

P-27

# AI at AMES

*Artificial Intelligence Research and Application  
at NASA Ames Research Center  
Moffett Field, California  
February 1985*

*edited by Alison E. Andrews  
Applied Computational Aerodynamics Branch  
STA*

PRECEDING PAGE BLANK, NOT FILMED

# AI AT AMES

---

Rumors of artificial intelligence (AI) activity at NASA Ames have been floating around for some time. To the relief of those of us here at Ames attempting to work in AI, those rumors have not been greatly exaggerated, and, in fact, the discovery of such a quantity and diversity of planned and on-going projects exceeded all expectations. To promote cooperation among scientists and better-informed planning in management, this document was conceived and prepared. Several months were required to gather and organize the project descriptions contained herein. It is hoped that the effort expended initially will make future updates easier to prepare.

This document contains three principal types of information, in this order:

1. charts of function versus domain for AI applications and interests, and research area versus project number for AI research
2. a list of project titles with associated project numbers and page numbers
3. project descriptions, including title, participants, and status

In particular, the chart for AI applications and interests is an attempt to present information in such a way that

1. function commonality across domains is shown
2. the amount and type of work in a particular domain is seen at a glance
3. blank regions are easily detected and evaluated for possible future work

Feedback on this presentation is requested and will be appreciated.

Many thanks to all of the scientists and engineers at Ames who contributed project descriptions. Their work made this document necessary - their patience, help, and encouragement made it possible.

### AI AT AMES

Domain Function*	AI Applications								AI Interests
	Life Science		Space Science		Earth Resources		Aeronautics		
	Human Factors	Life Sup. /Medicine	Space Station	Astro-nomy	Atmosph. Research	Remote Sensing	Aircraft Systems	CFD	
Prediction	1, 2, 3						18		43
Interpretation				10	14	15,16	18,19, 20		
Diagnosis	5, 6	8					19,22		44
Design							17,18	23,24	45
Planning				11,12, 13			18,19		
Monitoring	1, 2, 5						18,19, 20		
Control	3, 5	7	9				18,19, 20,21		
Debugging	5, 6						22		
Repair									
Instruction	4								46
Advice	5, 6								
Natural Language	2						18		
Machine Vision		7	9		14	16	18		
Expert System Tools									
Robotics		7	9						44,46, 47
Learning	3, 4								46

\* For function descriptions, see reverse side 1-255

## AI AT AMES

---

The following function categories and their descriptions are from Table 1.1, p.14 of Building Expert Systems, edited by F. Hayes-Roth, D. Waterman, and D. Lenat.

- PREDICTION - Inferring likely consequences of given situations (eg. military forecasting, traffic prediction, weather)
- INTERPRETATION - Inferring situation descriptions from sensor data (eg. speech understanding, image analysis, signal interpretation)
- DIAGNOSIS - Inferring system malfunctions from observables (eg. medical, electronic, mechanical, software)
- DESIGN - Configuring objects under constraints (eg. circuit layout, building, budgeting)
- PLANNING - Designing actions (eg. robot, route, communication, military, project)
- MONITORING - Comparing observations to plan vulnerabilities (eg. nuclear power plant, air traffic, disease)
- CONTROL - Interpreting, predicting, repairing, and monitoring system behaviors (eg. air traffic control, battle management, mission control)
- DEBUGGING - Prescribing remedies for malfunctions [planning, design, prediction] (eg. intelligent knowledge base and text editors)
- REPAIR - Executing a plan to administer a prescribed remedy (eg. automotive, avionic, and computer maintenance)
- INSTRUCTION - Diagnosing, debugging, and repairing student behavior (eg. intelligent computer-aided instruction)

AI AT AMES

AI Research																
Research Area	Projects															
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Human Perception, Cognition											X	X		X		
Human-Machine Interaction									X			X	X	X		
Robotics								X								
Machine Vision, Perception								X								
Machine Architectures						X										
Info. Extraction, Understanding					X											
Reasoning		X	X												X	
Knowledge Representation	X	X	X	X					X	X					X	X
Planning and Problem Solving														X		
Learning																
Natural Language														X		X
Automatic Programming																
Expert System Building Tools	X			X			X								X	

Category	AI Books
General AI	41
Expert Systems	42

## AI AT AMES

	<u>page</u>
1. <u>Automatic Detection of Procedural Errors</u>	9
2. <u>SMART CHECKLIST for Aircraft and Spacecraft</u>	9
3. <u>Army-Aircrew-Aircraft Integration Program (A<sup>3</sup>I)</u>	10
4. <u>Expert System for Pilot Training (A<sup>3</sup>I)</u>	10
5. <u>Plant Control and Failure Diagnosis</u>	10
6. <u>ORS Operator Advisor</u>	11
7. <u>Automatic Control of CELSS</u>	11
8. <u>Aerospace Medicine</u>	11
9. <u>SMART Program</u>	12
10. <u>Infrared Data Examination and Analysis Expert System</u>	12
11. <u>Kuiper Airborne Observatory Flight Planner</u>	13
12. <u>Halley's Comet Observation Scheduler</u>	13
13. <u>SIRTF Scheduler</u>	14
14. <u>Aerosol Particle Image Classifier</u>	14
15. <u>Remote Sensing Image Classification</u>	15
16. <u>Image-Based Geological Exploration</u>	15

## AI AT AMES

---

	<u>page</u>
17. <u>Conceptual / Preliminary Design of Aircraft</u>	16
18. <u>Single Crew Scout/Attack Helicopter</u>	16
19. <u>Real-Time Applications of Expert Systems</u>	17
20. <u>Advanced Integrated Flight Control System Study</u>	17
21. <u>Advanced Guidance Systems for Aircraft</u>	18
22. <u>Verification Testing for Digital Flight Control Systems</u>	18
23. <u>Automatic Zonal Grid Generation for CFD</u>	18
24. <u>CFD Expert System</u>	19
25. <u>Knowledge Representation and Knowledge Acquisition</u>	21
26. <u>Reasoning With Uncertainty</u>	21
27. <u>Fuzzy Rule-Making for Failure Detection and Expert Systems</u>	21
28. <u>System Procedural Knowledge Engineering Tools</u>	22
29. <u>Information Understanding</u>	22
30. <u>Symbolic Processor Architectures</u>	22
31. <u>Inference Engine Evaluation</u>	23
32. <u>Robotics Perception Laboratory</u>	23

## AI AT AMES

---

33.	<u>Concept Design of Intelligent Iconic Processors</u>	23
34	<u>Know. Rep. of an Executive Expert System Controller</u>	23
35	<u>Computational Models of Human Vision</u>	24
36	<u>Pilot-Cockpit Interface Design</u>	24
37.	<u>Information Processing Models</u>	24
38	<u>Aircrew Cockpit Communications</u>	25
39.	<u>Expert Systems Research</u>	25
40.	<u>Natural Language Research</u>	26
41.	<u>Book - Intelligent Machines</u>	27
42	<u>Book Chapter - Knowledge-Based Systems for CFD</u>	27
43	<u>Pilot Aids</u>	29
44	<u>Optimal Diagnostic Techniques</u>	29
45.	<u>AI / Numerical Optimization Integration</u>	29
46.	<u>Machine Learning, CAI</u>	29
47.	<u>AI Languages, Operating Systems</u>	29



# AI APPLICATIONS

\*\*\*\*\* LIFE SCIENCE \*\*\*\*\*

## HUMAN FACTORS

1.

Project: Automatic Detection of Procedural Errors  
Participants: Everett Palmer, LH (grant monitor)  
John Hammer, Georgia Tech  
Status: Work in progress  
Grant

### Project Description:

"Under a grant to Georgia Tech, Dr. John Hammer has developed a computer program (PLANE) which can automatically detect procedural errors made by an aircraft crew. The program is based on Schank's [Roger Schank of Yale] concept of scripts. The flight is structured as a four-level tree consisting of mission, flight phases, procedures and actions. Each node in the tree can be in one of four states (unstarted, inprogress, done, or aborted). As actions occur during the mission, the state of the tree is updated and erroneous actions are called out. During the coming year this program will be applied to data from a full mission simulation in the B727 simulator at Ames."

### Reference:

Hammer, John : "An Intelligent Flight Management Aid for Procedure Execution", IEEE Transactions on Systems, Man and Cybernetics, in press.

2.

Project: SMART CHECKLIST for Aircraft and Spacecraft  
Participants: Everett Palmer, LH  
Ed Lee, LH (Informatics)  
Status: Work in progress  
In-house

### Project Description:

"At Ames we are incorporating concepts from John Hammer's program into the design of a SMART CHECKLIST program. The goal of the SMART CHECKLIST is to aid the operator of aircraft and space craft systems in executing procedures. The program will also monitor for procedural errors made by the operator. This project will combine concepts from rule based models of human behavior, AI theories of story understanding, and syntax directed editors used in software development environments. The space shuttle payload that we have chosen to investigate is the Orbiting Refueling System (ORS)."

3.

Project: Army Aircrew-Aircraft Integration Program (A<sup>3</sup>I)  
Participants: Irving Statler, Y  
David Nagel, LH  
Earl J. Hartzell, LHAC  
Status: Work in progress  
In-house, contract

Project Description:

"[This] activity is a new one that the Aeromechanics Laboratory has undertaken jointly with NASA's Aerospace Human Factors Research Division. This ambitious endeavor, called the Army Aircrew-Aircraft Integration (A<sup>3</sup>I) Program, will attempt to develop a validated methodology for predicting the pilot behavior in a single-seat scout/attack helicopter. The model is intended to be used for helping engineers account for the design of cockpits and training systems. We have initiated some discussions with representatives from Stanford University about the possibility of developing an 'expert system' that might be useful as a checkpoint in the process of validating the human model. In the meantime, we may also be developing some expert systems for controlling opponent aircraft in simulations of air-to-air combat."

4.

Project: Expert System for Pilot Training (A<sup>3</sup>I)  
Participants: Wun Chiou, SI  
William Gevarter, SI  
Bruce G. Buchanan, Stanford University  
Status: Work in progress  
In-house, grant

Project Description:

This project involves the development of an expert system which is capable of transferring an instructor pilot's knowledge to a student pilot. The system must be able to learn in some sense, so that a model of the student's knowledge can be formed.

5.

Project: Plant Control and Failure Diagnosis  
Participants: Everett Palmer, LH (grant monitor)  
Bill Rouse, Georgia Tech  
Annette Knaeuper, Georgia Tech  
Status: Work in progress  
Grant

Project Description:

"Under a research grant to Georgia Tech, Dr. Bill Rouse and Annette Knaeuper have developed a rule based model to describe the behavior of the operator of a generic process control plant. The model, named KARL, controls the plant and diagnoses plant failures. The design goal of KARL was to develop a model that could balance the competing demands of controlling the plant with needs to cope with failures. During the past year they have modified the model so that it provides advice to the plant operator. During the coming year this model will be extended to the description of operators controlling space shuttle payloads."

6.

Project: ORS Operator Advisor  
Participants: Guy Boy, LH (ONERA-CERT-DERA)  
Will Taylor, LH (Informatics)  
Status: Work in progress  
In-house

Project Description:

"Dr. Guy Boy from ONERA-CERT-DERA in Toulouse, France is visiting our group [LH] for a year. He has developed rule based models to model crew performance in aircraft cockpits. His project at Ames will be to develop an expert system (HORSES) [Human-Orbital Refueling System Expert System] to advise the operator of the Orbiting Refueling System during system malfunctions. He is basing this system on a system he developed in France to aid the operator of a geosynchronous satellite. He has a first version of the HORSES system operating on our [LH] VAX 750. It is programmed in Franz Lisp."

LIFE SUPPORT / MEDICINE  
-----

7.

Project: Automatic Control of Closed Environment  
Life Support Systems (CELSS)  
Participants: Silvano Colombano, LXL  
Status: Planning stage  
Some In-house, most probably contract

Project Description:

"A typical operational CELSS module, as presently envisioned, will provide life support, at least in part, to a crew of astronauts, in the form of breathable air and food. It is not envisioned, however, that the crew should spend a substantial amount of their time tending the system. The ideal CELSS will be largely self-sufficient, will recognize and maintain the state or sequence of states that are necessary to fulfill its function. It will detect problems, attempt to provide a diagnosis, select a course of action for self-repair, or at least suggest one. The reason for this is that the system will certainly be extremely complex, and the crew cannot be expected to have mastered its intricacies.

For self-regulation this system will need software that integrates aspects of AI, simulation and process control. It will have to be completely reliable and run on equally reliable and compact hardware.

While still keeping the need for increasing integration in mind, separate areas of software development have been listed: Simulation, Expert Systems, Computer Vision, Robotics, Computer Aided Design and Computer Aided Process Control."

8.

Project: Aerospace Medicine  
Participants: James Stevenson, LH  
Status: Planning stage  
In-house

Project Description:

1-263

With a background in experimental psychology and biostatistics, Dr. Stevenson is exploring the possible use of expert systems in aerospace medicine.

SPACE STATION  
-----

ORIGINAL PAGE IS  
OF POOR QUALITY

9.

Project: SMART Program (Space Missions for Automation and Robotics Technologies)

Participants: Henry Lum, SI

Status: Planning stage  
In-house

Project Description:

"The SMART Program is proposed as a multi-flight Shuttle-based Automation and Robotics Test Facility for the validation of advanced robotics, automation, and telepresence technologies and real-time operational concepts. The Facility will offer the potential for evaluating 'standard' operational environments for robotics and automation applications. Technology and the over-all system capability will be upgraded periodically by the Ames Cooperative Research Team consisting of researchers from Ames, industry, and academia.

The necessity of a space flight is dictated by the constraints imposed by space such as remoteness, zero-G, and 'hostile' environment. It is planned that all facility experiments will be evaluated prior to flight in NASA's ground test facilities such as MSFC's Neutral Buoyancy Facility. This procedure will maximize the potential for a successful flight. Complexity of the flight experiments will progress from RMS-attached robots to supervisory tethered robots to free-flying multiple robots working in a controlled distributed environment towards a common work objective. Telepresence mode is feasible for the latter."

ASTRONOMY  
-----

10.

Project: Infrared Data Examination and Analysis Expert System

Participants: Paul Swan, SST  
Jeffrey Scargle, SST  
William Likens, LXR  
Robert Mecklenburg, SST (Informatics)  
Gary Villere, SST (Informatics)  
Mike Werner, SSA

Status: Work in progress  
In-house

Project Description:

"The primary effort of this project has been in the conceptual design of an Infrared Data Expert Assistant (IDEA) computer program which would utilize expert system techniques to assist the infra-red astronomer in the examination and analysis of the very large set of data which is now being made available from the IRAS program."

The program will incorporate:

- Command Language Interface ("being developed by using the LEX and

YACC programs provided as part of the UNIX operating system on the VAX")  
- Data Base Management System ("...has been implemented by buying a commercial data base management system available for the VAX computer, and entering into it the data from IRAS, as well as astronomical catalogs obtained on magnetic tape from the Goddard Space Flight Center.")  
- Expert Infrared Astronomy Knowledge ("...a set of rules of the form IF...THEN... concerning interpretation of the IRAS data, as well as two specific search procedures for solving the problem of identification and classification of the IRAS point sources.")

11.

Project:                   Kuiper Airborne Observatory Flight Planner  
Participants:           Philip Nachtsheim, SI  
                          John Stutz, SI (Informatics)  
                          Carolyn Banda, SI (Informatics)  
                          William Gevarter, SI  
Status:                   Work nearly completed  
                          In-house

Project Description:

A computer program named KAOS (Kuiper Airborne Observatory Scheduler) has been developed to perform flight planning. "The basic mode of operation of KAOS is generate and test, that is, a leg is calculated for the observation of an object and then tested. Typically an observation is rejected if (1) the object is outside of the window, (2) the leg overflies a restricted zone, (3) the leg overflies a warning zone, or (4) the completion of a leg leads to a point out of range. These rules can be relaxed by the user, and other rules can be added. In a sense, the system can be 'trained'."

"The essential features of the expert system are the data base, rule base, and inference engine:

- data base: catalog of objects and ephemeris data  
                  geographical locations of warning and restricted zones  
                  flight departure points.
- rule base: if...then... (or situation-action) rules
- inference engine: MRS, or Meta-level Reasoning System, written in LISP and developed at Stanford University"

Reference:

Banda, C., Stutz, J., Nachtsheim, P., Gevarter, W.: "User's Guide for KAOS", November 1984.

12.

Project:                   Halley's Comet Observation Scheduler  
Participants:           John Stutz, SI (Informatics)  
                          Wun Chiou, SI  
Status:                   Work nearly completed  
                          In-house

Project Description:

This expert system schedules observations in the KAO for the fly-by of Halley's Comet. The system is an extension of the KAOS system (described previously). The similarity of the application allows the use of the KAOS structure with only minor modifications. The knowledge base has been modified for the new application.

13.

ORIGINAL PAGE IS  
OF POOR QUALITY

Project: SIRTF Scheduler  
Participants: Phillip Nachtsheim, SI  
Status: Planning stage  
In-house

Project Description:

This project will develop an expert system to schedule the observations for the Shuttle Infrared Telescope Facility. The KAOS system will serve as the foundation for this system.

\*\*\*\*\* EARTH RESOURCES \*\*\*\*\*

ATMOSPHERIC RESEARCH  
-----

14.

Project: Aerosol Particle Image Classifier  
Participants: Libby Netland, SI  
Scott Starks, University of Texas  
Status: Work in progress  
In-house

Project Description:

"[The Aerosol Particle System (APS) is] a developmental system which will use expert system building techniques to automate the classification of sulfuric acid particles. This will function as an aid to stratospheric aerosol research. Each month, a U-2 aircraft collects sulfuric acid samples by exposing palladium wires to the stratosphere at 70,000 ft. elevation. These wires are then photographed under a Scanning Electron Microscope. The photographs are examined by one of the aerosol researchers, and the sulfuric acid particles are counted and sized. Since the photographs are taken at a high magnification, flaws and dark spots appear which must be discriminated from the sulfuric acid particles. For this reason, traditional particle counting systems are inadequate.

The APS software uses similar isolation techniques and numerical feature measurements as those used in traditional Image Classifiers. However, once the feature measurements are known, they are related symbolically rather than numerically to choose the correct classification for the unknown object. The APS data base contains rules about predefined objects instead of numerical statistics about the objects. One advantage of having a symbolic rather than numeric representation is that the system can be easily modified by adding rules."

Reference:

Starks, S., Netland, E., and Elizandro, D.: "Analysis of Aerosol Particles by Digital Image Processing Techniques", 1984 ASEE Annual Conference Proceedings, p. 1335.

REMOTE SENSING  
-----

15.

Project: Remote Sensing Image Classification  
Participants: William Likens, LXR  
William Erickson, SI  
Steve Engle, LXR (Informatics)  
Status: Work in progress  
In-house

Project Description:

"The problem selected for this demonstration is that of automated labeling by land cover of spectral clusters developed through unsupervised clustering of Landsat Multi-Spectral Scanner (MSS) imagery. The prototype is to label spectral clusters for Level I information; namely, urban, forest, range, water, barren, and 'other'. This problem is well suited for expert system analysis in that, 1) the set of possible solutions is clearly defined, and 2) the problem is well understood and routinely solved by image analysis professionals.

Inputs to the prototype system will consist not only of MSS spectral statistics, but also collateral data. These collateral data may include digital terrain, zoning, prior land cover maps, and other data. Data are to be statistically summarized when input into the system in order to reduce their volume and complexity.

The concept for the mature system emphasizes minimal inputs from the user with an emphasis upon use of a dedicated expert system processor, such as a Xerox 1108, linked to image analysis functions on a larger general purpose computer, such as a DEC VAX 11/780."

Reference:

Erickson, W.K., and Likens, W.C.: "An Application of Expert Systems Technology to Remotely Sensed Image Analysis", Proceedings of the Pecora 9 Symposium, Spatial Information Technologies for Remote Sensing Today and Tomorrow. IEEE, October 1984.

16.

Project: Image-Based Geological Exploration  
Participants: Wun Chiou, SI  
Status: Work completed  
In-house

Project Description:

An image-based expert system for geological exploration was developed by Wun Chiou while he was at JPL.

Reference:

Chiou, W.: "System Architecture of a Remote Sensing Expert System", Proceedings of the IEEE Computer Society Workshop on Computer Architectures for Pattern Analysis and Image Data Base Management, p243-25J.

AIRCRAFT SYSTEMS  
-----

ORIGINAL PAGE IS  
OF POOR QUALITY

17.

Project:                    Conceptual/Preliminary Design of Aircraft

Participants:             George Kidwell, FHS  
                           Megan Eskey, FHP

Status:                    Work in progress  
                           In-house, possible contracts

Project Description:

"The ultimate goal of this project is the development of an integrated system capable of greatly assisting the advanced aircraft designer in achieving the optimal configuration based on requirements, constraints, and available technologies. Such a system will necessarily be a hybrid using many computer programming and analytical techniques, such as knowledge-based expert systems, numerical optimization, parametric approximation, design synthesis, and several levels of analysis algorithms. The driving rationale behind this project is based on the increasingly divergent design goals of high performance (speed, maneuverability, revenue, quietness, etc.) and economy (cost, maintenance, size, noise, etc.). In other words, a globally-optimal solution is required, but it is subject to many diverse constraints and must be found in a very large design space.

The general concept is to employ a knowledge-based expert system to act as the design expert and executive for the network of methods. At the next level would be a numerical optimization program to deal with those variables that are continuous and finite. Beneath this would be a hierarchy of synthesis and analysis programs that would be selected at appropriate times by the expert system. A database manager is necessary to interface with the user and the many diverse elements of the system. Finally, such a system must be able to network automatically (or semi-automatically) among the most appropriate computers for the analysis currently being used."

18.

Project:                    Single Crew Scout/Attack Helicopter

Participants:             Irving Statler, Y  
                           David Key, YC  
                           Loran Haworth, YC  
                           Edwin Aiken, FSDC  
                           Earl J. Hartzell, LHAC  
                           James Voorhees, LHA

Status:                    Planning stage  
                           In-house

Project Description:

"The Aircrew-Aircraft Systems Division of the Army Aeromechanics laboratory is interested in applications of artificial intelligence which would make feasible the fielding of a single-crew combat helicopter. Applications of expert systems, natural language processing, computer vision, and problem solving and planning to both the flight path control and mission management crew functions are required to reduce the single pilot's workload to a reasonable level in the combat environment. The Aircrew-Aircraft Systems Division includes 'experts' in the fields of flight control/handling qualities and engineering psychology/human factors."



19.

**Project:** Real-Time Applications of Expert Systems  
**Participants:** Lee Duke, OFDC  
Victoria Regenie, OFDC  
**Status:** Work in progress  
In-house, contract, university grant

**Project Description:**

"The cockpit of a modern high performance aircraft is an exceedingly complex interface between a human pilot with limited resources and an avionics system and aircraft of almost limitless complexity. The pilot is often required to perform multi-item tasks, using multiple controllers in conditions of high stress and extreme danger while monitoring the health and status of an avionics system consisting of numerous sensors, weapons, and computers. The pilot is virtually saturated visually and manually. The problem facing the systems engineer is either to simplify the system or simplify the interface between the pilot and the vehicle.

The ultimate goal of the Ames Dryden research and development in expert systems is the intent driven cockpit. The research and development leading to this goal has been partitioned into several areas to allow an orderly development process with intermediate goals and useful products.

- Flight System Monitoring Functions
- Expert Control Systems
- Pilot's Associate

The Ames Dryden research and development in real-time applications of expert systems is intended to concentrate on applications rather than basic research in expert systems. However, the goal of this activity is both to develop useful expert systems and to focus on fundamental issues that can be pursued by others involved in basic research.

Two sub-activities are being pursued, both under the auspices of the Pilot's Associate segment of DARPA's strategic computing initiative. The first is an expert flight systems monitor for the X-29A Forward Swept Wing Aircraft. The second is a closed-loop, goal seeking system."

**Reference:**

Regenie, V.A., and Duke, E.L.: "Expert Systems Applications to Failure Modes and Affects Analysis, Testing and Real-Time Monitoring", NASA Ames Dryden Flight Research Facility X-29A Internal Document X-84-007, June 1984.

20.

**Project:** Advanced Integrated Flight Control System Study  
**Participants:** Dale Mackall, OFM (contract monitor)  
Boeing Military Airplane Company  
**Status:** Work in progress  
Contract

**Project Description:**

"The study is to provide a preliminary design for an advanced aircraft by integrating previously independent aircraft functions, such as the aerodynamics, flight control, propulsion, structures, and the pilot. The study is to examine the tools and methods available to accomplish the design and identify any deficiencies. The study will be assessing the tools and methods to be used for the design of the pilot-vehicle interface. Boeing is applying their work from the 'Avionics Expert Systems Definition Study' to this task.

A small in-house effort was accomplished to obtain a basic understanding of how AI techniques can be applied to the pilot interface. The emergency procedures for the electrical and flight control system of a fighter aircraft were implemented into an 'expert pilot assistant' demonstration using an IBM PC. A NASA TM is in editorial, and a demonstration disk is available."

21.

Project: Advanced Guidance Systems for Aircraft  
Participants: Heinz Erzberger, FSN  
Status: Work in progress  
In-house

Project Description:

"In the Aircraft Guidance and Navigation Branch we are applying AI techniques to the design of advanced guidance systems for aircraft. Current projects involve developing expert based systems for automated air traffic control and air-to-air combat."

22.

Project: Verification Testing for Digital Flight Control Systems  
Participants: Douglas Doane, FSN  
Jeremy Saito, FSN  
N. Rajan, FSN (Stanford)  
Status: Planning stage  
In-house

Project Description:

"The Advanced Verification and Validation Project (Digital Flight Control System Verification Laboratory) is considering the use of AI concepts to develop a verification testing methodology for digital flight control systems. Initial planning indicates that an 'expert system' approach may provide an effective mechanism."

COMPUTATIONAL FLUID DYNAMICS (CFD)  
-----

23.

Project: Automatic Zonal Grid Generation  
Participants: Alison Andrews, STA  
Kristin Hessenius, STA  
Man Mohan Rai, STA (Informatics)  
Status: Work in progress  
In-house

Project Description:

"Because it is usually difficult or impossible to generate a reasonable single grid about a general three-dimensional aircraft configuration, a computational flow field is often segmented into simpler regions or zones, which are then discretized separately. Intelligent zonal grid generation requires knowledge about zone criteria, grid generation capabilities, flow solver behavior, and expected flow field features. Obtaining a good zoning is important to solution accuracy, efficiency, and ease of grid generation. With some guidelines, a CFD expert familiar with the concept of zonal methods can come up with a reasonable zoning in two dimensions by 'just looking at' the problem's configuration, qualitatively noting shapes, orientations, abrupt transitions, relative positions, and other features. However, such expertise is not widespread, and it is difficult to express. Furthermore, complicated three-dimensional problems present even experts with difficulties in the visualization and specification of zonal boundary surfaces. Hence there is a need to systematize and automate the process of obtaining and evaluating a flow field zoning.

An expert system approach is a promising one for zoning because it offers a way to encode zoning knowledge and manipulate it within a highly developmental and extensible framework. A rule-based expert system is being built using MRS, a system building tool (written in Lisp) developed at Stanford University. Work is being done on a VAX 11/780."

24.

Project: CFD Expert System  
Participants: Scott Eberhardt, STC  
Rick Briggs, RIACS  
Status: Planning stage  
In-house

Project Description:

"The goal of this project is to implement a deep expert system which generates the grid and all necessary parameters for ARC2D (a two-dimensional Euler/Navier-Stokes flow solver) given only the geometry, along with Mach and Reynolds Numbers. The geometry will be interpreted as a combination of 'shapes' which will be abstracted from the raw data. The expert system will then work symbolically using only the shapes, which will be matched with a hierarchy of shape-frames. After the initial phase is completed, we will be examining the possibility of the expert system running autonomously in special cases, without resorting to ARC2D. If a significant percentage of problems can be handled entirely symbolically (without using a numerical code) this will open up an entirely new area of research."

# AI RESEARCH

ORIGINAL PAGE IS  
OF POOR QUALITY

25.

Project: Knowledge Representation and Knowledge Acquisition  
Participants: Henry Lum, SI  
Claire Wolfe, SI  
Bruce G. Buchanan, Stanford University  
Status: Work in progress  
Grant

Project Description:

By working on PROTEAN, an expert system which determines the three-dimensional molecular structure of a substance from NMR (nuclear magnetic resonance) data, the blackboard model BB1, which is a framework for knowledge representation and control, is examined.

Reference:

Clancey, W.J.: "Acquiring, Representing, and Evaluating a Competency Model of Diagnostic Strategy", Stanford HPP Report 84-2, February 1984.

26.

Project: Reasoning With Uncertainty  
Participants: Henry Lum, SI (grant monitor)  
Lotfi Zadeh, U.C. Berkeley  
Status: Work in progress  
Grant

Project Description:

"Fuzzy Logic" is one way to handle uncertainty in reasoning. This project focuses on the further development of fuzzy logic.

References:

Zadeh, L.A.: "A Computational Theory of Dispositions", Proceedings of the 1984 International Conference of the Association for Computational Linguistics.

Zadeh, L.A.: "Test-Score Semantics as a Basis for a Computational Approach to the Representation of Meaning", U.C. Berkeley Memorandum No. UCB/ERL M84/8, January 1984.

27.

Project: Fuzzy Rule-Making for Failure Detection and Expert Systems  
Participants: Henry Lum, SI (grant monitor)  
Tom Sheridan, MIT  
Status: Work in progress  
Grant

Project Description: 1-272

This project will investigate the use of fuzzy logic in diagnosis of failures in complex space systems.

28.

Project: System Procedural Knowledge Engineering Tools  
Participants: Henry Lum, SI  
Mike Georgeff, SRI  
Status: Work in progress  
Contract

ORIGINAL PAGE IS  
OF POOR QUALITY

Project Description:

"Active intelligent systems need to be able to represent and reason about actions and how those actions can be combined to achieve given goals. This knowledge is often in the form of sequences of actions or procedures for achieving given goals or reacting to certain situations.

[In the tools being developed] the knowledge representation has a declarative semantics that provides for incremental changes to the system, rich explanatory capabilities, and verifiability. The scheme also provides a mechanism for reasoning about the use of this knowledge, thus enabling the system to choose effectively between alternative courses of action."

Reference:

Georgeff, M.: "Development of an Expert System for Representing Procedural Knowledge", contract report, December 1984.

29.

Project: Information Understanding  
Participants: Henry Lum, SI (grant monitor)  
Richard Volz, U. of Michigan  
Status: Work in progress  
Grant

Project Description:

Under a grant to the University of Michigan, Richard Volz is investigating the integration and fusion of sensor information for use by expert systems. It is hoped that this research will contribute to space-borne robotics applications.

30.

Project: Symbolic Processor Architectures  
Participants: Henry Lum, SI (grant monitor)  
Edward A. Feigenbaum, Stanford University  
Status: Work in progress  
Grant

Project Description:

This long-term project undertakes to develop a symbolic processor architecture which can equal or surpass a fifth generation computer in performance.

References:

Long, C.: "Framework for Circuit Design", Stanford HPP Report 83-45, December 1983.

Dietterich, T.G.: "Learning About Systems that Contain State Variables", Stanford HPP Report 84-18, May 1984.

31.

Project: Inference Engine Evaluation  
Participants: Claire Wolfe, SI  
Rafael Villegas, SI  
Vivian Frederick, De Anza College  
Status: Work in progress  
In-house

Project Description:

"The strengths and weaknesses of several existing inference engines (such as MRS, EMYCIN, AGE, OPS5) are being evaluated for various types of applications and appropriate inference engines are being maintained for use throughout NASA. An intra-agency class will be conducted this summer (1985) to familiarize people with the Symbolics Lisp Machine and available expert system building tools."

32.

Project: Robotics Perception Laboratory  
Participants: Scott Starks, University of Texas  
Veena Bhatia, SI  
Harold Fujii, SI  
Rajiv Mehta, FSN  
Status: Work in progress  
In-house

Project Description:

An experimental robotics laboratory is being established to test various sensor hardware and software for robot perception systems. Laboratory and educational robots are being acquired to equip the lab. This work will contribute information needed for determining requirements and specifications for the SMART program (see applications project 9).

33.

Project: Concept Design of Intelligent Iconic Processors  
Participants: Wun Chiou, SI  
Carolyn Banda, SI (Informatics)  
Status: Planning stage  
In-house

Project Description:

The goal of this project is to develop a translation between symbolic representation of information and representation by icons. This work will be done on a Symbolics, and will make use of Easy Graph, a Lisp tool developed in-house to draw polygons and various other geometric figures.

34.

Project: Knowledge Representation of an Executive Expert System Controller  
Participants: Wun Chiou, SI  
Bruce G. Buchanan, Stanford University  
Status: Planning stage  
Grant, in-house

Project Description:

This project will undertake an in-depth look at the knowledge representation involved in the control of the space station expert sub-systems.

ORIGINAL PAGE IS  
OF POOR QUALITY

35.

Project: Computational Models of Human Vision

Participants: David Nagel, LH  
Albert Ahumada, LH  
Ken Neilsen, LH  
Andrew Watson, LH  
Larry Maloney, NRC  
John Parrone, NRC  
Amyjo Bilson, U. of Washington  
Brian Wandell, Stanford  
Jack Yellott, UC Irvine

Status: Work in progress  
In-house, contract

Project Description:

"Biological vision is the only working example of a system capable of recognizing objects under varying conditions. Vision is also the principal interface between the human and complex devices such as computers, cockpits, and space stations. We are constructing a computational model of the early stages in the human visual process. At present, we have working modules for processing temporal, spatial, and motion components of the visual input. Future modules will deal with stereo and color. The model is being validated by psychophysical experiments in our facilities. This model will improve our understanding of human and machine vision, and will guide the design of future displays, interfaces, and image management systems."

36.

Project: Pilot-Cockpit Interface Design

Participants: Everett Palmer, LH (grant monitor)  
Ken Papp, New Mexico State  
Renate Roske-Hofstrand, New Mexico State

Status: Work in progress  
Grant

Project Description:

"Under a grant to New Mexico State, Dr. Ken Papp and Ms. Renate Roske-Hofstrand are investigating features of interface design which will maximize the compatibility between the cognitive structures of pilots and the way information is organized for retrieval in the computer. They have developed a methodology based on link weighted networks which derives a network representation of how a pilot's knowledge about a specific subject domain is organized. They are applying this approach to the Flight Management System's Control Display Unit in the Advanced Concepts Flight Simulator at Ames."

37.

Project: Information Processing Models

Participants: Everett Palmer, LH (grant monitor)  
Misha Pavel, Stanford University  
Stuart Card, Stanford University

Status: Work in progress  
Grant

Project Description:

"We also have a grant with Drs. Misha Pavel and Stuart Card in the Psychology department at Stanford. The objective of their grant is to develop design principles for the use of displays with multiple windows. They have used production system like models to describe the information processing operators do when working with a computer. They are using an IRIS graphics system connected to a XEROX LISP machine."

38.

Project: Aircrew Cockpit Communications  
Participants: Miles Murphy, LH (contract monitor)  
Joseph Goguen, Structural Semantics  
Charlotte Linde, Structural Semantics  
Status: Work in progress  
Contract

Project Description:

"Under a contract with Structural Semantics, Drs. Joseph Goguen and Charlotte Linde have analyzed aircrew cockpit communications as linguistic phenomena and developed formalisms showing 'planning' and 'explaining' to be structured discourse types, described by formal rules. These formalisms are integrated with those describing the other most important discourse type within the cockpit: the command and control speech act chain. Command and control discourse is described as a sequence of speech acts for making requests (including orders and suggestions), for making reports, for supporting or challenging statements, and for acknowledging previous speech acts.

This work can have application to expert system interface, goal, and rule design - whether to ensure natural crew interaction (for near-term systems), or possible system understanding of crew communications (for very advanced systems). The formalisms are being further refined on data from in-house full mission simulations."

References:

- Goguen, J., Linde, C., and Murphy, M.: "Crew Communication as a Factor in Aviation Accidents". In Hartzell, E.J., and Hart, S. (eds) "Papers from the 20th Annual Conference on Manual Control", NASA Ames Research Center, 1984.
- Goguen, J. and Linde, C.: "Linguistic Methodology for the Analysis of Aviation Accidents", NASA CR 3741, 1983.

39.

Project: Expert Systems Research  
Participants: Rick Briggs, RIACS  
Status: Work in progress  
In-house

Project Description:

"A new model of expert systems is being developed which moves away from current rule-based approaches. The rule-based system is viewed as incapable of encoding higher level cognitive processes of experts. The deep expert system has been proposed, in which the lowest level is an EMYCIN-like rule-based system, but which has in addition a series of levels of abstraction which include analogical methods and deep abstract methodologies which solve from 'first principles' rather than doing manipulation of rules on the basis of the syntax of the rules. Rules are considered compiled pieces of knowledge which are used for convenience. A system of semantic primitives has been developed which is used at the 'deepest' level of the system. A deep expert system is currently being developed in the domain of CFD."



48.

ORIGINAL PAGE IS  
OF POOR QUALITY

Project: Natural Language Research  
Participants: Rick Briggs, RIACS  
Status: Work in progress  
In-house

Project Description:

"A program is being written to 'understand' (i.e. represent at a level equivalently deep to the representation which human beings create when they hear or read natural language) simple natural language sentences. Sentences are broken down into very deep representations expressed entirely in a set of semantic primitives, and a method of inferencing is used which allows the program to expect further types of sentences in further discourse."

Also being studied is Sastric Sanskrit, "an obscure untranslated branch which functions as an unambiguous automatic inference-generating knowledge representation language." It is a "remarkable natural language which is ambiguity and syntax free. The equivalence of the language to semantic nets has been demonstrated in 'Knowledge and Representation in Sanskrit and Artificial Intelligence', by Rick Briggs, to appear Spring 85 in AI Magazine."

## AI BOOKS

---

41.

William B. Gevarter, SI

"Intelligent Machines: An Introductory Perspective of Artificial Intelligence and Robotics"

1985, Prentice-Hall, Inc., Englewood Cliffs, N.J.

"This book provides an easy-to-understand, integrated view of the many diverse aspects of the fields of artificial intelligence (AI) and robotics. It incorporates a summary of the basic concepts utilized in each of the many technical areas; a review of the state-of-the-art; research developments and needs; an indication of the organizations involved; applications; and a 5-10 year forecast of emerging technology."

42.

Unmeel B. Mehta, STT

Contribution of the chapter "Knowledge-Based Systems for Computational Aerodynamics" in the book "Knowledge-Based Problem Solving", edited by J.S. Kowalik

1985, Prentice-Hall, Inc., Englewood Cliffs, N.J.

# AI INTERESTS

---

43.

George Tucker, OAF

Background:

Interests:

- Research pilot, helicopter operations
- Expert systems applied to aiding pilots
- may work on "pilot prompter" expert system as a starter project

44.

James T. Wong, XA

Interests:

- Mathematical characterization of functional systems
- Optimal diagnostic techniques for fault isolation
- Search techniques, knowledge representation, pattern recognition, and knowledge-based systems

45.

Hiro Miura, FHS

Interests:

- System optimization with mathematical programming methods, more generally passive and adaptive optimization of the decision making process
- Integration of AI type decision tools with numerical optimization methods

Application areas considered:

- Structural design
- Rotorcraft system
- Flight plan (military, civilian)
- Aerodynamics of wings and propellers

46.

Carolyn Banda, SI (Informatics)

Interests:

- Building expert systems
- Tools for building expert systems
- AI languages
- Programs that learn
- Programs that help people learn; CAI using AI techniques, such as constructing a model of the learner

47.

Mo Aidi, ECS

Interests:

- AI languages
- Operating systems
- Expert systems