

# ICAM

Institute for Computational and  
Applied Mechanics

## ACTIVITIES AND ACCOMPLISHMENTS OF ICAM

BY

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## SUMMARY

A brief historical background on establishing the Institute for Computational and Applied Mechanics (ICAM) is presented and basic goals and objectives are discussed. It is emphasized that the goal of the ICAM has been to develop and maintain a self-sustaining center of excellence in computational methods at Old Dominion University (ODU). Information is provided on funding sources and budget disposition, recent activities and accomplishments, list of graduate students supported on the program, and number of students who received graduate degrees (M. S. as well as Ph.D.). Information is also provided on research coordination with various scientists and engineers, and on different reports specifically written for ICAM.

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## INTRODUCTION

The essential background information, basic goals and objectives, and plans for the operation of the "Institute for Computational and Applied Mechanics (ICAM)" are given in the original proposal to the National Aeronautics and Space Administration (NASA) - Langley Research Center and the State Council of Higher Education-Commonwealth of Virginia (SCHEV). These are included in the first report of ICAM, ODU/ICAM Report 84-101, January 1984. However, certain basic material and background information are provided here for the convenience of the reader and continuity of the report.

With increasing national and international interests in computational methods, certain NASA Langley scientist and Old Dominion University (ODU) faculty started discussing the possibility of some kind of joint effort for education and research in computational methodology during the early part of 1981. This discussion continued periodically during the Spring of 1981. Upon the recommendation of the faculty of the Mechanical Engineering and Mechanics (MEM) Department, intensive efforts were made by S. N. Tiwari during 1981-1982 to contact key individuals at NASA Langley and NASA Headquarters and at local industrial organizations to explore the possibilities of training, education, and research in different areas of computation methodology. Enthusiastic response were received from all sources.

During the Spring of 1982, the Office of the Associate Vice President for Research and Sponsored Program at ODU circulated a memorandum indicating the availability of SCHEV funds for establishing centers of excellence in specialized fields providing interdisciplinary programs. The entire matter was discussed seriously by the MEM faculty and S. N. Tiwari was charge with the responsibility of establishing further contacts with appropriate individuals and prepare proposals for submission to NASA Langley and SCHEV.

Extensive discussions regarding the center of excellence followed between S. N. Tiwari and selected ODU faculty and administrators, NASA/Langley scientists, key

representatives of local organizations, and a few SCHEV officials. This resulted in the feasibility of a cooperative program between four ODU departments, Applied Mathematics, Computer Science, Mechanical Engineering and Mechanics and Oceanography. A comprehensive list of courses was developed to provide an interdisciplinary educational program in computational methods.

After receiving inputs from all sources, the entire matter was presented to the NASA Langley's Chief Scientists, Mr. Robert L. Tolson to seek Langley's support and endorsement of the program. In a few preliminary meetings, the feasibility and goals and objectives of the proposed center were discussed. After this, extensive discussions followed regarding an appropriate name for the center. The original name suggested was the Institute of Computational Fluid Dynamics. Mr. Tolson suggested that the center's activities should not be restricted to fluid dynamics and it should address the needs of other disciplines as well. He indicated that this was also the wish of the NASA Langley's Director, Dr. Donald P. Heath. Consequently, a various other names were suggested and we finally zeroed in on two names: (1) Institute of Fluid Mechanics and Computational Methods, (2) Institute for Computational and Applied Mathematics. Mr. Tolson preferred the second name but suggested that we replace the last word "Mathematics" with "Mechanics" to give an engineering flavor. This was agreed upon by everyone concerned and the proposed center was given the name "Institute for Computational and Applied Mechanics (ICAM)."

During the fall of 1982, proposals for the funding were submitted to NASA Langley and SCHEV. The NASA funding became available from May 16, 1983; but, due to certain misunderstanding, the SCHEV funding did not come until the following year. Thus, after about two years of probing, planning, and frustrations, the ICAM became a reality and the operation of ICAM officially started from June 1, 1983.

The entire activities of the ICAM was managed by an executive committee after receiving inputs from the administrative and advisory committee. The information on original members and make-up of each committee is available in ODU/ICAM Report 84-101, January 1984. For NASA Langley's activities, the guidelines provided by the Chief Scientist, Mr. Robert L. Tolson and University Affairs Officer, Dr. Samuel E. Massenberg were followed strictly. Many graduate students supported on the program graduated with M. S. and/or Ph.D. degrees. Extensive research works were conducted by various individuals associated with ICAM. This resulted in publications in different forms (Journals, Proceedings, Papers, and Reports). This report summarizes the ICAM's activities and accomplishments.

### **GOALS AND OBJECTIVES**

The goals and objectives of the Institute of Computational and Applied Mechanics (ICAM) are described, in detail, in the original proposal. These are discussed here briefly.

#### **Goals**

The main goal of the Institute of Computational and Applied Mechanics (ICAM) is to develop and maintain expertise in computational methods at the Old Dominion University and provide graduate education and training in this very important discipline of great national and International interest. Immediate attention will be the area of computational fluid dynamics, but the long range goal of ICAM will be to provide intensive education, training, research, and consulting services in other areas as well. The outcome of this effort will be beneficial, not only to the university, but also to the entire Tidewater area and the country. Another important goal is to develop resources for financial independence of ICAM through local, state, federal, and industrial supports; and explore the possibilities of larger funding base through contacts with big corporations and agencies.

#### **Objectives**

The objectives of ICAM may be outlined as follows:

1. Educational Program for Existing Faculty: Providing training programs for interested faculty in specific fields of CFD. This may be accomplished by conducting workshops and by attending specialized short courses. Provide support to competitively selected faculty to develop research expertise in various fields of CFD during the summer months.
2. Faculty/Visiting Scholar Program: Hire a nationally recognized expert in CFU on "soft" money. It is intended that this individual would become a permanent faculty member at a later date. Invite distinguished scholars to spend their sabbaticals at ICAM and interact with NASA/Langley.
3. Curriculum Development: Support for organizing, coordinating, and updating the interdepartmental curriculum for graduate instruction in CFD.
4. Graduate-Student Educational Program: Offer an effective research and training program in CFD for graduate students at Master and Ph.D. levels; emphasize participation by women and minorities in graduate programs.
5. NASA/Langley Participation: Develop effective procedures for providing graduate education to interested and qualified NASA employees; explore various areas of extensive research participation; exploit the knowledge and experience of NASA/Langley experts (as adjunct professors) in teaching selected courses; and organize special seminars, workshops and conferences of mutual interest.
6. Community Services: Cooperate with local industries and government agencies in conducting CFD research and other related matters of mutual interest.
7. Computational Facility: Improve existing facilities of the university's computer center. Acquire scientific computational facilities for specific use by the College of Engineering and Technology and College of Science and Health Profession. Request computer terminals (and accessories) to "hookup" with NASA/Langley computational facilities.
8. Long-Range Objectives: Maintain a center of excellence in computational methods at

the Old Dominion University and establish sound funding base for financial independence of ICAM.

### **FUNDING AND BUDGET DISPOSITION**

Funds were requested from ODU, the State Council of Higher Education Commonwealth of Virginia (SCHEV), and the NASA/Langley Research Center to start the activities of ICAM. Detailed information on funding and budget disposition is available in the original proposal.

The ODU funds were used in renovating the office spaces for faculty and students and for computer terminals. Most of this money came from the office of the Vice President of Academic Affairs through the School of Engineering.

The Mechanical Engineering and Mechanics Department provided partial support for a part-time secretary for the first year. The funds provided by SCHEV were used primarily for faculty support and the Visiting Scholar's Program.

The NASA funds for ICAM were available until 1995. Most of these funds were used to support the graduate students.

### **ACTIVITIES AND ACCOMPLISHMENTS**

Significant progress has been made in achieving the basic objectives of ICAM. The current plan of ICAM activities is shown in figure 1. The items listed in the ellipses are being pursued at present within the guidelines of available resources. Positive results have been obtained in the NASA/ICAM Educational Program and the NASA CFD Program. However, the current emphasis has been to develop the NASA/ICAM Educational Program. These and other activities are discussed briefly in this section.

#### **Graduate Students and Financial Support**

Graduate students were recruited by following various traditional and nontraditional approaches. Most of these students decided to work on different NASA projects. Thus, each student was assigned a NASA and an ODU advisor. Information on recent graduate

students, degree program, ODU and NASA advisors, and topic of research is provided in Tables 1-7.

Six to eight students were supported each year from ICAM funds. The amount of support varies from \$12,000 to \$14,000 per year, with senior students receiving the higher amount. According to the established policy, the ICAM support was provided for two years, a third year support was available only in special cases. The student's ODU advisor was responsible for the financial support of the third year and beyond. Information on students who completed the degree program on ICAM is provided in Table 8.

### **ICAM Minority Graduate Students Program**

Strong efforts are being directed to increase the participation by women and other minorities in the ICAM graduate program. The involvement of minority graduate students in the program is essential within the general guidelines of the ICAM educational program. This effort is designed to assist NASA, and the nation, in alleviating the shortfall of science and engineering workforce skills depicted in the report "Workforce 2000." The specific effort, therefore, consists of a special minority graduate student program in science and engineering that would provide fellowships and graduate research opportunities for qualified students at NASA Langley Research Center. This effort is coordinated with the help of Dr. G. V. Selby of the Mechanical Engineering Department of ODU.

### **Faculty Involvement and Support**

The Mechanical Engineering and Mechanics Department and the Applied Mathematics Department have had several faculty members who possessed varying degree of expertises in Numerical Methods, CFD, Aerodynamics, and Hypersonics. The faculty members were intensively involved in guiding research in different disciplines.

Selected faculty members have been associated with different ICAM students (see Tables 1-7). Some faculty members have been working in closer contact with students than others. Most of the students have done excellent work in promoting the faculty

research program. As a result of this effort, some faculty members have received grants from NASA to conduct independent research.

Limited funds were available for the faculty support and these were used very carefully to encourage the participation of the young faculty. Faculty supports were provided only during summer months. Within the constraints of limited resources, funds were also provided to several faculty to attend local and national conferences.

### **Visiting Scholars Activities**

ICAM has encouraged coordination of research activities with different research associates, visiting scholars, and visiting professors during summer months and academic years. These individuals interacted with Langley scientists and engineers to conduct research activities of mutual interests. Periodically, funds have been provided for such activities by specific research units at LaRC. Many of the visiting scientists, faculty, and post-doctoral fellows have participated in organized seminars and workshops at LaRC. This information is provided under the section on Research Coordination.

### **Curriculum Development and Computation Facilities**

During the first year of ICAM's operation, the Applied Mathematics Department and Mechanical Engineering and Mechanics Department revised certain existing courses and added new course to support ICAM. Recently, with help from key NASA/Langley scientists and ODU faculty, the existing curriculum has been revised and new courses have been added.

ODU has updated its computational resources by acquiring a new computer system; the system is hooked up with NASA/Langley computational facilities. The College of Engineering and Technology has acquired its own computational system and this is being used extensively by our graduate students.

### **Major Thrust and Topic of Research**

Several general topics for conducting research have been identified by the ODU/ICAM faculty; these are listed below in a somewhat vague order of importance.

1. Numerical and Computational Methods
2. Fluid Physics and Aerodynamics
3. Hypersonics and Aerothermodynamics
4. Combustion Processes and Propulsion
5. Aeroacoustics, Aerothermal Loads, Aerostructure, and Space Structure
6. Materials Research
7. Guidance and Controls
8. Artificial Intelligence and Robotics
9. Atmospheric Studies - Troposphere and Upper Atmosphere
10. High Performance Computing
11. Optimization and Multidisciplinary Research
12. High-Speed Research Programs

At present, efforts are directed mainly in the first four areas of research, and only limited (isolated) efforts have been directed in other areas.

### **Short Courses and Seminars**

Special seminar courses have been offered by ICAM at ODU and NASA/Langley at various times. ODU faculty, NASA/Langley scientists, and internationally recognized experts have participated in teaching these courses. Students have taken these courses for graduate credits. NASA employees and contractors have attended the classes on a regular basis; others attended selected lectures in areas of their specific interests.

### **Presentation and Publications**

The research work completed by ICAM graduate students, research associates, faculty, and visiting scientists and engineers have been presented at various national and international meetings and conferences. Essential findings of research activities are available in forms of referable papers, proceedings, reports, and archival journals. The volume of materials published is extensive and it is not desirable to list them here.

However, reports specifically written for ICAM are provided under the section ICAM Reports.

## RESEARCH COORDINATION

Coordination of research activities with different research associates, visiting scholars, and visiting professors are listed here. Individuals name, position, duration of association, institutional affiliation (for visiting scholars and professors) and topic of primary research activities are listed in a somewhat sequential order of dates of association.

1. Lakin, W. D (ODU Prof., 1984-1986)—Stability of Viscous Flow.
2. Smith, W. D. (ODU Asso. Prof., 1984-1986)—Curve Fitting and Grid Generation.
3. Thornton, E. A. (ODU Prof., 1984-1986)—Finite Element Analysis in CFD.
4. Baker, A. J., University of Tennessee (Summer 1984)—Finite Element Analysis.
5. Hafez, M., George Washington University (Summer 1984)—Transonic Aerodynamics.
6. Hughes, T. J. R., Stanford University (Summer 1984)—Finite Element Analysis.
7. Mastin, C. W., Mississippi State University (Summer 1984 and 1985)—Topology and Grid Generation.
8. Jim Morgan, K., University of Wales, Swansea, U. K. (Summer 1984 and 1985)—Finite Element Analysis.
9. Oden, J. T., University of Texas-Austin (Summer 1984)—Finite Element Analysis.
10. Osher, S., University of California-Los Angeles (Summer 1984)—Solutions of Euler Equations.
11. Thompson, J., Mississippi State University (Summer 1984 and 1985)—Elliptic Grid Generation.
12. Hou, T. H., Lockheed Engineering and Sciences Comp. (1985-1993)—Thermal Analysis of Polymers.
13. A. Eidson, T., Georgia Institute of Technology (Summer 1985 and 1986)—Large Eddy Simulation.
14. A. Eiseman, P., Columbia University (Summer 1985 and 1986)—Adaptive Grid Generations.
15. Pouquet, A., Observatoire de Nice, France (Summer 1985)—Statistical Turbulence.
16. Worster, M. G., Massachusetts Institute of Technology (Summer 1985)—Hydrodynamic Stability.
17. Erickson, L. E., Aeronautical Research Institute of Sweden (1986-1987)—Transfinite Techniques in Grid Generation.
18. A. Chitsomboon, T. (Res. Asso., 1986-1988)—Computation Fluid Dynamics (CFD).

19. Bai, J. M. (Res. Asso., 1987-1989)—Thermal Analysis of Polymers.
20. Abolhassani, J. S. (Res. Assoc., 1987-1990)—Grid General and Grid Adaption.
21. Schneider, G. E., University of Waterloo, Canada (1987-1988)—Metal Phase Change Energy Transport.
22. Vemuru, C. S. (Res. Asso., 1987-1990)—Applied Aerodynamics.
23. Ng, C. F., National Research Council, Washington, D.C. (1988-1989)—Aerodynamics and Acoustics.
24. Clarkson, B. L., University Wales, Swansea, U. K.- (Summer 1989 and 1990)—Aerodynamics and Acoustics.
25. Marchello, J. M. (ODU Prof., 1989-1991)—Polymer Infiltration Studies.
26. Reddy, R. M. (Res. Asso., 1989-1992)—Polymeric Materials.
27. Srinivasan, K. (Res. Asso., 1989-1992)—Composite Materials.
28. Yang, R. L. (Res. Assoc., 1989-1992)—Space Technology Development and Utilization Program.
29. Lakshmanan, B. (Res. Asso., 1989-Present)—Computational Fluid Dynamics and Applied Aerodynamics.
30. A. Raj, R. S., City University of New York (Summer 1990)—Space Technology Program.
31. Krishnamurthy, R., (Res. Asst. Prof., 1991-Present)—Propulsion, Radiation, and Computational Fluid Dynamics (CFD).
32. Sun, H. J., Beijing Institute of Engineering and Architecture, China (1991-1992)—Acoustic and Mechanical Measurements.
33. I. Holland, L. H. (Res. Asso., 1992-1996)—Studies on Environmental Engineering Programs.
34. Sadrehighi, I. (Res. Asso., 1993-1996)—Grid Generation and Aerodynamic Sensitivity Studies.
35. Bhat, T. R. S. (Res. Assoc., 1993-1996)—Instability Wave Models and Supersonic Jet Noise.
36. Miley, S. J. (Res. Assoc., 1993-1995)—Laminar Instability Measurement System for SLFC Flight Research Program.
37. Singh, D. J. (Res. Assoc., 199~1996)—Study of Shock Initiated Combustion with Application to Hypersonic Propulsion.
38. Ibrahim, A. H. (Res. Coordinator, Norfolk State University, 1996)—Variational Methods in Aerodynamic Sensitivity Studies.

## ICAM REPORTS

The research work produced by ICAM participants (Graduate Students, Research Associates, ODU Professors, and Visiting Scientists and Engineers) have been presented at national and international meetings and conferences, and have been published in the forms of Journal Articles, Papers, Proceedings, and Reports. Each participant published in his/her areas of interest. Thus, it is not an easy task to list all these publications here. However, reports specifically written for ICAM are listed below:

Tiwari, S. N., "Goals, Objectives and Plans for ICAM," Institute of Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 84-101, January 1984, 126 pages.

Tiwari, S. N., "Notes on Elements of Fluid Dynamics," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 84-102, January 1984, 201 pages.

Tiwari, S. N., "Recent Activities and Accomplishments of ICAM—A Progress Report," Institute of Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 87-101, May 1987, 45 pages.

Tiwari, S. N., "Graduate Program in Aeronautics—A Status Report," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 87-102, October 1987, 17 pages.

Vemuru, C. S. and Tiwari, S. N., "Inviscid-Viscous Interactions in Transonic Airfoil Aerodynamics," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 88-101, April 1988; also, NASA CR-183112 NAS 1.26:183112, April 1988, 124 pages.

Rhodes, J. A., Tiwari, S. N., von Lavante, E., "A Study of Flow Separation in Transonic Flow Using Inviscid and Viscous CFD Schemes," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 88-102, April 1988; also, NASA CR-183119 NAS 1.26:183119, April 1988, 218 pages.

Lee, K. P., Tiwari, S. N., and Gupta, R. N., "Viscous Shock Layer Analysis of Hypersonic Flows Over Long Slender Vehicles," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 88-103, August 1988, 223 pages.

Tiwari, S. N., "Graduate Program in Aeronautics—A Status Report," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 88-104, November 1988, 35 pages.

Lakshmanan, B., Tiwari, S. N., and Hussaini, M. Y., "Study of Three-Dimensional Separation and Flow Control at Wing/Body Junctions in High-Speed Flows," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 89-101, September 1989, 212 pages.

Tiwari, S. N. and Trivedi, P. A., "Radiative Interactions in Laminar Duct Flows," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 90-101, December 1990; also NASA CR-188150, December 1990, 121 pages.

Tiwari, S. N., "Graduate Program in Aeronautics—1990 Status Report," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 90-102, December 1990, 43 pages.

Yang, R. L. and Tiwari, S. N., "NASA Langley Research Center HBCU/OMU Program: 1990 Student Support Survey Summary Report," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 91-101, April 1991; also NASA CR-188149, April 1991, 20 pages.

Tiwari, S. N., "Infrared Radiative Energy Transfer in Gaseous Systems," Institute of Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 91-102, September 1991; also, NASA CR-188925, September 1991, 196 pages.

Tiwari, S. N., "Graduate Program in Aeronautics—1991 Status Report," Institute of Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 91-103, December 1991, 48 pages.

Tiwari, S. N., "Radiative Energy Transfer in Molecular Gases," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 92-101, February 1992; also NASA CR-190057, February 1992, 245 pages.

Liu, J. and Tiwari, S. N., "Investigation of Radiative Interaction in Laminar Flows Using Monte Carlo Simulation," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 93-101, June 1993; also NASA CR-194604, June 1993, 34 pages.

Liu, J. and Tiwari, S. N., "Study of Multi-Dimensional Radiative Energy Transfer in Molecular Gases," Institute for Computational and Applied Mechanics (ICAM) Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 93-102, October 1993 also NASA CR-194613, October 1993, 72 pages.

Tso, W., Hou, T. H., and Tiwari, S. N., "Analysis of Pultrusion Processing for Long Fiber Reinforced Thermoplastic Composite System," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 93-103, November 1993; also NASA CR-194504, November 1993, 81 pages.

Tiwari, S. N., "Graduate Program in Aeronautics-1993 Status Report," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 93-104, December 1993; also NASA CR-123456, December 1993.

Ahuja, J. K. and Tiwari, S. N., "Parametric Study of Shock-Induced Combustion in a Hydrogen-Air System," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 94-101, June 1994; also NASA CR-119734, June 1994, 62 pages.

Liu, J. and Tiwari, S. N., "Radiative Interactions in Chemically Reacting Compressible Nozzle Flows Using Monte Carlo Simulations," Institute for Computational and Applied Mechanics (ICAM), Old Dominion University, Norfolk, Virginia, ODU/ICAM Report 94-102, September 1994; also NASA CR-197133, September 1994, 53 pages.

**Table 1**  
**ODU/ICAM Graduate Study Information: AY 1990-91**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Ahuja, J.K. "Investigation of Shock Induced Mixing and Combustion Phenomena," 3.75, May 1994.	Ph.D. (MEM)	S. N. Tiwari	A. Kumar
Burgreen, G.W. "Shape Optimization Using Sensitivity Analysis and CFD," 3.71, May 1994.	Ph.D. (MEM)	O.A. Baysal	D. S. Miller
Coats, T. W. "Role of Constituents in Organic-Matrix Composites," 3.65, May 1992.	M.S. (CS) (MEM)	R. Prabhakaran	C. E. Harris
Issa, G. F. "Hierarchical Architectural System for Mechanisms Synthesis using Analogical Reasoning Techniques," 3.25, August 1991.	M.S. (CS)	M. Chew	S. N. Tiwari
Liu, J. "Radiative Interactions in Multi-Dimensional High-Speed Flows," 3.5, May 1994.	Ph.D. (MEM)	S. N. Tiwari	J. V. Shebalin
Robeson, M. E. "Investigation of Five-Point Bend Test for Composites," 3.7, May 1992.	M.S. (MEM)	R. Prabhakaran	D. C. Jegley
Sadrehaghighi, I. "Advanced Grid Generation Techniques for Aerodynamic Applications," 3.45, May 1992.	Ph.D. (MEM)	S. N. Tiwari	R. E. Smith
Thomas, A. M. "Investigation of Chemically Reacting and Radiating Subsonic and Supersonic Internal Flows," 3.65, May 1991.	M.S. (MEM)	S. N. Tiwari	J. J. Singh

**Table 2**  
**ODU/ICAM Graduate Study Information: AY 1991-92**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Ahuja, J. K. "Investigation of Shock Induced Mixing and Combustion Phenomena," 3.75, May 1994.	Ph.D. (MEM)	S. N. Tiwari	A. Kumar
Alcorn, C. W. "Studies Relating to Subsonic Base Flow," 3.82, May 1993.	Ph.D. (MEM)	C. P. Britcher	D. A. Dress
Burgreen G. W. "Shape Optimization Using Sensitivity Analysis and CFD," 3.71 May 1994.	Ph.D. (MEM)	O. Baysal	D. S. Miller
Chandrasekhar, R. "Radiative Interactions in Chemically Reacting Supersonic Internal Flows," 3.56, May 1993.	Ph.D. (MEM)	S. N. Tiwari	J. P. Drummond
Coats, T. W. "Role of Constituents in Organic-Matrix Composites," 3.65, May 1992.	M. S. (MEM)	R. Prabhakaran	C. E. Harris
Comer, K. S. "Study of Combustion Phenomena in a High Temperature Tunnel," 3.52, December 1994.	M.S. (MEM)	S. N. Tiwari	R. L. Puster
Crayton, K. A. "Studies on Electromagnetic Phenomena in High-Speed Flows," 3.25, December 1994.	M.S. (ECE)	O. R. Gonzalez	S. M. Joshi
Liu, J. "Radiative Interactions in Multi-Dimensional High-Speed Flows," 3.5, May 1994.	Ph.D. (MEM)	S. N. Tiwari	J. V. Shebalin
Robeson, M. E. "Investigation of Five-Point Bend Test for Composites," 3.7, May 1992.	M.S. (MEM)	R. Prabhakaran	D. C. Jegley
Sadrehaghighi, I. "Advanced Grid Generation Techniques for Aerodynamic Applications," 3.45, May 1993.	Ph.D. (MEM)	S. N. Tiwari	R. E. Smith
Thomas, A. M. "Investigation of Chemically Reacting and Radiating Subsonic and Supersonic Internal Flows," 3.65, May 1991.	M.S. (MEM)	S. N. Tiwari	J. J. Singh
Wilson, R. V. "Three-Dimensional Free Jet Flow," 3.70, May 1993	M.S. (MEM)	A. O. Demuren	T. B. Gatski

**Table 3**  
**ODU/ICAM Graduate Study Information: AY 1992-93**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program ODU</u>	<u>Advisor</u>	<u>NASA Advisor</u>
Ahuja, J. K. "Investigation of Shock Induced Mixing and Combustion Phenomena," 3.75, May 1994.	Ph.D. (MEM)	S. N. Tiwari	A. Kumar
Comer, K. S. "Study of Combustion Phenomena in a High Temperature Tunnel," 3.52, December 1994.	M.S. (MEM)	S. N. Tiwari	R. L. Puster
Crayton, K. A. "Studies on Electromagnetic Phenomena in High-Speed Flows," 3.25, December 1994.	M.S. (ECE)	O. R. Gonzalez	S. M. Joshi
Larsen, J. C. Analysis and Interpretation of ASGE DAta," 3.51, December 1993.	Ph.D. (MEM)	S. N. Tiwari	W. P. Chu
Liu, J. "Radiative Interactions in Multi-Dimensional High-Speed Flows," 3.5, May 1994.	Ph.D. (MEM)	S. N. Tiwari J.	V. Shebalin
Reeves, D. M. "Studies on Simulation of Neural Networks," 3.2, December 1993.	M.S. (ECE)	O. R. Gonzalez	D. Soloway
Sadrehaghighi, I. "Advanced Grid Generation Techniques for Aerodynamic Applications," 3.45, May 1993.	Ph.D. (MEM)	S. N. Tiwari	R. E. Smith
Sharifnia, A. "Investigation of Chemically Reacting Subsonic Flows," 3.56, May 1995.	Ph.D. (MEM)	S. K. Chaturvedi	J. J. Singh

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**Table 4**  
**ODU/ICAM Graduate Study Information: AY 1993-94**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

Student	Program	ODU Advisor	NASA Advisor
Ahuja, J. K. "Investigation of Hypersonic Shock-Induced Combustion in a Hydrogen-Air System," 3.84, August 1995.	Ph.D. (ME)	S. N. Tiwari	A. Kumar
Chylek, J. "Implementation of Improved Reynolds Stress Models to Three-Dimensional Compressible Flows," 3.57, August 1996.	Ph.D. (ME)	B. Lakshmanan P.	S. Pao
Comer, K. S. "Study of Combustion Phenomena for Application in a High-Temperature Tunnel," 3.52, December 1995.	M.S. (ME)	S. N. Tiwari	R. L. Puster
Crayton, K. A. "Studies on Electromagnetic Phenomena in High-Speed Flows," 3.35, December 1994.	M.S. (ECE)	O. R. Gonzalez	E. S. Armstrong
Larsen, J. C. "Analysis and Interpretation of SAG Data," 3.5, December 1995.	Ph.D. (ME)	S. N. Tiwari	W. P. Chu
Liu, J. "Radiative Interaction in Multi-Dimensional High-Speed Flows," 3.62, August 1994.	Ph.D. (ME)	S. N. Tiwari	J. V. Shebalin
Prabhu, A. A. "Numerical Studies on Incompressible and Compressible Boundary-Layer Flows," 3.40, August 1994.	M.S. (ME)	S. N. Tiwari	R. W. Barnwell

**Table 5**  
**ODU/ICAM Graduate Study Information: AY 1994-95**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Ahuja, J. K. "Investigation of Hypersonic Shock-Induced Combustion in a Hydrogen-Air System," 3.84, August 1995.	Ph.D. (ME)	S. N. Tiwari	A. Kumar
Bush, J. G. "Analysis and Interpretation of HighSpeed Shock-Tube Flow Field Data," 3.27, May 1996.	M.S. (ME)	S. N. Tiwari	G. Y. Anderson
Choate, R. E. "Numerical Investigation of High-Speed Nonequilibrium Flows," 3.56, May 1997.	Ph.D.	S. N. Tiwari	C.R. McClinton
Chylek, J. "Implementation of Improved Reynolds Stress Models to Three-Dimensional Compressible Flows," 3.57, August 1996.	Ph.D. (ME)	B. Lakshmanan	P. S. Pao
Holt, R. D. "Study on Electromagnetic Controls," 3.25, August 1996.	M.S. (ECE)	M. D. Meyer	F. Allario
Hwang, K. C. "Analytical and Experimental Investigation of Flow Laminarization on HSCT Type Wings," 3.27, December 1995.	M.S. (ME)	S. J. Miley	M. C. Fischer

**Table 6**  
**ODU/ICAM Graduate Study Information: AY 1995-96**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program ODU</u>	<u>Advisor</u>	<u>NASA Advisor</u>
Boregowda, S. C.	Ph.D. (ME)	S. N. Tiwari	A. T. Pope
"Analysis and Simulation of Human Thermal System," 3.8, August 1997.			
Bush, J. G.	M.S. (ME)	S. N. Tiwari	G. Y. Anderson
"Parametric Correlations for Generic Seramjet Comustors," 3.27, May 1996			
Choate, R. E.	Ph.D.	S. N. Tiwari	C.R. McClinton
"Numerical Investigation of High-Speed Nonequilibrium Flows," 3.56, May 1997.			
Chylek, J.	Ph.D. (ME)	B. Lakshmanan	P. S. Pao
"Implementation of Improved Reynolds Stress Models to Three-Dimensional Compressible Flows," 3.57, August 1996.			
Holt, R. D.	M.S. (ECE)	M. D. Meyer	F. Allario
"Study on Electromagnetic Controls," 3.25, August 1996.			
Hwang, K. C.	M.S. (ME)	S. J. Miley	M. C. Fischer
"Analytical and Experimental Investigation of Flow Laminarization on HSCT Type Wings," 3.27, December 1995.			
Ibrahim, A. H.	Ph.D. (ME)	S. N. Tiwari	R. E. Smith
"Variational Analysis and Optimization for Aerodynamic Applications," August 1996.			

**Table 7**  
**ODU/ICAM Graduate Study Information: AY 1996-97**

Information on graduate students, programs, ODU and NASA advisors, proposed topic of research, current QPA based on 4.00, and expected date for completion of the program is listed here.

<u>Student</u>	<u>Program ODU</u>	<u>Advisor</u>	<u>NASA Advisor</u>
Atsuchi, S.	M.S. (ME)	S. N. Tiwari	J. M. Seiner
"Drag Reduction on Circular Cylinders," 3.52, August 1997.			
Boregowda, S. C.	Ph.D. (ME)	S. N. Tiwari	A. T. Pope
"Analysis and Simulation of Human Thermal System," 3.8, August 1997.			
Bush, J. G.	M.S. (ME)	S. N. Tiwari	G. Y. Anderson
"Parametric Correlations for Generic Seramjet Comustors," 3.27, May 1996			
Hwang, J. G.	Ph.D. (ME)	S. N. Tiwari	G. Y. Anderson
"Analysis and Computation of Shock-Induced Combustion," 3.56, December 1999.			
Chylek, J.	Ph.D. (ME)	B. Lakshmanan	P. S. Pao
"Implementation of Improved Reynolds Stress Models to Three-Dimensional Compressible Flows," 3.57, August 1996.			
Larsen, J. C.	Ph.D. (ME)	S. N. Tiwari	W. P. Chu
"Analysis and Interpretation of SAGE II Data," 3.68, December 1997 .			
Robeson, M. E.	Ph.D. (ME)	R. Prabhakaran	M. Nemeth
"Studies on Composite Plates and Shallow Shells," 3.75, May 1997.			
Wilson, R. V.	Ph.D. (ME)	A. O. Demuren	D. M. Bushnell
"Computation of Complex Three-Dimensional Turbulent Free Jets," December 1996.			

**Table 8**  
**ODU/ICAM Graduate Study Information: Completion of Degree Program**

Information on former ODU/ICAM graduate students, degree program, ODU and NASA Advisors, topic of research, date of graduation, and present affiliation is provided here; the listing order is based on the date of graduation.

Student	Program	ODU Advisor	NASA Advisor
Irvine, L. D. "Minimal Norm Constrained Interpolation," May 1985, General Motors, Detroit, MI.	PH.D. (MATH)		
Mahaney, J. M. "Structural of Self-Shadowing and its Effect on the Thermal-Structural Behavior of Orbiting Trusses," May 1985, Macon College, GA.	M.E. (MEM)	E. A. Thornton	A. R. Wieting
Vemuru, C. S. "Viscous-Inviscid Interaction ofver Airfoils in Transonic Flows," December 1986, Analytical Services and Mterials Inc., Hampton, VA.	Ph.D. (MEM)	S. N. Tiwari	W. D. Harvey
Spall, R. E. "Vortex Breakdown Simulation Using the Full Three-Dimensional Navier-Stokes Equations," May 1987, High Technology Inc., Hampton, VA.	Ph.D. (MEM)	R. L. Ash	T. B. Gatski
Cuda, V. "Direct Simulation of Hypersonic Transitional Flows Over Blunt Slender Bodies," August 1987, Old Dominion University, Norfolk, VA.	Ph.D. (MEM)	R. L. Ash	J. N. Moss
Mani, M. "Investigation of Chemically Reacting and Radiating Supersonic Internal Flows," May 1988, McDonnell Douglas, St. Louis, MO.	Ph.D. (MEM)	S. N. Tiwari	J. P. Drummond
Rhodes, J. A. "A Study of Flow Separation in Transonic Flow Using Inviscid and Viscous CFD Schemes," May 1988, McDonnell Douglas, St. Louis, MO.	Ph.D.	S. N. Tiwari	M. D. Salas
Cannizzaro, F. "Assessment of Numerical Methods for Transonic Flow Computations," August 1989, Hampton University, Hampton, VA.	M.S. (MEM)	E. vonLavante	M. D. Salas
Hodge, S. L. "Vector Acceleration Techniques for Partial Differential Equations," August 1989, Hampton University, Hampton, VA.	Ph.D. (MATH)	W. D. Lakin	M. D. Salas
Bruns, R. L. "Numerical Analysis of Flow about a Total Temperature Sensor," 3.36, December 1989.	M.S. (MEM)	E. vonLavante	M. D. Salas

**Table 8**  
**(Continued) ODU/ICAM Graduate Study Information:**  
**Completion of Degree Program**

Information on former ODU/ICAM graduate students, degree program, ODU and NASA Advisors, topic of research, date of graduation, and present affiliation is provided here; the listing order is based on the date of graduation.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Trivedi, P. A.	M.S. (MEM)	S. N. Tiwari	J. J. Singh
"Infrared Radiative Interactions in Laminar Duct Flows," May 1990, Thermal Energy Inc., Roanoke, VA.			
Love, L.	J. M.S. (MEM)	T. E. Alberts	D. Soloway
"A Detailed Analysis of Dynamic Robotic Simulation," August 1990, Ph.D. Georgia Inst. of Technology, GA.			
Stewart, J. E.	M.S. (MEM)	S. N. Tiwari	R. E. Smith
"Grid Generation and Flow Computation About a Martian Entry Vehicle," August 1990, Computer Science Corp., Hampton, VA.			
Arriola, L.	Ph.D. (MATH)	J. H. Heinbockel	R. C. Costen
"A Generalization of Linear Multistep Methods," December 1990, Northern Kentucky Univ., Highland Heights, KY.			
Casper, J.	Ph.D. (MATH)	J. M. Dorrepaal	H. Atkins
"An Extension of Essentially Nonoscillatory Shock Capturing Scheme to Multi Dimensional Systems of Conservation Law, December 1990, Vigyan, Hampton, VA.			
Issa, G. F.	M.S. (CS)	M. Chew	S. N. Tiwari
"Hierarchical Architectural System for Mechanisms Synthesis Using Analogical Reasoning Techniques," August 1991, Old Dominion University, Norfolk, VA.			
Thomas, A. M.	M.S. (MEM)	S. N. Tiwari	J. J. Singh
"Investigation of Radiative Interactions in Supersonic Internal Flows," August 1991, Old Dominion University, Norfolk, VA.			
Mullaney, R. C.	M.S. (MEM)	T. E. Alberts	D. I. Soloway
"Passive Damping Augmentation for Space Manipulators," August 1991, Old Dominion University, Norfolk, VA.			
Coats, T. M.	M.S. (MEM)	R. Prabhakaran	C. E. Harris
"Experimental Verification of a Progressive Damage Model for Composite Laminates Based on Continuum Damage Mechanics," August 1992, Ph.D. Program at ODU.			
Robeson, M. E.	M.S. (MEM)	R. Prabhakaran	D. C. Jegley
"Analysis of Impact Damage of Composite Laminates Using Five-Point Bending," August 1992, Ph.D. Program at ODU.			

**Table 8**  
**(Continued) ODU/ICAM Graduate Study Information:**  
**Completion of Degree Program**

Information on former ODU/ICAM graduate students, degree program, ODU and NASA Advisors, topic of research, date of graduation, and present affiliation is provided here; the listing order is based on the date of graduation.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Alcorn, C. W.	Ph.D. (MEM)	C. P. Britcher	D. A. Dress
"Studies Relating to Three-Dimensional Subsonic Base Flow," May 1993, Aerospace Company, Washington, D.C.			
Sadrehaghighi, I.	Ph.D. (MEM)	S. N. Tiwari	R. E. Smith
"Grid Sensitivity for Aerodynamic Optimization and Flow Analysis," May 1993, Aerospace Industry, L.I., N.Y., New York.			
Wilson, R. V.	M.S. (MEM)	A. O. Demuren	T. B. Gatski
"Three-Dimensional Free Jet Flow," May 1993, Ph.D. Program at ODU.			
Chandrasekhar, R.	Ph.D. (MATH)	J. H. Heinbockel	R. C. Costen
"A Generalization of Linear Multistep Methods," December 1990, Northern Kentucky Univ., Highland Heights, KY.			
Casper, J.	Ph.D. (MEM)	S. N. Tiwari	J. P. Drummond
"Studies on Nonequilibrium Phenomena in Supersonic Chemically Reacting Flows," December 1993, Fluent Corporation, New Hampshire.			
Burgreen, G. W.	Ph.D. (MEM)	O. Baysal	D. S. Miller
"Shape Optimization Using Sensitivity Analysis and CFD," May 1994.			
Thomas, A. M.	M.S. (MEM)	S. N. Tiwari	J. J. Singh
"Investigation of Radiative Interactions in Supersonic Internal Flows," August 1991, Old Dominion University, Norfolk, VA.			
Prabhu, A. A.	M.S. (ME)	S. N. Tiwari	R. W. Barnwell
"Numerical Studies on Incompressible and Compressible Boundary-Layer Flows," August 1994, Ph.D. Program, RPI, Troy, New York.			
Crayton, K. A.	M.S. (ECE)	O. R. Gonzalez	S. M. Joshi
"Studies on Electromagnetic Phenomenon in High-Speed Flows," December 1994.			
Liu, J.	Ph.D. (ME)	S. N. Tiwari	J. V. Shebalin
"Radiative Interactions in Multi-Dimensional Chemically Reacting Flows Using Monte Carlo Simulations," December 1994, Aerospace Industry, Huntsville, Alabama.			
Reeves, D. M.	M.S. (ECE)	O. R. Gonzalez	D. Soloway
"Generalization Metrics for Neural Networks," May 1995.			

**Table 8**  
**(Continued) ODU/ICAM Graduate Study Information:**  
**Completion of Degree Program**

Information on former ODU/ICAM graduate students, degree program, ODU and NASA Advisors, topic of research, date of graduation, and present affiliation is provided here; the listing order is based on the date of graduation.

<u>Student</u>	<u>Program</u>	<u>ODU Advisor</u>	<u>NASA Advisor</u>
Comer, K. S.	M.S. (ME)	S. N. Tiwari	R. L. Puster
"Study of Combustion Phenomena for Application in a High-Temperature Tunnel," December 1995, Aerospace Industry, Washington, D. C.			
Hwang, K. C.	M.S. (ME)	S. J. Miley	M. C. Fischer
"Experimental Investigation of the Inlet Deflector Configuration Variation in the Flow Field at Mach 1.9," December 1995, Ph.D. Program at ODU.			
Ibrahim, A. H.	Ph.D. (ME)	S. N. Tiwari	R. E. Smith
"Vibrational Method in Sensitivity Analysis and Optimization for Aerodynamic Applications," August 1996, Norfolk State Univ., Norfolk, VA.			
Bush, J. G.	M.S. (ME)	S. N. Tiwari	G. Y. Anderson
"Parametric Corporation for Generic Scramjet Combustors with Ramp-Type Injectors," December 1996, Boeing Corporation, Seattle, WA.			
Wilson, R. W.	Ph.D. (MEM)	A. O. Demuren	D. M. Bushnell
"Computation of Complex Three-Dimensional Turbulent Free Jets," December 1996, Boeing Corporation, Seattle, WA.			
Holt, R. D.	M.S. (ECE)	M. Chew	S. N. Tiwari
"Hierarchical Architectural System for Mechanisms Synthesis Using Analogical Reasoning Techniques," August 1991, Old Dominion University, Norfolk, VA.			
Atsuchi, S.	M.S. (ME)	S. N. Tiwari	J. M. Seiner
"Investigation of Drag Reduction on a Two-Dimensional Circular Cylinder by Ejecting Jet from the Rear Stagnation Region," August 1997, Aerospace Industry, L.I., New York.			

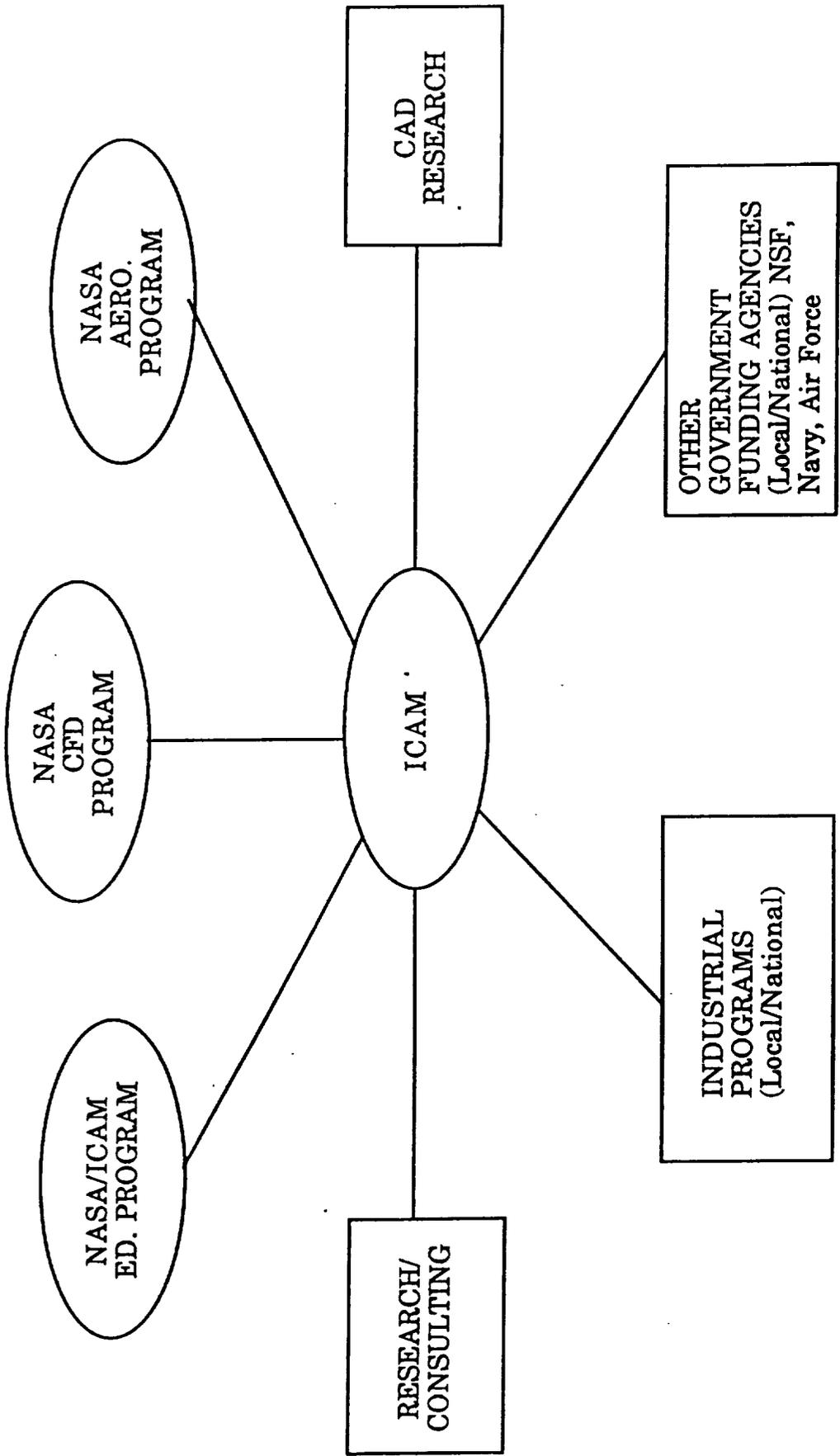


Figure 1. Plan of ICAM Activities