decade has been achieved primarily through dramatic advances in computer technology on the one hand, and through refined experimental techniques (such as the LDV) on the other hand. Important applications of transition prediction range from the design of flow conditions upstream of the NASP scramjet inlet to the computation of heating environments influencing turbine blade performance and lifespan. The present investigation has focused on a computational methodology for the fundamental case of transition in channel flow, in which recently published experimental data are utilized both as a stimulus and as a measure of merit of the method.

The research has proceeded along three avenues in parallel. The first task has consisted of the development and verification of a computer code which calculates the mean evolution of flow in a channel similar to the one employed experimentally by Blair and Anderson [1]. For simplicity, but without loss of essentials, the channel is restricted to have planar sloping walls, such that the mean flow is symmetrical about the centerline. The appropriate incompressible boundary layer equations are recast into dimensionless form in terms of a mean streamfunction, in which an invariant mean Reynolds number and the wall slope comprise two external parameters. One advantage to this streamfunction formulation lies in the imposition of an additional boundary condition, which represents the conserved total mass flux in the channel. This additional boundary condition provides an unusual means for calculating the varying local pressure gradient, which normally must be externally prescribed in a boundary layer analysis. As part of this task, an analytical test case has been created for the dual purposes of code verification and of highlighting the interactions between the Reynolds stress and the mean velocity profile. This test case generates a Reynolds stress by the residue in the momentum equation which is produced by a typical analytical velocity profile. By a substitution of this Reynolds stress into the appropriate code module, the correctness of the code may be verified, along with the accuracy of the computational method. For ease of quick implementation, the chosen method has consisted of an iterative integral scheme which is coupled with an upwind differencing algorithm in the streamwise direction.

The second task pursued during this research period has involved the development of a triple layer model for the Reynolds stress profile, which has been suggested and derived from experimental velocity profiles. It is demonstrated that the innermost length scale is based on the local friction velocity, the intermediate layer corresponds to the usual logarithmic "law of the wall" region in which the normalized Reynolds stress is approximately unity, and the outermost layer is represented by a closed mathematical form depending explicitly on the velocity profile in the wake region. Further development and implementation of this model will continue to the end of this research period and further pursuit will be proposed.

The third task has been comprised of scrutiny of the excellent database developed by Blair and others, and the planning of its incorporation into the transition analysis. These extensive measurements indicate that turbulent statistics in the transition regime may be considered to alternate between laminar and fully turbulent types, the proportions of which are quantified by a measured intermittency function. The downstream part of this intermittent description appears to fall in good agreement with the commonly quoted Gaussian form, whereas certain deviations are noted in the initial stages of transition. The strategy for transition modeling suggested in the present study involves the application of the triple layer Reynolds stress as factored by the intermittency function. Although this procedure is clearly semi-empirical, and it will rely on further information concerning transition onset, it is believed to comprise an effective computational characterization of the transition regime.

Recommendations for continued investigation fall into two categories. First, through the rapidly developing avenue of direct simulation by spectral methods, a reliable criterion should be sought for initial transition onset, which could be implemented in the present methodology. Direct simulation computations are currently adding insights to the transition phenomenon, which have not been possible in the past. However, these computations become excessively consuming in the last stage of transition even with current capabilities. Second, the study of the triple layer formulation ought to be pursued to a more mature completion. The initial results of the present study show promise of producing a practical engineering tool. Results of the methodology have yet to be compared sufficiently with the available data.

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EXPANSION AND ORTHOGONALIZATION OF MEASURED MODES FOR STRUCTURE IDENTIFICATION

by
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Abstract

Large flexible orbiting space structures, like the Space Station, cannot be assembled and tested on the ground due to their size and flexibility and due to the 1-g environment. Structure property identification and test/analysis correlation to validate math models of the structure must be performed from on-orbit tests. However, on-orbit measurements are typically made at only a few (p) structure points for only a few (m) dynamic response modes, while the finite element model to be validated will have many (n) degrees of freedom (dofs). The math model of the structure is often reduced to p dofs for the purpose of test/analysis correlation, but physical relationships that contributed to development of the n dof model may be lost. Another option is to expand the measured mode shape vectors from p dofs to n dofs, as an estimate of the full mode shape vector. Also, full mode shape vectors are often required to be orthogonal with respect to the structure mass matrix. Subsequent orthogonalization of the expanded vectors is necessary or a simultaneous expansion/orthogonalization technique is required.

The purpose of the work this summer was to investigate a new simultaneous expansion/orthogonalization method in comparison with two previously published expansion methods and a widely used orthogonalization technique. Each expansion method uses data from an analytical model of the structure to complete the estimate of the mode shape vectors. Berman and Nagy [1] used "Guyan" expansion in their work with improving analytical models. In this method, modes are expanded one at a time, producing a set not orthogonal with respect to the mass matrix. Baruch and Bar Itzhack's [2] optimal orthogonalization procedure was used to subsequently adjust the expanded modes. A second expansion technique was presented by O'Callahan, Avitabile, and Reimer [3] and separately by Kammer [4]. Again, modes are expanded individually and orthogonalized after expansion with the same optimal technique as above. Finally, a simultaneous expansion/orthogonalization method was developed from the orthogonal Procrustes problem of computational mathematics [5]. In this method, modes are optimally expanded as a set and orthogonal with respect to the mass matrix as a result.

Two demonstration problems were selected for the comparison of the methods described above. The first problem is an 8 dof spring-mass problem first presented by Kabe [6]. This problem, shown in Figure 1, is used often in the literature to demonstrate system identification techniques. Several conditions were examined for each expansion method including the presence of errors in the measured data and in the analysis models. "Guyan" expansion with orthogonalization and the simultaneous expansion/orthogonalization method performed comparably, both slightly better than the second method.

As a second demonstration problem, data from tests of a laboratory scale model truss structure [7] was expanded for system identification. The test article, shown in Figure 2, exhibits characteristics expected for large space trusses (ie. closely-spaced frequencies, low damping, among others). Tests with a complete structure provided a correlated analysis model and the stiffness and mass matrices. Tests of various damaged

configurations (one member removed for each case) produced measured data for 6 modes at 14 dof locations. To date, the measured data is expanded and the quality of the resulting full modes is being studied. Optimal-update system identification methods are being applied to determine the damage location.

There are several areas where work needs to be done to advance the field of structural identification using expanded modes. Of prime interest is the selection of dofs to be measured in a test. Expansion and identification are expected to depend considerably on the measured subset. Also, the quality of the measured mode shape data and its effect on the methods discussed should be investigated.

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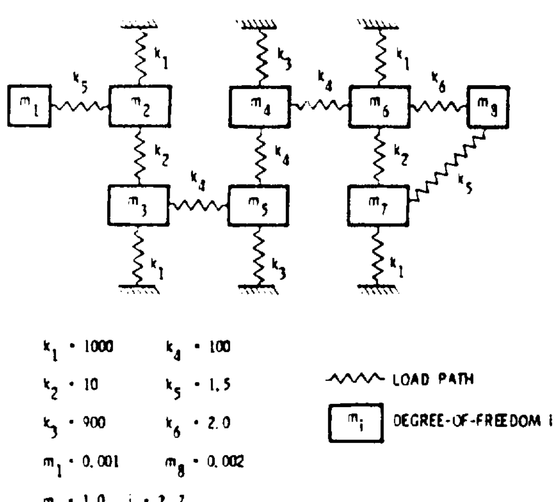

Fig. 1 Analytical test structure.

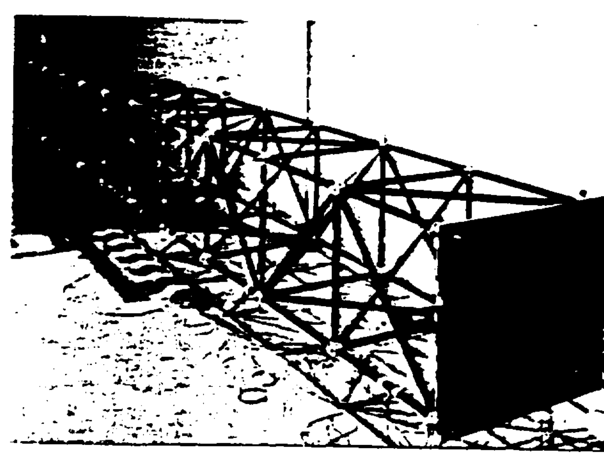

Figure 2. Ten-bay Generic Scale Model Truss Structure

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N90-25069

PROCESSING POLYMERIC POWDERS

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ABSTRACT

Background

The concept of uniformly and continuously depositing and sinter-fusing nominal 0.1 to 40 micron dimensioned electrostatically charged polymer powder particles onto essentially uniformly spread 5 to 20 micron grounded continuous fiber tow to produce a respoolable thermoplastic composite tow-preg was formulated at NASA Langley last summer [1]. The process was reduced to practice under a NASA grant at the University of Akron this spring. The production of tow-preg is called Phase 1. This work continues in Akron.

This summer, the production of ultrafine polymer powders from 5% to 10% (wt) polymer solids in solvent has been considered. This is Phase 0 and is discussed below. The production of unitape from multiple tow-pregs has also been considered. This is Phase 2 and is also discussed below. And another approach to Phase 1, also proposed last summer, has been scoped. This is Phase 1A and is also discussed below.

Phase 0 - Spray Drying

Most high-performance thermoplastic polymers are produced in solvent. LaRC TPI is available in an amic acid state in either diglyme, DMAC or n-MP. At solids contents of 5-10% (wt), the solution has syrup-like consistancy. Spray drying is one way of producing very fine powder from the first two solvents. Spherical particles of <1 to 20 microns were produced by air atomizing a solution through a conventional paint gun into a 5-liter heated reaction vessel [2], Figure 1. Powders of this particle size range are ideal for the Phase 1 powder coating facility. In the current scoping process, the powders appear to have some residual solvent. They fuse and change shape when washed with water, a standard solvent extraction fluid. A larger spray dryer with proper spray heads, tangential air flow and proper particle collection equipment is now being designed [3]. The development of this prototype facility will allow in-house production of small quantities of powder from experimental resins. These powders can be used with the current in-house fluid bed tow-pregging system or with the Akron electrostatic system.

Direct spraying of 5% solution of LaRC TPI in diglyme and DMAC onto spread tow, then oven-drying the tow, yielded very uniform coating with surprisingly good fiber bundle penetration. The amount of solids that can be applied in a single pass is small. As a result, multiple stages are required. This technique remains unscoped.

Phase 1A - Wet Sand Tow-Pregging

Coating of water-wet fibers with dry powder was probed briefly last summer, in what was called the "wet sand" approach [4]. This year, spread tow was first exposed to moisture from a home humidifier. Then dry LaRC TPI powder was aspirated with nitrogen and blown directly against the damp tow surface. Multiple applications yielded up to 40% (wt) resin on the spread tow. The final dampened tow-preg was then sinter-fused in a tube furnace. Although some powder was shaken off in handling, the final tow-preg contained 31.6% (wt) resin. The penetration was quite good despite the crude manual process and the coarseness of the powder used for the experiments.

The aspiration system used here was the same one proposed for the electrostatic coater last year [4]. This system was recommended as a possible replacement for the NASA fluidized bed.

Phase 2 - Consolidation to Unitape

The original intent of this summer's work was to determine the contact time, temperature and pressure needed to produce a prepreg from multiple tow-pregs. Some simple contact heating experiments using a soldering iron and a hot plate yielded interply temperature profiles. A finite difference computer program was developed for the two-dimensional moving heat source heat conduction problem with direction-dependent thermal conductivities. The model agrees reasonably well with the data, Figure 2. From this model, the interply temperature can be determined as a function of the velocity of the unitape under the contact heater. The dimensions of the contact heater can be then ascertained, knowing the time for autohesion [5].

A Minnesota company [6] has loaned us a prototype incandescant heater. It has been used to heat multiple tow-pregs to produce a prepreg and to heat individual tow-pregs to reduce boardiness. This company also fabricates electrostatic coating lines and is interested in working with us on Phase 1.

1. This 1988 work was done with A.L. Ogden, now at VPI&SU.

2. This work was done with Dennis Working, PMB/MD, NASA.

3. This work was done with Jim Nelson and Ricky Smith, PMB/MD, NASA, and John Marcello, ODU.

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6. BGK Finishing Systems, Inc., 4131 Pheasant Ridge Rd. N, Minneapolis MN 55434. Personal communication with Rick Ganyo, President, 20 June 1989.

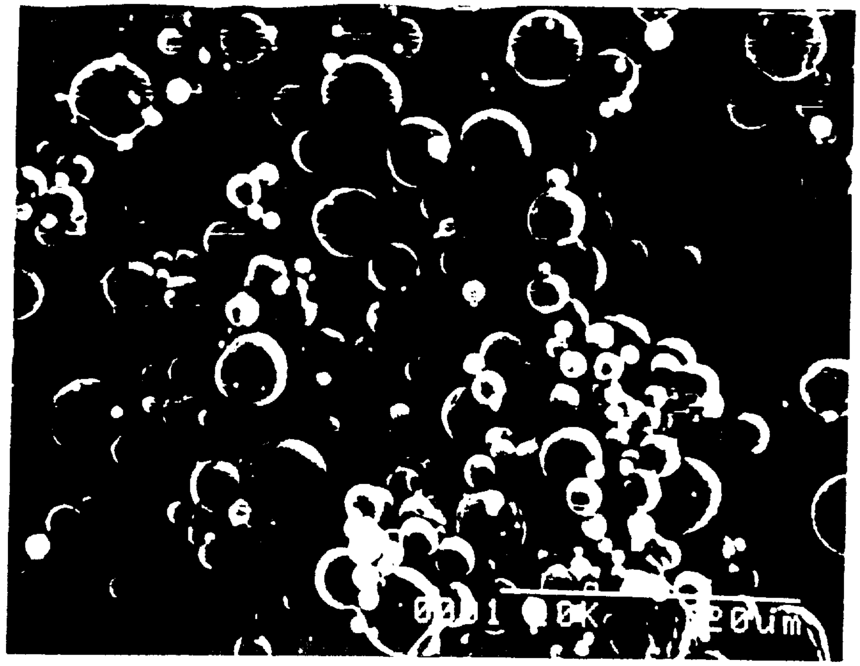

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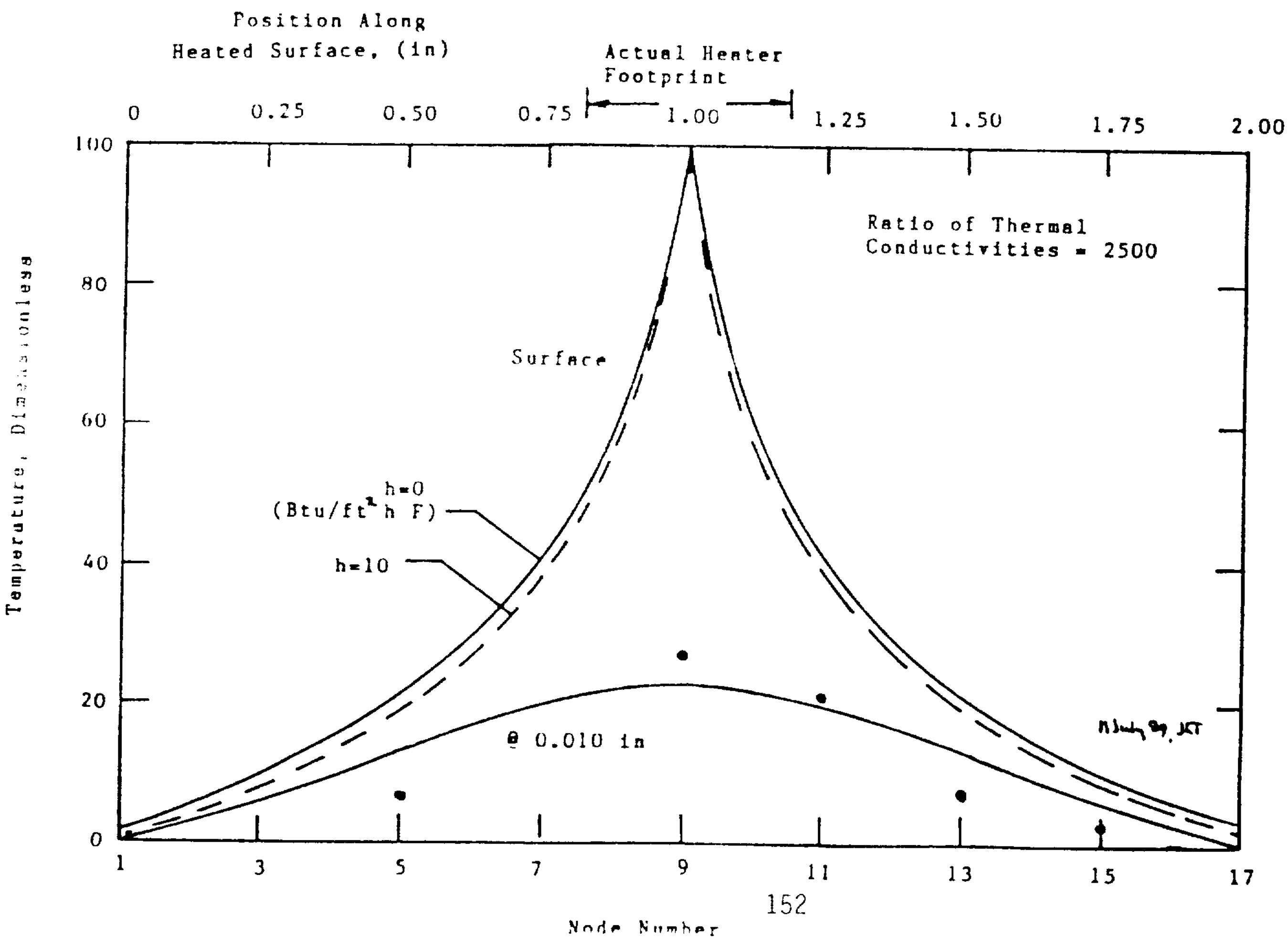
Figure 1. Scanning Electron Micrograph of Particles Recovered from Spraying 5% LaRC TPI in Diglyme and DMAC Through a Commercial Paint Spray Gun into Heated Reaction Vessel. [12 July 1989, with Dennis Working at NASA Langley].

Figure 2. Experimental and Theoretical Dimensionless Temperature Profile Through and Along LaRC TPI-Impregnated Carbon Fiber Tows (Two Plies). Steady State Stationary Heat Source with Thermal Conductivity Ratio, Along Fiber to Cross-Fiber, at 2500. 0.010 Inch Thick Tow-Pregs Produced at University of Akron. Solid Circles: Experimental Data Obtained With Soldering Gun at 720F and Hot Plate at 290F.



N90-25070

OPERATIONS AND SUPPORT COST MODELING USING MARKOV CHAINS

by

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Systems for future missions will be selected with life cycle costs (LCC) as a primary evaluation criterion. This reflects the current realization that only systems which are considered affordable will be built in the future due to the national budget constraints. Such an environment calls for innovative cost modeling techniques which address all of the phases a space system goes through during its life cycle, namely; design and development, fabrication, operations & support and retirement.

A significant portion of the LCC for reusable systems are generated during the operations & support phase (O&S). Typically, O&S costs can account for 60 - 80% of the total LCC. Clearly, O&S costs are wholly determined or at least strongly influenced by decisions made during the design and development phases of the project. As a result, O&S costs need to be considered and estimated early in the conceptual phase. To be effective, an O&S cost estimating model needs to account for actual instead of the ideal processes by associating cost elements with probabilities.

One approach that may be suitable for O&S cost modeling is the use of the Markov Chain Process. Markov chains are an important method of probabilistic analysis for operations research analysts but they have rarely been used for life cycle cost analysis. This research effort evaluates the use of Markov Chains in LCC analysis by developing an O&S cost model for an hypothetical reusable space transportation vehicle (HSTV) and suggests further uses of the Markov Chain process as a design-aid tool.

The HSTV goes through a series of possible life cycle states such as launch preperations, launch attempt, ascent, orbit insertion, orbital operations, deorbit and landing. Once the HSTV is deployed, its utilization is cyclic, with essentially the same sequence of events repeated over and over until eventually it is lost in an acciedent or retired. In Markov Chain terminology ,these last two states are called absorbing or trapping states. Once the HSTV enters an absorbing state its life comes to an end and it will have to be replaced. Each of these possible states are identified and defined as a Markov State and represented by a point. A pictoral map of the HSTV life cycle process is constructed by connecting these points by arrows which represent the possible transitions and associated probabilities. These probabilities can be developed from reliability analysis of the HSTV or from operational considerations. In keeping with the ground rules of the Markov Process, the probability of going from any one state to another is assumed to be constant and dependent only on the particular state in question, independent of recent history and exegenous factors such as weather.

It follows by intiution that in the long run, the HSTV will eventually enter either one of the two possible absorbing states, being lost in an acciedent or retired from service. The number of successful launches before HSTV enters a trapping state represents the expected life of the vehicle. This number and the expected number of visits to each state before entering an

C-3

absorbing state is computed utilizing the mathematics of the Markov Chain theory. In the next step, the total O&S costs is established by multiplying these expected number of visits to each state by the cost associated with each state and summing them up over all the states. Cost per launch is then computed by dividing the total O&S cost by the expected number of successful launches.

The analysis of research results indicate realistically that, when the probability of a loss resulting from a mishap is considered, the O&S costs are considerably higher than an ideal success oriented path. Furthermore, the expected life of the HSTV is very sensitive to variations in the probability of entering a trapping state. This finding is significant in the sense that it suggests further uses of the Markov Chain analysis as a spacecraft design aid tool. The same approach can effectively be used in comparing different designs in terms of LCC and predicting the reliability requirements to meet a desired operation life. The information obtained from O&S cost analysis using Markov chains can also be used for resource and work planning at each state.

In conclusion, the Markov Chain Process is a powerful tool that can effectively be used in many life cycle cost analysis situations.

N90-25071

Mars Rover Imaging Systems And Directional Filtering

Research Activities Summary

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On July 20, 1989 as suggested by my NASA research colleague Mr. Friedrich O. Huck, I attended a three day conference on Visual Information Processing for Television and Telerobotics (May 10-12, 1989) sponsored by NASA. Professor Surendra N. Tiwari's suggestion of an earlier contact certainly yields a good return in this case. My research task got a quick start. Computer literature searches were carried out both at Duke University and NASA Langley Research Center. The purpose is to enhance my personal knowledge based on the technical problems of pattern recognition and image understanding which must be solved for the Mars Rover and Sample Return Mission. My intensive study effort of a large collection of relevant literature resulted in a compilation of all important documents in one place. Futhermore, they are being classified into (i) Mars Rover (ii) Computer Vision - Theory (iii) Imaging Systems (iv) Pattern Recognition Methodologies (v) Other smart Techniques (AI, Neural Network, Fuzzy Logic, etc.). Our graduate student Perry Cornelius working for Dr. John Cleland of RTI on NASA's project dealing with technology transfer has been able to utilize this collections during this summer.

A decision was made jointly by Mr. Huck and myself that I should put my major effort to identify meaningful research problems of pattern recognition and image understanding relevant to the proposal entitled "Rover Imaging Systems for the Mars Rover/sample Return Mission". This proposal with Mr. Friedrich O. Huck as principal investigator, in my opinion, is one of the very best I have ever read. Clarity in presentation, precision in technical and high information contains in text body. So far as I was able to observe, many papers concerning various issues have been written about the Viking Lander project already. However, much progress in technology has taken place since the Viking Lander landed. This is particularly true for the computer vision field. So far as computer vision aspect of the Viking Lander project is concerned, the only scenes that could be dealt with were static and essentially two-dimensional in most instances. Azriel Rosenfeld recognizes three viewpoints for computer vision:

(i) Computational Vision: modeling biological visual systems

(ii) Machine Vision: solving practical problems

(iii) Image Understanding: deriving descriptions of the scene

My experience and interest although are primarily within the scope of (iii), However, the relevancy of (i) and (ii) are very crucial if we want to do a good job in (iii) as we shall explain later. If computer vision is regarded as a science in its own right, its central goal, as pointed out by Azriel Rosenfeld, is to obtain a description of the scene that is as complete and correct as possible. This includes both "recovery" of scene geometry and recognition of objects that may be present in the scene. For Mars Rover project, these problems are hard because they involve "object" classes that are difficult to define. To include the researcher such as Steven W. Squyres, Center for Radiophysics and Space Research of Cornell University is an excellent idea because without his expertise, I don't believe the image understanding problem is meaningful.

Looking back, the analysis of Viking Lander data either relies heavily on statistical methodologies or as in many cases studies heuristic in nature. It is important to point out that scenes containing natural objects such as crater, rocks or even lava flows are much harder to handle, because such object classes are hard to define. Recognizing the advances in pattern recognition, AI, neural network, fuzzy logic and other techniques, we can expect to do much better for the Mars Rover project. In addition, methods of handling three-dimensional scenes and time-varying scenes may prove to be very important to the Mars Rover project. I am currently looking for some potential applications as I study Mr. Huck's proposal.

NASA sponsored a workshop in 1988 entitled "Neural Networks and Fuzzy Logic" at Johnson Space Center. It is worthwhile to mention in passing that my student has completed his Ph.D degree dissertation at Duke University in the reseach area of fuzzy logic and another student is in the process of writing dissertation in the area of neural network jointly directed by Professor Jack Rebman and myself. I believe both technologies are very much relevant to Mars Rover project in other application areas if not in computer vision.

During early July of 1989, A conference between Mr. Huck and myself convinced both of us that the problem of high compression image coding via directional filtering perhaps is worthy of our research effort. This problem has become my number one priority on the list ever since. The combination of transform domain coding of the low frequency component and spatial domain coding of the directional components led to the compression ratios higher than 30 to 1. As has been claimed by some researchers, this is quite remarkable because the conventional techniques offer the compression ratios of 5 to 8 for non adaptive schemes and can go up to 16 at best for adaptive schemes.

Progress in computer vision, including picture transmission has depended on the steady increase in available computer power and speed. Still largely lacking is a theoretical framework for designing solutions to computer vision problems. The compression image coding problem just mentioned is a case in point. After an enormous amount of work in this topic, some researchers decided to take a drastic change of direction which ultimately lead to a drastic improvement in performance. This novel approach has two distinguished lines of thinking: (1) Making the use of a better understanding of the human visual which has just happened recently. (2) Spatial domain interpretation: the property of some transforms (such as 2 dimensional Fourier transformation, to distribute the energy of an image in a way that it is more adequate for coding than the spatial distribution.

My research effort since early July focus on the fundamental issue of designing such a filter. However, the further study of the extension of information theory into two dimensions is needed because one can not design a filter without a thorough understanding of the natural phenonmena. I have begun some mathematical derivations which hopefully, will lead to a better understanding and the design of the "directional filters". Two aspects have been quite clear to me that these analytical works are going to be useful: (i) Mathematical results would help to explain some statements made by various researchers which are but intuitive and heuristic in nature. (ii) New interpretation and insight are possible after these mathematical results are graphically displayed via digital computers. I sincerely hope it is possible for NASA to provide some funds for me to continue my work, which has just begun.

Simultaneous Structure/Control Synthesis with Nonnegligible Actuator Mass

David C. Zimmerman
Department of Aerospace Engineering
University of Florida
Spacecraft Control Branch

Future spacecraft and space structures are envisioned to be quite large by current standards. In consideration of the cost of transporting material into space, these spacecraft will most likely be lightweight, relatively flexible, and lightly damped. Thus, small disturbances may cause large amplitudes of vibration at low frequencies. Although the passive damping found in these structures may be an important dissipative mechanism, the need to meet stringent spacecraft performance criteria may require the use of active vibration control. The overall performance of an actively controlled structure can be enhanced by designing both the structure and controller simultaneously. This summers work has focused on the case where the mass of the actuators that are needed to implement the control law has a significant effect on the overall structural dynamics.

A nonlinear optimization problem is posed in which the RMS pointing error of the structure after a slew maneuver has been completed is minimized subject to constraints on the total mass of the spacecraft and its' fundamental frequency. One may envision that the structure could be designed light, and is therefore highly flexible. This would then require a large control effort to maintain performance, with a corresponding large actuator mass. Therefore, the total mass of the spacecraft would be the sum of a small structural mass and a large actuator mass. At the opposite extreme, one could envision the structure to be heavy and relatively stiff. Therefore, only a small control effort would be required to maintain performance, with a corresponding small actuator mass. Thus, the total mass of the spacecraft would be the sum of a large structural mass and a small actuator mass. The nonlinear optimization procedure is then used to investigate what the optimal tradeoff is between structural and actuator mass from a performance point of view.

The initial aspects of this work has investigated how to determine the required actuator mass in a physically meaningful manner. The calculation of the actuator mass is based on the expected worst case time optimal rigid body slew maneuver. The mass calculation is dependent on the specifics of the maneuver, the flexible control law gains, and the actuator mass to torque (or force) ratio. The methodology used is to determine in modal space the time to peak displacement and velocity on a mode by mode basis. With the peak times in hand, one can then determine the peak modal displacements and velocities. It is then assumed that the peaks occur at the same time and add in the worst possible manner. This assumption leads to a conservative actuator mass approximation. Because the actuator mass calculation will comprise the innermost loop in the optimization procedure, the balanced realization model reduction technique [Moore, 1981] is employed to reduce the computational burden.

Figure 1 shows the overall flow of the simultaneous structure/control methodology. Both structural (dimensions) and control (gains) parameters are adjusted by the optimizer to minimize the RMS pointing error of the structure. The inner iteration loop between the FEM of the structure, the LQR control design and the actuator mass calculation essentially tightens the coupling of the structure and control designs. To further reduce the computational burden of the inner loop, first and second order approximations are used for eigenanalysis and LQR control design when the actuator mass change is less than 10% of its previous value.

The methodology is being tested on a generic structure. Experienced gained will have direct application to various ongoing Spacecraft Control Branch projects.

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STRUCTURE/CONTROL PROBLEM

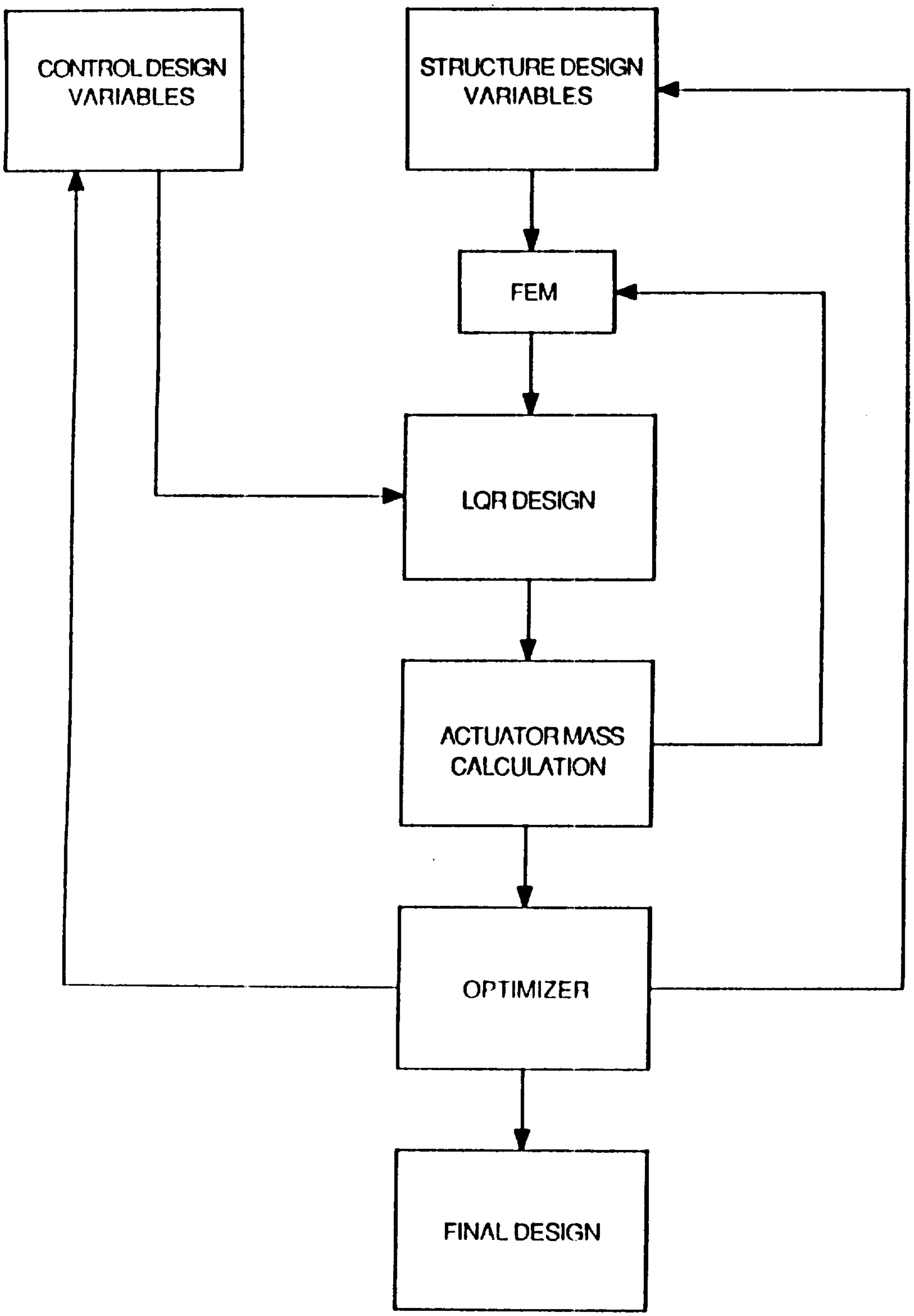

Figure 1

APPENDIX V

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 this summer?

   Very much so ________
   Somewhat ________
   Minimally ________

4. My research colleague and I have discussed follow-on 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 deepening 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 it in a professional publication.
   ______ Heard about it from colleague.
   ______ Other (explain). ______________________________
   ____
   ____

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

   Yes ______ No ______
   ______ DOE
   ______ Another NASA Center
   ______ Air Force
   ______ Army

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

____

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 ($800) 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 with 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 for 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 __________.

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 1990?

   $__________________

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 QUESTIONS

NASA-ASEE

SUMMER FACULTY RESEARCH PROGRAM

QUESTIONNAIRE FOR RESEARCH ASSOCIATES

Please complete and return to Suren Tiwari by August ~~9~~ 15, 1989, NASA MAIL STOP 105A.

1. Would you say that your Fellow was adequately prepared for his/her research assignment?

   YES NO (Circle One)

   Comments: ______________________________

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

   Comments: ______________________________

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

   YES NO (Circle One)

   Comments: ______________________________

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

YES NO (Circle One)

Comments: ______________________________________

____

____

____

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

Comments: ______________________________________

____

____

____

____

Signature ______________________

APPENDIX VI

GROUP PICTURE OF RESEARCH FELLOWS

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

NASA/ASEE SFFP
Summer 1989
List of Attendees

Top Row: Left to Right

1. Dr. Robert Arenburg
2. Dr. Marion Hansen
3. Dr. Johnny Houston
4. Dr. James Throne
5. Dr. Greg Byrd
6. Dr. David Zimmerman
7. Dr. Peyman Givi
8. Dr. Resit Unal
9. Dr. George Henderson
10. Dr. Rex Kincaid
11. Dr. Alan Hernried
12. Dr. Louis Gratzer
13. Dr. William Brewer

Middle Row: Left to Right

1. Dr. Terry Green
2. Dr. Ted Akinyanju
3. Dr. Zia Razzaq
4. Dr. Hari Bidasaria
5. Dr. Shoi Hwang
6. Dr. Yu-Kao Hsu
7. Dr. Marvin Klutz
8. Mr. Herbert Armstrong
9. Dr. Rishi Raj
10. Dr. Paavo Sepri
11. Dr. James Price
12. Dr. Sailes Sengupta
13. Dr. Paul Wang
14. Dr. John Kosmatka

Front Row: Left to Right

1. Dr. Surendra Tiwari
2. Dr. George Rublein
3. Mrs. Debbie Young
4. Dr. Jeng-Nan Juang
5. Dr. Lila Roberts
6. Dr. Joseph Keiser
7. Mrs. Margaret Manning
8. Dr. Moira LeMay
9. Dr. Suzanne Smith
10. Dr. Steven Hooper
11. Dr. Steven Cushing
12. Dr. Walter Gerstle

Not Pictured: Dr. Joseph Hafele
Dr. Danny Liu
Dr. Mark Mear
Dr. Greg Selby

Report Documentation Page

NASA National Aeronautics and Space Administration

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12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Langley Research Center Hampton, VA 23665-5225		13. Type of Report and Period Covered Contractor Report 5 June - 11 August 1989
		14. Sponsoring Agency Code

15. Supplementary Notes

Langley Technical Monitor: Dr. Samuel E. Massenberg

16. Abstract Since 1964, the National Aeronautics and Space Administration (NASA) has supported a program of summer faculty fellowships for engineering and science educators. In a series of collaborations between NASA research and development centers and nearby universities, engineering faculty members spend 10 or 11 weeks working with professional peers on research. The Summer Faculty Program Committee of the American Society for Engineering Education supervises the programs. Objectives: (1) To further the professional knowledge of qualified engineering and science faculty members; (2) To 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 Fellows' research topic. The lectures and seminar leaders will be distinguished scientists and engineers from NASA, education or industry.

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