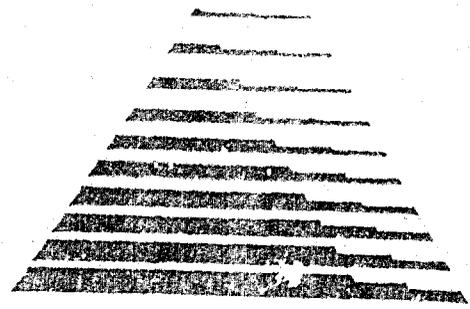


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FINAL REPORT
INSTITUTE FOR AVIATION RESEARCH
AND DEVELOPMENT
RESEARCH PROJECT

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William H. Wentz, Jr. and John B. Breazeale

Project Period Nov 1986 - Nov 1988

U. S. ARMY RESEARCH OFFICE

Grant No. DAAL 03-87-G-0003

January, 1989

THE WICHITA STATE UNIVERSITY

WICHITA, KANSAS, 67208

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The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

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Executive Summary			
The proposal which The Wichita State University submitted to the Army Research Office in April, 1986, and which resulted in the contract for which this document is the final report, stated, "...At the end of the two-year development program, an advanced research center will be in place, involved in continuing research of high interest to government and industry, and providing training at the PhD-level students for careers in aviation-related technical disciplines."			
This objective has been met. A new 74,000 sq. ft. building is currently under construction to house the activities of the Institute for Aviation Research, with completion scheduled for late 1989. Laboratory equipment has been acquired and made operational to support the research. The University is providing support for key faculty and administrative position, including →			
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The Institute's Industrial Advisory Committee, and cooperative linkages between the Institute, the Barton School of Business at WSU, and the Wichita/Sedgwick County WI/SE Partnership assure that new technologies developed will be made available to manufacturers with minimum delay. The Institute has gained designation as a Kansas Center of Excellence, qualifying it for support from the state, to assure the sustained maintenance of the new laboratories.

Interdisciplinary research projects have been conducted in the following areas with ARO sponsorship:

1. Composite Structures
2. Basic Materials
3. Advanced Software
4. Propulsion and Mechanisms
5. Computer and Common Software

This research has involved 23 faculty members, 29 students and has resulted in 51 publications and presentations. A summary of expenditures of the ARO grant monies illustrates the distribution of effort for the two-year ARO program:

(All amounts in thousands)	
Building	\$1,870
Equipment	\$1,359
Projects and staff	<u>\$1,771</u>
Total	\$5,000

The Institute is now positioned for sustained, significant research and advanced training of graduate students in a wide range of technical disciplines related to aviation.

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1. DEVELOPMENT OF THE INSTITUTE FOR AVIATION RESEARCH

In 1986, The Wichita State University began a program to develop an advanced aviation technology center. Assistance was sought from federal, private and local government sources. Two major federal research grants played a key role in this development initiative: one from the U. S. Army, administered through the Army Research Office, and a second from the Federal Aviation Administration, administered through the Technical Center. This report documents achievements on the ARO portion of the Institute for Aviation Research development project.

In the original grant proposal (ref.1), The Wichita State University presented to the Army those aspects of its development plan which "... would be of interest to the United States Army and to the industry as they relate to advanced helicopter design and development..." Research was proposed in four technical areas: composite structures, basic materials, advanced software, and propulsion and mechanisms.

The project had two major components: first, to systematically acquire necessary laboratories and instrumentation; second, to enhance the faculty and staff capabilities and to produce significant research by undertaking topical research projects in the four areas of research named above. Progress reports, site visits to Army laboratories, symposia, and publication of technical papers and reports have been used to disseminate research results.

A second major research contract was awarded to the Institute in late 1986 by the Federal Aviation Administration (ref.2), for research in topics related to aviation safety. The FAA and ARO research contracts have been in many ways complimentary in the development of the Institute, especially as relates to laboratory facilities.

The nature of the grant agreement between The Wichita State University and the Army permitted flexibility in use of the grant funds to accomplish the overall objectives of the proposal. As the work progressed, it became apparent that all the equipment items planned could not be acquired and made fully operational within the two-year period of the grant. Therefore, reallocation of resources was made to utilize a portion of the grant funds for some of the costs of the new building to house the Institute. The University, in turn, is providing the resources to complete most of the ARO technical projects originally proposed over a three-year period rather than the originally planned two-year period.

The Institute was conceived as a research entity which would attract support from a number of quarters. Since one objective of the research is to aid in the rapid transfer of technical information from the laboratory to the manufacturing industry, the Institute has taken steps to achieve that objective, with assistance from industry and state and local governmental sectors.

In January, 1988, the state of Kansas, acting through the Kansas Technology Enterprise Corporation (KTEC), designated the Institute for Aviation Research as one of its "Centers of Excellence." An evaluation of the Institute and its Business Plan (ref.3) by an external review team in December resulted in a favorable report, and recommendations not only to continue state support for the Institute, but also enhancement of that support. These recommendations are a measure of both the appropriateness and the credibility of the activities of the Institute to date. Support from this combination of Army, FAA, State of Kansas, Sedgwick County, City of Wichita, and aviation corporations assures the relevance of the research, and the continued success of the Institute as an enterprise devoted not only to discovery but also to bringing the fruits of research quickly to the manufacturing sector of our nation.

A brochure describing the Institute and its capabilities has been published (Ref. 4). The following sections of this report describe the building, and laboratories and equipment. Later sections describe the significant results, publications, and personnel supported.

1.1 Building

As described in the original proposal, a major new structure to house the Institute for Aviation Research was one key element of the WSU master development plan. The final design is a three-story, 74,000 sq. ft. structure with a variety of specialized laboratories for aviation-related research, as well as space for technicians, secretarial and administrative support staff. The building is designed to accommodate interdisciplinary research teams, including visiting researchers from government, industry and other universities.

Funding for the building is from a variety of sources, including the ARO grant, a US Department of Education Grant, private contributions and city and county governments.

The design has been completed, and construction began in October, 1988. Completion is scheduled for late 1989. Laboratories housed in the new building are listed below:

Advanced Materials

Composite Materials

Computer Integrated Manufacturing

Computer Aided Design/Computer Aided Manufacturing

Icing

Propulsion

Human Factors

Flight Simulator

Flow Visualization

Crash Dynamics

1.2 Laboratories and Equipment

Key laboratories developed with ARO support are:

Advanced Materials

Composite Materials

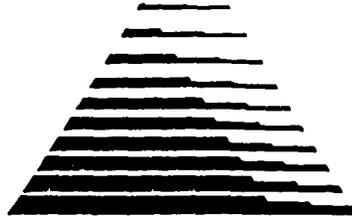
Structures

CAD/CAM

Computing and Software Engineering

Propulsion

The pages which follow highlight each of these laboratories, and list equipment, projects, and key faculty. Equipment acquisitions under the present ARO contract are noted.



INSTITUTE FOR AVIATION RESEARCH

A Kansas Center of Excellence • The Wichita State University

Wichita, Kansas 67208-1595 (316) 689-3678

ADVANCED MATERIALS LABORATORY

Facilities:

	<u>Sponsor</u>
* Scanning Electron Microscope (SEM)	ARO
* Transmission Electron Microscope (TEM)	ARO
* X-Ray Diffractometer	ARO
* Optical Microscope	ARO

Projects:

* Aluminum-Lithium Formability	ARO
* Al-Li Scratch Sensitivity	ARO
* Erosion	ARO

Key Faculty:

Dr. J. Ho, Professor, Physics
Dr. P.G. Wahlbeck, Professor, Chemistry
Dr. W.T.K. Stevenson, Associate Professor, Chemistry
Dr. J. Chaudhuri, Assistant Professor, ME
Dr. J. Talia, Assistant Professor, ME

Contacts: Dr. J. Talia, 316/689-3402
Dr. W.H. Wentz, Jr., 316/689-3678



INSTITUTE FOR AVIATION RESEARCH

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COMPOSITE MATERIALS LABORATORY

Facilities:

- * Programmable Oven
- * Ultrasonic Testing
- * Autoclaves
- * Hydraulic Press
- * Static and Dynamic Physical Test Machines
- * Fabrication

Sponsor

ARO
ARO
ARO
ARO

Projects:

- * Damping
- * Fatigue
- * Environmental Effects
- * Tooling Design
- * Fabrication Processes

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ARO

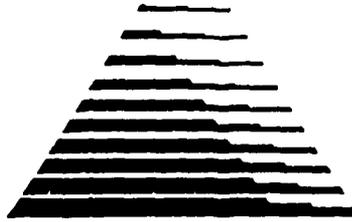
Key Faculty:

Dr. A.R. Graham, Professor, ME
Dr. W.D. Bernhart, Professor, AE
Dr. B.L. Smith, Professor, AE
Dr. W.J. Horn, Associate Professor, AE
Dr. S. Hooper, Assistant Professor, AE
Dr. J. Chaudhuri, Assistant Professor, ME
Dr. W.T.K. Stevenson, Associate Professor, Chemistry

Staff:

Dr. W. Becker, Composite Materials Laboratory Director, IAR
M. Wadsworth, Engineer

Contact: Dr. Wayne Becker, 316/689-3525



INSTITUTE FOR AVIATION RESEARCH

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STRUCTURES LABORATORY

Facilities:

- * 22 kip MTS Universal Testing Machine
- * 55 kip MTS Universal Testing Machine
- * Instrumentation
 - * Load cells, strain gages
 - * Data loggers
 - * Hydraulics, load frame
 - * Environmental chamber

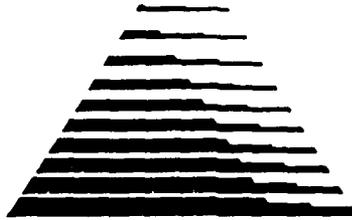
Sponsor

ARO

Key Faculty:

Dr. W.D. Bernhart, Professor, AE
Dr. B.L. Smith, Professor, AE
Dr. W.J. Horn, Associate Professor, AE
Dr. S. Hooper, Assistant Professor, AE

Contact: Dr. B.L. Smith, 316/689-3410



INSTITUTE FOR AVIATION RESEARCH

A Kansas Center of Excellence • The Wichita State University

Wichita, Kansas 67208-1595 (316) 689-3678

COMPUTING and SOFTWARE ENGINEERING

Facilities/Systems:

- * VAX 8650
- * IBM 3081-D16
- * Ethernet, J-net, ISN's
- * Hot Bench
- * Graphics Workstations
- * Symbolics Artificial Intelligence
- * Vision Systems
- * Finite Element Modeling (NASTRAN)
- * Aerodynamic Paneling (VSAERO)

Sponsor

ARO

ARO

FAA

Projects:

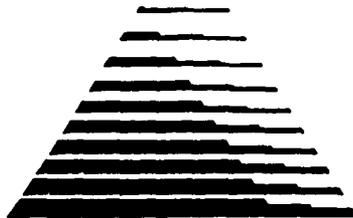
- * Software Reliability
- * Ada Systems Development
- * Computational Fluid Dynamics

FAA

Key Faculty:

Dr. A.R. Elcrat, Professor, Mathematics and Statistics
Dr. J. Hutchinson, Professor, Mathematics and Statistics
Dr. W.D. Bernhart, Professor, AE
Dr. J. Zytchow, Professor, Computer Science
Dr. M. Suchenek, Associate Professor, Computer Science
Dr. J. Tomayko, Associate Professor, Computer Science
Dr. Z.M. Wojcik, Associate Professor, Computer Science
Dr. M. Papadakis, Assistant Professor, AE
Dr. M. Greywall, Professor, ME

Contact: Dr. J. Hutchinson, 316/689-3630



INSTITUTE FOR AVIATION RESEARCH

A Kansas Center of Excellence • The Wichita State University

Wichita, Kansas 67208-1595 (316) 689-3678

PROPULSION LABORATORY

Facilities:

	<u>Sponsor</u>
* Inlet Test Rig	ARO
* Pressure, Hot Film, Laser Velocimetry	ARO
* 2-D and 3-D Computational Fluid Dynamic Codes	ARO

Projects:

* Turbo-Shaft Inlet Analysis/Test	ARO
* Particle Separators	
* Turbo-Diesel Design Program	ARO
* Transmission Gear Stresses	ARO

Key Faculty:

Dr. M. Greywall, Professor, ME
Dr. J. Harris, Assistant Professor, ME
Dr. M. Najj, Assistant Professor, ME
Dr. P. Steranka, Assistant Professor, ME

Contact: Dr. M. Greywall, 316/689-3402

2. SUMMARY OF SIGNIFICANT RESULTS

Topical research under this grant was conducted by small project teams. A list of the projects from the original proposal follows, with status of each project noted. Because of time required to acquire key equipment items, most of the project schedules were extended beyond the original two-year period of ARO sponsorship. Even though ARO sponsorship ended in November, 1988, the University is supporting the completion of these projects, under the revised schedule as noted.

In most cases some publications have already resulted. In all cases, ARO support will be acknowledged as the project publications are released. Publications, technical conference presentations, faculty and graduate students supported, and student theses and dissertations are given in later sections of this report.

WSU/ARO PROJECT SUMMARY

Project Number	Project Area	Investigators	Remarks
1.	Composite Structures		
1.0	Composites Structures Laboratory	Becker	Completed 11/88
1.1	Delamination of Composite Laminates	Hooper	Completion 8/89
1.2	Static and Fatigue Behavior of Fiber Reinforced Composite Materials Having Negative Poisson's Ratio	Chaudhuri	Completion 8/89
1.3	Damping Characteristics of Composite Materials	Bernhart	Completion 8/89
1.4	Evaluation of Adhesive Bonded Joints Under Static and Cyclic Loading	Hooper	Combined with 1.1 Com. 8/89
1.5	Environmental Effect on Low-Velocity Impact Tests on Composite Material Panels	Horn	Completion 8/89
2.	Basic Materials		
2.0	Major Equipment Items: Optical Microscope, SEM, TEM, X-Ray	Talia	Completed 11/88
2.1	Influence of Strain Rate Hardening on the Formability of Aluminum-Lithium Alloys	Chaudhuri	Completion 5/89
2.2	Solid Particle Erosion of Composite Materials	Talia	Completed 11/88
Added Project	Effects of Scratches on Fatigue Properties of Aluminum-Lithium Alloys	Talia	Redirection of Erosion Project Com. 12/88
3.	Advanced Software		
3.1	Learning Mechanisms for Intelligent Control Systems	Zytkow	Completed 8/88

3.2	Architectural and Algorithmic Approaches for Digital Image Processing	Fang	Terminated 8/87 Faculty member re- signed
4.	Propulsion and Mechanisms		
4.1	Adiabatic Diesel/Gas Turbine Compound Engine Cycle Evaluation and Optimization	Harris	Completed 12/88
4.2	Internal Aerodynamics in Offset Inlet Diffusers	Greywall	Completion 8/89
4.3	Chain-Drive Power Transmission Systems (Change to: Gear-Drive Power Transmission Systems)	Naji	Completion 8/89
5.	Computer and Common Software	Santhanam	Completed 11/88

3. DISSEMINATION OF RESEARCH RESULTS

A variety of methods are being used for dissemination of the results of the research conducted under this grant. First, direct communications between university researchers and Army research laboratory personnel were established. In particular, site visits to the Army Aerostructures Directorate at NASA Langley Research Center and the Propulsion Directorate at NASA Lewis Research Center resulted in coordination and focusing of the WSU research activities in Composite Structures, Basic Materials, and Propulsion and Mechanisms.

The lists which follow give conference presentations and publications of the Institute reporting research conducted under this grant. Since most of the research projects have been extended with WSU support beyond the grant period, additional publications are planned. Acknowledgement of Army support will be made as these are completed, and information copies will be provided to the ARO and appropriate Army laboratories.

3.1 Conference Presentations

S. Alyan, "Crack-Opening and Crack-Growth Resistance of Graphite/PEEK and Graphite/Epoxy Laminates Containing Large Center Cracks," Presentation at the Fourteenth Annual AIAA Techfest, Wichita, November 13, 1987.

S. Alyan, "Failure Mechanisms of Graphite/Epoxy and Graphite/PEEK Composites", Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 10, 1988.

Y. Ballout, "Erosion Mechanisms of Composite Materials," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 10, 1988.

J. Chaudhuri and Q. Jang, "Effect of Special Orientation on the Fracture Behavior of Graphite/Epoxy Laminates," Presentation at the Fourteenth Annual AIAA Techfest in Wichita, November 14, 1987.

M. Greywall, "Partially Parabolized Computations of Flow Through Offset Inlets," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 11, 1988.

J. A. Harris, "Simulation of Compound Cycle Engine for Aircraft Applications," Presentation at the Fourteenth Annual AIAA Techfest, Wichita, November 14, 1987.

S. Hooper, "A Review of Current Composite Materials Delamination Research at Wichita State University," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 10, 1988.

A. Inchekel and J. E. Talia, "Small Surface Scratches Interaction - Another Effect on the Fatigue Life of Al-Li," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 10, 1988.

P. S. Mangat, "A Study of the Influence of Strain Rate Hardening on the Formability of Al-Li Alloys," Presentation at the Fourteenth Annual AIAA Techfest, Wichita, November 13, 1987.

B. L. Smith, S. J. Hooper, "Characterization of Delamination in Composite Laminates," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 10, 1988.

P. O. Steranka, "Progress in a Basic Study of Engine Inlet Aerodynamics," Presentation at the Fourteenth Annual AIAA Techfest, Wichita, November 14, 1987.

P. O. Steranka, "Engine Inlet Aerodynamics Research at WSU Institute for Aviation Research," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 11, 1988.

W. Wentz, "Status of the Institute for Aviation Research at Wichita State University," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 12, 1988.

J. Zytow, "Automated Learning Better Tactics by Experimentation," Presentation at the Fourteenth Annual AIAA Techfest, Wichita, November 14, 1987.

J. Zytow, "Improving the Tactical Decisions by an Automated Pilot; Search Mechanism Guided by Experience and Prediction," Presentation at the Fifteenth Annual AIAA Techfest, Wichita, November 11, 1988.

3.2 Publications

Y. Ballout, J. E. Talia, "Wear Erosion of Glass-Fiber Composites," accepted for SAE General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 11-13, 1989.

Y. Ballout, J. E. Talia, "The Macrostructural Effect of the Composite Materials on Solid Particle Erosion," accepted for SAE General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 11-13, 1989.

D. W. Becker, "Producibility for Polymer/Fiber Composites," chapter for the Advancement of Materials and Process Engineering Encyclopedia of Composites, 1989.

J. Chaudhuri, Q. Jang, "Effect of Special Orientation on the Fracture Behavior of Graphite/Epoxy Laminates," Proceedings of the 3rd Technical Conference on Composite Materials, Sept. 1988, American Society for Composites.

J. Chaudhuri, V. Gondhalekar, A. Inchekel, J. E. Talia, "X-Ray Rocking Curve Analysis of the Effects of Aging and Deformation in Al-Li Alloys," TMS-AIME Annual Meeting, Symposium on Light-Metals Alloys for Aerospace Applications, 1988.

V. Gondhalekar, J. Chaudhuri, A. Inchekel, J. E. Talia, "X-Ray Analysis of Aging and Deformation Characteristics in Al-Li Alloys," SAE General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 11-13, 1989.

M. Greywall, "A New Approach for Grid Generation," 41st Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, November 22-24, 1988.

M. Greywall, "Streamwise Computation of Three-Dimensional Incompressible Potential Flows," Journal of Computational Physics 78, 178, (1988).

M. Greywall, "Streamline Grid Generation for 3-D Flow," Bulletin of the American Physical Society 32, 2039, (1987).

M. Greywall, "A New Approach for Grid Generation," Bulletin of the American Physical Society, 33, 2265, (1988).

M. Greywall and N. Zeytinoglu, "Wall Functions for k and epsilon for Turbulent Flow Through Rough and Smooth Pipes," Eleventh International Symposium on Turbulence, October 17-19, 1988, University of Missouri-Rolla.

J. A. Harris, A. M. Youssef, "Simulation of Turbocompound Two-Stroke Diesel Engine," SAE 1989 General Aviation Aircraft Meeting, Wichita, KS, April 11-13, 1989.

S. J. Hooper, "A Mixed Mode Fracture Analysis of the Cracked Lap Shear Specimen Using a Sublaminar Approach," 30th SDM Conference, August 18, 1988.

S. J. Hooper, R. Toubia, "Free-Edge Effects of Quasi-Isotropic Laminates Subject to Tension/Compression and Hygrothermal Loadings," submitted for General Aviation Meeting and Exposition, Wichita, KS, April 11-13, 1989.

A. Inchekel, J. E. Talia, "Influence of Surface Generated Scratches on the Fatigue Life of Al-Li Alloys," accepted for SAE General Aviation Aircraft Meeting and Exposition, Wichita, KS, April 11-13, 1989.

M. R. Naji, M. Haidar, "An Experimental Dynamic Analysis of Sprocket Load Distribution," accepted for the ASME 5th International Power Transmission and Gearing Conference, Chicago, IL, April 25-27, 1989.

J. Ontko, J. A. Harris, "Transients in the Counterflow Heat Exchanger," A. L. London Symposium, Stanford University, Stanford, CA, accepted March 23-24, 1989.

J. Talia, T. Toriyama, P. K. Mazumdar, "A Study of the Fatigue Behavior in Scratched Samples of Al-Li (2090 - T3) Alloys, submitted for presentation at the Fifth International Al-Li Conference, March 28-31, 1989.

J. Talia, A. Inchekel, V. Gondhalekar, and J. Chaudhuri, "Stretch Formability of Sheet Al-Li," TMS-AIME Annual Meeting, Symposium on Light-Metals Alloys for Aerospace Applications, 1988.

J. Talia, A. Inchekel, "The Effect of Surface Generated Scratches on the Fatigue Life of Al-Li Alloys," TMS-AIME Annual Meeting, Symposium on Light-Metals Alloys for Aerospace Applications, 1988.

J. Talia, "Quasi-Cleavage Fracture in Fatigue," 12th Congress of Scientific Investigation, February 1988, with C. Melendez and P. K. Mazumdar.

J. Talia, "Influence of Anodic Oxidation on Fracture Behavior of Tungsten," TMS-AIME Fall Meeting, October, 1987, with R. Gibala.

J. Talia, "Effect of Oxide Films on the Fatigue Behavior of Al-Li Alloys," submitted to Int. J. of Fracture, 1988.

J. Talia, "Surface Oxide Softening in Hexagonal-Closed Packed Metals," submitted to J. Mat. Sci. Letters, 1987.

J. Talia, "Surface Morphology in Ductile Erosion," submitted to Wear, 1987.

J. Talia, "Surface Ripples Formation Mechanism on Ductile Wear Erosion," Proceedings of the ASM Materials Congress, Cincinnati, Ohio, October 1987.

J. Talia, "Solid Particle Erosion in Composite Materials," Proceedings of the ASM Materials Congress, Cincinnati, Ohio, 1987.

J. Talia, J. Chaudhuri, "Formability Studies in Al-Li Alloys," TMS-AIME Annual Meeting, Phoenix, AZ, January, 1988.

J. Talia, K. Farhat, "X-Ray Characteristics of Undoped Semi-Insulating GaAs and The Effect of Oxide Films on the Fatigue Behavior of Al-Li Alloys," IAR 88-109, December, 1987.

J. Zytchow, "A Methodology for Multisearch Systems," Z. Ras and L. Saitta (eds.), Methodologies for Intelligent Systems 3, North Holland, New York, NY, 1988, p. 343-352, with Andrzej Janowski.

J. Zytchow, "Utilizing Experience for Improving the Tactical Manager," Proceedings of the Fifth International Conference on Machine Learning, June 1988, Morgan Kaufmann Publ., p. 449-450, with Michael Erickson.

J. Zytchow, "Tactical Manager in a Simulated Environment Methodologies for Intelligent Systems," (eds) Z. W. Ras and M. Zemankowa, Elsevier Science Publishing Co., October 1987, p. 139-147, with Michael Erickson.

J. Zytkow, "Combining Many Searches in the FAHRENHEIT Discovery System," Proceedings of the Fourth International Workshop on Machine Learning, June 22-25, 1987, Morgan Kaufmann Publ., Los Altos, CA, p. 281-287.

J. Zytkow, "Data-driven Approaches to Empirical Discovery," Technical Report 88-24, University of California, Irvine, 1988, 28p, with Pat Langley.

J. Zytkow, "Real-time Decision Making for Autonomous Flight Control," accepted for the Proceedings of SAE General Aviation Meeting, April 1989.

J. Zytkow, "Deriving Basic Laws by Analysis of Processes and Objects," accepted for the International Workshop on Computational Approaches to Discovery, Stanford, Jan 7-8, 1989. Also accepted for the book: Computational Approaches to Discovery, 1989.

4. LIST OF SCIENTIFIC PERSONNEL

4.1 Faculty Researchers

<u>Name</u>	<u>Department</u>
Dr. William Wentz	Aeronautical Engineering
Dr. A. Richard Graham	Mechanical Engineering
Dr. John Hutchinson	Mathematics
Dr. John Breazeale	University Professor
Dr. Jharna Chaudhuri	Mechanical Engineering
Dr. Jorge Talia	Mechanical Engineering
Dr. Jan Zytkow	Computer Science
Dr. James A. Harris	Mechanical Engineering
Dr. James Bowyer	Mechanical Engineering
Dr. Mahesh Greywall	Mechanical Engineering
Dr. Paul Steranka	Mechanical Engineering
Dr. Mohammad Naji	Mechanical Engineering
Dr. Walter Bernhart	Aeronautical Engineering
Dr. Walter Horn	Aeronautical Engineering
Dr. Steve Hooper	Aeronautical Engineering
Dr. Bert Smith	Aeronautical Engineering
Dr. T. Paramasivam	Aeronautical Engineering
Dr. Gary Crown	Computer Science
Dr. Bruce Koehn	Computer Science
Dr. V. Subramanian	Computer Science
Dr. Wojcik	Computer Science
Dr. Zhi-Xi Fang	Computer Science
Dr. Nasser Fard	Industrial Engineering

4.2 Students Supported

<u>Name</u>	<u>Department</u>
Chia-Yin Hwu	Aeronautical Engineering
Q. Jang	Mechanical Engineering
R. Subramanian	Aeronautical Engineering
M. Shih	Aeronautical Engineering
A. M. Latifi	Mechanical Engineering
M. Erickson	Computer Science
A. Youssef	Mechanical Engineering
S. Khandan	Mechanical Engineering
B. J. Kitchen	Mechanical Engineering
H. Moosavi	Mechanical Engineering
S. Swangwanna	Computer Science
L. Zhao	Computer Science
A. Tohmaz	Mechanical Engineering
M. Said	Mechanical Engineering
A. Inchekel	Mechanical Engineering
G. Vasant	Mechanical Engineering
Y. Ballout	Mechanical Engineering
F. Rehman	Mechanical Engineering
P. Gien	Aeronautical Engineering

J. Ontko	Mechanical Engineering
S. Prakash	Computer Science
C. Appl	Aeronautical Engineering
S. Alyan	Mechanical Engineering
T. Nguyen	Computer Science
P. Mangat	Mechanical Engineering
C. Thomas	Mechanical Engineering
M. Henderson	Aeronautical Engineering
T. Wu	Aeronautical Engineering
R. Toubia	Aeronautical Engineering

4.3 Degrees Awarded and Theses

Master of Science by Mehran Latifi - Thesis Title: "Solid Particle Erosion in Composite Materials," 1987.

Ph.D. by Shahab Khandan - Thesis Title: "Partially Parabolized Computation of Two-Dimensional Internal Viscous Flows," 1988.

Master of Science by Khoden Farhat - Thesis Title: "The Effect of Oxide Films on the Fatigue Behavior of Al-Li Alloys," 1988.

Master of Science by Q. Jang - Thesis Title: "Effect of Special Orientations on the Fracture Behavior of Graphite Epoxy Laminates," 1988.

Master of Science by Michael Shih - Non-thesis, 1988.

Master of Science by Michael Erickson - Thesis Title: "A System for Automated Concept Learning," 1988.

Master of Science by Sulyuth Swangwana - Thesis Title: "Squeeze: An Algorithm Which Combines Two Plans Together," 1988.

Master of Science by Tuan Nguyen - Thesis Title: "Image Signal Processing: A Segmentation Method Suitable for Multiprocessor System," 1988.

Master of Computer Science by Liande Zhao - Practicum Title: "The FAHRENHEIT Discovery System: Implementational Studies and Experiments," 1988.

Master of Science by J. S. Ontko - Thesis Title: "Transients in the Counterflow Heat Exchanger," Completion May, 1989.

5. REFERENCES

1. "The Institute for Aviation Research and Development Research Project Proposal" submitted to the United States Army Research Office by The Wichita State University, April 28, 1986.
2. "Aviation Safety Research Proposal," submitted to the Federal Aviation Administration Technical Center, by the Institute for Aviation Research and Development at The Wichita State University, May 23, 1986.
3. "Committed to Excellence in Aviation Through Research - Business Plan for FY1989-FY1991," submitted to the Kansas Technology Enterprise Corporation by the Institute for Aviation Research at The Wichita State University, September, 1988.
4. "Institute for Aviation Research - The Wichita State University," published by the Office of University Communications, 1988.