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ABSTRACT

This paper examines the work of resident engineers in a university setting. The need for engineers with industrial experience is established, and the benefits of using resident engineers in training programs are cited. Attributes and problems associated with the practice are studied from the viewpoints of industry, government, universities, and the engineer himself. (CP)

A RESIDENT ENGINEER

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ABSTRACT

A resident engineer is defined as a qualified engineer from industry or government who returns to the University to teach/educate on a full time basis for a short period of time, 1 to 3 quarters. In a way this is an old idea that has been widely used in other professions but was really not adopted by engineering. Due to many factors the time has come to give it serious consideration. Indeed, it is part of the University/Industry/Government Cooperative Educational Program proposed by Professor Brodsky of Iowa State University.

This paper explores the problems and needs for and the benefits and costs of such a program to the University, Industry and Government, the profession and the individual himself. This material is presented from the viewpoint of the author who has spent 18 years with the Federal Government (NASA) and recently spent two quarters teaching at Iowa State University on an intergovernmental exchange program that could serve as a model for a Resident Engineer Program.

INTRODUCTION

This paper is concerned with the need for a Resident Engineer Program. A resident engineer is defined as a qualified engineer from industry or government who returns to a university to teach on a full-time basis for a short period of time (one to three quarters). In a way, this is an old idea that has been widely used in other professions, but has never really been adopted by the engineering community. It now needs serious consideration and indeed, it is part of a University/Industry/Government Cooperative Educational Program proposed by Professor Brodsky of Iowa State University.[1] The primary purpose of this paper, then, is to consider the problems that lead to a need for a Resident Engineer Program and the benefits and costs of such a program. Before doing so, however, let me first describe a little of my own personal background and how I have come to support a cause so far from my principal area of work.

I graduated from the University of Minnesota with a Bachelor of Aeronautical Engineering degree (5-year degree) in 1957 and since then have conducted research in various aerospace activities with NACA/NASA. During the past year, I supervised a research staff of 25 engineers in the field of aerodynamics. During my 18 years with the federal government, I received my graduate training at Stanford University on a part-time basis beginning in 1958, receiving my MS degree in 1963 and my PhD in 1970. Hence, I have been close to the educational process, both as a researcher and as a student for many years. I also have four children (the oldest is a freshman in college) whose education I follow very closely. Recently (November 1973 to June 1974) I elected to spend two quarters as a visiting professor in the Aerospace Engineering Department at Iowa State University. All of this involvement with education has let to a rather keen interest on my part in the educational process.

THE PROBLEMS AND NEEDS

While at Iowa State University I observed several factors that could lead to stagnation of the institution and a decline in the quality of the students. I believe that these factors exist to various degrees in all Aerospace Engineering Departments. The factors are:

1. A young staff
2. A staff that lacks engineering experience
3. A staff that is nearly all tenured

This situation is a result of the rapid growth in enrollment and faculty during the early days of the space age, with many of the faculty coming directly from graduate schools and having little or no experience outside the University. Also, tenure was granted readily under this growth condition. With the sudden decline in enrollment, starting in the late 1960s, many of those without tenure were dismissed. These factors, when combined with the low (but at present) stable enrollment situation, will result in few chances to hire new or experienced staff members for the next 10 to 15 years. This could be disastrous for the aerospace engineering community, since it is at the forefront of a rapidly changing technology where it is essential for the staff to keep up to date. This is difficult to do while teaching a heavy class load, advising, etc.

To corroborate the observations made at Iowa State University, I, with the aid of the Aerospace Department Heads Association, made a survey of the Aerospace Engineering Departments in the United States. Replies from 23 out of 55 schools were obtained (table 1). A copy of the questionnaire and a tally of the results is given in table 2. A brief summary of those results is given in the appendix. Before discussing the results, I should note that no questionnaire could be so all-inclusive as to answer all questions. Ambiguities occurred as well as misinterpretations. These will be pointed out when necessary. Nevertheless, I feel the results provide an important insight into the problems.

The age distribution of Aerospace Engineering Department staffs, obtained from this survey, is shown in figure 1. Note that the distribution of ages is heavily skewed to the younger age group. This is true of universities in general[2] and resulted from the rapid staff expansion that universities underwent during the early sixties.

There is one exception: the youngest group. This low percentage of staff in the very youngest group may already be a reflection of the reduced hiring brought on by the decline in enrollment. If this trend persists, in 10 to 15 years the age distribution will be skewed to the older age group.

The experience distribution is shown in figure 2. Figure 2a shows the rough breakdown, with 50% of the staff having less than 5 years experience. A slightly more detailed distribution is shown in figure 2b. Here we see 39% having less than 3 years experience. The survey also indicated that between 5 and 10% had no experience other than summer work. This inexperience is, as noted earlier, a result of the rapid expansion of the staff in the early sixties resulting in hiring young PhDs directly out of school.

Note: it was not clear in the survey whether consulting was to be considered work experience. I did not intend it to be. Consulting represents a rather specialized type of work that is not representative of industrial experience. This is particularly true if one is interested in design-oriented experience. The inclusion of consulting experience in any of the surveys would not alter the conclusion that the staff lacks experience. In fact, removal of any such data would strengthen such a conclusion.

The last observation made was on the high percentage of tenured staff. This observation was borne out by the survey, since the survey showed that, on the average, 75% of the faculty is tenured.

Finally, the enrollment statistics for Aerospace Engineering students, though well-known,[3] are shown for completeness in figure 3. The general trend for aerospace enrollment is likely to hold for some time, because the present monetary and fiscal situation leads to poor job potential in the aerospace field, and the environmental and energy factors lead students to other fields. Combining the enrollment picture with the other three factors discussed above, one comes to the conclusion that there will be relatively minor changes in the Aerospace Engineering Department staffs for the next 10 to 15 years. This situation could lead to stagnation of Aerospace Engineering Departments and a further shift of students to other fields. Furthermore, it is inconsistent with the idea that aerospace is a spearheading technology.

The needs, as seen for the industry/government point of view, have already been alluded to above but will be reiterated for clarity. They are: 1. Aerospace is a technology spearheading activity and hence needs well-trained engineers. 2. There is a critical need for creative, young, design-oriented engineers.

These needs of industry/government will not be met, in the long run, under the present situation existing at the university without the aid of some sort of program to offset or compensate for the lack of experience. I believe the Resident Engineer Program may help solve this problem and should be given serious consideration.

BENEFITS AND COSTS

In this section, I will explore some of the benefits and costs to the various contributors to a Resident Engineer Program. These contributors are the university, industry/government, the profession, and the individual himself. When I speak of costs, I refer not only to monetary costs but more importantly to those hidden factors, imaginary or real, that are present when a program of this type is considered.

The University

The obvious benefits of such a Resident Engineer Program would be the regular exposure of students to fresh, varied, and experienced industrial or government engineers. This can help offset the inexperience factor outlined in the previous section. Another benefit is that the resident engineer, having no vested interests in the department, can be a useful critic of curriculum, teaching methods, etc. In addition, having very few advising and committee duties, the resident engineer should have time to mix with students in "rap" sessions or other means of informal communication to expose the student to the engineer as a person; this is an important factor for development of mature engineers. There are other benefits, but these illustrate the basic point.

What are the costs? First let me speak of the monetary costs. These need not be large. For example, in a relatively large department with a staff of 10, why cannot 1 of the 10 be a resident engineer? This method is employed by many other departments of the university. In this case, the only additional expense may be for travel and salary differential; hopefully, the company from which the resident engineer comes would pay for this. Another inexpensive approach is the exchange program suggested in Professor Brodsky's proposal.[1] In my own case, when I went to Iowa State University under the Intergovernmental Personnel Act of 1970, Professor Iverson went to Ames Research Center. In this case the University had very little additional expense.

From my own experience and from conversations with some university personnel, it would appear that there are no other costs, hidden or otherwise.

Government/Industry

The advantages to industry or government are more subtle; however, they may be more important. Evidence of a lack of sensitivity to this subtlety was voiced in the recent NASA/University Conference.[4] The benefits to government or industry are better prepared graduates and employees with a fresh outlook.

If a resident engineer program were continually in effect, the student would have 4 years of exposure to a practicing engineer. Properly carried out, this exposure should have tremendous influence on the quality and motivation of the graduate. In addition, the resident engineer could be a good recruiter of prospective employees for his home firm or agency, as he would have considerable contact with the students, as well as be in a position to locate good consultants from the staff for his firm or agency.

What about benefits of a renewed engineer? After many years at the same job, with only a couple of weeks vacation every year, a short period of time spent teaching can be a very refreshing experience. The engineer in residence should return to his home firm or agency with a broader and fresher outlook on his job and also about himself. This latter point can have even greater benefits.

The costs to industry or government are not as small as for the university, but the benefits of the entire program really are for the industry or government since the training of better engineers for their staffs is what the Resident Engineer Program is all about. At worst, the financial cost to industry or government will be that of a sabbatical program for their employees. The hardest costs to bear, however, will be the loss of a good employee for a short period of time, or permanently if he discovers that he enjoys teaching better than his engineering job. I feel that this issue of temporary loss of a good employee is a "strawman" issue that is always thrown up whenever programs of this sort are discussed. The long-term benefits surpass any short-term deficiencies. I guess I would conclude this point by noting that any company that is so critically dependent on one man for 6 to 9 months is probably not operating in such a manner that one would want to expose students to personnel from that staff. As for losing a good employee permanently, isn't there always a risk associated with any situation that has potential?

The Profession

Two benefits to the profession from the Resident Engineer Program come to mind. The first is rather obvious, namely, that of a better prepared and higher quality engineer who enters the profession. The second is probably as important, but not as obvious, and that is a professional awareness. Let me try to explain. First, the young engineer, who graduates after 4 years of college, has had relatively little exposure to an engineer. He has, however, been exposed during those 4 years to professors who teach engineering, but whose basic profession is engineering education, not engineering. The difference is subtle,[5] but important. If the staff had a resident engineer, the student would have some exposure to a person who considers himself or herself a professional engineer. I think this exposure would be beneficial to the student, and the result would be a deeper interest in the profession and in the professional organizations.

There are no direct costs to the profession itself; however, there are a couple of things that the cognizant professional society (AIAA) should consider as its responsibility. First, the AIAA may be in the best position to monitor the operation of such a program. This is what Professor Brodsky's program suggests.[1]

At one time I considered a second responsibility having to do with evaluating the effectiveness of such a program. Evaluating the effectiveness of educational programs is a popular thing to try to do these days. Those attempts at evaluation have contributed significantly to the increased cost of education. In a Resident Engineer Program where costs, although not high, can be a point of contension, maybe we should concentrate our resources on doing a good job. By this I mean, the careful selection and matching of participating engineer to resident engineer positions with a single candid evaluation of the resident engineer at the end of his university appointment for the sole purpose of improving the selection process. Hence, maybe we should "make a judgment in faith"[6] that the Resident Engineer idea is a good one and devote our resources to making sure it works.

The Individual

In this particular section, I am going to hit very briefly on the benefits and costs to the individual and then switch directly to the consideration of my own particular experiences at Iowa State University. The benefits of the Resident Engineer Program to the individual are as follows: First, he would develop a broader outlook and obtain a better understanding of the problems and possibilities of engineering education. Second, he would get a chance to "recalibrate" himself—that is, after years of working in the same environment, where one judges one's merits by those around him, there would be the opportunity to get into an environment with new people and situations and see whether the old evaluation survives. Third, the individual would get a chance to retrain or update himself in a particular area, if this is his desire or the company's desire. Finally, he may have the opportunity to work on some project of considerable personal interest, but one that has low priority in his company.

The costs are highly dependent on the individual situation. One factor is a lack of security, that is the individual in leaving his parent organization may wonder if he will be overlooked for promotions, bypassed for special projects, etc. The individual may also have to undergo some financial loss. During the relatively short time of the exchange (going to the university) one would seldom be totally reimbursed for all of his expenses. Then, there is that all-important factor of disruption of the family. In many cases, children are in school and it could disrupt their education. In addition, in the case of teenage children in junior high school, there is reluctance on the part of children to go away from their friends for even as much as 3 to 6 months. There are other factors, and the important ones I will cover in the next section when I deal with my own individual experience at Iowa State University.

A BRIEF CASE HISTORY OF A RESIDENT ENGINEER

As noted earlier, I spent two quarters (winter and spring of 1973-74 school year) as a visiting professor at Iowa State University in the Department of Aerospace Engineering. I went under the Intergovernmental Personnel Act of 1970 (5 U.S.C. 3371-3376) and Professor James Iverson of Iowa State University came to Ames Research Center. My schedule called for me to spend one-third of my time continuing my research work and two-thirds of my time teaching, presenting seminars, and interacting with the staff. During the winter quarter, I taught one undergraduate course in aerodynamics and during the spring quarter I continued teaching this course and added a graduate level course in parameter identification (the science of extracting system parameters from dynamic data). During these two quarters, I also presented five talks: three technical seminars, one talk to the student branch of AIAA, and one seminar on my views on engineering education to the University engineering staff. In addition, I participated in staff meetings, was involved in the discussion of several new courses and, toward the end of my stay, I wrote a rather lengthy critique of the aerospace engineering curriculum. The foregoing represents my basic schedule at Iowa State Univerisity, but really gives little information about the real benefits of such a program.

Whether or not the students that I was teaching will be any better or worse for their exposure to me is difficult to say. I can only give a couple of observations. First, at the end of my first quarter, I took the normal teachers' rating poll to assess my effectiveness as a teacher. The poll indicated that my classroom style left something to be desired, which was not surprising considering it was my first experience at teaching. However, there was an indication from the poll, as well as from the students, that I conveyed a sense of interest and excitement about the subject which they found refreshing. I think the ability to convey a sense of excitement reflects my experience in working in the subject area. I also spent a fair amount of time talking with the students to determine what had interested them in aerospace engineering and what their other special interests were. I think that through this dialogue (I managed to have at least one hour each quarter with each student), I did establish some kind of rapport with them. This has been borne out by the fact that several have contacted me since I returned to Ames Research Center. As to whether I had any impact on the staff itself, I have no idea. However, I might indicate that through contact with the staff I have discovered several areas of common interests that may lead to some future cooperative efforts.

From my own personal standpoint, I encountered all of the particular costs that I described earlier. In particular, I was concerned about the security of my job at NASA. This turned out to be totally unfounded; indeed, I returned to NASA with a promotion. The promotion was not necessarily the result of my going to Iowa State, but I do feel that the experience at Iowa State put me in a much better position to handle my new job. I had a chance to recalibrate myself, as I noted earlier, and I have a much better outlook on engineering education, both as to its potential and its particular limitations. I also experienced many frustrations. There were a lot of changes that I felt should be made in engineering education that I could not influence. I also found that there are many pressures on the staff that result in the particular direction in which engineering education has gone. For example, outside activities such as staff meetings and committee meetings of various sorts, student counciling, etc., put a heavy burden on the staff. I found that teaching two completely new classes represents an extremely heavy load if you really try to do a good job; anyone who does not think so does not really understand what teaching is all about.

SUMMARY

In summary, the staffs of Aerospace Engineering Departments are, in general, young and lacking in engineering experience other than teaching. Furthermore, a large fraction of the staff is tenured. Finally, aerospace engineering enrollment has declined drastically over the past 5 to 7 years. At present, the enrollment is nearly constant, but there is very little reason to expect any increase in the near future. When all of these facts are combined, there would appear to be few chances for the additions of new staff members for the next 10 to 15 years. This could lead to a serious decline in the quality of aerospace engineering graduates. Steps need to be taken to combat this rather serious situation.

A Resident Engineer Program is recommended as one of these steps. From a consideration of the various benefits and costs, it appears worth a try. From my own personal experience, I believe it can work. The survey indicated that 8 out of 23 Aerospace Engineering Departments already have some sort of program that utilizes industrial or government engineers to teach classes. From the survey it was not clear whether interaction is of the depth suggested for a Resident Engineer Program, but they do bring experienced engineers to campus.

REFERENCES AND FOOTNOTES

1. Brodsky, R. F.: A Proposed University/Industry/Government Cooperative Aero Educational Program. A paper presented at the NASA/University Conference on Aeronautics, October 23-24, 1974, at the University of Kansas.

2. Brooks, Harvey: Are Scientists Obsolete? Science, November 8, 1974, vol. 186, no. 4163, pp. 501-508.

3. DeBra, Daniel B.: Education. Aeronautics and Astronautics, March 1975, vol. 13, no. 3. pp. 30-31.

4. Marchman, James F. III: Save the (A.E.) People. Aeronautics and Astronautics, December 1974, vol. 12, no. 12, pp. 18-20.

5. Thomas, J. L.: Can We Teach Responsibility? Engineering Education, April 1975, vol. 65, no. 7, pp. 772.

6. Richard R. Heppe, of Lockheed-California Co. used this phrase during the AIAA/ASEE Education Panel of the 13th AIAA Aerospace Sciences Meeting (Jan 20-22, 1975) when he was discussing the point of determining the effectiveness of the Resident Engineer Program.

APPENDIX

A SURVEY OF AEROSPACE ENGINEERING DEPARTMENTS

A survey was made to determine the age and experience distribution of Aerospace Engineering Department staffs. A survey form was sent to all university Engineering Departments having "Aerospace" in their title—about 55 altogether. Replies were received from 23 departments. Those returning the survey form are listed in table 1. A compilation of results from 21 of those are listed on the survey form in table 2. This survey leaves much to be desired. Results were not always consistent from any one department and, as I discovered when I started to analyze the data, some of the questions are ambiguous. For example, I did not make it clear as to what extent I wanted consulting to be considered as work experience. In spite of these drawbacks, I believe that the data are useful. The age, experience, and tenure are indicative of the overall problems that face Aerospace Engineering Departments.

The age and experience distributions obtained from the survey are shown in figures 1 and 2. A recent set of enrollment statistics,[3] shown in figure 3, are based on Engineering Joint Council Statistics through 1973 and an AIAA survey for 1974. The survey shows that the age, experience, and tenure conditions that I had observed at Iowa State University during my recent stay there as a visiting professor are true of Aerospace Departments in general.

Normalized age and experience density distribution are shown in figures 4 and 5. The density for each age group was obtained by dividing by the respective span of that age group. When the span of the age group was undefined as in the cases <30, >60, and >10 a span of 5 years was used. Shown in this manner, data from one age group can be compared directly with data from another age group. This is not as readily done with the bargraphs of figs. 1 and 2. In the age distribution, we see a large number of relatively young staff members, with the exception of very young (less than 30 years). This exception probably reflects the decline in enrollment statistics that has been going on for the last 5 years and hence less hiring of new faculty. If this decline persists for another 10 years, the staff age distribution will become skewed to the older end.

The normalized experience distribution (fig. 5) shows a very inexperienced staff, which can only become less experienced with time unless precaution is used in hiring.

TABLE 1

UNIVERSITIES RETURNING SURVEY FORMS

Auburn University
Auburn, Alabama

California Institute of Technology
Pasadena, California

University of Florida
Gainesville, Florida

Georgia Institute of Technology
Atlanta, Georgia

University of Illinois, Champaign
Urbana, Illinois

Iowa State University
Ames, Iowa

University of Kansas
Lawrence, Kansas

Louisana State University
Baton Rouge, Louisiana

University of Maryland
College Park, Maryland

Mississippi State University
Mississippi State, Mississippi

University of Missouri, Rolla
Rolla, Missouri

North Carolina State University
Raleigh, North Carolina

University of Notre Dame
Notre Dame, Indiana

University of Oklahoma
Norman, Oklahoma

Rensselaer Polytechnique Institute
Troy, New York

Rutgers University
New Brunswick, New Jersey

University of Tennessee, Knoxville
Knoxville, Tennessee

University of Tennessee Space
  Institute
Tullahoma, Tennessee

University of Texas at Arlington
Arlington, Texas

University of Texas at Austin
Austin, Texas

U.S. Air Force Academy
USAF Academy, Colorado

Virginia Polytechnique Institute
Blacksburg, Virginia

Wichita State University
Wichita, Kansas

TABLE 2

SURVEY FORM AND PRELIMINARY SUMMARY OF RESULTS
(21 Departments)

1.	Total number of full-time staff	293
2.	Total number of full-time equivalent staff (teaching only)	231
3.	Total number of tenured staff	220
4.	Age breakdown (full-time staff) less than 30 years old	14
	between 30 - 40	114
	between 40 - 50	83
	between 50 - 60	61
	older than 60	13
5.	Experience breakdown (full-time staff)	
	A. Total number with industry-government experience, including summers	
	less than 1 year experience	34
	between 1 and 3	75
	between 3 and 5	48
	between 5 and 10	61
	greater than 10	53
	B. Number with industry-government experience not counting summer employment	
	less than 3 years experience	104
	between 3 and 5	49
	between 5 and 10	52
	greater than 10	51

TABLE 2 (Concluded)

C. Number of faculty with industry-government experience (not including summer jobs) within the

last 5 years	103
5 to 10 years	73
10 to 15 years	44
longer than 15 years ago	19

D. Number of faculty with industry-government experience (including summers) within the last

2 years	111
2 - 5 years	48
5 - 10 years	59
10 - 15 years	23
longer than 15 years ago	14

Name of School ____________________

Department Name ____________________

Closest Aerospace Industry ____________________

Number of 1974 Aerospace Engineering Graduates: 353 Batcheloric Degrees
70 Advanced Degrees

Do you presently have arrangements with industry or government personnel to teach on a part-time basis? Full-time, short-term basis?

No Arrangements - 15 Arrangements - 8

Would an ongoing Resident Engineer (industry or government engineer on short term, one quarter to a year's time, appointment to your staff) program be of benefit to your department?

Yes - 22 No - 1

Figure Captions

Fig. 1. Age Distribution (21 Departments).

Fig. 2. Experience Distribution (21 Departments).

(a) Coarse Distribution

Fig. 2. Experience Distribution (21 Departments).

(b) Detailed Distribution Below 5 Years

Fig. 3. Undergraduated Enrollment Trends, Based On EJC Data Through 1973 and AIAA Survey For 1974.

Fig. 4. Normalized Age Density Distribution.

Fig. 5. Normalized Experience Density Distribution.

AGE DISTRIBUTION
(21 DEPARTMENTS)

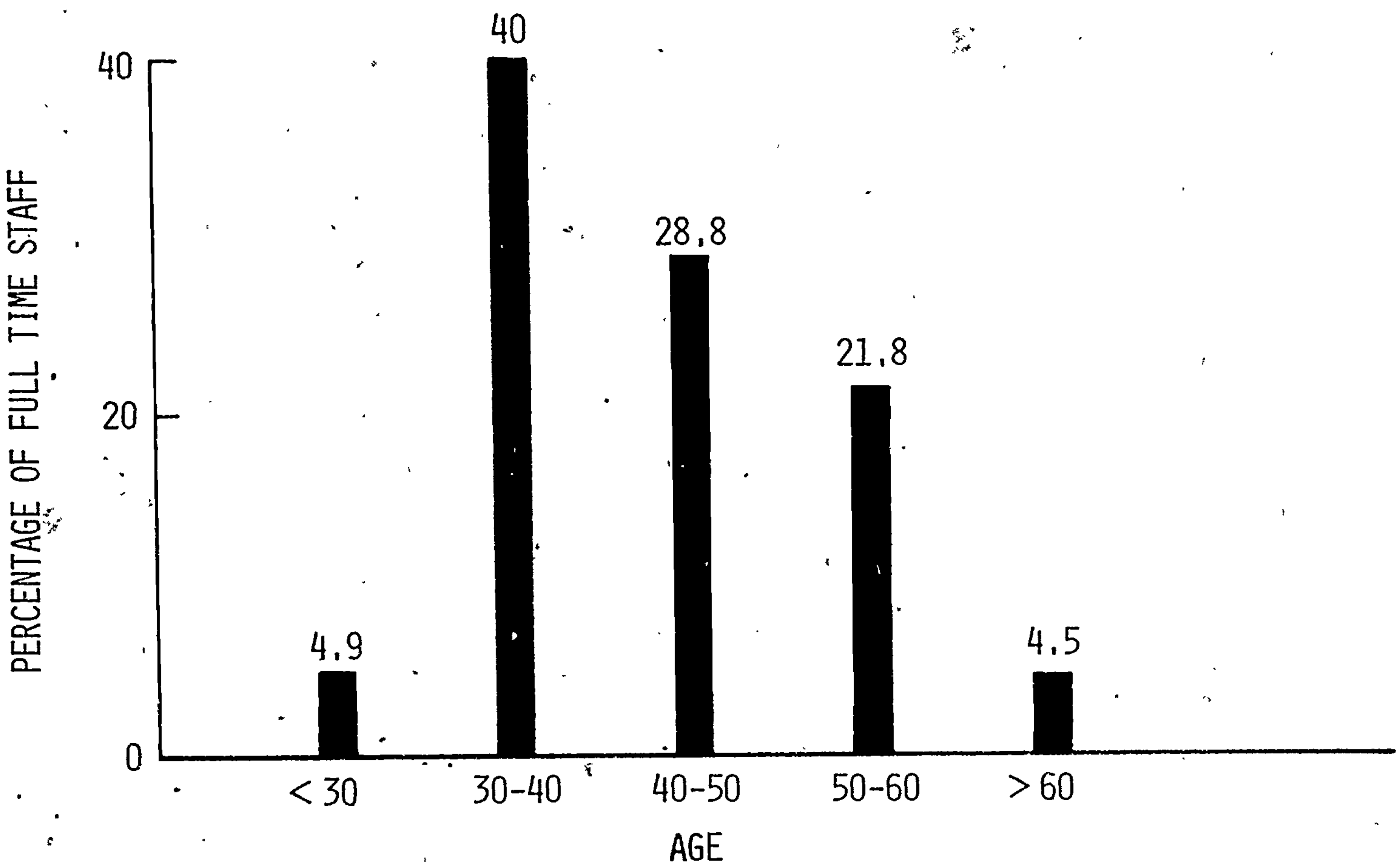

Fig. 1

COARSE EXPERIENCE DISTRIBUTION
(21 DEPARTMENTS)

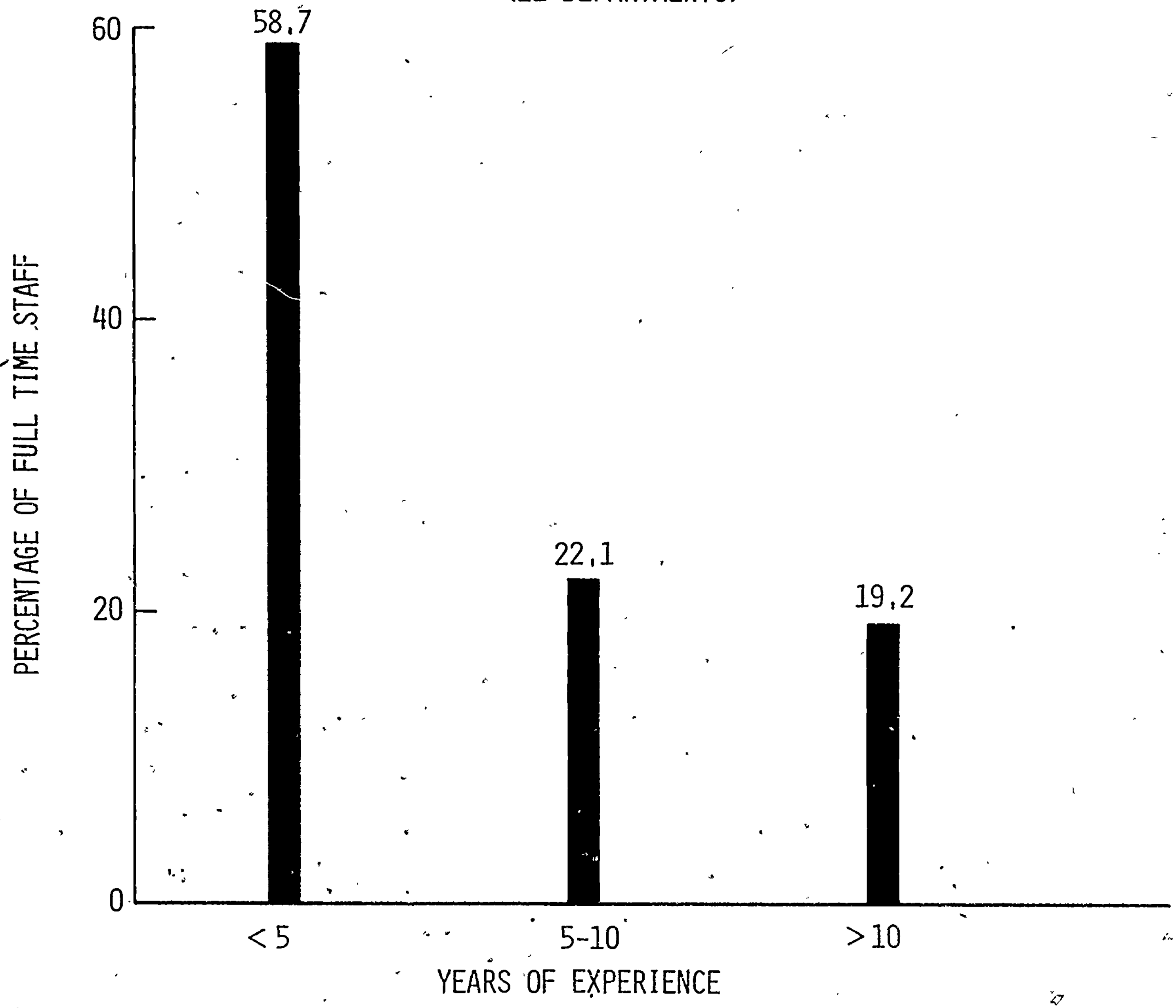

Fig. 2a

EXPERIENCE DISTRIBUTION - DETAILED BELOW 5 YEARS
(21 DEPARTMENTS)

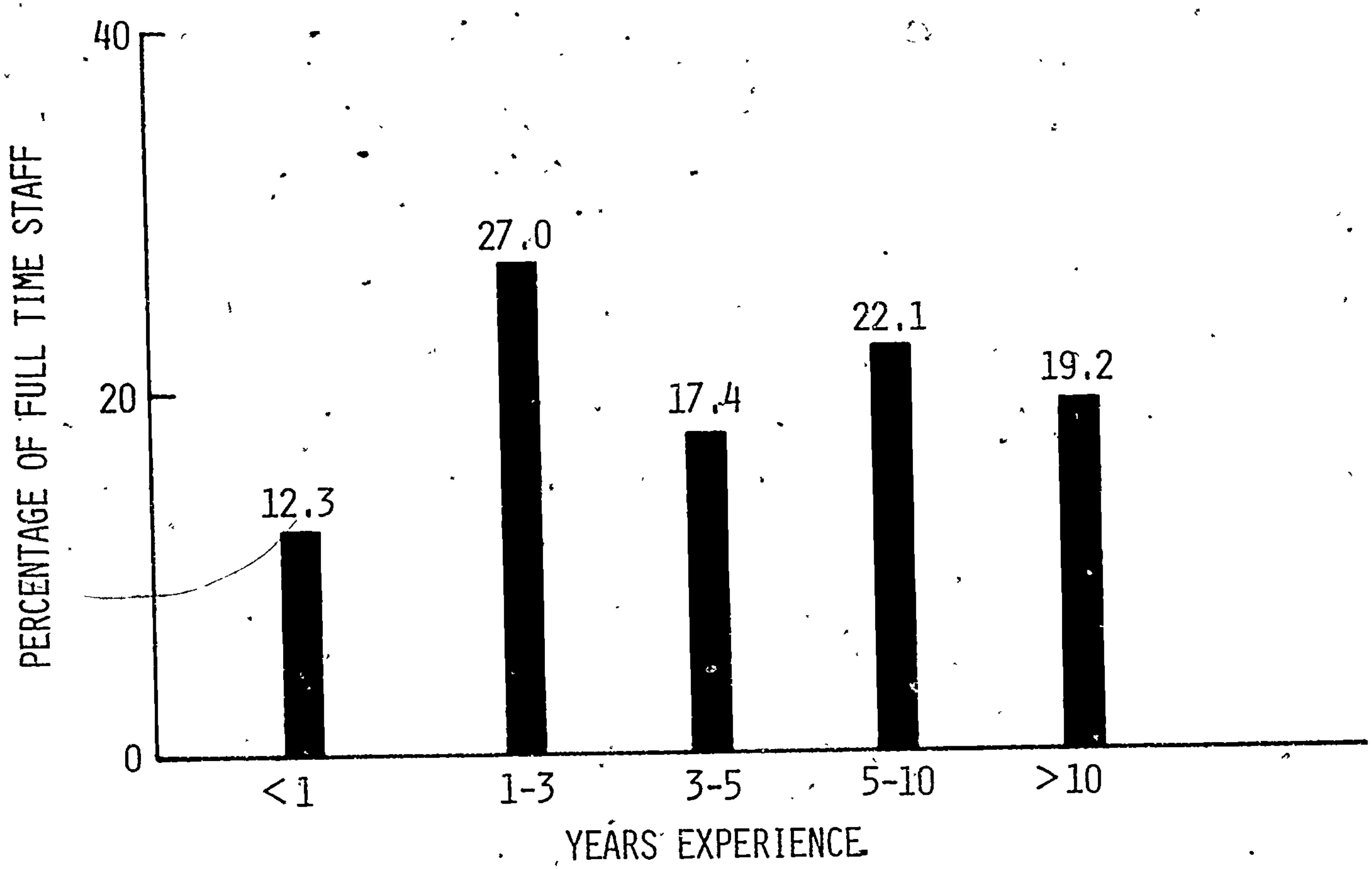

Fig. 2b

UNDERGRADUATE ENROLLMENT TRENDS

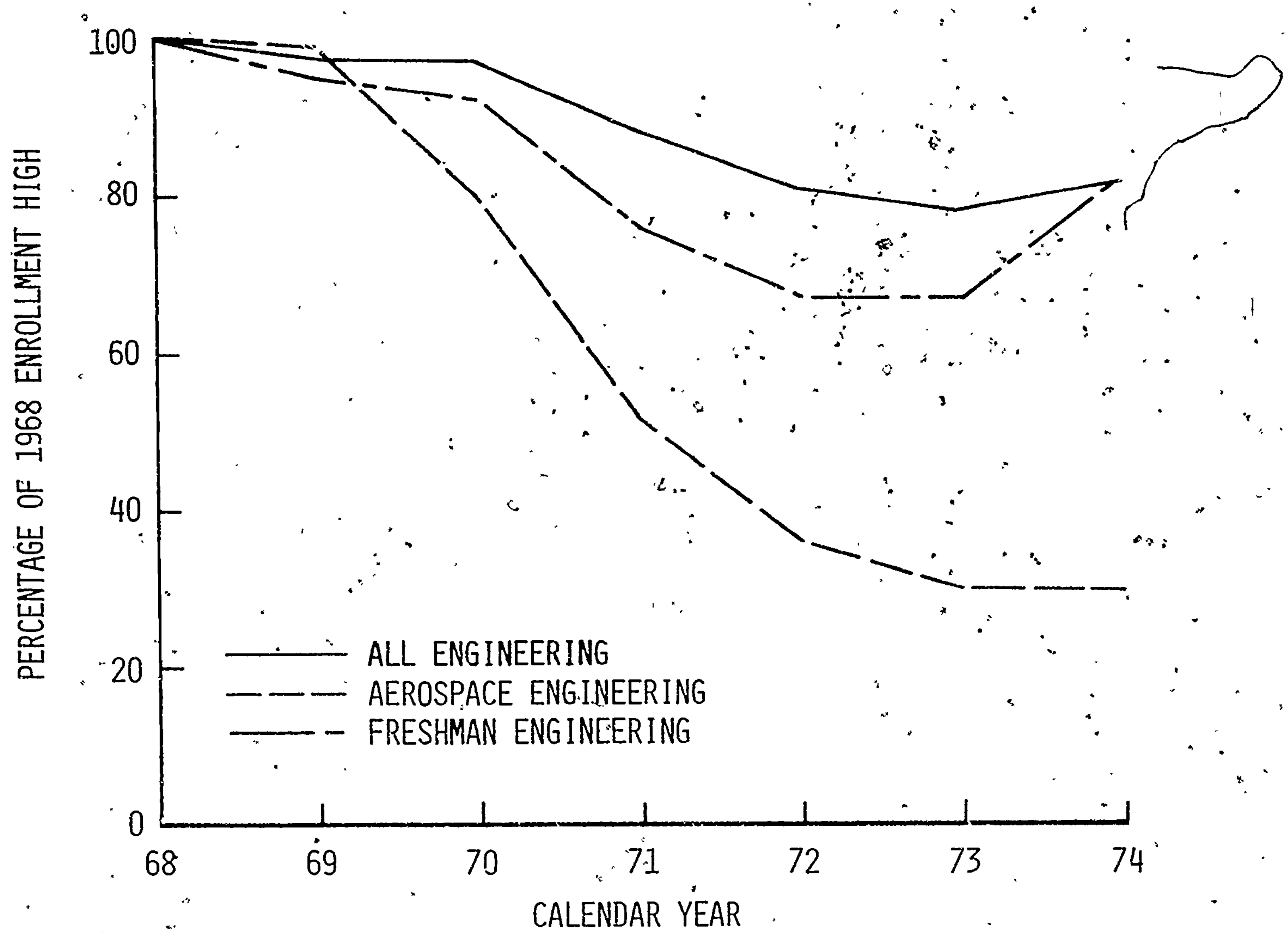

Fig. 3

NORMALIZED AGE DENSITY DISTRIBUTION

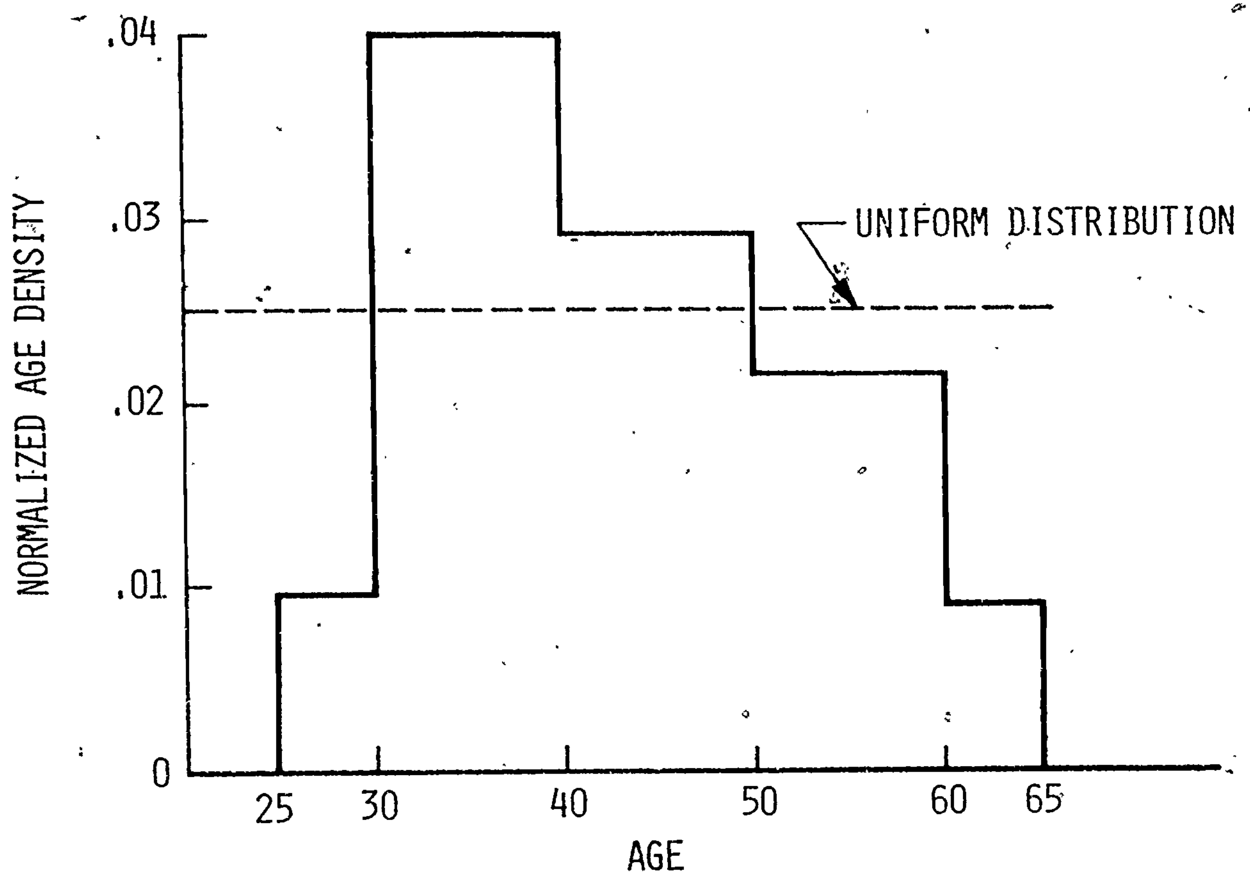

Fig. 4

NORMALIZED EXPERIENCE DENSITY DISTRIBUTION

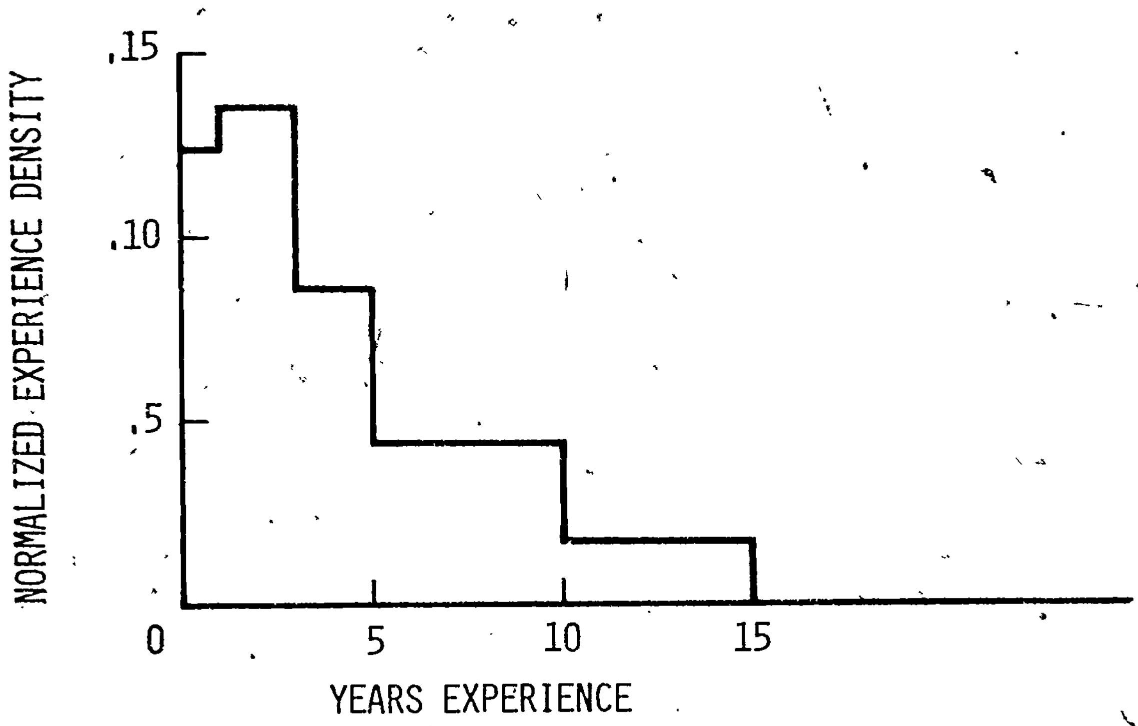

Fig. 5