Title
Human-Initiated Failures and Malfunction Reporting



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# Human-Initiated Failures and Malfunction Reporting*

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*Summary*—Two studies were conducted to determine the extent and nature of human-initiated failures in missile systems. The first study[1] compared malfunction data obtained from written reports with data gathered from interviews with line and supervisory personnel. The study revealed large discrepancies in emphasis and extent of data between the reporting methods. Written reports generally were concerned only with failed equipment; interview data with operational, near, or possible malfunctions. The results indicated that personnel tend to report human-initiated malfunctions as equipment malfunctions, thus avoiding incrimination of themselves or their fellow workers. The second study[2] attempted to establish the extent of unreported human-initiated malfunctions. Examination indicated that in individual missile systems, human-initiated malfunctions comprised from 20 to 53 per cent of all system malfunctions. It was also revealed that in two missile systems, human-initiated holds accounted for 16 and 23 per cent of total holds, respectively. Human-initiated malfunction data were further classified into the kinds of operations in which these malfunctions occurred. The percentages in these classifications are indicated in this report. Malfunction-reporting practices were reviewed to establish their effectiveness in revealing these data and to indicate the way in which the reporting schemes serve, or fail to serve, the problem of indicating human-initiated malfunction in order that corrective action may be taken.

## Introduction

It has been suspected that the human being is a major contributor to system failure; many attempts have been made to reduce this failure by removing the cause (*i.e.*, through automation). At the same time, however, the human in many ways contributes to the reliability, as well as the unreliability, of the system. Further, there is good evidence that the machine replacement of the human is fraught with many problems. Consequently, the problem is not answered by the sweeping generalization of "get the human out of the system." Rather, it becomes necessary to know how much, and in what manner, the human contributes to system failure.

There is a realization that the human does tend, where he can, to cover the mistakes that he or his fellow worker makes. "Foolproof" reporting systems have appeared which purport to reveal the true situation, only to find that the human still manages to avoid reporting his coworker or himself. As a result, the suspicion of human-initiated malfunction remains only a suspicion except in the rare cases where a peculiar incident has disclosed the human as an instigator of a particular malfunction.

During the course of the studies reported here, it was found that in every missile system examined, at least one disastrous failure could be traced to human-initiated malfunction. Since these were disastrous failures, a great deal of effort was put into an investigation to determine their cause. Of course, such extensive procedures as this for tracing the cause of each and every malfunction are certainly precluded on the basis of time and cost. However, without such investigation, and with a reporting system within which there is much latitude for ascribing cause, human initiation of malfunction is not normally revealed.

## Information as a Function of Reporting Method[3]

### *Method of Approach*

An examination was made of all written reports (Missile Status Reports, Inspection Reports, Field Performance Reports, etc.) used in malfunction reporting on one missile system. Those incidents which clearly indicated that a person was directly responsible for the actual malfunction were recorded, analyzed, and grouped into areas. A similar procedure was followed for information obtained through interviews.

Interviews were relatively unstructured. The following statements and questions were presented to more than 50 line and supervisory personnel:

1) We are interested in identifying types of errors that relatively inexperienced service personnel might make when a fully operational missile system is turned over to them. We would like you, as someone who has been working with this missile for some time, to tell us what you believe might cause service personnel the greatest difficulty. (In other words, what is there about your job that is most likely to lead to human error that may be responsible for an abort or a missile malfunction?)

2) Incidents are quite useful for identifying likely sources of errors that individuals might make in preparing this missile for a successful operation. I wonder if you have witnessed or heard of any such incidents that might have led to a missile malfunction if they had not been corrected in time?

3) We are interested in identifying possible trouble spots in getting this missile ready for launching. Would you tell me what there is about your job that is most troublesome or difficult?

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[1] M. Rappaport and J. Cooper, "A Preliminary Study of the Human Factors Problems Associated with the Operation of the (*Name is Confidential*) Missile System," SRI Project No. ID-274; November, 1957.

[2] A. Shapero, *et al.*, "Human Engineering Testing and Malfunction Data Collection in Weapon Test Programs," Wright Air Dev. Div., Tech. Rept. No. WADD-TR-60-36; February, 1960.

[3] The information contained in this section is based on findings reported by Rappaport and Cooper.[1]

4) Do you have any communication difficulties that occur during preparation of the missile for launching (access to information you need, communication with others, etc.)?

A depth interviewing technique was employed; the second question was asked when it was felt that the interviewer had drained the subject on the first question, and so forth. In almost every case, good rapport was easily established and the subjects became eager to disclose whatever information they could recall. Notes were kept and immediately transcribed after each day's interviewing.

*Findings*

It was found that those malfunctions which indicated human initiation were reported much more frequently in interviews than in written reports. It is impossible to state the extent of overlap other than to say it was small. The nature of the techniques employed in collecting these data make the data incomparable from one mode of reporting to the other. It must be understood that the importance which the human ascribes to a particular malfunction, mishap, or possible mishap will influence the results. For example, a particular mishap could be sufficiently spectacular so that all respondents would report it, thus producing 50 verbal reports as opposed to one written report. This would bias the amount of overlap. It would also be possible to have written "squawks" which would fail to be reported in interviews. However, interviews often did reveal unreported malfunctions that had occurred, as well as malfunctions that had almost occurred or had been covered up.

The malfunction reports were classified in the following categories:

- Control Display Factors
- Improper Assembly
- Accessibility
- Logistics
- Communication
- Forgotten or Incomplete Operations
- Working Conditions
- Safety
- Housekeeping
- Workmanship

The number of written reports and the number of verbal reports in each category were compared. Some indication of the discrepancy-of-reporting results is shown in Fig. 1. The results in the two categories shown in Fig. 1 are representative of the results obtained in all categories. These discrepancies are apparently not significant for the $N$ in question.

If the interview data are examined, it can be seen that, among other things, Item 1, "too many screws," could well lead to inadequate inspection; Item 3, "workstands in way," to safety hazards or part damage; Item 6, "equipment in wrong areas," to time losses or use of dangerous jury-rigs; Item 8, "special tools needed," to damage through use of wrong tools or time losses in locating tools. Certainly there are many possible corrections needed that would probably not be reported under written-reporting methods until an actual, resultant mishap did occur.

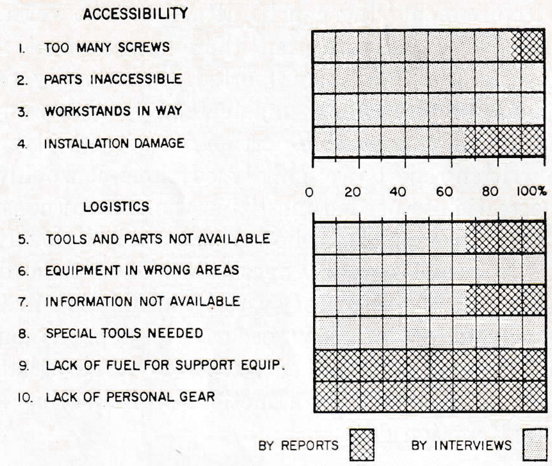


Fig. 1—Example of areas of discrepancy between verbal and interview reporting.

Alluisi[4] reclassified these data in terms of probable cause, namely, faulty design, faulty construction, and faulty operations (Table I). As indicated in this table, written reports reveal mainly those failures to which a

TABLE I
CRITICAL INCIDENTS DIRECTLY RESPONSIBLE FOR ACTUAL OR POTENTIAL HUMAN-INITIATED MALFUNCTIONS IN A MISSILE SYSTEM

| Type of Critical Incident | Frequency of Incidents (per cent) As Noted in Reports | As Given in Interviews |
|---|---|---|
| Incidents Attributable to Faulty Design | (1.9) | (21.7) |
| Faulty console design | 1.0 | 6.3 |
| Ground equipment "cumbersome" | 0 | 5.6 |
| Parts not accessible or special tools required | 0.6 | 6.0 |
| Safety hazards | 0.3 | 3.8 |
| Incidents Attributable to Faulty Construction | (80.8) | (29.0) |
| Wiring errors | 27.7 | 1.7 |
| Parts errors (including fasteners, connectors, lugs, etc.) | 49.3 | 23.4 |
| Other construction errors | 3.8 | 3.9 |
| Incidents Attributable to Faulty Operations | (17.3) | (49.3) |
| Faulty communications | 4.4 | 17.8 |
| Poor work place arrangements | 3.8 | 18.2 |
| Use of support equipment damages missile | 2.5 | 2.8 |
| Specific switching operations in error | 5.3 | 2.4 |
| Incidents based on "time pressures" | 0. | 5.6 |
| Other incidents (including faulty logistics) | 1.3 | 2.5 |
| Sum of Percentages | 100.0 | 100.0 |
| Total Number of Incidents | 318 | 286 |

[4] E. Alluisi, "Reliability and Human Malfunctions," Unpublished paper, Stanford Res. Inst., Menlo Park, Calif.; 1958.

"failed equipment" tag can be attached. The verbal reports, however, indicate that there are a great many failed operations that go unreported. Additionally, design deficiencies are practically undetected by written reports, yet they occupy a sizeable portion of the verbal reports. If the written reports were analyzed alone, it would seem that correction is needed mostly in the area of construction. The interview data, however, would obviously demand a first look at faulty operations. Thus, the order of alleviating the problems of system malfunction in terms of the frequency of their occurrence depends on the method of reporting. It seems necessary, then, that any reporting scheme include a method of indicating all of these malfunction data.

## The Extent and Nature of Human-Initiated Malfunctions[5]

### *Method of Approach*

A survey was made of malfunction-data collection efforts in nine missile weapon systems. Malfunction reports, in whatever form they occurred, were examined and an analysis was made of the reports to identify the human-initiated malfunctions. A malfunction was identified as human-initiated when the human component could be clearly identified as the causative agent in the *immediate* train of events leading to the failure. Specific identification was made on the basis of coding or narrative description such as "human error," "reversed leads," "incorrect part installed," "part omitted," "incorrect torque," etc. Those malfunctions whose classification was doubtful were re-examined, as far as possible, for supporting evidence of correct classification. Unless such evidence could be found, they were classified as equipment-initiated malfunctions. Thus, the extent of human-initiated malfunctions reported tends to be a conservative estimate.

Only those malfunctions that occurred from the time of receipt of the missile at the base to the time of launching were considered. As a consequence of this limitation, it was necessary to discard 35 per cent of the reports for one missile system. Those malfunction reports which had been determined as human-initiated were then sorted for each missile system in terms of the kinds of operations that were performed incorrectly. The classification of operations used was based on an investigation of the way in which missile count-down operations were described. Malfunction-reporting procedures used in these systems were then reviewed to determine the similarity and differences between procedures and the information that these procedures would be likely to reveal.

### *Findings*

The reports considered in this study were 3829 malfunction reports from seven missile systems and 419 unscheduled-hold reports from two missile systems. The number of reports ranged from 130 on one system to 1391 reports on another. Of the 3829 malfunction reports, 39 per cent were classified as reports of human-initiated malfunctions; of the 419 unscheduled holds, 20 per cent were classified as human-initiated. (See Fig. 2.) Further examination of the unscheduled holds indicated that the human-initiated holds were responsible for 22 per cent of the unscheduled-hold time.

The human-initiated malfunctions ranged from 20 to 53 per cent for individual missile systems. Fig. 3 shows a system-by-system breakdown for these data. Included in this figure are independent estimates made by personnel from two missile systems which were not examined in the course of the study (systems J and K). Both of these estimates were given as 35 per cent, about mid-point of the range. There was no indication that the percentage of human-initiated malfunctions was in any way dependent

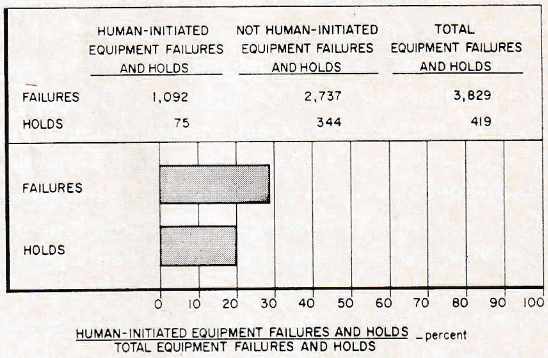


Fig. 2—Human-initiated equipment failures and unscheduled holds as a per cent of total equipment failures and unscheduled holds during missible launch and prelaunch activities for seven missile systems.

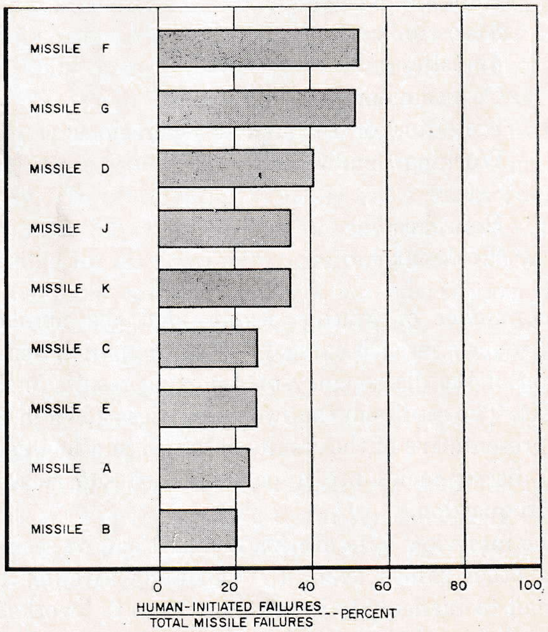


Fig. 3—Human-initiated equipment failures as a per cent of total equipment failures during missile launch and prelaunch activities.

[5] The findings in this section are based on the report by Shapero, *et al.*[2]

on the number of reports examined for individual systems.

While no precise assessment can be made of the extent of the human contribution to system malfunction, it is safe to say that it is sufficiently large that it must be reckoned with and is probably the *largest single identifiable portion* of cause of system malfunction, 1/5 to 1/2 of all malfunctions.

Unscheduled-hold data were available for only two systems. The data examined revealed that human-initiated holds were responsible for 23 per cent of all unscheduled holds in one system and 16 per cent in the other system.

The classification of operations shown in Fig. 4 is based on a study of count-down procedures for six missile systems. It was found that 23 operational verbs and their synonyms covered the procedures which were called out in missile count-downs; regardless of company affiliation, missileers generally used the same terms in describing the operations. Of the human-initiated malfunctions identified, however, almost all of the malfunctions reported fell into four categories only: assemble, position, move, and adjust.[6] Interviews with field personnel have revealed that malfunctions occur as a result of the performance of many operations such as communicating, inspecting, monitoring, etc. In addition, there are good indications that many malfunctions are an indirect or secondary result of procedural failures. Sometimes these procedural failures do not result in actual failure, but they do degrade system performance. For example, it is possible for an operator to start an operation at the wrong time either through error or accident. If this is caught quickly enough, no apparent harm is done, although an overload might result that would show up later in failed or degraded equipment. Furthermore, performance of the equipment might be degraded and still be within tolerance.

There is evidence that human-initiated malfunctions cause critical failures that sometimes go unreported. For example, in one missile system it was found that a technician misconnected two adjacent identical receptacles. Despite the fact that this resulted in a "scrubbed launch" and a damaged missile, reports concerning this major failure revealed no indication of this chain of events. Had not the particular search been instigated, it is quite possible that those concerned would not have had the information to correct this potentially critical malfunction-producing situation.

Table II shows the tabulation of failure data for two systems that used the Ballistic Missile Division Failure and Condition Code List. Despite the fact that an analysis indicated 322 human-initiated malfunctions in one system and 193 in the other, reporting personnel classified

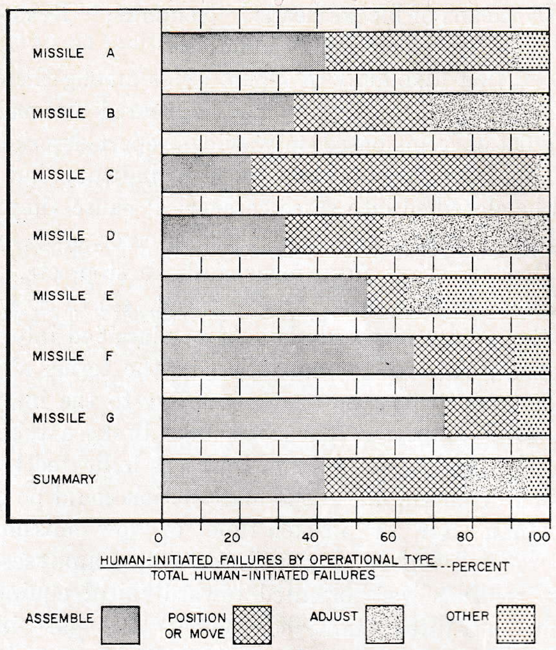


Fig. 4—Human-initiated equipment failures during missile launch and prelaunch activities, classified by operation, for seven missile systems.

TABLE II
COMPARISON OF MALFUNCTIONS LABELED AS HUMAN ERROR VS MALFUNCTIONS ANALYZED AS HUMAN-INITIATED

| Missile System | Number of Malfunctions Reported | Malfunctions Labeled as Human-Error On Reports | Malfunctions Analyzed as Human-Initiated By SRI |
|---|---|---|---|
| A | 1,291 | 3 | 322 |
| B | 977 | 0 | 193 |

as human error only three incidents in one system and none in the other.

## Analysis of Present Reporting Forms

The magnitude and criticalness of human-initiated malfunctions demand that reporting forms be such as to reveal the extent and nature of these malfunctions. Consequently, one phase of the study[2] was directed toward an analysis of present reporting forms.

### *Findings*

The failure-reporting methods of six contractors were reviewed. Of these contractors, three used the Air Force Ballistic Missile Code (Exhibit WDT 57-3) as their failure-reporting method; one contractor used his own code in addition. The other three contractors used their own reporting codes exclusively. The Ballistic Missile Code includes one item labeled "Human Error." Of the remaining codes examined, only one included a corresponding term, "Human Factors." All of the reporting systems reviewed provided a space for narrative descrip-

[6] In the classification scheme, missileers seem to identify "move" with towing, carrying, etc., while "position" seems to indicate keying-in, putting into a specified position, etc. However, it was impossible, on the basis of reports examined, to distinguish between "position" and "move."

tion, by means of blocks headed "Remarks," "Reason for Report," or "Description of Trouble."

No explicit taxonomy of report items among the codes could be found. Rather, the codes appeared to consist of a long list of items based on previous report descriptions. An analysis of these terms seemed to indicate that they could be classified into three categories: cause (improper handling, installed improperly, human-error, etc.), symptom (low emission, poor focus, fails to stop, etc.), and condition (broken base, rusty, fused, etc.). However, even though the terms used could be classified into these categories, the loose organization of the terms allowed for the selection of the term according to the intent or needs of the reporter. Thus, if a man broke a tube and thereby caused a malfunction that was indicated by low emission of an amplifier, the malfunction could be coded as "human error" or "broken tube" or "low emission."

All reports, reporting procedures, report analyses, and report routines were oriented toward failed equipment. System, subsystem, unit, component, and part identification were heavily emphasized on all forms. In many instances the failure report had to be accompanied by the failed piece of equipment. Only one system examined provided for the transmission of human-initiated malfunction data to human engineering personnel. Little evidence was found of any attempt to alert the reporter or analyst to the human contribution to malfunction.

While the reporting systems examined varied somewhat from one to the other, all provided, in greater or lesser degree, the following information:[8]

1) Identification of the failed part. This was usually extensive and might require as many as twelve entries including part name, number, serial number, as well as the same data for the next two higher levels of assembly.
2) Identification of replacement parts.
3) Operating and calendar-life data on the failed part.
4) Date and general activity area when failure was discovered—*i.e.*, "Manufacturing," "Test," "Operations."
5) Failure symptoms—narrative or multiple checkoff.
6) Cause of failure—narrative or multiple checkoff.
7) Corrective action taken.

## Discussion

The key points of the findings may be summarized as follows:

1) An appreciable amount of system malfunction may be ascribed to human initiation.

2) The extent of human-initiated malfunction is such that corrective action must be taken.

3) Corrective action cannot be taken until the true condition of malfunction and its cause are revealed.

4) Personnel tend not to report themselves or their co-workers, thus avoiding guilt implications.

5) Reporting systems as they are presently constituted not only do not encourage the accumulation of human-initiated malfunction data but also make it actually difficult to report these data.

6) Reporting systems must be so organized as to supply data on human-initiated malfunctions as well as equipment-initiated malfunctions.

Since present reporting schemes are all heavily equipment-oriented, it is important to examine the effect of this orientation on providing the data necessary for overcoming system malfunctions in whatever manner or degree they occur. The reporting of equipment failures provides a basis for: a) statistical treatment of these data for reliability consideration, b) component selection, and c) origination of individual corrective action.

The information on part life, activity area, and corrective action that is given to the analyst serves to define the context in which the malfunction occurred and to provide a basis for examining and validating the cause of malfunction. These data, however, do not provide explicit and organized information about the human's contribution in the events leading to a malfunction or any clue as to his performance within the casual chain that led to the malfunction. Thus, the analyst can make an intelligent decision as to what action to take only if the equipment malfunction is equipment-caused. If, on the other hand, there is human initiation in the chain of events leading to the failure, it is quite likely that the analyst will not have a true picture of the system condition. When the human component is the primary or major contributor to the system malfunction, and information about this contribution is not at hand, the analyst can easily arrive at an erroneous conclusion and may possibly suggest a costly and useless corrective action.

The human does not fail in the same sense that equipment fails. He fails to perform a specific task at a specific time. In most cases, he will *accurately* perform the same failed task on repeat. The task must then be examined to determine whether the performance is a task variable or a vagary of individual performance. Since it has been established that the human tends not to report information on the vagaries of individual performance, and since this information is necessary, it must be obtained through other means or channels. All the methods for indicating human-performance data used by the contractors seemed inadequate for revealing data on human-centered malfunctions.

The activity-area breakdowns used in the malfunction-reporting schemes were too gross to allow identification of specific human performances involved in a malfunction and, therefore, were not conducive to the restaging of the conditions under which the malfunctions occurred. Activity-area breakdowns were usually confined to terms such as "Inspection," "Test," "Manufacturing," etc. Code categories were ambiguous, using symptom, cause, and nature interchangeably. They were not a sufficiently clear identification of whether or not the malfunction was hu-

[7] Shapiro, *op. cit.*, p. 14.
[8] *Ibid.*, p. 35.

man-initiated. The use of narrative description also proved unsatisfactory as a means of identifying human-initiated malfunctions. Personnel indicated that it was difficult to obtain narrative statements from operating personnel. In addition, most report forms allowed so little space in the description block that the amount of information that could be indicated was seriously limited.

No reporting method examined identified the operation or environment during which the failure was recognized as a failure. It is, however, precisely this operational information that is needed for the determination of action on human-initiated malfunctions. The identification of the operation in which the malfunction occurs allows the analyst to:

1) Make a logical determination of probable cause.

2) Take proper corrective steps if the malfunction is determined to be human-initiated.

3) Determine causes or corrections experimentally, if necessary.

4) Look at procedures, sequences, etc. within operations as a means of corrective action.

5) Allow the reporter a method for placing blame on an impersonal operation rather than reporting a personal incrimination of himself or his fellow worker.

In order, then, for the analyst to have a true picture of system condition, the reporting procedures must provide data on factors of human-initiated as well as equipment-initiated malfunctions. To do this, the data concerning the individual malfunction must:[9]

1) Identify the failed item.

2) Describe the symptoms by which the failure was identified.

3) Provide a means for describing the dynamic interactions of the failed item with other parts of the system and with the system's environment.

4) Provide information concerning the past experience of the individual failed item that might be pertinent to the failure event.

5) Provide information concerning random intrusions into the system that might be pertinent to the failure event.

The collection of operational information would be a relatively simple extension of present reporting methods. The positive effects of this have been shown. Further, it would serve to reduce the requirements for interviews, observations, and special studies that are presently carried on to make determinations on human performance. It would greatly enhance system reliability, and would serve to identify and provide a means through which human contribution to system malfunction would be, if not eliminated, greatly reduced.

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J. W. Altman

In 1951 he joined the American Institute for Research, Pittsburgh, Pa., where he is presently an Executive Scientist and the Director of the Engineering Psychology Program. Along with a general responsibility for a number of research tasks and projects concerned with the support of a variety of systems and human factors development techniques, Dr. Altman has recently directed a study to evaluate psychological and sociological factors as they relate to individual adjustment in a fallout shelter.

Dr. Altman holds a membership in the American Psychological Association and the Society of Engineering Psychologists.

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Edward M. Bennett was born in New York, N. Y., on September 18, 1924. He received the B.S.E.E. degree from the Massachusetts Institute of Technology Cambridge, in 1947; and the M.S.E.E. degree, the M.S. degree in social psychology, and the Ph.D. degree in personality psychology in 1949, 1950 and 1951, respectively, all from Purdue University, Lafayette, Ind.

E. M. Bennett

From 1947 to 1950 he was a member of the teaching staff of the Department of Electrical Engineering at Purdue University. From 1951 to 1957, he was first an Instructor and then an Assistant Professor of Psychology at Tufts University, Medford, Mass. During this period, he also served as a consultant to a number of major industrial corporations and military installations. As Associate Director of the Bio-Mechanics Laboratory at Tufts from 1957 to 1959, he was involved in research on the problems of man in space. Since 1959 he has been with The MITRE Corporation, Bedford, Mass., as head of the System Reliability Sub-Department of the Human Factors Department.

Dr. Bennett is a member of Sigma Xi, Eta Kappa Nu, Psi Chi, the American Psychological Association, the American Sociological Association, the American Association of University Professors, the American Association for the Advancement of Science, and the Society for the Psychological Study of Social Issues.

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Irving Budnoff was born in New York, N. Y. on February 10, 1924. He received the B.S. degree in psychology from New York University in 1944, and at present is a candidate for the Ph.D. degree in industrial psychology at the University of Southern California, Los Angeles.

I. Budnoff

From 1944 to 1945, he was employed as a Statistical Research Psychologist by the Klein Institute of Sales Aptitude Testing, New York, N. Y. In 1945 he was appointed a Teaching Fellow in Psychology at New York University. From 1946 to 1947, he served in the Army as a Clinical Psychologist. After several years as Vocational Counselor, industrial psychologist, and as Personnel Director at Channel Master, Ellenville, N. Y., he moved to Los Angeles, where, in 1960, he joined the University of Southern California's Electronics Personnel Research Group as Research Assistant.

Mr. Budnoff is a member of the American Psychological Association, Psi Chi, and Beta Lambda Sigma.

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Joel Cooper (A '53) was born in Baltimore, Md., on January 23, 1914. He received the A.B. degree in Industrial Engineering, and the M.S. degree in Psychology, both from San Jose State College, San Jose, Calif., in 1957 and 1959, respectively.

J. Cooper

From 1954 to 1959, he was employed by Stanford Research Institute, Menlo Park, Calif., in the Control Systems Laboratory, Behavioral Sciences Program and the Systems Analysis Group, as an Engineering Psychologist. Since July 1959, he has been employed by the Human Engineering Analysis Branch of Northrop Corporation, Norair Division, Hawthorne, Calif., as a Senior Scientist.

Mr. Cooper is a member of A.R.S., Society for General Systems Research, Psi Chi, International Society for General Semantics, and the Human Factors Society.

John F. Corso was born in Oswego, N. Y., on December 1, 1919. He received the B.Ed. degree in 1942 from State University of New York, Oswego, N. Y. and the M.A. and Ph.D. degrees in experimental psychology from the State University of Iowa, Iowa City, in 1948 and 1950, respectively.

J. F. Corso

From 1950 to 1951, he served as Chief of the Sound and Vibration Section of the Psychology Branch, Army Medical Research Laboratory, Fort Knox, Ky. From 1951 to 1952, he was Chief of the Human Factors Office at the Rome Air Development Center, Griffiss Air Force Base, Rome N. Y. Since 1952, he has been on the Faculty of Pennsylvania State University, University Park, and holds the rank of Professor of Psychology. In addition, he is the Director of the Human Factors Research Program of the Department of Psychology and a Psychological Consultant to HRB-Singer, Inc., State College, Pa.

Mr. Corso is a member of APA, Sigma Xi, Acoustical Society of America, American Institute of Physics, AAAS, and AAUP.

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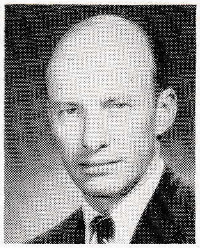
James W. Degan was born in Chicago, Ill., on March 2, 1921. He received the A.B. degree in 1942, and the Ph.D. degree in 1950, both in psychology from the University of Chicago, Chicago, Ill. During his graduate career, he was a research assistant and research fellow at the Psychometric Laboratory of the University of Chicago.



J. W. Degan

During World War II, he served as a Communications Officer in the European Theatre of Operations in the Infantry and the Signal Corps of the U. S. Army. From 1950 to 1951, he was a member of the faculty of the University of California at Los Angeles, holding joint appointments in the Psychology Department, the School of Business Administration, and the Institute of Industrial Relations. From 1951 to 1958, he was a member of the technical staff of Lincoln Laboratory of the Massachusetts Institute of Technology, Lexington, Mass., where he was associated with the Communications and the Digital Computer Divisions. Since 1958, he has been the head of the Human Factors Depart-