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NASA CENTER OF EXCELLENCE IN MAN-SYSTEMS RESEARCH

ANNUAL REPORT

JUNE 1985

Training Grant GT 23-005-802

University of Michigan Transportation Research Institute
Institute of Science and Technology
The University of Michigan
Ann Arbor, Michigan 48109

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Period 1 June 1984 through 31 May 1985

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NASA CENTER OF EXCELLENCE IN MAN-SYSTEMS RESEARCH

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The University of Michigan
Ann Arbor, Michigan 48109

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EXECUTIVE SUMMARY

This report reviews the progress and status of the NASA CENTER OF EXCELLENCE IN MAN-SYSTEMS RESEARCH during its first year. It provides a roster of students and a financial report, updating two previous interim letter reports (14 November 1984; 28 February 1985).

During the 1984-85 school year, NASA Research Fellow awards were made to five doctoral students, representing Bioengineering (2), Psychology (2), and Industrial and Operations Engineering (1). A sixth student was awarded limited research support in Mathematical Psychology. Currently four students are receiving support. Four additional students, selected from about 30 candidates, have been admitted to date for the fall term, representing Aerospace Engineering (2), Computer Sciences and Electrical Engineering (Artificial Intelligence) (1), and Industrial and Operations Engineering (1). One additional student in Aerospace Engineering will receive research support. Several other students with incomplete applications are still being evaluated.

During seminars in both the fall and winter terms a wide variety of aerospace-related topics were presented, and students had an opportunity to meet outstanding researchers from NASA, other government agencies and industry, including apollo 16 astronaut General Duke. All four current students will be visiting NASA Ames in June, and one will be taking the University's Human Factors course in July. A new course tentatively entitled "Special Topics in Aerospace Human-Machine Systems" is planned for the fall. The program is developing smoothly, and the number and quality of applicants is above expectations. The first year's experience indicates that the forecast budget can support more students than originally proposed.

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I. INTRODUCTION

This report outlines the progress and status of the training program NASA CENTER OF EXCELLENCE IN MAN-SYSTEMS RESEARCH, for the initial year ending 31 May, 1985, under Training Grant GT 23-005-802. In conformance with grant requirements, a roster of student trainees and their qualifications is provided as Appendix A, and a final financial report is provided as Appendix C, both of which have been previously submitted separately in other formats. Copies of seminar programs, recruiting announcements, and faculty resumes are also attached (Appendices D, E, G.). During this first year it was important to keep the sponsor closely informed of progress and particularly to communicate any changes, problems, or technical guidance requiring resolution, normal to development of any new program. In this regard this report provides an updating of two previous interim progress reports submitted 14 November 1984 and 28 February 1985 (Appendix F).

II. BACKGROUND

The primary purpose of the Center is to support NASA by providing training with a strong interdisciplinary emphasis for doctoral students of exceptional promise. A basic goal is to ensure development of individuals capable of looking at a total systems approach to aerospace or aviation problems. Increasingly complex technology requires research competence in areas of perceptual and cognitive skills necessary for effective decision-making, problem-solving, human reliability, and performance prediction. The prominence of artificial intelligence, robotics, and other specialized areas in aerospace and industrial research requires scientists and engineers with training which overlays traditional academic disciplines. The program emphasizes research at the man-machine interface and has evolved as one response to National Research Council studies, in 1982 and 1983, dealing with national research needs. The program was intentionally left flexible, to provide latitude to develop according to general guidelines.

The original three-year proposal envisioned three students in the fall of 1984, increasing to 15 to 20 students by the end of the third year. During the first year the program has been represented by a core of six academic departments (Anthropology, Aerospace Engineering, Electrical and Computer Engineering, Industrial Hygiene, Industrial and Operations Engineering, and Psychology), one research division (UMTRI/Human Factors), the Center for Ergonomics, the Human Performance Center, the Aircraft Research Laboratory, and the Bioengineering Program. The interdisciplinary nature of the core faculty is indicated by the major units involved: the School of Public Health, the Medical School, the College of Literature, Science and the Arts, and the College of Engineering.

Regular required seminars (given under an already established course number have been used this first year) to provide cross-disciplinary training. Due to the large variety of courses available within the University, it was believed there were already sufficient options so that new courses *per se* would not be necessary, since new subjects or materials could be introduced in seminar format. This concept appears to be working well.

III. STUDENT RECRUITING AND SELECTION

To be eligible for this program a student must be admitted to a graduate department or school of the University of Michigan, in a doctoral track program. In addition to the academic records and letters of recommendation an applicant must submit to the University, we also require a letter of application providing a statement of intent--why the applicant wants to be considered for a grant, what his (or her) motivation and background interest are, and what the applicant's objectives are. This turns out to be an important document in initial screening. In at least two instances--that of a medical student and an economics student--there was serious question as to the applicant's professed motivation and whether a professional career in aerospace human factors was really the objective. An applicant who can demonstrate no related hobbies, interests, courses, experience, or background to support his application is on weak ground.

We are pleased to report that the quality of the applicants to date has been exceptionally high. Many have just graduated from an undergraduate program and plan to continue on for a doctorate.

Others have received an undergraduate degree, have gained experience in an aerospace-related job, and have subsequently decided to return to school for an advanced degree.
Some of the latter applicants have had impressive work records, including aerospace human factors work at Lockheed, Boeing, NASA Johnson Space Center, IBM, Honeywell, Air Force Flight Dynamics Laboratory, Edwards Rocket Propulsion Laboratory, and NASA Headquarters. Such backgrounds, combined with a strong academic interdisciplinary program, should produce some outstanding doctorates of potential interest to NASA.

Despite the late start (funds for this grant were actually not received until late July, 1984) and the fact that most students had made a graduate program commitment decision by the preceding April or May, the initial recruiting was very successful. By concentrating on students in the core departments who were already admitted to a doctoral program we were able to identify seven applicants. From these, seven we selected our first three NASA Research Fellows, all with outstanding records. Faculty in the Departments of Psychology, and Aerospace Engineering and in the Bioengineering Program were especially cooperative in encouraging the best available students to apply. A brief description of each student is provided. Appendix in A, along with the student's own statement of intent. In addition, copies of two dissertation proposals are included: "Spatial Localization During Pursuit Eye Movements," (John Sullivan -

Psychology), and "Accuracy of Radionuclide Ventriculography in the Detection of Coronary Artery Disease" (Keith Levi - Mathematical Psychology).

Through May, 1985, we have received some 30 more applications, from which six additional NASA Research Fellows have been selected. These have included one in the winter term, one in the spring term, and four who will enter in the fall of 1985; a fifth will receive research support only. We are undecided on two additional candidates whose applications are as yet incomplete.

Our original recruiting in July and August of 1984 was of necessity focused on students already admitted to Graduate Programs in one of the participating core departments, at the University of Michigan. However, since last fall our efforts have been aimed at establishing a national recruiting base. In this regard we have employed several approaches, including contact with colleagues in the various disciplines, sending flyers to numerous educational institutions for posting on bulletin boards, publishing announcements in technical journals, and placing ads in selected student newspapers. Four of our Center faculty attended the Human Factors Society annual meeting and distributed a plentiful supply of our initial brochures, and considerable effort was made to announce the opportunities of the program in face-to-face contact with key human factors educators. Center faculty also made lists of the most prominent academic departments in their respective fields, and announcements were sent out directly to these departments around the country.

To obtain as wide a circulation as possible we have attempted to list the NASA grant program with national reference sources, with mixed results. One of those is SPIN (Sponsored Program Information Network) is a nation-wide computerized on-line data base of the Research Foundation of State University of New York. This system is used by colleges and universities and other users to obtain grant and fellowship information. Another source is <u>The Grants Register</u>, a reference source book of grant information. However, this is published only once every two years, and we will have to wait another year to be included.

We have also notified selected professional journals in the various fields. Another technique that seems to work in the short term is to place an ad in selected student newspapers on various campuses. This worked surprisingly well with the "Michigan Daily" and University Record" as a preliminary test, and we plan to run ads periodically in a number of such periodicals. To date a combination of these techniques seems to have produced best results. That is, student newspaper ads work for a short period, but probably word of mouth (faculty advisor, professors at various universities to students), bulletin board announcements at scientific meetings and around the country, and notices in professional journals and association newsletters all can be effective. During the coming year we expect to publish a brochure and distribute it widely.

We are now getting an increased geographic distribution of applicants. To illustrate this point, four (40%) of the first ten applicants were from Michigan. Subsequently only (10%) of the last ten have been from Michigan; others are from the states of Arizona, Ohio, Iowa, New York, North Carolina, and Washington. Similarly, representation has been from a wide variety of colleges and universities.

Academic disciplines are also tending toward a wide balance, which should assist in maintaining the interdisciplinary emphasis of this program. The first five Fellows represented the disciplines of Psychology (2-Sullivan, Nilsen), Industrial and Operations Engineering (1-Telep), and Bioengineering (1-Dagg), with a sixth (Levi-Psychology) receiving partial support. Subsequent awards have included Bioengineering (1-Beisel), Aerospace Engineering (3-Braunstein, Sheagren, Oppedahl (expect partial support)), Computer and Electrical Engineering (1-O'Day). Two additional applicants in Industrial and Operations Engineering (Cornelius, Lewis) are being considered for the fall term. We have also had un-successful applicants in additional disciplines of law, economics, medicine, anthropology, and nuclear engineering. However, in the future we expect to see a continuing diversity of disciplines.

IV. STUDENT PROGRAM

Since the lead time was so short at the initiation of the grant there was not time to design and implement new courses. But we were fortunate in utilizing an outstanding fall seminar series under auspices of the Department of Aerospace Engineering, previousley arranged by Prof. Harm Buning. A schedule of these is attached in Appendix D. Note the pertinence of the topics and the quality of the visiting scientist, including a Deputy Director of NASA. Additional seminars included Brig. General Duke, an Apollo 16 astronaut. A second astronaut, Harrison H. Schmidt, was also scheduled to lecture but could not get here due to a storm. He is expected to be here in the fall.

During the winter term a seminar series was given. This was listed under course numbers for Aerospace Engineering, Bioengineering, Industrial and Operations Engineering, and Psychology. Each lecture was followed by ample discussion. Since the lectures were attended by Center faculty as well as NASA Fellows, this regular seminar became the central means for student--faculty interaction. The seminars covered a wide variety of subjects with an emphasis on interdisciplinary research. A NASA orientation was provided with two guest lectures by Dr. Nagel and William Reynard of NASA Ames, and discussion of Dr. Anderson's spacelab experiment. A lecture on NASA technology exchange was also scheduled by Charles Kubakawa of NASA Ames, but postponed until fall. We expect that this NASA orientation will contine in subsequent seminars. A copy of the winter seminar program is also provided in Appendix D.

Several additional seminars or presentations were also attended by the students and faculty. One example was the Aerospace System Design class presentation of Project Lustar on 22 April. Support was provided by NASA Lewis for this class, which involved a preliminary design of a Lunar Transport Vehicle to carry astronauts and equipment from the Space Station to the surface of the moon.

At least one student expects to be attending the two-week summer session Human Factors course. This University of Michigan course has become internationally known, and one of the instructors, Dr. Paul Green, is part of our Center Faculty.

All four current Fellows will be traveling to NASA Ames the week of 24 June for orientation with the Aerospace Human Factors Research Division. They expect to brief staff on their current work and interests and in turn hope to establish further relationships and communication with NASA human factors researchers and programs. One student expects to stay for a longer period.

Currently a faculty subcommittee chaired by Prof. Howe is developing a course which we expect to offer in September. This two-credit course, tentatively titled "Special Topics in Human-Machine Systems," will cover contemporary topics in human machine systems and aerospace applications. Relevant theoretical background will be provided in topics such as information processing, manual control and feedback control systems, biomechanics, transportation systems, mental workload, psychophysics and decision theory.

Due to the diversity of disciplines, each entering Fellow must be individually counseled and guided toward specific courses and areas which will complement his own discipline. Most entering graduate Fellows already have basic math and science backgrounds and are proficient in computer systems. New courses are being developed at Michigan in the area of robotics, which would benefit our students. Two of our students have experience and interest in Artificial Intelligence, and we expect to direct them to specific professors or courses for further work. We are finding that the seminar format provides the best faculty-student interchange, supplementing their course and research activities. We are attempting to ensure that all students expand their knowledge in areas outside their own discipline, chiefly through efforts of the Center faculty representatives from the various departments. Two of our students have completed course requirements and are working on dissertations. Conflicting schedules for courses and meetings, and diverse student levels within our initial group continue to be factors to be resolved. As previously noted, developing a balanced program will be a long-term process; our toughest task to date has been to find a common time each week when students and staff can meet.

V. ADDITIONAL ACTIVITIES

Several additional activities deserve mention. During the year individual faculty members have visited NASA facilities or communicated with NASA colleagues fairly frequently. In an attempt to keep in touch with activities of the Aerospace Human Factors Research Division and to discuss our program as it develops, all eight Center faculty members visited NASA Ames at the outset of the program in August, 1984. Subsequently, Prof. Snyder visited Dr. Chambers or Dr. Nagel periodically throughout the year, as travel took him to the San Francisco area. Prof. Weintraub is again at NASA Ames this summer as a Visiting Scientist. Profs. Armstrong, Kochhar, and Snyder are tentatively planning further visits this summer to work for short periods with specific scientists and activities. In turn, Drs. Nagel and Reynard have visited here. We feel that good communication, between ourselves and NASA, is important to in order to ensure that our program is developing with mutual understanding and guidance, and that we are in touch with the directions and focus of NASA research needs and interests. Similarly, it is essential that our students are able to relate to areas of interest within the Aerospace Human Factors Research Division; the students' visit this summer to Ames should help establish such ties. We would encourage visits of NASA staff here and hope that a basis for improved communication can be worked out by additional NASA staff presentations here this fall. In this regard, Dr. Lauber and Charles Kubakowa of NASA Ames have agreed to present seminars.

Last August Profs. Howe, Van Gunst, Kochhar, and Snyder visited the Air Force Flight Dynamics Laboratory at Wright-Patterson AFB in Dayton. Of particular interest was the opportunity to try the new VCASS visual system within a pilot's helmet in an F-15 simulator. We are planning another two-day trip to familiarize the NASA Fellow students with research of the Aerospace Medical Research Labs and the Human Factors Division. Both Col. George Mohr, AMRL Commander, and Henning Von Gierke, Chief of the Bionics Division, have extended personal invitations.

Prof. Tom Armstrong will be participating in a "Gloves for Extraterrestrial Activities" workshop at NASA Johnson Space Center on 26-28 June. Previously Prof. Snyder participated in the Boeing 720 controlled crash at Edwards AFB as a NASA/FAA technical observer.

Of special importance to the development of facilities useful to the NASA Center of Excellence program is the differential maneuvering flight simulator, which has been acquired by the Department of Aerospace Engineering from Vought Corporation. Profs. Howe, Van Gunst, and Kochhar will be involved with this simulator, and related human-factors research sponsored by the USAF Human Resources Laboratory. The simulator is expected to become operational within six to nine months and will provide an unusual training and research opportunity for our students.

APPENDIX A

1. ROSTER OF STUDENTS

NASA RESEARCH FELLOWS AND ASSOCIATES

I. Fall Term - 1984

1. Jeff Dagg, Redford, Michigan - entering Ph.D. program in Bioengineering (Dr. Clyde L. Owings, faculty Center advisor).

Jeff received a B.S. in Biochemistry in the Honors Program from University of Michigan-Dearborn in 1984, and he has an unusual background of interests, (telescope building, antique clock repair, building radio control models), and experience combining life sciences and mechanics. For two years he was a summer engineering student at the Chevrolet Engineering Center where he worked in Vehicle Safety and Value Engineering. He plans to supplement his biochemistry degree with further courses in engineering and physiology, and is particularly interested in the development of artificial limbs and in devices which support humans in hostile environments such as space. A straight A student (except for 3 B+s) his undergraduate GPA is 3.9. A copy of Jeff's statement of purpose is attached in Appendix A2.

2. John Sullivan, Brooklyn, N.Y. - Ph.D. candidate in Psychology (Prof. Dan Weintraub, faculty Center advisor).

John has successfully completed formal course requirements, prelims and languages, and has an excellent record and background for eventual NASA research. He earned a B.A. in Psychology at Brooklyn College in 1977 (GRE Apt=1330, adv (Psych)=710), with a 4.0 GPA, earning a New York State Regents Scholarship, Dean`s Honor List, and graduating magna cum laude. Recommendations were high including: "a first rate laboratory worker and shows much promise as a productive and scholarly research psychologist"; "superbly well-equipped", "I recommend him to you without the slightest reservation" (by Fulbright Lecturer). His current research interests are related to problems of visual localization during and after smooth pursuit eye movements. In particular, he is examining the effects of varying the proximity of the background pattern to visually pursued targets on localization accuracy. Such research has relevance for the design of any artificial environment in which visual-motor coordination and localization accuracy are requisites for efficient human performance. He has also been involved in projects which examine people's sensitivity to acceleration, velocity, and mass information in dynamic visual displays, and has expressed an interest in computer systems design. A copy of John's dissertation proposal is attached (Appendix A2).

3. Bart Telep, Clarkes Summit, Penn. - entering Ph.D. program in Industrial and Operations Engineering, specializing in human factors engineering. (Prof.Dev Kochhar, faculty Center advisor).

Bart earned a B.S. degree *cum laude* in Psychology from the University of Scranton, 1984, where he was on the Dean's list, 3.49 GPA (major 3.64; 4.0 index). He had two years undergraduate work at the Pennsylvania State University. He was a lab assistant in Physiological psychology and involved in research in experimental psychology, with knowledge of SPSS, IBM and Apple computer statistical analysis programs, and the Russian language. Bart's capabilities and promise seemed to be higher than his scholarly achievements would indicate. He initiated studies in human factors in the industrial and operations engineering department, and Bart had been awarded a reduced traineeship. However, Bart concluded at the end of the fall term that the Department required more mathematics than he was interested in, and he withdrew from the University of Michigan and is no longer in our program.

4. Keith Levi, Mina Lake, South Dakota - Ph.D. candidate in Mathematical Psychology (Prof. Dan Weintraub, faculty Center advisor)

A fourth student, Keith Levi, has been awarded limited research and travel support ($3750) subsequent to my communication to Dr. Chambers of 19 September 1984, and letter to Frank Owens of 8 October (with response of 22 October). Keith was our unanimous top candidate, but chose a V.A. scholarship which awards some $2,000 more than the NASA grant.

Keith has an unusual background, having attended the University of South Dakota, Northern State College (Aberdeen), and receiving a B.S. degree with Honors, in 1979, with a 4.0 GPA. Among his undergraduate honors: Scholarship for Top Psychology Major (1978); Award for Most Outstanding Junior in Psychology (1978); Presidential Scholarship (1974); National Merit Finalist (1973); Outstanding Teenager of America (1972); Who's Who Among American Teenagers (1972); National Honor Society (1972-3). Subsequently, he earned an M.A. (1981) in fundamental measurement, scaling, statistics, and is concurrently completing a second M.A. in computer science at the University of Michigan.

Keith's dissertation research is on the quality of medicine decision making in the context of tests for coronary artery disease using Nuclear Ventriculography (MUGA). In addition he is conducting research on application of the theory of adoptive systems as applied to space mission planning (Defense Dept. Strategic Computing Program) with 25% support from Honeywell (Man-Machine Sciences Group, Minneapolis) where he was an intern during 1983-84. A copy of Keith's statement of interests and objectives, resume, and dissertation outline are included in Appendix A2.

II. Winter Term - 1985

5. Erik Nilsen, Harbor Beach, Michigan - 1st year graduate student in Experimental Psychology. (Prof. Dan Weintraub, faculty Center advisor).

Erik received a B.A. in Psychology from Graceland College (Iowa) with a perfect undergraduate 4.0 GPA and 4.0 overall GPA. He was accepted for the Psychology graduate program at Michigan with interests in cognitive experimental psychology and quality of work with computers in organizational psychology areas of specialization. Along with his course program he is currently working on a research project with Dr. Judith Olson concerned with man-systems design questions assessing the cognitive load that various computer software packages put on users. He has a good base in experimental design, computer programming, systems design, and mathematics.

III. Spring Term 1985

6. Jeff Beisel, Pensacola, Florida. Admitted to the Bioengineering Program. (Probable faculty Center advisor, Dr. Clyde Owings)

Jeff received an undergraduate degree in civil engineering (structures) from the University of Michigan in 1980, where he was ranked number one in C.E. and in upper 2% in College of Engineering (3.912 GPA). He has since been developing operating systems, hardware, and programming languages. He is responsible for designing

"ETAKE2," an entire system to aid the typical construction estimator and owns his own company in Pensacola. His focus here would be on neuromuscular transmission. His background is wide ranging, and he appears to exemplify the interdisciplinary aspects of our program. Due to personal problems involved in moving, selling his house, and leaving his business, he deferred entering until the spring term, and then requested a fall entry. A final decision has not been made, but probably he will be required to resubmit for faculty reevaluation.

The following students have been admitted during the 1st year but will not enter the program until September.

IV. Fall Term-1985

7. Kenneth Braunstein, Philadelphia, Pennsylvania. Admitted to the Aerospace Engineering graduate program in the College of Engineering starting in September. (Prof. Robert M. Howe will be his faculty Center advisor, together with Roger Van Gunst).

Ken received a B.S.C.E. degree in Civil Engineering from Rutgers University, and an M.S.E. degree in Mechanical Engineering from Stevens Institute of Technology. His undergraduate GPA was 3.81 and his graduate GPA 3.75. He has had seven years experience as a mechanical engineer, and has interests in aerodynamics, propulsion, dynamics and control, and control of flexible structures with application to future space station development. A copy of his application statement is attached.

8. Martha Anne Sheagren, Ann Arbor, Michigan. Admitted to the Aerospace Engineering graduate program, she represents the first woman to receive a NASA Research Fellowship in this program. (Her faculty Center advisors will be Prof. Robert M. Howe and Roger Van Gunst).

Martha received a B.S.A.E. degree in Aerospace Engineering from the University of Michigan in 1985, attaining an almost perfect 3.947 GPA. Among her many honors she was on the Dean's list, a recipient of the Women Engineer's Scholarship, a member of Tau Beta Pi, Sigma Gamma Tau, and Golden Key Honor Societies. In the summer of 1980 she was a midshipsman at the U.S. Naval Academy, and has had jobs as a Veteran's Administration Laboratory Assistant and as a computer monitor at the University of Michigan Apollo Computer Lab. During this summer she is working as a summer human factors intern at McDonnell Douglass Aircraft Company in St. Louis. Her present interests are in structural mechanics and design, particularly structural failure in aircraft and aerospace systems from a human factors system viewpoint. A copy of her resume and letter of interest are included in Appendix A2.

9. Stephen O'Day, Ann Arbor, Michigan. Admitted to Ph.D. program in Electrical Engineering and Computer Science, with main interest in Artificial Intelligence. (Expected faculty Center advisor Dr. Clyde Owings).

Steve received a B.S. degree in Mathematics and an M.S.E. degree in Engineering from the University of Michigan - Dearborn. His undergraduate GPA was 3.12 and his recommendations have all been exceptional to outstanding. He has been working during the past year at the University of Michigan Space Physics Laboratory on a NASA project involving software for a space shuttle program. He plans to concentrate in the area of artificial intelligence on his doctoral program. A copy of his statement of interest is attached (Appendix A2).

We expect to offer research support for the following student:

10. Mark Oppedahl Northfield, Minnesota. Admitted to the graduate program in Aerospace Engineering. (Faculty Center advisor Prof. Robert Howe or Roger Van Gunst).

Mark received a B.A. degree (Physics/English) from St. Olaf College. He was a National merit scholar, member of the physics honor society, and the Dean's list. His GPA was 3.94, while he earned a 720 verbal (96 %tile), and 770 analytical GRE scores. Mark has a particular interest in physics with a long-range career goal "either to become involved in the research and design of space vehicles and space structures, concentrating especially on manned missions, or to take part in such missions." Since he has accepted a Department Fellowship we will only be awarding partial research support.

Several students are still under consideration for the fall term with incomplete applications. Two who have an excellent chance of being awarded NASA Research Fellowships include:

11. Patrick E. Cornelius, W. Lafayette, Indiana. He has applied to the Industrial and Operations Engineering Ph.D. program with an emphasis in human factors. (Faculty Center advisor would probably be Prof. Thomas Armstrong or Prof. Dev Kochhar).

Pat has an exceptional background for future NASA research, including experience in isolation sociology. He received a B.S. in Astronautical Engineering from Purdue University in 1975, and is presently in the M.S. program in IOE/Human factors at Purdue. His undergraduate GPA is 3.26 but he reportedly has all A's in his graduate work. He has worked as a Research Engineer at Edwards AFB Rocket Propulsion Laboratory, was an Air Force Pilot (Captain), flying T-38 jets and B-52 bombers. In 1980 he worked for ITT/National Science Foundation, wintering over at the geographic South Pole one year and at Palmer Station another year, assisting an isolation sociologist. During the summer of 1984 he worked (with Dr. Bluth) on reducing the data and compiling a book (Analogues between Space Stations and Antarctic Stations) for NASA, complementing a Submarine Analogue and data from the Russian Space Program. Topics included manual control, equipment monitoring, and crew workload. In 1983-84 he served as a NASA Consultant to California State University, Northridge. His vitae and statement are attached. We are currently awaiting his GRE score (taken in June), whether he has been admitted by the I.O.E. department, and documentation of his graduate grades. Assuming these are satisfactory he will be offered a NASA Research Fellowship.

12. Ruthan Lewis, League City, Texas. Has applied to the Industrial Operations and Engineering and Bioengineering Programs, not yet apparently deciding on which to concentrate in. (Probable faculty center advisor would be Prof. Kochhar or Prof. Owings).

She earned a B.S. in Biomechanics from the University of Maryland, and an M.S. in Industrial Engineering from Texas Tech in Biomechanics and Work Physiology. She has been employed by the Lockheed Human Factors sections, NASA Man-Systems Division, Johnson Space Center. Her current work involves conducting research in intravehicular biomechanics, crew workstation design, and advanced spacecraft. Her thesis was "Effects of Fatigue on the Kinematics of Sagittal Lifting." At this time her application is incomplete, and no admissions decision has been made.

2. STUDENT RESUMES, LETTERS OF INTENT, OR DISSERTATION PROPOSALS

JEFF DAGG
BIOENGR

Becoming a part of the Center of Excellence in Manned Vehicle Systems program would further direct my education along the path I am pursuing and give me an opportunity to meet a career objective of being involved in the space program. I am sincerely interested in the interfacing of man and machines in frontier environments such as space. Being involved in such a program would further expose me to the interdisciplinary training that I believe is necessary to solve many of the complex problems facing a technological society.

My educational and working experiences have been proceeding along these lines. As an undergraduate I concentrated in Biochemistry but filled my electives with math courses and selections from the Honors Program that related to the interdependence of man, science, and society. I did my Independent Study with the math department simulating problems in celestial mechanics. For three years I have spent my summers working in Chevrolet's Value Engineering program. The purpose of this group is to organize teams composed of people of different disciplines to solve engineering design, procedural, and processing problems. Acceptance into the Manned Vehicle Systems program would place me in the educational and career environment that I am seeking.

Jeff K. Dagg
23 August 1984

STATEMENT OF PURPOSE

My background shows my interest in the life sciences and mechanics. In high school I was a lab assistant for the biology department, and in college I am majoring in biochemistry. My hobbies include telescope building, antique clock repair, and building radio control models. My experiences in an engineering environment include two years as a summer student at the Chevrolet Engineering Center where I worked in Vehicle Safety and Value Engineering. I am used to working in interdisciplinary programs due to my participation in the Honors Program at UM-Dearborn.

At present my career goals include research and, possibly, teaching. I am particularly interested in the development of artificial limbs and in devices which support humans in hostile environments such as space. To get into these areas I feel that I should supplement my biochemistry degree with some engineering and physiology.

Michigan's graduate program offers me just such an opportunity. The school has the facilities to offer a meaningful program, and the bioengineering degree enough flexibility to meet my needs.

Jeff K. Dagg
11/6/1983

John Sullivan
PSYCHOLOGY

John Sullivan
207 C
Perry Building, Human Performance Ce
330 Packard

Center of Excellence
222 UMTRI
University of Michigan

Dear Dr. Snyder,

Enclosed is a copy of my dissertation proposal. Please note that there are many more experiments proposed than will probably be run, and that the content of many of the studies will be amended in the course of discussion with my dissertation committee members. The proposal best serves as an indication of my current area of interest and specialization within psychology. If there are any comments or questions you would like to put to me, I would be happy to discuss it with you. I would welcome the opportunity.

Sincerely,
John Sullivan

Dissertation Proposal :

Spatial Localization During Pursuit Eye Movements

by

John Michael Sullivan

University of Michigan
Ann Arbor

January, 1985

Introduction

If an observer watches a target moving across his visual field with his eyes stationary, the target seems to move faster and further than if the observer follows the target with a pursuit eye movement. This effect, known as the Aubert-Fleischl paradox (Brown, 1931), has been investigated since the late 1800's and has been largely explained in terms of an eye movement under-registration hypothesis (Mack & Herman, 1972, 1973, 1978; Dodge, 1904; Brown, 1931; Stoper, 1967, 1973; Festinger & Canon, 1965; Festinger, Sedgewick, & Holtzman, 1976). When a target moves across the visual field and the observer's eyes are stationary, the target's motion is registered by the retinal motion. When a subject tracks a target in an otherwise dark environment, most retinal motion is nulled. In order to register the speed or extent of the object's motion, some awareness of oculomotor activity is therefore necessary. The under-registration hypothesis attributes the reduction in perceived velocity during pursuit to the failure of some portion of the oculomotor activity to be registered by perceptual processes which are responsible for maintaining a sense of spatial stability.

Empirical Investigations of the Under-registration Hypothesis

The details of the under-registration hypothesis are still much in doubt. Although under-registration has been measured as a loss in registered velocity (e.g., Mack & Herman, 1978; Yasui & Young, 1975), some results imply fixed losses of velocity, independent of variation in tracking velocity, while other reports suggest proportional losses occur. Mack & Herman (1973), for example, report a 1°/sec loss in registered velocity at both 3 and 10.5°/sec velocities, while Dichgans, Korner, & Voight (1969) report that the perceived speed of an untracked target is approximately 1.6 times that of a tracked target, a 38% velocity under-registration. Note that in a later study, Mack & Herman (1978) report their effects in terms of a 10% under-registration of velocity, but since they did not systematically vary velocity, their conclusions seem to be largely a matter of arbitrary interpretation. Others have side-stepped the velocity under-registration hypothesis completely and report that no extraretinal velocity registration occurs at all, but instead a perceptual 'default' velocity assumption of .1 to 1°/sec is made at the perceptual level whenever the eye is in motion (see Festinger, Sedgewick, & Holtzman, 1976).

Miller (1980) also recently measured underconstancy during pursuit. In his study, subjects tracked targets in harmonic motion with a period of .33 Hz and with trajectory extents ranging from 1.5 to 13°. Miller reports that the relationship between movement amplitude and the mean underestimate is approximately linear. This linearity suggests a fixed proportional loss of velocity information, since movement time was held constant. (However, it is possible that the effect could be a simple underestimation of distance moved independent of registered velocity.) Notably, this linear relationship contradicts the results found in a very similar situation investigated by Festinger et. al. (1976). In their study, observers tracked targets in harmonic motion with periods fixed at .5 Hz and trajectories subtending 2, 4, and 8° of visual angle. Their measure of registration, called 'perceptual tracking distance', did not change much with changes in trajectory size. It was, however, influenced greatly by tracking duration so that lower oscillation frequencies in the other conditions seemed to produce more registered distance. The authors argued that the dependence of the effect on duration suggests that subjects are integrating a probable movement rate over time, and that this assumed rate is fairly constant. Thus, when the period (duration) of oscillation is fixed, observers 'register' the same amount of target displacement regardless of actual displacement. The authors strongly suggest that very little actual eye velocity (or position) information is registered and that retinal slip produced by tracking targets oscillating in triangular (rather than harmonic) motion is responsible for the small under-registration measures commonly reported.

This result, in turn, contradicts Mack & Herman's (1972) report in which a uniform velocity loss of 1°/sec occurs for each of the two velocity levels (4.5°/sec and 10.5°/sec) examined. Unlike Festinger et. al. (1976), Mack & Herman found that the *slower* (and longer) tracking conditions produce more 'under-registration' (not less) than the faster moving target. To *increase* the distance unaccounted for during tracking, Mack & Herman actually lengthened the tracking time of the faster stimulus.

The assessment of position constancy is even more complicated by Miller's (1980) other results, which suggest that repetition of a pursuit movement can change the amount of under-registration from 11% during non-repetitive pursuit movements, to 33% for repetitive (5 sweeps) harmonic tracking. This has led to a rather complicated registration hypothesis in which a distinction is made between central and peripheral control of tracking. Predictable movements are believed to be relegated to a peripheral control mechanism, which apparently is not monitored. Consequently, all control functions performed at this level are not registered centrally, and so eye movements are not registered. How the perceptual system decides how far the eye has travelled, in the absence of this information, is unclear: it may assume the anticipated trajectory has been performed; it may partially monitor eye position centrally; it may use alternate retinal error feedback. The dual control system hypothesis does not seem to predict specifically why underestimations of eye movements should result during peripheral control.

Finally, there exists yet another opinion on the under-registration hypothesis. Hansen (1979) recently attempted to replicate the Festinger et. al. (1976) tracking experiment while investigating ballistic arm movements to pursued targets. Instead of finding a severe perceptual under-registration of eye movements, Hansen found nearly complete compensation for pursuit. The difference between the two studies seems to be the degree to which subjects were impressed to respond to egocentric versus retinocentric target motion. Howard (1982) suggests that when subjects are faced with a choice, retinocentric target motion may well dominate the subject's perceptions. Complete compensation for pursuit movements was also found by White (1976), who measured the effectiveness of masking stimuli during a pursuit tracking task. White compared masking effects on tilt discrimination as a function of spatial position of the mask. As subjects tracked a moving target, a tilt discrimination stimulus was flashed, followed by masks which could occupy either the same spatial or the same retinal location as the discrimination stimulus. White found that masks in the same spatial positions produce the greatest elevation in threshold.

To summarize, pursuit underconstancy effects have been reported as proportional under-registrations of velocity and of distance; as a constant under-registration of velocity; and as a nonregistration of velocity. The last effect is hypothesized to be dependent on tracking duration, with default constant velocity assumptions made at the perceptual level (where no real movement registration is actually available). And finally as an artifact of instructional set.

Simply stated, there is large disagreement and need to resolve these sharply differing opinions. Since few of the methods employed in each of the studies mentioned resembles any other, paradigm differences are obviously implicated. But this cursory evaluation of the problem fails to capture the degree to which studies differ. For example, the range of experimental parameters investigated varies widely: Festinger et. al. (1976) and Miller (1980) use harmonic repetitive target motions, while most other researchers use a constant velocity tracking target. The tracking velocities range from 1°/sec to 15°/sec; tracking extents range from 2° to 90° of visual angle. Few researchers report where, relative to the subject's primary visual direction, the movement begins and ends -- it is probably symmetric across the subject's median plane, but it should be reported. Some target motion is tracked across flat surfaces, some across semi-flat surfaces (e.g. CRT screens), and some across curved projection screens. Effects are also reported in unstandardized ways: Mack & Herman (1972, 1973) report data in terms of their saccadic controls; Festinger et. al. (1976) and Miller (1980) report registered pursuit relative to the pursuit movements the eye actually made (not relative to objective target motion); Stoper (1973) reports perceived stationarity relative to objective stationarity; Festinger & Canon (1965) report only absolute errors, ignoring constant errors of direction.

Most critically, response measures differ widely: Stoper (1973), for example, based his conclusions about pursuit registration upon subjects' reports of optimal apparent motion to target flashes made during tracking. Miller (1980) requested subjects to either re-fixate the starting position of the pursuit movement, or adjust a spot to the starting location. Dichgans et. al. (1969) recorded magnitude estimations of target displacements. Festinger et. al. (1976) asked subjects to adjust the offset of two tracked spots to mimic the perceived angle of motion of an untracked moving spot. Mack & Herman (1976) asked subjects to null the perceived motion of untracked targets presented near the tracking target. White (1976) measured tilt threshold changes during spatial and retinal masking. Many of the responses subjects are typically asked to make seem to be about some characteristic of the stimulus which they are *not* looking at during tracking. Howard (1982) criticizes this aspect of the research, suggesting that "...people have reasonably accurate awareness of the headcentric location of an object which they are pursuing, but a poor ability to localize objects in the stationary background."

Finally, it should be noted that visual direction constancy is not solely affected by the type of eye movement. The fact that pursuit movements are employed in a study, and that underconstancy effects are observed, does not mean that one caused the other. Direction constancy is also affected by a variety of factors not directly related to pursuit eye movements, but which may covary with pursuit movements. Merely sitting in the dark for a few minutes can make fixated targets appear to move about (i.e., the autokinetic effect). In addition to autokinesis, other known factors influencing perceived visual direction include: the symmetry of the visual field (Brosogle, 1969; Roleofs, 1959); asymmetric convergence (Morgan, 1978; Hill, 1972; Werner, Wapner, & Bruell, 1953); prolonged asymmetric fixation (Paap & Ebenholtz, 1976); induced motion (Brosogle, 1969; Dunker, 1929); and phoria of the occluded eye during monocular viewing (Ono & Weber, 1981). For example, it is not difficult to see that if a subject is making a slow tracking motion toward a position in the periphery, there is likely to be an underconstancy effect based only on the final eccentricity of the final eye position. Added to this is a potential effect from posttetanic potentiation (Paap & Ebenholtz, 1976) attributable to prolonged asymmetric strain on the eyes. Nothing can be concluded about pursuit eye movements unless some of these factors can be balanced out.

Proposed Studies to Investigate Position Constancy During Pursuit

The series of studies proposed here attempts to assess pursuit movement effects using a paradigm that does not require a subject to divide his attention between tracking an object in motion and rendering a judgement about the location of a remembered position out in the periphery. Instead, subjects are asked to remember the position of a target spot which appears in one of several positions ranging from the primary position to 6° left or right of primary position. After the target disappears, a tracking spot is presented at some distance (left or right) of target position (2, 4, or 6°). The tracking spot will begin to move across the subject's visual field. When it reaches the remembered location of the target spot, the subject signals this by pressing a button at the appropriate moment. The subject, at this point, should think he is looking directly at the remembered position. The paradigm is similar to those used by Rosenbaum (1976), Runeson (1977), and Jagacinski et al. (1984) to explore velocity extrapolation. Unlike those paradigms, the moving object in these studies is always visible, the target position is invisible, and eye movements are be carefully recorded to verify the subject is tracking the moving target.

Experiment Ia: Varied Velocity, Constant Distance

Based on the reports mentioned earlier, it is not entirely clear how much extra-retinal information contributes to direction constancy, nor is it clear which experimental factors in visual pursuit tasks influence the degree of underconstancy observed. This experiment will attempt to clarify this by examining tracking in a situation in which a subject observes only the tracked object and reports when the tracked object reaches the egocentrically defined straight ahead direction. Thus, the experiment avoids asking subjects to make reports on untracked objects, and it avoids asymmetric configurations of objects in the visual field, known to disturb the sense of direction (Brosogle, 1968; Roleofs, 1959).

The observer is first asked to make several adjustments of a movable object to the visual straight ahead in a darkened room. The positioning object will be started from both 10° left and 10° right of the objective egocentric straight ahead and several adjustments will be gathered to determine the subjective straight ahead (primary visual direction).

Before the start of the tracking trial, the subject will be reminded of the previously set primary direction by the presentation of a line marking this position. The primary direction indicator will then disappear, and the tracking object will appear at 6° to the left or right of the subjective primary direction. The tracking target will then begin to move toward this subjective center position at one of three different velocities: 1, 2, or 3°/sec. The subject's task is to respond with a keypress when the target reaches the primary position. As soon as the subject responds, the tracking target will disappear.

Predicted results: If subjects are under-registering the velocity of the target motion at a constant rate, we can expect to find that responses occur at nearly the same target position after the initiation of the target's motion. For example, if the objective motion of the target is 3°/sec and the subject registers only 2°/sec velocity (a 33% under-registration), a target starting at −6° from primary position should be perceived to reach 0° when it is actually at +3°, 3 secs after target motion begins. A 6°/sec target appears to move at a 4°/sec rate if there is a 33% under-registration; assuming that the distance is the same, the subject sees the target arrive at primary position 1.5 secs after initiation, when the target is actually at +3°. (Note that this is merely an example and that such high velocities at short distances put more demand on temporal precision than can reasonably be expected.)

Experiment Ib: Varied Distance

If subjects are assuming a fixed rate of movement, delays in responding should be nearly uniform across all velocities. The delay itself can provide an approximate measure of the perceptual system's baseline 'assumed' target velocity. If, on the other hand, Mack & Herman's (1972) suggestion that a uniform velocity loss of 1°/sec exists, then subjects should overshoot the target proportionately more during low velocities than during higher velocities. These proportions, however, should remain constant within a particular velocity level, unaffected by overall magnitude of tracking path length. For example, a target movement of 3°/sec should appear to a subject as a 2°/sec velocity. The subject should estimate the time the target takes to move 6° to be approximately 3 secs instead of 2. In this case, the target will have actually moved 9°. The underestimation of velocity by 1/3 will result in an estimate which is greater than it should be by 1/3. (9° − 1/3(9°) = 6°). If, target motion velocity is 4°/sec, and the subject registers only 3°/sec, then the underestimate will be 1/4 for all trajectory magnitudes. In order to test this hypothesis, a supplementary experiment can be run, varying the magnitude of the trajectories using 8°, 6°, and 4° distances from primary visual direction.

Control Experiments:

Experiment II: Visible Target. As a simple control for timing accuracy in the task, subjects will be given the same task to perform with the primary position indicator visible during tracking. This allows one to assess any constant error due to pure response delays which are unrelated to extraretinal eye movement registration.

Experiment III: Judgements on Early Retinal Slip. There is a chance that subjects might perform this task by interpolating an initial retinal slip over a time interval. Retinal slip is particularly likely if the tracking target's initial velocity is instantaneous (Festinger & Easton, 1974). If subjects merely collected velocity information during the start of the target's motion, and had no access to eye position information during tracking, then presenting subjects with only the initial 150 to 200 msecs of the tracking target's motion may be sufficient to obtain the same results as in the first experiment. This time interval represents the normal latency to initiate a pursuit eye movement (Rashbash, 1961; Robinson, 1965), so it can be assumed that the retinal slip seen during this time frame occurs across a relatively stationary eye, and provides the subject the purest source of information concerning the target's velocity. It should also be noted that this latency does not systematically vary with target velocity (Rashbash, 1961). Consequently, Experiment I can be re-run so that observers see only a brief retinal slip velocity. The subject must then select an interval of time which it will take the tracking object to reach a remembered spatial position.

Experiment IV: Judgements with Ramped Target Motion. It has been argued by Festinger and his co-workers (Festinger, Sedgewick, & Holtzman, 1977) that retinal slip velocity produced by instantaneous target motions are responsible for the low amounts of underconstancy observed by other researchers (e.g., Mack & Herman, 1972, 1973). Presumably, retinal slip velocity can be roughly interpolated over time so that constancy appears to be preserved by eye movement registration when cognitive extrapolations are actually taking place. To prevent this, Festinger et. al. have used harmonically ramped velocity profiles which reduce the retinal slip of a tracked object. They have observed little evidence of constancy during smooth pursuit using this kind of target motion. This control experiment will likewise replicate Experiment I using a sinusoidally ramped initial velocity. Unlike Festinger et. al. (1976), the target velocity will not continuously vary throughout the trajectory like the oscillating patterns Festinger used. Instead, the ramp will be restricted to a 1 sec time interval during which the velocity will rise from 0 to a 1, 2 or 3°/sec velocity and level off.

Experiment V: Control for Memory of Target Position as Affected by Fixation

To determine how accurately a subject can remember where primary position is located in the dark, a control experiment will be run which is similar to ones by Paap & Ebenholtz (1976), Park (1969), and Merton (1961). These experiments show that memory for a position in the dark tends to wander in the direction of fixation. This effect could potentially contaminate the results of the preceding experiments and should be assessed before any strong conclusions are made.

After viewing the primary position indicator as in Experiment I, the subject is asked to fixate a target located at the normal starting position of the pursuit stimulus for a fixed duration derived from the time typically taken for a target to reach primary position. The fixation target, however, will remain stationary. After the fixation interval, the fixation target will disappear and the subject will be asked to judge whether a flashed probe spot appears to the left or right of the remembered location of primary position. The experiment can be run using double random staircases which converge on the subject's PSE, or using the method of constant stimuli to obtain some data on sensitivity. Subjects are expected to be more accurate in this task than in the ones reported by the previously mentioned researchers. In those studies, fixation durations were about 30 secs, and fixation eccentricity was, at minimum, 12°. The shifts observed in PSE for primary position were displaced by only about 1° (Paap & Ebenholtz, 1976). Given that fixation duration and eccentricity directly affect the magnitude of the direction shifts, the small values of these parameters used in the present experiment would not be expected to greatly alter the subject's sense of direction.

Movement Cues During Pursuit Tracking

Whether or not a failure of constancy is observed in Experiment I, it is of some interest to know what role retinal background motion plays in producing a perception of target motion. It is commonly known that sensitivity for movement is heightened in situations producing relative motion. Do constancy mechanisms benefit from the presence of relative movement? Can this cue be used to supplement extra-retinal sources of position information? Suppose, for example, position constancy is achieved by taking into account eye movement, but that eye movement registration is either noisy or somehow less than precise. Given the opportunity, the perceptual system might use the relative movement between the tracked target and a stationary object to fortify, interpret, or substitute the weakly sensed information that the eye is in motion. (Of course, this will only be accurate if the reference point is assuredly stationary. If the reference object is not stationary, the resulting performance might be worse than it would have been if no relative displacement information had been present at all.) Rather than suggest that eye movement is under-registered, we might suggest that relative motion cues are greatly weighted in the case of position constancy.

A Case Study: The Filehne Illusion

When one tracks a target moving across a patterned background, the background itself is often seen as moving in the opposite direction. This illusory motion is commonly called the Filehne illusion (Filehne, 1922). Like the Aubert-Fleischl illusion, the Filehne illusion has been explained in terms of the eye movement under-registration hypothesis: the relative retinal movements between tracked and untracked objects is only partially compensated for by the registered eye movement, so that the movement not compensated for makes the stationary background pattern appear to move in the direction opposite to the tracked target's motion. Mack & Herman (1978) demonstrated that the effect seems to depend on relative motion between the target and background objects in close proximity to the tracking target. They did this by comparing constancy measures in the presence of tracking when relative movement cues were present and absent. Subjects were asked to report on the direction of movement of a briefly displayed (.2 secs) target while they tracked another target at 5°/sec. The untracked target started out as stationary, and was adjusted via a double random staircase procedure to produce the PSE for stationarity. The mean loss of constancy was 3.35°/sec, or 67%. In the second experiment, prior to the appearance of the untracked target, the pursuit target disappeared; it reappeared after the untracked target disappeared. Nevertheless, subjects continued tracking during the blanked interval, albeit at a reduced rate. The measured loss in constancy dipped down to about 16%. This suggests that relative movement cues can have a dramatic effect on the measured stability of untracked targets. Mack & Herman (1978) conclude that two factors are responsible for losses of position constancy during pursuit eye movements: velocity under-registration and relative motion between target and background when the background is immediately adjacent to the tracked target. The qualification of the latter factor is important since it must account for why the visual world normally looks stable during pursuit tracking — all of the background area which is not adjacent to the target seems stable, and only a small region near the target actually appears to move in the opposite direction. This so-called 'adjacency principle' was initially described by Gogel (1974) to explain illusory deviations of the movement trajectories of spots in movement configurations. It suggests that the salience of relative motion cues varies directly with proximity.

Studies like this one, which elicit reports from subjects of untracked target motions assume that the perception of motion in the background occurs because of the unregistered motion of the tracked target (e.g., Stoper, 1973; Festinger et. al., 1976; Mack & Herman, 1978). To assume that the target's motion is also perceived accurately would seem to suggest the illogical view that excess motion is being registered. However, in an experiment by Wallach, Bacon, & Schulman (1978) precisely this idea was suggested. They presented subjects with a rectangular frame which oscillated horizontally while a spot of light within the frame oscillated vertically in synchrony with the frame. Subjects perceived the movement of the spot within the frame as a 45° oblique trajectory, apparently combining an induced motion from the frame with the vertical motion of the spot. When subjects were asked to report the movement of the frame, the reports were objectively veridical. That is, the movement attributed to the spot *was not subtracted* from the movement of the frame. This example demonstrates that the simple notion of ***motion conservation*** can be violated. Rock (1983) suggests that perceptual *motion conservation* is still a viable hypothesis provided that the manner in which the movement configuration is organized is taken into account. When the spot is viewed, it is seen as a part of a frame of reference provided by the rectangular frame, and implicitly inherits whatever movements apply to that reference frame. Movement of the spot is seen *relative* to the rectangle, much as the movement of a fly climbing up a galloping horse's back is seen only in relation to the horse, and not relative to the viewer's egocenter. Though the *report* of the spot's movement does not add in the rectangle's movement, the spot is seen as part of the rectangle's movement system (whatever the motion of that system may be). Rock suggests that if the movement of the spot relative to the rectangle is combined with perceived movement of the rectangle (relative to the subject), the net motion of the spot will accurately reflect its absolute motion. However, this kind of perceptual vector decomposition and recombination may be impractical or impossible to perform with nested reference frames. Thus, a careful dissection of the movement configuration suggests that *motion conservation* may indeed occur even in situations where the subjects' responses seem to violate it.

To return to the main point, the simple notion of *motion conservation* which is implicitly adopted by some researchers may be overlooking how the organization of the moving configuration affects how motion is reported. Responses which violate *motion conservation* do, in fact, occur. To be safe, it is wise not to infer object motion using evidence other than explicit reports of the tracked object's movement.

The discussion of motion perception relative to other reference frames has also been taken up in modeling machine recognition of moving patterns (Marr & Vania, 1979). Marr and Vania persuasively argue for the generality and power of using relative object motion in recognizing patterns of movement. When a common motion vector is subtracted from the component movements in a recognition process, the pattern becomes normalized. For example, a galloping horse can look like a galloping horse whether it moves past the observer at 5 mph or 10 mph, or whether its gallop is viewed on a stationary television screen. We do not recognize its gait from recollections of limb trajectories relative to ourselves. The gait is recognized by limb movements *relative* to the horse's body. This is not to deny the necessity of accurately detecting an object's motion relative to oneself: one sometimes needs to duck flying bricks, avoid traffic, and catch an occasional fly ball. But a great deal of movement perception is accomplished by focusing on the relative movements of components in the movement configuration. It may be that either type of of movement detection can be performed, but that absolute motion is only detected at times when physical interaction is required between the viewer and the object viewed. In view of this, it does not seem surprising, therefore, that subjects make their best subject relative localizing responses when the motor system actively participates in the response process (Hansen & Skavenski, 1977). This observation has led some (Bridgeman, Lewis, Heit, Nagle, 1979) to conclude that a separation exists between the perceptual and motor system's sense of spatial location. This separation has not been shown adequately using tasks which are balanced with respect to response demands. Those studies which have attempted to do so (Miller, 1980) fail to observe the hypothesized accuracy differences. It is currently unclear how well subjects can respond to one form of movement information in the presence of the other. It is common knowledge that sensitivity is greater to relative than to absolute movement cues; and, in many experiments, responding can be best characterized as a perception of relative motion. The only study to unambiguously ask for a subject relative response in the presence of conflicting object relative movement was sketchily reported by Farber (1982) in a brief abstract. In his study, subjects visually tracked a slowly oscillating spot embedded in a frame which moved so that the induced movement of the spot was in the opposite direction to the objective movement. Farber asked his subjects to track the spot's movement manually. Despite the fact that the eyes were following the target's real motion, the manual tracking actually followed the illusory movement.

Finally, Howard (1981) suggests that ambiguity in what a subject understands his task to be may be responsible for differences in measured effects. Take the different results found by Festinger et. al. (1976) and Hansen (1979). If the subject reports retino-centric motion of the untracked target spot, while tracking another target, the Festinger et. al. result would be reported.

That is, the subject reports the trajectory painted across his retina. If the subject reports head-centric motion, then Hansen's result would be expected. Note the different result is *not* a matter of relative motion, but of *retinal vs. head-centric* reference frames. If a subject is always required to report the position of the tracked object, the ambiguity is eliminated since the tracked object would always occupy the same retinal coordinate, namely the fovea.

To summarize: (1) Past research on pursuit tracking in the presence of relative motion has erroneously assumed subject reports of background motion strictly adhere to the assumption of perceived motion conservation; (2) There is a danger in examining position constancy using relative motion. The perceptual system may be biased to perceive relative movement in strictly passive viewing situations, or it may not be capable of analyzing the absolute motion of objects embedded in nested movement configurations. (3) Subjects may interpret ambiguous requests to report movement using either a retinal reference frame or a 'head-centric' reference frame.

All of these pitfalls can produce under-registration-like responses, but in no case is under-registration directly a factor. A more accurate characterization for some might indeed be under-utilization of extra-retinal information. This would imply that a source of information is present, but used with a degree of flexibility.

The following studies represent an attempt to sort out the manner in which different forms of relative displacement might affect position constancy.

Experiment VI : Effect of Local Stationary Background on Constancy

This study attempts to determine how adjacent relative motion might affect position constancy during tracking. In a sense, it is a clarification of Mack & Herman's (1978) study on the Filehne illusion. They concluded that when such relative motion cues from adjacent stimuli are present, a dramatic increase in under-constancy can be observed. To put it another way, the effect of adjacent targets on the perceived speed of the tracked target is to make the tracked target appear to move slower than normal. This is, however, an inference based on the assumption of motion conservation as previously described. This experiment will test Mack & Herman's conclusions using a more direct paradigm.

The position signalling paradigm outlined in Experiment I can be enhanced to produce localized relative motion cues. Like Experiment I, subjects will be reminded of the primary visual direction with a position target. When ready, the position target will disappear and the tracking object will appear either 6° to the left or right of the primary visual direction. Surrounding the target will be an imaginary 'radius of visibility' of approximately 1°. Normally invisible points along the movement path of the tracking target will appear when they fall within the imaginary radius surrounding the target, and disappear when the radius moves past. Consequently, all relative movement will be confined within this 1° radius of visibility. Thus, subjects will be provided with a stimulus which should produce a potent Filehne illusion since no visible objects will be permitted to be seen outside the area immediately adjacent to the tracked target.

Interpretation of results: If the Filehne illusion is to be seriously interpreted as an underconstancy phenomenon, or if a shift in salience of relative motion cues overrides or interferes with head-centric position constancy, then subjects should perceive the background pattern as moving in the opposite direction to the tracked target. They should therefore underestimate the tracked target speeds, by virtue of the *motion conservation* assumption, and signal the arrival of the tracking target later than in Experiment I. On the other hand, the local movement cues may heighten the subject's registration of the target's velocity; subjects may signal the arrival of the target at the primary direction earlier than in Experiment I, perhaps demonstrating a better sense of target motion. The latter outcome would suggest that velocity cues from the perceived relative movement can be applied to the target or background in a manner that may be modified by the observer's attention. That is, when a subject is asked to report on the movement of untracked objects, perceived relative motion is attributed to them. When reports are made concerning the movement of tracked objects, the perceived movement is redistributed. It would also suggest that retinal slip velocity is used by subjects to keep track of the distance the eye has moved. Retinal slip velocity, however, is only one of several other possible retinal bases of position constancy. Displacement distance of the tracked object from a stationary visible landmark, for example, would also provide information about how far the eye is turning during pursuit tracking. Since this requires a continuously visible stationary landmark to be present, it is not a factor in the present experiment.

Experiment VII: Replication of Filehne Illusion

This experiment is a simple control to demonstrate that a Filehne illusion is obtained under the same stimulus conditions as in Experiment VI. Subjects will be given the same tracking task, but will be asked to indicate the direction of perceived motion of the background spots near the tracking target. Unlike Experiment VI, the background target spots will be movable. Using multiple random staircases to adjust the background motion, the subjects' PSE's for background stationarity can be determined. If a Filehne illusion is obtained, the background should be appear stationary when actually moving with the tracking target in the same direction. Mack & Herman's (1978) study suggests that the background velocity should be approximately 67% of the tracking velocity.

Experiment VIII: Influences of Background Motion

This experiment is identical to Experiment VII except that instead of the relative movement points remaining stationary, they will move either 1°/sec with or against the pursuit target. If subjects use velocity information in determining how far they have tracked, the background patterns moving with the tracking target should make the subject's response signal later than normal; the patterns moving against the target motion should make the subjects signal earlier. No difference between the two conditions would support the hypothesis that relative local velocity information is not used in making localization judgements.

The paradigm could easily be expanded to explore factors like background size, pattern density, general pattern proximity, continuously visible landmarks, and peripheral/foveal influences on position constancy.

Conclusions

The studies outlined in this proposal should help to clarify an area of perception which, to put it modestly, is in disarray. The facts behind the eye-position registration hypothesis have been clouded practically since its inception by the failure to observe consistent, reproducible data.

Methodological variations and inappropriate inferences may be partly responsible, but it is also possible that some perceptual arbitration between egocentric (i.e., eye position) and exocentric (i.e., visual) sources of information can occur, particularly when they do not converge. Indeed, the literature on adaptation to displaced vision suggests that in such a conflict, felt eye position is recalibrated to conform to the shifted view. Likewise, the amount of turn in visual angle which a given eye movement represents can be recalibrated in accordance with the displacement of the retinal image. A mismatch between the motor command to the eye and consequent retinal displacement will result in a perceived movement of the entire visual field at first, but gradually adaptation effects a recalibration of the motor commands to suit the altered visual situation (Miller, Anstis, and Templeton, 1981). Given this demonstrable flexibility on the part of the motor system in subservience to the dictates of purely visual information, it seems unrealistic to expect that extra-retinal feedback will be 'trusted' by the perceptual system as a source of definitive and invariant eye position information. Perhaps the information is accurate in the short term. But, perhaps it is in a process of continuous recalibration, slow to respond to transient inconsistencies between retinal and extra-retinal information, but responsive in the long term to a consistent mismatch. What sort of visual information would the recalibration process require? Stationary objects dispersed throughout the visual field or the 'ground' portions of visual scenes would probably be best. The accuracy with which an eye movement is made could be instantly determined by whether the fovea landed where it was 'directed' to go; the visual world, for the most part, is stationary so there is ample opportunity for this to happen.

This idea has a few interesting ramifications. The autokinetic effect, for example, may actually be a manifestation of an attempt by the visual system to recalibrate itself without the normal retinal feedback; the fixated spot appears to move because extra-retinal information is moving 'out of calibration'. Likewise, other kinds of viewing under reduced visual conditions could also produce localization anomalies (e.g., the Roleofs effect).

From the tentative conclusions and speculations entertained in this proposal, only a murky picture emerges of the operation of spatial constancy mechanisms involved in perception. More (and better) research is needed to understand this important capability which underlies human spatial orientation.

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ERIK NILSEN
Psychol.

Dr. Snyder;

I would like to be considered for the NASA Center of Excellence in Man-Systems Research Training Grant. My name is Erik Nilsen and I am a first year graduate student in Experimental Psychology. I have talked with Dan Weintraub about the program and I believe that it fits my research interests and career direction very well. I also feel that I have some skills that I can bring to the program.

My research interest is in the area of cognitive engineering. I want to apply the insights of cognitive psychology to the evaluation and design of man-system interfaces. These interfaces will be most successful when they take the information processing capabilities of people into account. Many present systems can be considerably improved in this area. One approach to improve the man-system interface is to look at the present systems and find out where it is not fitting well with peoples information processing abilities. Studying various systems in the same domain will give us ideas for designing a better system as well as generating hypotheses about how the human mind works.

I am currently working on a research project with Dr. Judith Olson which is concerned with man-system design questions. We are trying to assess the cognitive load that various computer software packages put on users. We have chosen three spreadsheet programs, (Lotus 1-2-3, Multiplan, and Visicalc) to look at first. The types of cognitive load that we are looking at are 1) perceptual load, 2) working memory load, 3) long term memory load, and 4) planning load. this research is still in its germinal stage but I believe that it will yield some valuable information about the design of man-system interfaces.

I have asked the graduate office to send you my transcripts. I feel that my courses in experimental design, computer programming and systems design and mathematics have given me a good base for further training. I am able to learn quickly and am very interested in learning about the contributions that areas outside of psychology can bring to the design of man-machine systems. I hope that you will consider me a good candidate for your training grant.

Sincerely,

Erik Nilsen

Erik Nilsen

Keith LEVI
Psychol.

STATEMENT OF INTERESTS AND OBJECTIVES

My work in graduate school has been pointedly directed at the type of research represented by the Man-Vehicle Systems program. In particular, my work has emphasized fundamental applications of psychological theories. This has been supported by substantive coursework in decision theory, perception, and learning and memory. I have also done coursework in fundamental measurement, scaling, statistics (MA in 1981) and computer science (M.A. expected in 1985). I have used this background to do original research in the areas of preferential and risky choice, evaluation of subjective probability forecasts, and artificial intelligence. The work on preferential choice was done under the direction of Professors Clyde Coombs and Frank Yates of the University of Michigan's Mathematical Psychology Department. It involved a model of conditional choice which allowed for interaction between stimuli. The work on risky choice was done over three years as a research assistant for Dr. Coombs. Our focus was a study of a bilinear model as a descriptive theory of choice under risk. My work on evaluating probabilistic forecasts was done under the direction of Dr. Yates. I have recently resubmitted a revised paper on a scoring rule I developed for evaluating forecasts. I expect this to be published in the near future. My interest in artificial intelligence has developed over the last several years. I have pursued this interest in a human factors context during this last year as an intern in Minneapolis, Minnesota, with Honeywell's Man-Machine Sciences (MMS) group.

MMS is a human factors group in Honeywell's main research and development center, the Systems and Research Center. *Each year, MMS selects several interns from a nationwide competition of graduate students near the level of Ph.D. candidate. In my year at Honeywell, I have applied my skills to precisely the type of problems encountered in Man-Vehicle Systems. Examples of typical projects include the human-factors design of a highly automated cockpit for next generation helicopters, and the design of a space-station maintenance system with an emphasis on AI technologies. Most recently, I have been working on a mission planning algorithm for missions with multiple objectives under risk. We recently received special IR&D funds to do this project by winning a center wide proposal competition. I have included a brief description of our proposal. I plan to complete my part of the project this fall at the University of Michigan under the direction of Professor John Holland of the Computer Science Department.

In conclusion, I feel that my goals, interests, and skills are particularly well-suited to the Man-Vehicle Systems program. Even though I plan to complete my doctoral program in another year, I think that my background will allow me to receive substantial benefits from the program, as well as contribute to others in the program.

* MMS has annually sent visiting lecturers to the Human Factors session of the University of Michigan's Summer Engineering Conferences. John Brock has lectured each of the last four years, and this year Dr. Robert North was also present.

RESUME
Keith Randell Levi

Date of Birth: May 20, 1955
Marital Status: Married, three children

University Address:	Human Performance Center University of Michigan 330 Packard Road Ann Arbor, MI 48109
Home Address: (Until August 29, 1984)	203 Northdale Blvd Coon Rapids, Minnesota 55443 (612) 757-9199
(After September 1, 1984)	2514 Stone Drive Ann Arbor, MI 48105

Education

Ph.D. Mathematical Psychology
University of Michigan, Ann Arbor
(To be completed October, 1985)

M.A. Statistics
University of Michigan, Ann Arbor
1981

M.A. Computer and Communication Sciences
University of Michigan, Ann Arbor
(To be completed May, 1985)

B.S. Psychology (Summa Cum Laude)
Maharishi International University
1979

Areas of Specialization

Human inference and decision making--emphasis on mathematical models.
Artificial intelligence--emphasis on expert systems, explanation, planning, learning.

Papers and Presentations

Levi, K. A signal detection framework for the evaluation of probabilistic forecasts. Under revision for publication in Organizational Behavior and Human Performance.

Levi, K., & Kovach, P. Example-based expert systems: Aids for knowledge acquisition. Proceedings of the Eighth International Honeywell Computer Science Conference, Bloomington, Minnesota, May, 1984.

Goldstein, W.M., Levi, K., & Coombs, C.H. The bilinear model of preference. Manuscript in preparation.

Work Experience

Graduate Student Research Assistant, Department of Psychology, University of Michigan, Summer 1979 to Summer 1983. Worked with Clyde Coombs on studies of decision making and risk.

Graduate Student Teaching Assistant, Department of Statistics, University of Michigan, Fall 1982 and Winter 1983. Taught labs, held office hours, graded and constructed exams and homeworks for a large introductory statistics course for advanced undergraduates and beginning graduate students (Statistics 402).

Intern Research Scientist, Systems and Research Center, Honeywell Inc., Minneapolis, Mn., August 1983 to August 1984. Worked with Honeywell's human factors group. Contract and IR&D projects included expert systems for maintenance and training, expert systems as assistants to a helicopter pilot, a planning system for an autonomous vehicle, a comprehensive review of AI technologies, and a knowledge acquisition tool for a decision aid. Other major duties included customer presentations and proposal preparation.

Awards

Most Outstanding Psychology Major, 1977-78, 1978-79.
National Science Foundation Graduate Fellowship, 1979-82.
Honeywell Human Factors Intern, 1983-84.
Honeywell Initiatives Grant, 1984.

References

Advisor

Dr. J. Frank Yates
Human Performance Center
University of Michigan
330 Packard Road
Ann Arbor, Michigan 48109
(313) 763-2092

Dr. Clyde Coombs
Department of Psychology
University of Michigan
580 Union Drive
Ann Arbor, Michigan 48109
(313) 764-6335

Dr. David E. Meyer
Human Performance Center
University of Michigan
330 Packard Road
Ann Arbor, Michigan 48109
(313) 763-1477

NASA Center of Excellence in Man-Systems Research
Letter of Intent

I am currently an undergraduate student in Aerospace Engineering at the University of Michigan. I have been accepted to the University of Michigan as a graduate student in Aerospace Engineering. I will begin graduate studies for a M.S. Degree in the Fall of 1985. My future plans include obtaining a P.h.D. in Aerospace Engineering.

My area of interest is structural mechanics and design. I am concerned with an important aspect of structural mechanics; namely, structural failure in aircraft and aerospace systems which result in human fatality. Studying such structural failure would provide valuable insight for the safe design of these systems. I feel the investigation of structural failure is an important human factors problem since it can effect man so drastically.

A NASA Center of Excellence in Man-Systems Research Fellowship would enable me to study this important human factors problem on both a M.S. and P.h.D level. I would greatly appreciate your support for my further studies in the form of a NASA Fellowship.

Thank you very much for your time and consideration.

Sincerely,

Martha Sheagren

Martha Sheagren

NASA Center of Excellence in Man-Systems Research
University of Michigan
Application Statement
Kenneth A. Braunstein

My life long fascination with manned space flight and my recently affirmed decision to pursue studies in aerospace engineering/dynamics and control have led me to an interest in being involved with man-systems research as related to aerospace applications. Having worked as a mechanical engineer for seven years on projects which have required interaction with many people, I have gained experience which will be applicable to the interdisciplinary nature of this field.

The primary reason that I decided to continue my graduate education, in addition to satisfying my academic goals, was to become involved in aerospace work and my specific interests evolved as I learned more about the different areas of study. Although I had been interested in control systems I at first looked into programs in aerodynamics and propulsion because of my training and experience in the "thermal-fluids" area. I then decided to investigate programs in dynamics and control and found that having a background in a different area would not be too great an obstacle. Because my intent was to become involved in aerospace projects I was attracted to research programs concerned with the control of flexible structures, with the anticipated application of this work to future space station development. The shifting of my interests as I learn more about the field has now led me to consider man-systems research, an area which will be intellectually satisfying and which may lead me to direct involvement with the manned space program.

To work with NASA or any of the industries involved with the space program has long been an ideal of mine, though one that I pushed aside for many reasons until recently. The idea of being involved directly in development programs or missions, although I was never sure in what capacity, has always been part of the dream. It has been the manned space flights that have always intrigued me and although we have progressed from the early days of hearing the garbled voice communications to the now "routine" shuttle videocasts I am no less awed during each mission by the idea of humans orbiting the earth or traveling beyond. The idealistic part of my career goal requires that I play some part in the future activities in this realm. The man-systems research program partly fulfils that goal because it will provide some contact with NASA. Having the opportunity to receive training in the study of human performance in man-systems may lead me to involvement in R & D for components to be used on future manned missions and may also result in involvement with missions operations.

I am less able to discuss the more technical aspects of the man-systems research program since I am only beginning my study of dynamics and control. I anticipate that my desire to learn control theory and dynamics will be fulfilled and that involvement with the interdisciplinary program will broaden my perspective and thereby add to my knowledge in both my own and other disciplines. Working with people who are part of a "control system" and with people from other disciplines is likely to provide a good balance to the otherwise technical aspects of dynamics and control. This is similar to the situation in my current position, which requires working with other disciplines and occasionally visiting job sites and plant personnel.

Participating in man-systems research will allow me to do dynamics and control systems work which is theoretically advanced (from my current point of view) and to also be involved with the space program and its personnel. This combination will fulfill both my academic interests and my long standing personal goals.

Kenneth A. Braunstein 4/13/85

Martha Anne Sheagren

Present Address
413 Washtenaw #4
Ann Arbor, MI 48104
(313) 994-3234

Permanent Address
1718 Hermitage Road
Ann Arbor, MI 48104
(313) 994-3558

Objective To attend graduate school and receive a M.S. in Aerospace Engineering.

Education The University of Michigan
B.S. in Aerospace Engineering
Expected graduation date: December 1985

GPA: 3.947 (A=4.0)

Honors
Tau Beta Pi Honor Society
Sigma Gamma Tau Honor Society
Golden Key Honor Society
Society of Women Engineers Scholarship
Dean's List

Experience

Fall 1984, Summer 1984 — **Computer Monitor**, University of Michigan, Ann Arbor, MI.
Monitored an Apollo Computer Lab in the School of Engineering by assisting students with software and hardware problems.

Summer 1984 — **Undergraduate Research Assistant**, University of Michigan, Ann Arbor, MI.
Studied the effects of polymer addition on drag in turbulent boundary layers using a laser doppler velocimeter.

Summer 1982 — **Cashier and Salesperson**, Frank's Nursery, Ann Arbor, MI.

Fall 1980 — **Salesperson**, Herman's World of Sporting Goods, Ann Arbor, MI.

Summer 1980 — **Midshipman**, United States Naval Academy, Annapolis, MD.

Summer 1979, Summer 1978 — **Laboratory Assistant**, USVA Hospital, Ann Arbor, MI.
Studied the effects of antibiotics on Staph. Aureus in an Infectious Disease Lab.

Special Skills Knowledge of Fortran on Burrows and Apollo systems.

College Activities
Tau Beta Pi Honor Society
Sigma Gamma Tau Honor Society (Treasurer)
Golden Key Honor Society
American Institute of Aeronautics and Astronautics
Society of Women Engineers
Intramural Sports

References References and transcripts available upon request.

STATEMENT OF INTEREST

Introduction

My name is Stephen O'Day, and I am applying for a NASA Research Fellowship in the human factor aspects of man-systems research. I am currently enrolled in the PhD program in Computer Engineering where my main interest is in artificial intelligence; to study the human mind as an information processor and to understand it's abilities, capabilities, and it's limits. Using this knowledge to design environments, display and control systems is what I understand human factors engineering to be. It is an area of research that I have found very interesting in the past as a graduate student working on a masters degree in Industrial and Systems Engineering. From this experience, I feel that this is a very important area of research and one that I would, very much, like to be a part of in the future.

Why Human Factors ?

Modern technology has, in general, made our world a better place. We are more productive, more efficient, more powerful, we can go faster, farther, and higher than ever before mainly due to the machines at our disposal. However, our world has also become more complex than ever before. These same machines that make us productive and efficient can also be a hindrance to us if they are not designed properly.

This is why I believe that Human Factors is a vital area in which research is sorely needed. It is imperative that high technology machines be designed in such a way that people can read, understand, and control them quickly, easily, and accurately. Failure to do so could cost a lot of time, money and possibly human lives.

This is how I fit in !

Human factors is a discipline that overlaps many fields of study. I feel that my experience in Mathematics, Industrial and Systems Engineering, and Computer Science is just the kind of diverse background that NASA is looking for. Through this interdisciplinary graduate program and with the assistance of a research fellowship, I feel I could make a significant contribution to NASA and to the University of Michigan.

PATRICK EDWARD CORNELIUS
515 Main Street
Lawrenceburg, Indiana 47025
tel: 812-537-4727

JOB OBJECTIVE With my background in isolation sociology coupled with my pilot and engineering experience, I am ideally suited to provide input into the design of any manned space station or vehicle. In any rocket propulsion position I would also be of service to your company. My managerial ability should not be overlooked. One day I hope to be a crewmember on a space station. I am willing to travel, and/or relocate.

EDUCATION Granted a BS in Aero/Astronautical Engineering from Purdue University in May 75. Majored in Rocket Propulsion/Minored in Vibration and Dynamics.

Air Force Schools including: management, technical writing, survival, Army Airborne Paratrooper training, Leadership, toxic/hazardous chemicals/substances, various nuclear weapons handling.

Antarctic Schools including: expedition management, survival, electronics, diesel equipment, electrophoresis, computer systems, fire fighting.

WORK EXPERIENCE Jun 83 - present: **consultant** for NASA with California State University, Northridge. My job was to summarize, analyze, and prepare information on productivity and socio/psychological data collected on two Antarctic missions. I co-authored a book to be used by NASA design engineers in development of the space station. I learned a great deal about management and organizational skills as applied to task accomplishment.

Aug 1980 - Jun 1983: Was a **member of Science support team** at South Pole Station and Palmer Station Antarctica with the National Science Foundation. Please refer to attachment. The intense social dynamics of the isolation periods allowed great enhancement of 'people skills'.

Sep 1971 - Aug 1980: This period includes my university years in which I was a 4-year scholarship **cadet** (same status as Air Force Academy). I was commissioned a short time after my graduation in May 75. Then I worked at Edwards Rocket Propulsion Lab as a **research engineer** in the field of plume effects. We modeled the plume flow from the rocket exhaust and then experimentally verified our computer model with a ultra high altitude cyrogenic chamber in which a hydazine thruster was fired. The quartz crystal microbalances in the plume could measure particulates to great precision. In our assumption we could not use continuum flow equations of motion. The Knudsen number was too large. No boundary layer exists in the traditional sense but we did make use of Navier Stokes equation with slip boundary conditions. Some areas were treated as free molecular flow.

Next during this period I became a **pilot** and flew high performance jet aircraft including the T-37, T-38, B-52-G, and some others. My formation flying in the T-38 Talon was considered exceptional. I was honorably discharged in Aug 1980 as a Captain. My management training in Air Force schools coupled with my leadership as a Captain were important during this period.

EXTRA-CURRICULAR ACTIVITIES/HONORS I was awarded the 4-year all expense paid scholarship to the college of my choice by the Air Force. Out of about 1800 pilot candidates I was rank ordered 52 and allowed to enter pilot training (only 60 were chosen). I was decorated with the Antarctic Service Medal by the National Science Foundation twice.

I scuba dive, fly, and love archery. I also read a great deal and have a personal computer.

PUBLICATIONS Co-authored book on similarities of isolation in Antarctic Stations and Space Stations. Dr. B. J. Bluth and myself/NASA publication.

PERSONAL DATA I am a US citizen, age 31, single, Caucasian, male, 5'10" tall, 178 lbs. in weight, excellent health.

References and additional information available upon request.

FROM: Patrick E. Cornelius
Purdue University School of
Industrial Engineering
Grissom Hall (rm. 271) Human Factors (317-494-5166)
West LaFayette, IN. 47907 hm(317-743-6816)

TO: Professor Richard G. Snyder
NASA Center of Excellence in Man-Systems Research
222 UMTRI
Institute of Science & Technology
The University of Michigan
2901 Baxter Rd.
Ann Arbor, MI 48109-2150

Dear Professor Snyder:

I am presently a research assistant at Purdue University for a Professor Salvendy in the school of Industrial Engineering (Human Factors). I have just started my masters program. I plan to finish my masters degree in 18 months (around May 86). I have a BS in Astronautical Engineering and Engineering Science from Purdue which was granted in May 1975. I have been an engineer at the Edwards Rocket Propulsion Lab (my major was in rocket propulsion). Also I flew Northrup T-38 Talons and the Boeing B-52-G Stratofortress for the Air Force. I was discharged in 1980 as a Captain and joined ITT with the National Science Foundation. I 'wintered-over' at the Geographic South Pole one year and at Palmer

Station another. During this time in the Antarctic I keep data for a Dr. B. J. Bluth (an isolation sociologist from Cal State Northridge) along with my other work tasks helping the PI's. Dr. Bluth and I worked this summer reducing the data and compiling a book for NASA (only an in-house version for now) which complemented the ones already finished. The others included a Submarine Analogue and the data from the Russian Space Program. Our book is called "Analogues between Space Stations and Antarctic Stations". Some of the topics that we looked at include manual control, equipment monitoring, and crew workload. I kept daily records in quantitative form. I also kept a microcassett audio tape log which is over 1000 pages transcribed for the year in isolation at Palmer. I am extremely interested in Space Station or Space Vehicle work.

As one can see my background is interdisciplinary in nature and quite varied. I have attempted to set goals for myself which make my dream of living and working in a space colony attainable. If you think that I might have a chance of being selected for your program at the completion of my masters degree or even sooner please send me the necessary paper work. I understand that the University of Michigan is considered one of the very best schools of Industrial Engineering and I would be pleased to join your team. I am striving for quality and need great challenge. Thank you for your time. Please contact me soon.

Sincerely,

Patrick E. Cornelius

Patrick E. Cornelius

ACCURACY OF RADIONUCLIDE VENTRICULOGRAPHY IN THE DETECTION OF CORONARY ARTERY DISEASE

KEITH LEVI

DISSERTATION TOPIC

MATHEMATICAL PSYCHOLOGY

Description of the Project

This proposal will serve as the basis for a Ph.D. dissertation in mathematical psychology. Two major objectives are proposed: a) estimation of the potential diagnostic accuracy of radionuclide ventriculography (MUGA) in predicting the presence or absence of coronary artery disease (CAD), b) examination of various formats for reporting the interpretations of the results to the referring physician. The accuracy of interpretations of the MUGA will be evaluated both for the ability to make correct predicitons and to correctly represent the degree of certainty of each interpretation.

Cases having MUGA and coronary angiograms for possible CAD will be drawn from existing files at the Ann Arbor VA and University of Michigan Medical Centers. Each of six readers will interpret 150 MUGA tests over a several month period (10-15 per week). A few interpreters will reread a portion of the MUGA tests to allow assessment of intraobserver variability. Physicians using 4 different formats will initially estimate the probability of CAD after being presented with clinical data only, then again after seeing and interpreting the MUGA test. Results from coronary angiography will be used as the gold standard for the presence and extent of CAD.

These data will be evaluated by using techniques from expected utility theory and signal detection theory. This anaylsis will include constructing and comparing receiver operating characteristic (ROC) curves, defining cogent utility functions, computing expected utilities for the predictions, and determining optimal operating positions. The expected utility scoring rule will be compared with the results of other scoring rules for subjective probabilities.

APPENDIX B

TECHNICAL PUBLICATIONS

During this period no publications of a technical nature associated directly with this program have been published by faculty or students. It is anticipated that at least two dissertations and several publications will result in the second year.

APPENDIX C

FINANCIAL REPORT

The attached financial report provides a summary of the first year (1984-85) compared with the actual expenditures. The balance remaining of $54,281 on 31 May is carried forward and has been integrated in the readjusted second year (1985-86) budget previously forwarded.

Several items require further explanation. The majority of unexpended funds were in two categories, student tuition and student research support. Tuition was considerably below the projected amount because many of the 1st year students were in-state residents and the budget was based upon an assumption of out-of-state costs. Similarly, student research support was less than projected since only two of the students were at a point where they were actively conducting dissertation research. By the second year it is expected that costs in both of these categories will be proportionately higher as more out-of-state students are attracted and more students become involved in research.

A line total of $2500 for flight simulator support could not be used until the simulator was operational, and is expected to be used in July.

A carry-over of $9000 for visiting lecturers was a result of unexpected but fortuitous luck since during the fall term we utilized the Department of Aerospace Engineering's seminar series (in which speaker travel expenses were already paid), and during the spring term several of the lecturers were from NASA and did not seek reimbursement.

The year-end balance, while totaling an overall surplus, shows a deficit of $-12,279 in the category of salaries and wages which is an artifact. This is due to the sponsor's request that we include the non-budgeted item of $13,319 June-August travel expenses and salary for Prof. Weintraub's summer scientist position at NASA Ames. It was agreed that this amount would be re-credited in the second year's budget by NASA.

We were also able to effect some savings, obtaining some $5000 in support for needed initial office equipment from the University of Michigan Transportation Research Institute. This consisted of an IBM XT Model #86 Computer with IBM 5201 Quietwriter Printer, an IBM electronic typewriter and other accessories. The University also contributed 20% of the 1st year salary of the Administrative Assistant as a cost-sharing gesture.

Taking all of these matters into consideration, the projected budget turned out to be fairly accurate, and the surplus due to a combination of unforseen fortuitous circumstances.

NASA Center of Excellence In Man-Systems Research

Summary of 1984-85 Expenses

Period Ending 31 May, 1985

Account	Proposed Budget	Expended	Projected Balance 31 May (1)
Salaries & Wages (021896)	78,736	66,295.41	(-12,378.65) (2)
Staff Benefits (20%)	15,747	11,576.70	(- 2,557)
Visiting Lecturers (021887) Consultants	10,000	1,000.00	9,000
Materials & Supplies (021896)	5,940		
Supplies & Postage	720	2,411.80	(- 1,891.80)
Telephone	2,520	984.00	1,336.00
Tech. Ill/Repro.	2,700	1,760.47	739.53
Computing Center	2,000	630.00	1,270.00
Travel Faculty	12,280	3,742.00	6,708.00
Recruiting Students (021888)	5,000	1,990.22	2,809.78
National Conference	0		
Flight Simulator (021891)	2,500	0	2,500.00
Student Stipend (021893) (500/Mo. Acad. Yr.) (1000/Mo. Summer)	28,500	27,180.00	1,320.00
Research Support Student (021894) (1000 Term)	17,000	5,715.00	11,285.00
Student Tuition (021892)	48,200	13,426.27	31,848.73
Student Travel (021895)	8,910	6,620.00	2,290.00
Total Direct Costs	234,813	151,585.00	54,281.00
Indirect Costs (17% Computer)	14,769	8,256.83	
(8% MTDC Excl Tuition)	340		
TOTAL BUDGET ESTIMATE	249,922		

(1) Projected balance 31 May is estimated from our records since University Accounting figures not available until about June 10.

(2) This includes $13,319 advance summer salary to cover Dr. Weintraub at NASA Ames June-August at sponsor's request. This amount to be reimbursed by NASA in 1985-86.

APPENDIX D

LECTURE AND SEMINAR PROGRAMS

AEROSPACE HUMAN FACTORS SEMINAR WINTER TERM 1985
3:30 - 5:00 AEB RM 115
Aerospace Engineering 800
Bioengineering 590
Industrial and Operations Engineering 891
Psychology 808 (Section 1)
(1 graduate credit; staff)

1. 18 January (Prof.D. Weintraub) (Friday 3:00) The Utility of Head-Up Displays: Eye Focus vs Decision Time

2. 21 January (Prof. R. Howe) Aerospace Engineering. Control Systems.

3. 28 January (Prof. R. Howe) Control Systems Applications

4. 4 February (Prof. D. Weintraub) Psychology in the Aerospace Environment/Vision and Vision Perception Studies

5. 11 February (Dr. P. Green) Person-Computer Interactions

6. 4 March (Prof D. Kochhar) Visual Aspects of Pilot Licensing and Performance

7. 11 March (Prof. T. Armstrong) Occupational Health Considerations in Aerospace Systems and Emergency Egress and Task Analysis

8. 18 March (Prof. R. Van Gunst)Differential Maneuvering Simulator

9. 25 March (Prof. R. Snyder) Biomedical Impact Research, Aircraft Accidents and Crash Survivability: Federal/Manufacturer Safety Issues

10. 1 April (Prof. David J. Anderson) The University's Bioengineering Program and Posture Experiments Associated with Space Lab I

11. 8 April (Guest Lecturer) James Brinkley, Chief Biomedical Protection Branch, Biodynamics and Bioengineering Division, USAF Aerospace Medical Laboratories, Wright-Patterson AFB. Impact and Windblast :Advanced Development of Air Force Escape Systems.

12. 12 April (Guest Lecturer) Dr. William Reynard, Chief, Aviation Safety Reporting System Program Office, Aero-Space Human Factors Research Division, NASA Ames NASA's Aviation Safety Reporting System

13. 15 April (Guest Lecture) Prof. John Templer.Regents Professor of Architecture, Georgia Institute of Technology Architectural Systems Design of a Space Hospital

14. 22 April (Guest Lecturer) Dr. David Nagel, Chief, Aero-Space Human Factors Research Division, NASA Ames NASA's Program in Human Factors Research

15. To be scheduled (Guest Lecturer) Charles Kubakawa. NASA Ames NASA Technology Application in the Aerospace Industry

*Additional guest lectures may be scheduled 10:00-12:00 Fridays, as announced.

THE NASA CENTER OF EXCELLENCE

IN MAN-SYSTEMS RESEARCH

invites you to attend an

Aerospace Human Factors presentation by

DAVID J. ANDERSON

Chairman Bioengineering Program

University of Michigan

"THE UNIVERSITY'S BIOENGINEERING PROGRAM AND

POSTURE EXPERIMENTS ASSOCIATED WITH SPACE LAB I"

Monday, April 1, 1985

3:30 - 5:00

Rm. 115 Aerospace Engineering Building

THE NASA CENTER OF EXCELLENCE

IN MAN-SYSTEMS RESEARCH

invites you to attend an

Aerospace Human Factors presentation by

JAMES BRINKLEY

Chief Biomedical Protection Branch

USAF Aerospace Medical Laboratories

Wright-Patterson AFB

"IMPACT AND WINDBLAST: DEVELOPMENT OF

AIR FORCE ADVANCED EJECTION SYSTEMS"

Monday, April 8, 1985

3:30 - 5:00

Rm. 115 Aerospace Engineering Building

THE NASA CENTER OF EXCELLENCE

IN MAN-SYSTEMS RESEARCH

invites you to attend an

Aerospace Human Factors presentation by

DR. WILLIAM REYNARD

Chief, Aviation Safety Reporting System Program Office

Aero-Space Human Factors Research Division

NASA Ames

"NASA's AVIATION SAFETY REPORTING SYSTEM"

Friday, April 12, 1985

3:30 - 5:00

Rm. 115 Aerospace Engineering Building

THE NASA CENTER OF EXCELLENCE

IN MAN-SYSTEMS RESEARCH

invites you to attend an

Aerospace Human Factors presentation by

JOHN TEMPLER

Regents Professor of Architecture

Georgia Institute of Technology

Atlanta

"ARCHITECTURAL SYSTEMS DESIGN

OF A SPACE HOSPITAL"

Monday, April 15, 1985

3:30 - 5:00

Rm. 115 Aerospace Engineering Building

THE NASA CENTER OF EXCELLENCE

IN MAN-SYSTEMS RESEARCH

invites you to attend an

Aerospace Human Factors presentation by

DR. DAVID NAGEL

Chief, Aero-Space Human Factors Research Division

NASA Ames

"NASA's AERO-SPACE HUMAN FACTORS RESEARCH"

Monday, April 22, 1985

3:30 - 5:00

Rm. 115 Aerospace Engineering Building

AEROSPACE ENGINEERING 380 -- UNDERGRADUATE SEMINAR -- 1 hr (PF)

FRIDAY 3:30-5:00   RM 107 AEB   FALL 1984

LECTURES IN AEROSPACE ENGINEERING

Friday, September 7	Prof. Harm Buning, Senubar Coordinator INTRODUCTION; VIDEO TAPE: "AEROSPACE TECHNOLOGY FOR THE 1990's" Summary of AIA Aerospace Technical Committee study; Panel members: J.E. Krebs, GE, VP and General Manager, D.J. Grommesh, Gates Learjet, VP Research and Engineering, L.F. Buchanan, GD, VP, Engineering and Program Dev., L.M. Mead, Jr., Grumman Aerospace, Special Tech. Assistant to President.
Friday, September 14	Henry G. Reichle, Senior Research Scientist, NASA Langley Research Center. MEASUREMENT OF AIR POLLUTION FROM SATELLITES
Friday, September 21	Stephen Staich, Senior Staff Engineer, TRW. THE GAMMA RAY OBSERVATORY
Friday, September 28	Pieter G. Buning, Research Scientists, NASA Ames Research Center. USING COMPUTER GRAPHICS TO LOOK AT COMPUTATIONAL FLUID DYNAMICS RESULTS
Friday, October 5	William F. Powers, Manager, Control Systems Department, Ford Motor Company. COMPUTER CONTROL OF AUTOMOBILE ENGINES
Friday, October 12	George M. Skurla, Chairman of the Board and President, Grumman Aerospace Corporation. TITLE TO BE ANNOUNCED
Tuesday, October 16	Paul E. Garber, Historian Emeritus and Ramsey Fellow, National Air and Space Museum The Smithosonian Institution. THE WRIGHT BROTHERS
Friday, October 26	Robert F. Freitag, Deput Director, NASA SPACE STATION STATUS REPORT

Friday, November 2	Jim Loudon, Staff Astronomer, the University of Michigan Exhibit Museum, Lecturer.
	DISCOVERIES ON THE MOON AND THEIR IMPLICATIONS FOR THE FUTURE
Friday, November 9	Stephen C. DeBrock, Program Manager, Advanced Programs, Lockheed Missiles and Space Company.
	SELECTED SPACE STATION PRELIMINARY DESIGN TOPICS
Friday, November 16	Thomas J. Armstrong, UM Professor of Industrial Health.
	ERGONOMICS AND AEROSPACE SYSTEMS
Friday, November 30	Charles W. Kauffman, UM Associate Research Engineer, Lecturer Aerospace Engineering.
	FIRES AND EXPLOSIONS IN TRANSPORTATION ACCIDENTS
Friday, December 7	SEMINAR EVALUATION; TERM PAPER DUE DATE

U of M | **NASA**

Aerospace Engineering Department
Aerospace System Design
Project LUSTAR

Support by
Lewis Research Center
Cleveland, Ohio

The 1985 Aerospace System Design Class cordially invites you to the design presentation of:

Project *LUSTAR*
Monday APRIL 22, 1985
Chrysler Center Auditorium
Ann Arbor, Michigan
7-9 pm.

Originated in Spring of 1965, the Aerospace System Design Course has grown in popularity to its current record size of fifty members.

Aerospace System Design has received support and encouragement from NASA through the new "NASA University Design Course Program". The Class has been involved in a preliminary design of a Lunar Transport Vehicle. This vehicle transports people and equipment from the Space Station to the surface of the moon.

This presentation is the culmination of four months of research and development. It will highlight the major design areas of Project LUSTAR. We hope you can join us.

Sincerely,

Daniel E. Sebo

Daniel E. Sebo
Project Manager

James D. Camp

James D. Camp
Assistant Project Manager

APPENDIX E

RECRUITING ANNOUNCEMENTS

NASA CENTER OF EXCELLENCE
IN MAN-SYSTEMS RESEARCH

THE UNIVERSITY OF MICHIGAN
Institute of Science and Technology
Transportation Research Institute
Baxter and Huron Parkway
Ann Arbor, Michigan 48109-2150
(313) 764-8036

NASA Graduate Training Grant Program

The National Aeronautics and Space Administration has provided funds for the University of Michigan to support a limited number of NASA Research Fellows in an interdisciplinary graduate program in the human factor aspects of man-systems research. These fellowships are intended for highly motivated and exceptional students expecting to enter a doctoral program.

Participating academic departments include Aerospace Engineering, Anthropology, Computer & Electrical Engineering, Industrial Health & Industrial and Operations Engineering, and Psychology, as well as the Center for Ergonomics, Human Performance Center, and the University of Michigan Transportation Research Institute.

Background:

The increasing complexity of aerospace systems has created an acute need for scientists and engineers with a greater understanding of interdisciplinary tools, methods, and approaches in the design of technology systems involving people. This conclusion has been discussed in several National Research Council studies of NASA's needs.

Education in a given academic field often results in a limited view of a systems problem and narrows the directions from which the problem may be solved. Consequently the University of Michigan has been selected to establish a new program to help train human factors and systems scientists, especially those interested in NASA's aeronautics and space problems.

Areas of particular interest to NASA, such as manual control, equipment monitoring, flight crew workload, environmental design, etc., will be considered. The systems approach allocates functions between machines and humans on the basis of which system component is best suited for optimal performance of the man-systems combination. Students will be exposed to courses, seminars, research problems, and field experience which are designed to create an outlook which is broader than that normally associated with their major field of study.

The initial students selected for this program to date represent Bioengineering, Industrial and Operations Engineering, and Psychology disciplines.

Curriculum:

Most of the course requirements for students enrolled in this program will be determined by the student's major department. Students will be asked to enroll in additional courses or seminars to assure they have a broad knowledge of human factors research. Students may also be asked to take several field trips. For the most part, course requirements will be tailored to the individual student needs and interests in consultation with the student and his or her department advisor.

Faculty:

Core faculty members include:

Thomas Armstrong, Ph.D. M6017 SPH II 764-2594	Industrial Health/Center for Ergonomics
Paul Green, Ph.D. UMTRI 307 764-4158	Industrial and Operations Engineering/ Transportation Research Institute Human Factors Division
Robert Howe, Ph.D. 314 AEB 764-3395	Aerospace Engineering
Dev Kochhar, Ph.D. 158 IOE 763-0133	Industrial and Operations Engineering/ Center for Ergonomics
Clyde Owings, Ph.D., M.D. 5060 E. Engr 764-9588	Electrical and Computer Engineering/ Department of Pediatrics/Bioengineering
Richard Snyder, Ph.D. 222 UMTRI 764-8038	Anthropology Transportation Research Institute
Roger Van Gunst, M.S.A.E. 321 AEB 764-7200	Aerospace Engineering
Dan Weintraub, Ph.D. 132 Perry 763-0588	Psychology/Human Performance Center

These Faculty members have particular skills as scientists, are trained in multiple disciplines, have knowledge of human factors/ergonomics, and have backgrounds including aviation/aerospace experience.

Efforts of the core faculty will be supplemented by other faculty members from the University and by guest lecturers from industry and government agencies.

Student Support

Students accepted in this program will receive tuition, plus $7,500 annual stipends at the rate of $500 per month for nine months, and $1,000 per month for three summer months. In addition, up to $1,000 per term per student will be available for research support. Expenses will be paid for travel to a NASA research facility each year. The opportunity for additional NASA research support is promising.

Employment Opportunities

This program has arisen as a result of the acute need for Ph.D.'s trained in the interdisciplinary study of human factors. Students who receive training through this program will represent a select group of unusually well-qualified individuals who will be highly qualified for employment as scientists, engineers, or managers by NASA and the aerospace industry.

Application Requirements for Individual Graduate Student Support

Applicants for these traineeship grants must be U.S. citizens. Applicants must apply to the appropriate University of Michigan graduate school of their choice. In addition, they also must provide the NASA Center of Excellence with the following items of information:

1. A copy of the original application for admission to the Rackham School of Graduate Studies and copies of all academic transcripts which accompanied that application.

2. Copies of all letters of recommendation for financial aid as well as any other letters of recommendation which accompanied the original application for admission to graduate school.

3. A single page written by the student describing his or her interests, experience, and objectives.

4. For students who have already completed one or more terms in graduate school at The University of Michigan, an up-to-date copy of their graduate school transcript, a list of courses currently planned to be taken next term, and letters of recommendation from at least <u>two</u> University of Michigan faculty members with whom they have had contact.

Selection Criteria

Selection of the student recipients of the traineeship awards will be made by The University of Michigan faculty participating in the Center of Excellence in Man-Systems Research. The selection will be based on the excellence of the academic record of the applicants, their interest in interdisciplinary research, and their commitment to the area of human factors research.

Application deadline for winter term: March 15, 1985

Applications should be submitted to:

Professor Richard G. Snyder
NASA Center of Excellence in Man-Systems Research
222 UMTRI
Institute of Science & Technology
The University of Michigan
2901 Baxter Road
Ann Arbor, MI 48109
(313) 764-8038

or may be submitted through any of the faculty representatives listed above.

For further information contact:

Joan McPherson
Administrative Assistant
(313) 764-8039

THE UNIVERSITY OF MICHIGAN

Graduate Study in Aerospace Human Factors

The National Aeronautics and Space Administration has provided funds for the University of Michigan to support a limited number of NASA Research Fellows in an interdisciplinary graduate program in the human factor aspects of man-systems research. These fellowships are intended for highly motivated and exceptional students expecting to enter a doctoral program.

Participating academic departments include Aerospace Engineering, Anthropology, Computer & Electrical Engineering, Industrial Health & Industrial and Operations Engineering, and Psychology, as well as the Center for Ergonomics, Human Performance Center, and the University of Michigan Transportation Research Institute.

Curriculum

Most of the course requirements for students enrolled in this program will be determined by the student's major department. Students will be asked to enroll in additional courses or seminars to assure they have a broad knowledge of human factors research. Students may also be asked to take several field trips. For the most part, course requirements will be tailored to the individual student needs and interests in consultation with the student and his or her department.

Support

Students accepted in this program will receive tuition, plus $7,500 annual stipends at the rate of $500 per month for nine months, and $1,000 per month for three summer months. In addition, up to $1,000 per term per student will be available for research support. Expenses will be paid for travel to a NASA research facility each year. The opportunity for additional NASA research support is promising.

For More Information

Additional details on the program can be obtained by calling the program director, Dr. Richard G. Snyder at (313) 764-8038 or Joan McPherson, administrative assistant, at (313) 764-8039 or by writing to:

The University of Michigan
NASA Center of Excellence in Man-Systems Research
222 UMTRI
Huron Parkway & Baxter Road
Ann Arbor, MI 48109-2150

APPENDIX F

INTERIM LETTER REPORTS

1. 14 November 1984

2. 28 February 1985

NASA CENTER OF EXCELLENCE IN MAN-SYSTEMS RESEARCH

THE UNIVERSITY OF MICHIGAN
Institute of Science and Technology
Transportation Research Institute
Baxter and Huron Parkway
Ann Arbor, Michigan 48109-2150
(313) 764-8038

Richard G. Snyder, Ph.D.
Professor of Anthropology
College of Literature, Science, and the Arts
Research Scientist
UMTRI/Institute of Science and Technology
Director

Daniel J. Weintraub, Ph.D.
Professor of Psychology
Faculty, Human Performance Center
College of Literature, Science, and the Arts
Co-principal investigator

Robert M. Howe, Ph.D.
Professor of Aerospace Engineering
College of Engineering
Co-principal Investigator

Thomas H. Armstrong, Ph.D.
Associate Professor of Industrial Hygiene
School of Public Health
Faculty, Center for Ergonomics
College of Engineering

Paul A. Green, Ph.D.
Assistant Research Scientist
Human Factors Division, UMTRI
Assistant Professor of Industrial and Operations Engineering
College of Engineering

Dev S. Kochhar, Ph.D.
Associate Professor of Industrial and Operations Engineering
Faculty, Center for Ergonomics
College of Engineering

Clyde L. Owings, M.D., Ph.D.
Associate Professor of Pediatrics and Communicable Diseases
Medical School
Associate Professor of Electrical and Computer Engineering
College of Engineering
Research Scientist
UMTRI/Institute of Science and Technology

Roger W. Van Gunst, M.S.A.E.
Lecturer and Research Scientist
Head, Aircraft Research Laboratory
Department of Aerospace Engineering
College of Engineering

Joan E. McPherson
Administrative Assistant

Neil D. Gerl, M.S.
Assistant Project Representative
Div. of Research Dev. and Admin.

November 14, 1984

Dr. Alan B. Chambers
Chief
Aerospace Human Factors Research Div.
Ames Research Center
National Aeronautics and Space Admin.
Moffett Field, California 94035

Dear Al:

In an effort to keep you fully advised of our progress I'd like to bring you up to date with the following review and comments. As I noted in my letter of 8 October to Frank Owens, things continue to proceed smoothly and we seem to have resolved most of the problems related to getting a program of this nature underway by the fall term with a relatively short lead time.

I. Background:

Much of the initial effort concerned local recruiting and selecting of students, coordinating with the various departments involved, and subsequently establishing procedures and channels within the University, working out budgetary controls and other administrative matters. We have had frequent staff meetings averaging at least once a week of either the entire Center faculty or principals, and in between have kept in close communication by memos and telephone. During this early period it has been important in my mind to have as full Center faculty participation as possible in the molding of a program, and we have now established some basic guidelines, precedence, and common understanding of philosophy that will greatly assist the subsequent process. As you can see we now have our own stationery, which I think provides the recipient with a sense of the wide range of interdisciplinary nature of the Center.

Last month we moved my offices to new quarters, from the fourth to second floor, of the UMTRI building. This has now been established as the NASA Center of Excellence in Man-Systems Research, and presently physically consists of three offices and a large 30' Aviation Laboratory, which includes my collection of 18-30,000 technical documents and reports. While we are well settled, obviously it's going to take me a long time yet to complete unpacking these materials - this is the first move I've made in 15 years! Some negotiation was involved with UMTRI in this move, and they also agreed to provide the NASA Center of Excellence with a computer, IBM electric typewriter, and other assistance. An IBM XT Model #86 computer with IBM 5201 Quietwriter printer and accessories has been ordered, all together the University is contributing over $5000 to this support.

One initial need which took nearly two months to conclude, due in part to position advertising requirements, interviews and other negotiations, was the selection of an Administrative Assistant (although for budgetary reasons we combined the duties of both secretary and administrative assistant). It was important that this individual have outstanding abilities, be familiar with University and governmental procedures, and with student requirements, and have experience with symposia or organizing meetings, and publications. An unexpectedly large and well-qualified number of applicants applied, including one individual who was a pilot and owned her own airplane. We were very fortunate in obtaining Joan McPherson in this position, who ably functions as both secretary and administrative assistant - and who has greatly assisted in smoothly arranging all the paperwork needed in getting the initial students underway.

Joan has had 15 years prior experience with the University in various capacities ranging from clerk receptionist to departmental secretary to administrative assistant in areas such as Communications, legal, Research Development and Administration, and as administrative secretary to the Chairman of the Department of Mechanical Engineering. Her previous responsibilities included maintenance of annual operating budgets in excess of $1 million, work with University publications, and advertising. In addition she has worked closely with students. Despite the fact that she claims to have only been in an airplane twice in her life, she obviously has super qualifications for this position. In negotiating for her services, the University has agreed to pay the first year for that amount (20%) of her salary above that budgeted.

II. Students:

So far we have selected three NASA Research Fellows, and I will try to briefly provide you with some background for each. There were six applicants in August for the fall term (3 in psychology, 1 in industrial and operations engineering, and 2 in bioengineering). Faculty in the Department of Psychology and in the Bioengineering Program were particularly enthusiastic and cooperative in pointing the best available students towards this program and in expediting application materials, with very limited notice.

1. Jeff Daag, Redford, Michigan - entering Ph.D. program in Bioengineering (Dr. Clyde L. Owings, faculty center advisor).

   Jeff received a B.S. in Biochemistry in the Honors Program, from University of Michigan-Dearborn in 1984, and he has an unusual background of interests, (telescope building, antique clock repair, building radio control models), and experience combining life sciences and mechanics. For two years he was a summer engineering student at the Chevrolet Engineering Center where he worked in Vehicle Safety and Value Engineering. He plans to supplement his biochemistry degree with further engineering and physiology, and is particularly interested in the development of artificial limbs and in devices which support humans in hostile environments such as space. A straight A student (oops 3 B+s) his undergraduate GPA is 3.9.

2. John Sullivan, Brooklyn, N.Y. - Ph.D. candidate in Psychology (Dr. Dan Weintraub, faculty center advisor).

   John is at a more advanced level, having successfully completed formal course requirements, prelims and languages, but has an excellent record and background for eventual NASA research. He earned a B.A. in Psychology at Brooklyn College in 1977 (GRE Apt=1330, adv (Psych)=710), with a 4.0 GPA, earning a New York State Regents Scholarship, Dean's Honor List, and graduating magna cum laude. Recommendations were high including: "a first rate laboratory worker and shows much promise as a productive and scholarly research psychologist"; "superbly well-equipped", "I recommend him to you without the slightest reservation" (by Fulbright Lecturer). His current research interests are related to problems of visual localization during and after smooth pursuit eye movements. In particular, he is examining the effect of varying the proximity of the background pattern to visually pursued targets on localization accuracy. Such research has relevance for the design of any artificial environment in which visual-motor coordination and localization accuracy are requisites for efficient human performance. He has also been involved in projects which examine people's sensitivity to acceleration; velocity, and mass information in dynamic visual displays, and has expressed an interest in computer systems design.

3. Bart Telep, Clarkes Summit, Penn. - entering Ph.D. program in Industrial and Operations Engineering, specializing in human factors engineering. (Dr. Dev Kochhar, faculty center advisor).

Bart earned a B.S. degree cum laude in Psychology from the University of Scranton, 1984, where he was on the Dean's list, 3.49 GPA (major 3.64; 4.0 index). He had two years undergraduate work at the Pennsylvania State University. He was a lab assistant in Physiological psychology and involved in research in experimental psychology, with knowledge of SPSS, IBM & apple computers statistical analysis programs, and the Russian language. Bart's capabilities and promise seem to be higher than his scholarly achievements would indicate. He is initiating studies in human factors in the industrial and operations engineering department and may be expected to work in studies of the Center for Ergonomics. As a T.A. Bart has been awarded a reduced traineeship.

A fourth student, Keith Levi, has been awarded limited research and travel support ($3750) subsequent to my communication to you of 19 September 1984, and letter to Frank Owens of 8 October (with response of 22 October). Keith was our unanimous top candidate, but chose a V.A. scholarship which awards some $2,000 more than the NASA grant; a subject we should discuss further:

4. Keith Levi, Mina Lake, South Dakota - Ph.D. candidate in mathematical psychology (Dr. Dan Wientraub, faculty center advisor).

Keith's dissertation research is on the quality of medical decision making in the context of tests for coronary artery disease usine Nuclear Ventriculography (MUGA). In addition he is conducting research on application of the theory of adoptive systems as applied to space mission planning (Defense Dept. Strategic Computing Program) with 25% support from Honeywell (Man-Machine Sciences Group, Minneapolis) where he was an intern during 1983-84.

Keith has an unusual background, having attended the University of South Dakota, Northern State College (Aberdeen), and receiving a B.S. degree with Honors, in Psychology from Maharishi International University (Fairfield, Iowa), in 1979, with a 4.0 GPA. Among his undergraduate honors: Scholarship for Top Psychology Major (1978); Award for Most Outstanding Junior in Psychology (1978); Presidential Scholarship (1974); National Merit Finalist (1973); Outstanding Teenager of America (1972); Who's Who Among American Teenagers (1972); National Honor Society (1972-3). Subsequently, he earned an M.A. (1981) in fundamental measurement, scaling, statistics, and is concurrently completing a second M.A. in computer science at the University of Michigan.

He had done research in the areas of preferential and risky choice, evaluation of probability forecasts, and artificial intelligence. Examples he has given of work conducted at Honeywell include the human-factors design of a highly automated cockpit for next-generation helicopters, design of space station maintenance system with an emphasis on Al technologies, and a mission planning algorithm for missions with multiple objectives under risk.

Three other students are loosely associated with the Center. Colleen Paye, graduate student in Bioanthropology, has been awarded a training grant which will be administered by the Center, from the University of Dayton under U.S. Air Force contract. She is working on tissue depths relative to body skeletal landmarks, previously unknown information, which will be directly utilized by the Air Force in ADAM, the mathematical model for the future crash/ejection dummy. Two work study students, include Steve Peterson, (Industrial and Operations Engineering) who is assisting Dr. Snyder in aviation aspects, and Edgar Vela (Industrial and Operations Engineering/Human Factors) who is assisting Dr. Armstrong in industrial hygiene and public health training areas of this program.

III. Recruiting:

The recruiting effort during the initial two months of July and August was concentrated, through necessity dictated by extremely short time limitation, on students already admitted to one of the participating departments and the University of Michigan graduate school. This effort was more successful than anticipated in that a total of seven candidates were identified and applied. Under the conditions one would expect that the best candidates would already have scholarship support, be otherwise committed, or there would be too short a time interval to learn of the new program and apply, especially for students away from the University during the summer. Yet, one candidate applied from Pensacola, Florida, another from Minneapolis. In this initial recruiting effort the graduate admissions committee of several departments, as well as individual graduate advisors greatly assisted in identifying potential candidates. Interestingly, the Department of Psychology lost at least one highly sought after doctoral student because another school could offer better support, and we suspect that it was quickly perceived that the NASA grant program could become a potentially valuable asset in certain cases to assist an academic department in attracting the very top students. With compatible goal and mutual interests at stake in a very competitive area several of our participating departments have strongly assisted us.

Subsequently, our efforts have been focused on establishing a national recruiting base. In this regard, four Center faculty attended the recent Human Factors Society meeting, armed with our initial brochures and made considerable face-to-face contact with key human factors educators. In particular Dr. Paul Green made an especial emphasis in recruiting activities.

We have evolved a four page flyer describing the program, as well as a one-page description, and are presently in the process of sending these out. Copies are attached for your information. Further down the line we expect to develop a slicker brochure, perhaps on the order of the Institute of Science and Technology brochure (copy also attached).

Currently brochures, consisting of both the 4 page and 1 page descriptions, are being mailed to the 248 educators listed by the Human Factors Society.

We purchased gummed pre-addressed labels for $20. Center faculty from each discipline have also made lists of the most prominent academic departments in their respective fields, and we are in the process of mailing out recruiting brochures to these as well.

Another technique we are trying is to list the NASA grant program with national reference sources. One such is SPIN (Sponsored Programs Information Network) which is a nation wide-computerized system on-line data base of the Research Foundation of State University of New York. Although this system grant and fellowship information is available to colleges and universities and users on a nationwide basis. We are also attempting to get listed in The Grants Register, a reference source book of grant information. The difficulty is that this book is only published every two years. Thus some of the recruiting effort will require a longer term for results.

Currently we are also considering ads in selected student newspapers on various campuses, comparable to the University of Michigan's "Michigan Daily" and "University Record". In addition, we are notifying selected professional journals in the various fields. Again, because of publication lead-time, some of these will not result in positive results in the short term.

To assist this effort we expect to give talks on the program where helpful. For example, Dr. Weintraub made a presentation at the Department of Psychology faculty meeting this past week, and I am scheduled to discuss the program at the next Anthropology department staff meeting. I have also received an open invitation to touch on the NASA Center of Excellence at Georgia Institute of Technology, which has a Center of Excellence sponsored by the Army in engineering.

IV. Student Program:

During the first term the Department of Aerospace Engineering in particular, has had an outstanding series of seminars which we have recommended our students attend. A copy is attached, and you will note that the speakers have included several NASA scientists as well as prominent aerospace industry scientists and managers. Of special note, Robert Freitag, Deputy Director, NASA, provided an excellent review of the Space Station on October 26. He, as well as most of the other speakers, are former graduates of the Department of Aerospace Engineering at the University.

In addition, we have had unusual additional opportunities for the students to get lectures of unusual quality in aerospace areas. On 19 September, for example, General Charles Duke, USAF, Apollo 16 Astronaut, described his walk on the moon and other aspects of the space program and our students had ample opportunity to ask questions on a wide variety of technical issues. It is my understanding that Dr. Billings will be lecturing here in Industrial hygiene for Dr. Armstrong, and this will also be attended by our students.

This first term there has not been sufficient lead time to organize more formal courses, nor will the students schedules for the most part, permit further course loads. We have primarily been relying upon resources already scheduled within the University, such as the aerospace seminars (which we plan to cosponsor next year), or those of the other participating departments, combined with frequent communication with the four students, on 3 December, for example, Levi and Sullivan will discuss their doctoral research in a seminar with the entire Center faculty and other students.

Starting in January, we plan a required seminar (under psychology, industrial and operations engineering, and bioengineering course numbers) which will consist of about two lectures by each faculty member, the first of which will give a introductory discussion of his discipline, and the second focus on a specific area of research within the discipline. I will forward a final course listing or syllabus when this is finalized. Concurrently, we expect to invite selected speakers in a separate series who will discuss particular systems (such as the 767) or disciplines or research in industry or government. One example (to show how far one must consider the systems approach) is Dr. John Templer, of Georgia Institute of Technology, who has agreed to discuss the role of architecture in construction of a space hospital. We are working on ensuring that all students take specific courses to expand their knowledge in areas outside their own discipline, but at present this has not proven to be as simple a task as it may at first seem. Loads, conflicting schedules, and diverse student levels of our initial group are factors to be resolved. Developing a balanced program is a long-term process and probably our toughest task. As this develops I will keep you advised.

V. Other Items of Intent:

A number of activities are developing from, adjunct to, or in cooperation with the NASA Center of Excellence to date, and as pertinent items occur I will keep you advised. The Department of Aerospace Engineering has now acquired the differential maneuvering flight simulator, which Professor Howe mentioned to you on our visit in August, from the Vought Corporation. The two simulator cockpits currently represent a generic configuration and they will be initially utilizing a data package from NASA Langley for the math model simulation, using an AD10 computer. An initial research program is planned once it is operational in about six months, to be supported by the Human Resources Laboratory. Besides Bob Howe, Roger Van Gunst and Dev Kochhar (IOE) will be involved with this simulator. I believe Bob has several additional projects under consideration. We have budgeted $2500 for student training purposes utilizing this simulator once it becomes operational.

Four of us (Howe, Van Gunst, Kochhar) and I visited the Air Force WPAFB Flight Dynamics Lab in August, and have been invited by Col. Mohl, AMRL Commander, to visit the Aerospace Medical Research facilities as well, and we will plan a return trip, and try to get the students there also.

Recently I received an invitation from John Martin at NASA to attend the NASA/FAA Controlled Impact Demonstration at Edwards which I would like to do. Since the November 10 test was postponed I'm not yet sure when this will be rescheduled; perhaps on the 24th. That might provide a good opportunity to drop by and talk with you in greater detail if you would be available on the 26th; or do you plan to also be at Edwards? I also have not yet met Frank Owens and I will plan to touch base with him when I am next in Washington.

At some point before May we should arrange a trip to Ames for our students and I should appreciate your thoughts as to the most convenient and appropriate time for you. I think that you'll find these are shaping up to be of exceptional caliber and since two, Levi and Sullivan, will be completing their dissertations in the near future, you may want to look at them closer relative to the future needs of your group. Further, some sort of summer period or other period of interaction for the students at Ames would seem to be mutually beneficial. Any thoughts on this?

This letter has turned out to be much longer than I had intended but I hope that this will serve to fill you in on our progress to date and provide a basis for continuing communications. Once you have had an opportunity to review this any suggestions or comments you might have would be greatly appreciated.

Sincerely,

Richard G. Snyder, Ph.D.

RGS/jm
Encls: a/s

NASA CENTER OF EXCELLENCE
IN MAN-SYSTEMS RESEARCH

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28 February, 1985

Dr. David C. Nagel
Chief
Aero-Space Human Factors Research Division
Ames Research Center
National Aeronautics and Space Administration
Moffett Field, California 94035

Dear Dr. Nagel:

At our last meeting on 19 February I indicated that I would be following up with further information on the progress of this program, particularly with regard to the status of the budget and students. Although you will be receiving a more detailed report of the first year's progress in another two months several present activities are related to plans for next year and should be brought to your attention at this time.

In general things are continuing to run smoothly. Good communications with the various departments having students in the program, and with the University administration, have enabled us to establish and streamline procedures to better assist the students. While the various departments and colleges have fairly uniform requirements and paperwork relative to admission, procedures and other matters may differ. We are now equipped to answer most questions posed and in this regard Joan McPherson, our administrative assistant, has played an important role. We feel that we are interacting well in integrating the new NASA program into the University system.

In November I reported that the University of Michigan Transportation Research Institute (UMTRI), where our quarters are housed, had agreed to provide the NASA Center of Excellence with an IBM XT Model #86 computer, IBM 5201 Quietwriter printer and accessories and other assistance in establishing an efficient office. Since then we have also obtained an Olympia International Electronic Compact 2 typewriter. One problem still seemed to be that we were not receiving all of our telephone calls, because of nationwide time differences and calls occuring after normal office hours. To ensure that we could be reached day and night and on weekends at all hours we have subsequently installed an inexpensive but effective Cobra telephone answering service. This is used at any time that myself or Ms. McPherson is not available to answer the telephone, and we anticipate that this will be an effective communications tool.

Student status

During the first term last fall we had three NASA Research Fellows. These were Jeff Dagg (Bioengineering), John Sullivan (Psychology), and Bart Telep (Industrial and Operations Engineering). In addition a fourth student, Keith Levi (Mathematical Psychology), was awarded limited research support. A summary of their backgrounds and interests has been provided previously. One student, Bart Telep, has withdrawn from the University, after one term, advising us that he feels that the human factors program in the industrial and operations engineering department requires more mathematics than he is prepared to handle. This has been our only set-back to date.

Two new students were selected for the winter term, however one of these will not be able to start until the spring term (8 May):

1. Erik Nilsen is a first year graduate student in Experimental Psychology. Along with his course program he is currently working on a research project with Dr. Judith Olson concerned with man-systems design questions assessing the cognitive load that various computer software packages put on users. He has a good base in experimental design, computer programming, systems design and mathematics.

2. Jeff Beisel has been admitted to the Bioengineering program. He received an undergraduate degree in civil engineering (structures) from the University of Michigan in 1980 where he was ranked number one in C.E. and in upper 2% in College of Engineering (3.912 GPA). He has since been developing operating systems, hardware, and programming languages. He is responsible for designing "ETAKE2", an entire system to aid the typical construction estimator and owns his own company in Pensacola. His focus here will be on neuromuscular transmission. His background is wide ranging and he appears to exemplify the interdisciplinary aspects of our program.

Thus at the present time we have three full-time NASA Research Fellows (two in psychology, one in bioengineering), a fourth (psychology) to whom we are providing research support, and a fifth (bioengineering) who will be entering in May. In addition, three other students are loosely affiliated with the Center, two work study students, and one pre-doctoral student (Forensic Anthropology) who is working on a student training grant to provide basic tissue information for the Air Force mathematical model for ADAM, the future military crash/ejection dummy. One student (Industrial and Operation Engineering) has left the program.

I should also mention that the applicants for the winter term included one individual with a space law goal and another with an economics background. In the latter case, the individual truly appeared to be a "generalist" with widespread interests ranging from radio and optical astronomy to flying, business, and even designing rockets. He provided a difficult decision because on the one hand he had exceptional intellect (national merit scholar, etc. etc.), obvious and proven ability (president of his own consulting company to assist manufacturing companies, including General Motors) and yet on the other hand insufficient depth in necessary background (mathematics) in physical sciences for a graduate aerospace program. He was advised to consult with various staff members concerning taking additional basic courses if he wished to be further considered. An individual like this does not fit the mold of rigid academic structure, yet gives promise to be a creative and innovative scientist. We should be flexible in evaluating such individuals, and I suspect that we may see others with non-conventional backgrounds.

Fall 1985

Our deadline for student applications for the Fall, 1985 term is 15 March, and we expect to make decisions by 1 April. The prospects for adding some additional exceptionally promising students look very encouraging. We are now just beginning to see the results of our initial nationwide recruiting, and have had a particularly good response as a result of a notice in the Human Factors Society Bulletin in January.

While all applications expected have not yet been received, several illustrate the types of backgrounds of applicants already indicating a strong and serious commitment to a future aerospace human factors professional career. In fact, at least three applicants have already had experience in space research.

. One, presently in Seattle with the Boeing human factors group has worked on the Peace Keeper (MX) project, Man Machine Systems and Boeing space station projects. She is interested in doing additional work in nuclear medicine.

. Another, with a B.S. in Astronautical Engineering and Engineering Science is presently in a Masters degree program in human factors at Purdue. A former AF jet pilot, he has experience as a rocket propulsion engineer at Edwards, spent 2 years in the Antarctic with the National Science Foundation, and has assisted in compiling a book for NASA "Analogue between Space Stations and Antarctic Stations."

. Yet another is presently with the Lockheed Human Factors section in the NASA Man-Systems Division at the Johnson Space Center in Houston. She has been conducting research in intravehicular and extravehicular activity biomechanics, crew-workstation design, and other human interfaced space systems for advanced spacecraft and space station development. She has a M.S. in Industrial Engineering and a B.S. in Biomechanics.

. Another applicant has a masters degree from Dartmouth College (cognitive/perceptual Experimental Psychology) and experience including human factors engineering internship at IBM, and interests in artificial intelligence, computer technology, and creative problem solving.

. Several of the applicants in Aerospace Engineering appear to have exceptional backgrounds, one having studied a year at the University of Lenningrad. One, still in the process of applying, has a background in energy system management, including the first masters degree in Nuclear Engineering awarded to a female at the University of Arizona.

I hope that these brief samples of current applicants will convey some idea of the breadth and astonishing backgrounds of applicants that have been attracted to this program to date. I would anticipate that for next September we could select at least five new Fellows, including several women, and expand the disciplines having students in the program to include aerospace engineering and industrial and operations engineering.

Needs

. It would be most helpful if we could arrange for all of the students to travel to Ames sometime late this spring for an orientation visit, as we have previously discussed and budgeted.

. Since they should be making summer plans relative to research or study, and our training grant specifies that "close and frequent interaction of student trainees with an appropriate NASA Research Center is highly desirable," we would like to pin down what possibilities may exist for any of the students to have an opportunity to work at Ames for any period this summer. Such first-hand experience should be mutually useful and would certainly boost motivation.

As I recall our brief discussion on this point, you suggested that I forward some background on each student at this time so division chiefs could better determine how any might fit into specific programs. In this regard background and a summary of interests is attached for Sullivan (Psychology - Vision), Levi (Psychology), Dagg (Bioengineering), Nilsen (Psychology), and Beisel (Bioengineering).

. You further indicated that you were planning to visit Ann Arbor around the end of the winter term (which is about 25 April). This would provide an opportunity to brief the students (and faculty) concerning current activities and priorities of your Division, and also so that you could personally meet each student individually and get a better idea of how they might interface with research activities. This should be considered at your earliest travel opportunity in order to provide adequate planning time, since the students will have to commit to summer schedules soon.

Budget

At the present time we are well within the first year's budget and project that the second year's budget, starting 1 June, will also be adequate as is. Based upon this first year's experience we anticipate that we will need to readjust some budget categories but can do this through reduced cost savings in other areas, without any overall increase. Since a detailed accounting will accompany our annual report in June 1, I will only touch upon some specific points and trends at this time.

Our costs have initially been less than expected for several reasons. First, we were almost two month's into the first year before funds were received, and this delayed our schedule as well as our start-up in recruiting and other activities. Another factor was the timing, which normally would not have allowed sufficient time to recruit, select, and enter students until the winter or spring terms. We were fortunate, despite this to be able to select from an initial pool of well qualified students already admitted to the University. However a number of cost savings have occurred as well. To date we have also been able to save on budgeted student tuition and stipends simply because three of our students did not have to pay out-of-state tuition, and two students have received reduced stipends over that budgeted because of other support.

We have spent no funds on student travel at this point since this is primarily programmed for an April or May trip of several days to NASA Ames at the end of the spring term. We currently are planning another visit to research facilities at the Aerospace Medical Laboratories at Wright-Patterson AFB in Dayton, but this will involve little cost. We also have sufficient funds for a second visit of faculty, to AMES, since we were able to take advantage of low-cost air fares during the trip last August, and the duration was briefer than originally planned.

A benefit from these cost savings is that we have been able to involve more students for less cost. While this is not expected to continue, primarily because most applications are now coming from out-of-state (tuition) candidates, we do expect to be able to offer more students some participation then originally projected and for no greater cost than originally budgeted. One thing that we did at the onset was to establish an accounting system, through conferences with representatives of Federal Accounts, Research Administration (DRDA), Accounting, and others. This resulted in a breakdown into 10 accounts, which has enabled greatly simplified accounting (e.g. student recruiting, student stipends, student tuition, student travel, etc, are each kept separately.) This has been transferred to Lotus computer program. By June the only adjustments estimated at the time will involve several items of salaries, as we pick up the 20% currently provided by the University for our administrative assistant, and readjust faculty increases. Similarly, supplies and postage have run more than expected, although telephone and computer costs have been less.

In summary, we have effected beneficial cost savings so far during this first start-up year due to the late start, low number of out-of-state students, delay of and cost savings in travel, cost sharing of some student support, and other favorable factors. This first year we have also saved costs on visiting lecturers by taking advantage of some scheduled visits already arranged by Aerospace Engineering. We anticipate some teaming up in the future as well, particularly through Professor Harm Buning's Aerospace Design course. However, with the expected increase in out-of-state students (90% of applicants for fall so far), seminar schedules, facility visits, and additional activities, such as hosting a National Conference, during the second year we expect a catch-up effect of additional expenses over that budgeted the first year. Yet the bottom line is that we expect to be able to involve more students for no more cost than that budgeted for next year (85-86).

Sincerely,

Richard G. Snyder, Ph.D.
Director

RGS/jm

Enclosure:

1. Summary backgrounds and interests of students, to assist in determining where they might best interact in Ames Aerospace Human Factors Division summer research activities.

xc: Dr. A. Chambers

Student Backgrounds

The following five students will be available during the summer period for variable internship activities at NASA Ames. A brief resume is provided for each to allow you some judgement about programs where some interaction might be arranged. Please contact us for futher information on any of these NASA Research Fellows.

1. Jeff Dagg, Redford, Michigan - entering Ph.D. program in Bioengineering (Prof. Clyde L. Owings, faculty center advisor).

Jeff received a B.S. in Biochemistry in the Honors Program, from University of Michigan-Dearborn in 1984, and he has an unusual background of interests, (telescope building, antique clock repair, building radio control models), and experience combining life sciences and mechanics. For two years he was a summer engineering student at the Chevrolet Engineering Center where he worked in Vehicle Safety and Value Engineering. He plans to supplement his biochemistry degree with further engineering and physiology, and is particularly interested in the development of artificial limbs and in devices which support humans in hostile environments such as space. A straight A student (oops 3 B+s) his undergraduate GPA is 3.9.

2. John Sullivan, Brooklyn, N.Y. - Ph.D. candidate in Psychology (Prof. Dan Weintraub, faculty center advisor).

John is at a more advanced level, having successfully completed formal course requirements, prelims and languages, but has an excellent record and background for eventual NASA research. He earned a B.A. in Psychology at Brooklyn College in 1977 (GRE Apt=1330, adv (Paych)=710), with a 4.0 GPA, earning a New York State Regents Scholarship, Dean's Honor List, and graduating magna cum laude. Recommendations were high including: "a first rate laboratory worker and shows much promise as a productive and scholarly research psychologist"; "superbly well-equipped", "I recommend him to you without the slightest reservation" (by Fulbright Lecturer). His current research interests are related to problems of visual localization during and after smooth pursuit eye movements. In particular, he is examining the effect of varying the proximity of the background pattern to visually pursued targets on localization accuracy. Such research has relevance for the design of any artificial environment in which visual-motor coordination and localization accuracy are requisites for efficient human performance. He has also been involved in projects which examine people's sensitivity to acceleration; velocity, and mass information in dynamic visual displays, and has expressed an interest in computer systems design.

3. Erik Nilsen, Harbor Beach, Michigan. First year graduate student in Experimental Psychology, (Prof. Dan Weintraub, faculty advisor.)

Erik entered during the winter term and has an exceptional academic background with a 4.0 psychology GPA and 4.0 overall GPA. His research interest is in the area of cognitive engineering and he wants to apply the insights of cognitive psychology to the evaluation and design of man-systems interfaces. He is presently working on a research project with Dr. Judith Olson concerned with man-system design questions; in particular trying to assess the cognitive load that various computer software packages put on users.

A fourth student, Keith Levi, has been awarded limited research support due to being recipient of a V.A. Scholarship, making him ineligible for dual tuition/stipend support.

4. Keith Levi, Mina Lake, South Dakota - Ph.D. candidate in mathematical psychology (Prof. Dan Weintraub, faculty center advisor).

Keith's dissertation research is on the quality of medical decision making in the context of tests for coronary artery disease using Nuclear Ventriculography (MUGA). In addition he is conducting research on application of the theory of adaptive systems as applied to space mission planning (Defense Dept. Strategic Computing Program) with 25% support from Honeywell (Man-Machine Sciences Group, Minneapolis) where he was an intern during 1983-84.

Keith has an unusual background, having attended the University of South Dakota, Northern State College (Aberdeen), and receiving a B.S. degree with Honors, in Psychology from Maharishi International University (Fairfield, Iowa), in 1979, with a 4.0 GPA. Among his undergraduate honors: Scholarship for Top Psychology Major (1978); Award for Most Outstanding Junior in Psychology (1978); Presidential Scholarship (1974); National Merit Finalist (1973); Outstanding Teenager of America (1972); Who's Who Among American Teenagers (1972); National Honor Society (1972-3). Subsequently, he earned a M.A. (1981) in fundamental measurement, scaling, statistics, and is concurrently completing a second M.A. in computer science at the University of Michigan.

He has done research in the areas of preferential and risky choice, evaluation of probability forecasts, and artificial intelligence. Examples he has given of work conducted at Honeywell include the human-factors design of a highly automated cockpit for next-generation helicopters, design of space station maintenance system with an emphasis on A1 technologies, and a mission planning algorithm for missions with multiple objectives under risk.

5. Jeffrey Beisel, Pensacola, Florida (West Bloomfield, MI) entering Ph.D. program in Bioengineering (Prof. Clyde L. Owings, faculty center advisor).

Jeff was selected for a fellowship during the winter term, but will be unable to start until spring term (May 8) due to other commitments with his software development company. A 1980 graduate of the University of Michigan in Civil Engineering (Structures), Jeff ranked 1st in a class of 94 in Civil Engineering and 13th of a class of 901 in the entire college of engineering, graduating summa cum laude with a 3.9 GPA. He had additional undergraduate work at the University of Delaware, Roger Williams College, Illinois Institute of Technology, Lawrence Institute of Technology and Michigan State University. His focus will be in the area of Neuromuscular Transmission and electronic interaction with the body, and will be working in joint medical-engineering programs. Since leaving school Jeff has developed his own company, and has designed an entire computer system software package for the construction industry, and "ETAKE2" has been sold to Digital Systems of Florida for nationwide marketing. He expresses strong motivation to continue his graduate education concentrating in Bioengineering, and his performance to date demonstrates that he has an unusual potential.

APPENDIX G

FACULTY RESUMES

A review of faculty qualifications and experience is provided for the 1984-1985 Center participating core faculty. They represent a unique key to the University of Michigan interdisciplinary capabilities. Not only does each professor represent a different academic discipline, but most are cross-trained in at least two areas, and each has experience as a scientist or pilot for NASA or other governmental or industrial organization. Neil Gerl, Project Representative at DRDA, is also a former rated Naval Aviator.

Other faculty with talents unique to this program have provided assistance. In particular, Dr. David J. Anderson (Chairman of the Bioengineering Program, and Professor of Electrical and Computer Engineering, College of Engineering, and Professor of Otorhinolaryngology, Medical School) who has presented a seminar on his Space Lab Vestibular experiments and generously advised on potential Bioengineering applicants.

Administrative Assistant is Joan McPherson, who has 16 years experience at the University of Michigan in various capacities in areas such as Communications, Legal, Research Development and Administration, and as administrative secretary to the Chairman of the Department of Mechanical Engineering. Her previous responsibilities included maintenance of annual operating budgets in excess of $1 million, work with University publications and advertising, and she has worked closely with students. She is the only full-time staff member and provides close contact and assistance to the students.

1. Richard G. Snyder (B.A., M.A., Ph.D.; Diplomate, ABFA) Director

Professor of Anthropology
Department of Anthropology
College of Literature, Science and Arts;

Research Scientist
University of Michigan Transportation Research Institute
Institute of Science and Technology

The Center program is coordinated and directed by Richard G. Snyder, Professor of Anthropology, Research Scientist, and for some 14 years, head of the Biomedical Department, UMTRI. His background includes Federal government, industry, and University experience.

From 1957-59 he was an Associate Research Engineer at the Applied Research Laboratory, College of Engineering, University of Arizona, concurrently advancing to Associate Professor of Systems Engineering (Numerical Analysis), and serving as a Human Factors Consultant in advanced military communications at the Army's Electronics Proving Ground, while finishing his doctorate. From 1960 through 1966, he was Chief, Physical Anthropology, Protection and Survival Laboratories, Civil Aeromedical Research Institute, Federal Aviation Agency, and a research pilot. From 1966 through 1968 he was Manager, Biomechanics Department, Automotive Safety Research Office, Engineering Staff, Ford Motor Company, and responsible for directing Ford's biomedical grants and contract research at various universities. He has also held research and academic appointments in Systems Engineering or Anthropology at Michigan State University and the Universities of Oklahoma, Chicago, Arizona, and Michigan.

His education included premedical studies at Amherst College, various military aviation engineering technical schools while in military service, and graduate work at Cornell University and the University of Arizona, from which he received the degrees B.A. (1956), M.A. (1957), and the first Ph.D. (1959) in Physical Anthropology (Bio-Anthropology), with a minor in Zoology. Additional work was done at the Universities of

Vermont, New Hampshire, Wisconsin, and postdoctoral courses at Ohio State University, The University of Michigan, the USAF School of Aerospace Medicine, Tweed Foundation, National Association of Medical Examiners, and Princeton University/Ford.

A commercial, military, and qualified production and research test pilot with some 5,500 flight hours, Dr. Snyder has flown since 1945 in over 70 aircraft models, including multi-engine, seaplanes, helicopter/rotorcraft, jet and prop fighters and heavy transports. He flew 100 combat missions in Korea, receiving 10 decorations including the DFC and three Air Medals. In the winters of 1952-53 he flew in project "High Flight," a pioneering effort to fly jet fighters across the North Atlantic, nearly seven years before commercial jet airliners. While with FAA, he owned his own RCAF F-51 Mark IV Mustang fighter, in which he won 4th place in the 1964 Transcontinental National Air Race, and in 1965 experimentally modified for an attempt at the world transcontinental speed record for propeller aircraft. He has held TOP SECRET and NATO COSMIC security clearances; currently SECRET.

Dr. Snyder has authored some 400 scientific publications, reports, and presentations on safety, impact trauma, and biomedical areas of aviation and aerospace medicine, including the chapter on "Impact" in the NASA Bioastronautics Data Book. He is a Fellow of the Aerospace Medical Association, the American Association for the Advancement of Science, the American Anthropological Association, the Explorer's Club (having led an expedition), and the American Academy of Forensic Sciences. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a member of numerous other aviation, medical, and scientific biological societies. He has been a U.S. member of the Aerospace Medical Panel (Biodynamics), Advisory Group for Aeronautical Research and Development, NATO, a consultant for NASA, CPSC, USAF, USA, USN, HEW, the U.S. Dept. of Justice, and other governmental and industrial organizations, and in 1973 was appointed to the Executive Council of CHABA, and in 1984 to the Committee for Trauma Research, Commission on Life Sciences, National

Academy of Sciences-National Research Council. He is a Director and certified Diplomate of the American Board of Forensic Anthropology.

International recognition as an authority on impact trauma and human tolerance, and aviation safety has resulted in awards of the National Safety Council (Award for Research in Accident Prevention) in 1970, the Society of Automotive Engineers (Arch T. Colwell Award for Research) in 1973, the Aerospace Medical Association/Lockheed Aircraft Co. (Harry G. Moseley Award in Flight Safety) in 1975, and the 1978 Award for Professional Excellence by the Life Sciences and Biomedical Engineering Branch, Aerospace Medical Association. In 1981 he was awarded the Admiral Luis de Florez Flight Safety Award for "outstanding contributions to aviation safety" by the Flight Safety Foundation. In 1982 he was recognized by the Society of Automotive Engineers for Excellence in Oral Presentation at the Aerospace Congress, and in 1983 honored for his technical contributions to air transport cabin safety.

Dr. Snyder has 24 years experience directing numerous research projects and programs, both as a recipient and in technical management of Federal and Industrial research. He has taught nine courses in Anthropology and been on 12 doctoral dissertation committees in 4 colleges of The University of Michigan. He is presently advising one pre-doctoral student.

2. Daniel J. Weintraub (A.B., M.A., Ph.D.) Co-Director

Professor of Psychology
Department of Psychology

and, Human Performance Center
College of Literature, Science and the Arts

Strong guidance in human factors area is provided by Daniel J. Weintraub Professor of Psychology, Department of Psychology, College of Literature, Science and the Arts. Professor Weintraub is also a member of the faculty of the Human

Performance Center. In college, Dr. Weintraub received a Navy ROTC scholarship, and was subsequently a Navy pilot who spent most of active duty years after flight school back in the Pensacola training command as a flight instructor. Service obligation completed, he enrolled in graduate school of the University of Illinois, receiving the Ph.D. degree (1962) in Experimental Psychology with a minor in Mathematical Statistics.

His initial academic post (1962) was at The University of Michigan and he has been there ever since (full professor since 1970). During the 1975-76 academic year he was a visiting research scientist at the Aerospace Psychology Division of the Naval Aerospace Medical Research Laboratory, NAS Pensacola. Major research projects were an exploratory look at the utility of head-up displays, and experiments concerning the functional visual field. Weintraub spent a semester's sabbatical (fall 1980) at the London School of Economics and Political Science, followed by a National Research Council-NASA Research Associateship (1981-1983) with the Man-Vehicle Systems Research Division, NASA Ames (Moffett Field, CA). At NASA he carries out experiments concerned with head-up displays, which included the monitoring of eye movements and eye accommodation (focus). He is currently at NASA Ames from June - August.

His primary areas of research interest lie in vision and visual perception. His best-known research is with geometrical visual anomalies (Illusions), many of them applicable to flying. He is very interested in visual problems associated with aerospace applications. There are two reasons for the applied interests. The first is his conviction that if a researcher cannot apply his academic specialty to the real world, then he should worry about whether his work represents merely the playing of scientific games. The second reason is that he states he is a "hanger bum". Being associated with flying and flying research is enjoyable. He holds commercial single-engine land instrument ratings, and now flies for fun. As an experimental psychologist with major interests in vision and visual perception, visual illusions in flying, and human factors research in head-up displays, Professor Weintraub plays a major role in this program.

3. Robert M. Howe (B.S., A.B., M.S., Ph.D.) Co-Director

Professor
Department of Aerospace Engineering
College of Engineering

Dr. Robert M. Howe received his B.S. in Electrical Engineering from the California Institute of Technology in 1945 while serving in the U.S. Navy. After his separation from the Navy he returned to Oberlin College, where in 1947 he received an A.B. in physics. In 1947 he received an M.S. in physics from the University of Michigan and in 1950 a Ph.D. in physics from the Massachusetts Institute of Technology. At this time he joined the faculty of the Department of Aeronautical Engineering (now called Aerospace Engineering) at the University of Michigan as an instructor, rising to the rank of Professor by 1957.

The early research of Dr. Howe at Michigan was primarily in analog simulation, including both hardware and applications. Under U.S. Air Force sponsorship he was involved for many years in research on training-type flight simulators for aircraft and, later, spacecraft. In addition he did extensive work as a consultant for Link Aviation in the development of their initial jet transport simulators. From 1963 to 1968 he served as Chairman of Information and Control Engineering, an interdepartmental graduate program at the University of Michigan. In 1968 he became Chairman of the Department of Aerospace Engineering, a position he held until 1983.

Along with Drs. Paul Fitts and Richard Pew from the Department of Psychology, Dr. Howe initiated in 1967 a NASA-sponsored research program in manual control. Over the next eight years this program turned out many Ph.D. students in both Psychology and Aerospace Engineering, and was responsible for a number of interdepartmental seminars. More recently Dr. Howe has been involved in a NASA Ames-sponsored program in helicopter dynamics and simulation. He currently teaches courses in flight dynamics, guidance and control, dynamics of real-time digital simulation, and nonlinear control systems. His publications include over 60 articles in scientific and engineering journals as well as a book on analog computers. He is a member of Tau Beta Pi, Phi Beta Kappa, Sigma Xi, SCS and AIAA. He holds the grade of Fellow in the IEEE.

Dr. Howe was the first national chairman of Simulation Councils Inc., the predecessor of the Society for Computer Simulation (SCS). He served as a member of the U.S.A.F. Scientific Advisory Board from 1971 until 1978, at which time he received the Meritorious Civilian Service Award from the Air Force Chief of Staff for "outstanding contributions in guidance and control, and flight simulation." In 1983 he received the AIAA deFlorez Training Award for Flight Simulation. He is a past member of the Space Systems Technology Advisory Committee for NASA, and has consulted for many organizations through the years. He is currently a consultant for Applied Dynamics International and is chairman of the Research Advisory Panel for the U.S.A.F. Human Resources Laboratory, Operational Training Division.

4. Roger Van Gunst (B.S.A.E., M.S.A.E.)

   Lecturer
   Research Scientist
   Head, Aircraft Research Laboratory
   Department of Aerospace Engineering
   College of Engineering

Roger Van Gunst is a member of the Department of Aerospace Engineering staff, and heads the Aircraft Research Laboratory. He conducts research in the area of applied aerodynamics and teaches a course in aircraft flight test methods.

Mr. Van Gunst obtained experience in military flight operations as a Navy pilot and maintenance officer. This flight experience covered a range of missions from light-attack aircraft-carrier operations to training pilots for the South Vietnamese Air Force.

Following this military experience, Mr. Van Gunst obtained a master's degree in aeronautical engineering and began flying with Langley Research Center as a research pilot. During the eight-year period as a NASA Research Pilot, he was involved with research projects associated with cockpit flight displays for fixed and rotary wing aircraft, pilot workload studies, simulator analysis of aircraft characteristics and performance/handling quality studies of aircraft modifications.

His background in military and civilian flight operations combined with his experience in flight and simulator research studies of operator-system interface characteristics and current classroom teaching will provide an important ingredient in formulating the proposed curriculum. It is envisioned that Mr. Van Gunst will provide an important link between the research concepts and their operational evaluation and application. As with Dr. Weintraub, his experience with NASA will prove especially important in providing guidance towards NASA's needs and objectives. His background is particularly significant for the man-machine interface and cockpit display subjects which are two primary subject areas addressed in the Center of Excellence program.

5. Dev S. Kochhar (B. Tech. (Hons.) M.E., M.A.Sc.,Ph.D.)

Associate Professor
Industrial and Operations Engineering
College of Engineering

Dev S. Kochhar received a B.Tech. (Hons.) degree in Mechanical Engineering from I.I.T.Kharagpur, and the M.A.Sc. and Ph.D. degrees in Systems Design from the University of Waterloo in Canada. He is Associate Professor of Industrial and Operations Engineering in the College of Engineering. His principal research effort for the past 12 years has been in investigating the role and function of humans as components of complex systems in industry, manufacturing and air and road transportation. A special emphasis has been to understand the unique significance of visual and perceptual factors in the acquisition and processing of information, and how this affects equipment design.

He has been the principal or co-investigator on projects for the Air Force Office of Scientific research, the National Institute for Handicapped Research, the Departments of Transportation, Civil Aviation, Health and Welfare, and the National Science and

Engineering Research Council. Other sponsors have included various State Research Councils and industry including the Monsanto Co., Firestone Tire and Rubber Co., Kaiser Aluminum and Chemical Co., Burroughs, Michigan Bell, ITT, Ford, UTDC, and the U.S. Department of Labor. These efforts are reflected in some 45 technical papers and reports. Topics covered have included human performance in office and industrial environments, job and work place design, human machine interaction and interface design, and the unique performance of special populations. The research most relevant to the NASA grant is the work done on the performance of monocular pilots (see Aerospace Medicine, 49(5), 698-706, 1978).

Dr. Kochhar joined The University of Michigan in 1980, after serving in a similar capacity in Canada. He is a Senior Member of the Institute of Industrial Engineers, Society of Manufacturing Engineers, Member of the Human Factors Society, IEEE Systems Man and Cybernetics Group, Rehabilitation Engineering Society of North America, and the Operations Research Society of America. He is a registered professional engineer (Ontario).

6. Thomas J. Armstrong (B.S.E., M.P.H., Ph.D.)

   Assistant Professor of Industrial Hygiene
   Department of Environmental and Industrial Health
   School of Public Health

   and Faculty, Center for Ergonomics

Thomas J. Armstrong received a B.S.E. in Aerospace Engineering in 1971, a M.P.H. in Industrial Health in 1972, and a Ph.D. in Industrial Health and Industrial & Operations Engineering in 1976, all from The University of Michigan. Dr. Armstrong is an Assistant Professor of Industrial Health in the School of Public Health were he teaches industrial hygiene, engineering and ergonomics. He is also on the staff of the Center for Ergonomics.

His major research interests include evaluation and control of physical stresses in the work place. His current work includes study of repetitive trauma disorders, procedures for analysis of physical work stresses, design of hand tools, and emergency egress from business aircraft. Dr. Armstrong also has a strong aviation background, having been a commercial pilot and C.F.I.

Dr. Armstrong is a member of the American Industrial Hygiene Association, American Institute of Industrial Engineers, and American Biomechanics Society.

7. Clyde L. Owings (B.S., M.D., Ph.D.)

   Associate Professor of Electrical and Computer Engineering
   Department of Electrical and Computer Engineering
   College of Engineering;

   Associate Professor of Pediatrics and Communicable Diseases
   Department of Pediatrics and Communicable Diseases
   University of Michigan Medical School;

   Associate Research Scientist
   University of Michigan Transportation Research Institute
   Institute of Science and Technology

Dr. Clyde Owings, an Associate Professor of Electrical and Computer Engineering, also holds joint appointments in the Medical School, UMTRI, thus can provide unusual interdisciplinary insight to this program. He also is a former pilot and USAF medical officer.

He is a member of the Acoustical Society of America, American Medical Association, Biomedical Engineering Society, Institute of Electrical and Electronic Engineers and Sigma Xi. He serves as a student counselor in Bioengineering, member of the Medical and Hospital Quality Assurance Committee, and on various other committees. He is a Director of the Professional Standards Review Organization and on the Board of Directors, Institute of Electrical and Electronic Engineers, Southeast Michigan Section. He has research experience directing or co-directing several major studies for the U.S. Consumer Product Safety Commission, and is author of a number of medical and engineering papers and presentations.

Dr. Owings currently teaches in both the Medical School and College of Engineering. Of particular importance to the proposed program is his course on "Biomedical Instrumentation and Design" taught as Bioengineering 472 and Electrical and Computer Engineering 472.

8. Paul A. Green (B.S., M.S.E., A.M., Ph.D.)

Assistant Research Scientist
Human Factors Division, UMTRI

Adjunct Assistant Professor in Industrial and Operations Engineering
Department of Industrial and Operations Engineering
College of Engineering

Dr. Green holds joint appointments as an Assistant Research Scientist in Human Factors, UMTRI, and teaches as an Adjunct Assistant Professor in Industrial and Operations Engineering. He is responsible for teaching the undergraduate human factors laboratory course and a course for seniors and graduate students on human factors in computer systems. He is the first Michigan recipient of a joint doctoral degree in Psychology and Industrial and Operations Engineering, and thus is representative of the interdisciplinary approach which we hope to develop in the Center of Excellence training program.

Dr. Green currently is the past Chairperson of the Human Factors Society Computer Systems Technical Group (HFS-CSTG), and the present Chair of HFS-CSTG Program Committee. His expertise is in design and evaluation of visual displays, especially pictoral symbology, design of controls, person-computer interaction, and human motor performance. With Dr. Richard Pew, he is responsible for organizing and teaching The University of Michigan Human Factors summer course. His contributions to the Center teaching program are especially pertinent.