Research Note 80-41

IFV/CFV PERSONNEL SELECTION ANALYSIS

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This report describes the development and application of an analytic methodology to identify specific needs for "extranormal", or above average levels of, aptitudes, characteristics or behaviors for each IFV/CFV crew position. Tests for assessing those extranormal attributes were also identified. Other issues addressed were: the need for special personnel selection and management procedures; the proportions and sources of the personnel pool likely to be trainable or crosstrainable in each of the IFV/CFV crew positions; and implications for IFV/CFV MOS career structures.

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SUMMARY

This is the final report of an analysis to determine extranormal* selection requirements for crew members of the Infantry Fighting Vehicle (IFV) and Cavalry Fighting Vehicle (CFV). It was prepared by Dunlap and Associates, Inc., for the U.S. Army Research Institute for the Behavioral and Social Sciences under Modification P00004 to Contract No. DAHC 19-78-C-0016. Three earlier reports by Dunlap and Associates, Inc (Lenzycki et al., 1978; Lenzycki et al., 1979; Eckenrode and Hamilton, 1979) provided essential basic data for analyzing IFV/CFV personnel tasks, subtasks and elements and implied personnel attributes. Those documents were supplemented by newly developed action scenarios to help identify new or unique requirements for the IFV/CFV crew members.

The present investigation required that an analytic methodology be developed and applied to identify specific needs for extranormal aptitudes, characteristics or behaviors for each crew position. Test procedures for those extranormal attributes were also to be determined, as an aid in crew selection. Other issues to be addressed in this effort were: the need for special personnel selection and management procedures; the proportions of the designated Military Occupational Specialty (MOS) personnel pools likely to be trainable or crosstrainable in each of the IFV/CFV crew positions; and implications for IFV/CFV MOS/career structures.

The procedures developed to achieve the research objectives began with a clarification of objectives and assumptions. That clarification served mainly to emphasize the investigation's concern with extranormal attributes only. It was then determined from other concurrent efforts that the two vehicles (IFV and CFV) were similar enough so that a single consolidated set of five crew positions was appropriate for this analysis: Track Commander, Driver, Gunner, Firing Port Weapon Operator (IFV only) and Observer (CFV only). Next, a taxonomy of 62 personnel attributes was constructed, and a representative set of IFV/CFV mission scenarios was developed. The operators' task and subtask demands occurring during exercise of the mission scenario were analyzed to identify which of these attributes in the taxonomy were required to perform the task or subtask. Current infantry and cavalry tasks were analyzed to determine the soldier attributes required to

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*A requirement for an aptitude or other personnel characteristic was defined as "extranormal" if a higher level is required than possessed by the average person; i.e., by 50% of the population.

perform the tasks. These attributes were then compared with those required to perform the IFV/CFV mission to identify those attributes that were new or unique to IFV/CFV. Six potentially extranormal attributes were identified for the Track Commander (TC) and Gunner positions, and three for the Driver position, on the basis that they appear to be new to current MOS 11B or 19D personnel. Those attributes are especially needed to perform the new or unique IFV/CFV tasks, and they are not now used individually for personnel selection. Any of the attributes is considered extranormal if it must be possessed at the level of the mean or higher so that 50% or less of the personnel pool will provide the necessary level.

A computer based model was developed to estimate the proportion of the personnel pool possessing specified levels of the identified attributes. The model inputs are: (1) the required cutoff score for each attribute or test; (2) the intercorrelations between those scores and job performance; and (3) the intercorrelations between attribute test scores. The model uses a Monte Carlo technique to generate a large data bank representing sets of scores for thousands of candidate IFV/CFV crew members. The statistics of interest are generated from that data bank. Those statistics include: (1) the number or proportion of the "sampled" population that satisfy the multiple attribute requirements; (2) the number satisfying the criterion on each individual attribute; (3) means, standard deviations and ranges for any subset of scores; (4) an index of predicted job performance for each member of the sample; and (5) various other statistical parameters and tables.

At the present state of knowledge regarding IFV/CFV tasks and personnel attributes, there is no sound empirical basis for setting specific cutoff scores for the individual attribute tests or the prediction index. Repeated exercising of the computer based model during this investigation demonstrated the great sensitivity of "percentage of qualifying personnel" to variations in cutoff scores for the multiple attributes and to variations in their intercorrelations. A graph was developed to provide a convenient visual method for approximating the "percentage of qualifying personnel" as a function of those cutoff and intercorrelation parameters. Because that percentage is so sensitive to variations in attribute cutoff scores and intercorrelations, and since no empirical data were available for specifying values for those two parameters, a method had to be devised to provide the best estimates possible at the present time.

Using a process of independent assessment and subsequent consensus by project team members (subject matter experts) a best estimate was made (in the absence of actual, measured correlation data) for the minimum acceptable test level of each attribute. Those cutoffs ranged from the 10th percentile to the 25th percentile of the population, and thereby did not create extranormal requirements in themselves. In combination, however, those cutoffs could present a selection problem. It is estimated that about 59% of those tested for TC or Gunner positions will fail to pass on all six required cutoff scores. About 39% of those tested for the Driver position will fail to pass on all three cutoff scores for that position. The individuals passing on all required cutoffs were further assessed using a weighted linear combination of attribute test scores. That combination was computed by using a multiple regression procedure based upon best estimates (in the absence of actual, measured correlation data) of each attribute's association with job performance. The weighted combination allows all candidates to be ranked in terms of a single index of expected job performance, thus permitting selection of the "best" candidates for training. Future research can be conducted to determine a specific cutoff score for the prediction index. The conclusion of the present effort remains that no extranormal requirement is now determined to exist in the IFV/CFV personnel selection process.

The tests for the six attributes of primary concern in this investigation are identified, and published normative data are given for population samples which appear to be most similar to the IFV/CFV personnel pool. Finally, implications for personnel management and career development are addressed and recommendations made for crew member grades and sequences for promotion from one crew position to the next.

Appendices provide supporting data, including: attribute definitions; mission scenarios; test instrument details; the computer-based model for estimating multiple attribute distributions; and references from the literature.

I. BACKGROUND AND OBJECTIVES

The Infantry Fighting Vehicle (IFV) and the Cavalry Fighting Vehicle (CFV) are two versions of the same vehicle (MICV/TBAT II) under development and procurement by the U.S. Army. The IFV will be manned by a crew of nine (9) possessing MOS 11B; the CFV will be manned by a crew of five (5) possessing MOS 19D. Earlier studies by this contractor (Lenzycki, et al., 1978; Eckenrode and Hamilton, 1979) have developed and validated task descriptions for each position in the IFV and CFV. Further analysis revealed that there are no major dissimilarities in the tasks performed by the Track Commander, Gunner and Driver in either vehicle when in the mounted position (Lenzycki, et al., 1979). The results of those earlier analyses were used in the present effort to identify and describe: (1) the aptitudes, characteristics and behaviors for IFV/CFV crew members that may require selection procedures; (2) the candidate selection procedures and tools; (3) implications for special personnel management procedures; (4) the proportions and sources of the personnel pool likely to be trainable or crosstrainable in each of the IFV/CFV crew positions; and (5) implications for IFV/CFV MOS/career structures.

II. THE ANALYTIC METHODOLOGY

The method for determining extranormal IFV/CFV attributes and selection test instruments is depicted as a flow block diagram in Figure 1. "Extranormal" attributes are those unique, required attributes, characteristics and behaviors which an insufficient proportion of the manpower pool possesses or can be trained to possess.

The analysis began with a statement of goals (Block 1). These goals are as follows:

- To identify specific needs for extranormal aptitudes, characteristics, or behaviors per crew position and to estimate the needed level of those aptitudes, characteristics and behaviors.

- To determine or estimate normal levels of the extranormal aptitudes, characteristics and behaviors which are available in the current personnel pools.

- To identify and select candidate selection procedures for those aptitudes, characteristics and behaviors determined to comprise extranormal IFV/CFV requirements.

All those goals were accomplished as intended, with the exception that no research data (correlations between attributes and job performance) were available to support the estimation of needed attribute levels (as noted in the first goal statement above). Instead, the needed levels of those aptitudes were estimated by a process of independent assessment and subsequent discussion with consensus by the four project staff members with the most knowledge of IFV/CFV tasks and personnel attribute requirements. Details of that "best estimate" process are described in Chapter VI of this report.

The key to keeping the analysis within manageable proportions has been to focus on the identification of "extranormal" attributes, and the avoidance of analyses clearly not directed toward "extranormal" attributes. Based on the above goals, plus the time constraints of this study, a set of working assumptions (Block 2) was developed to insure the timely

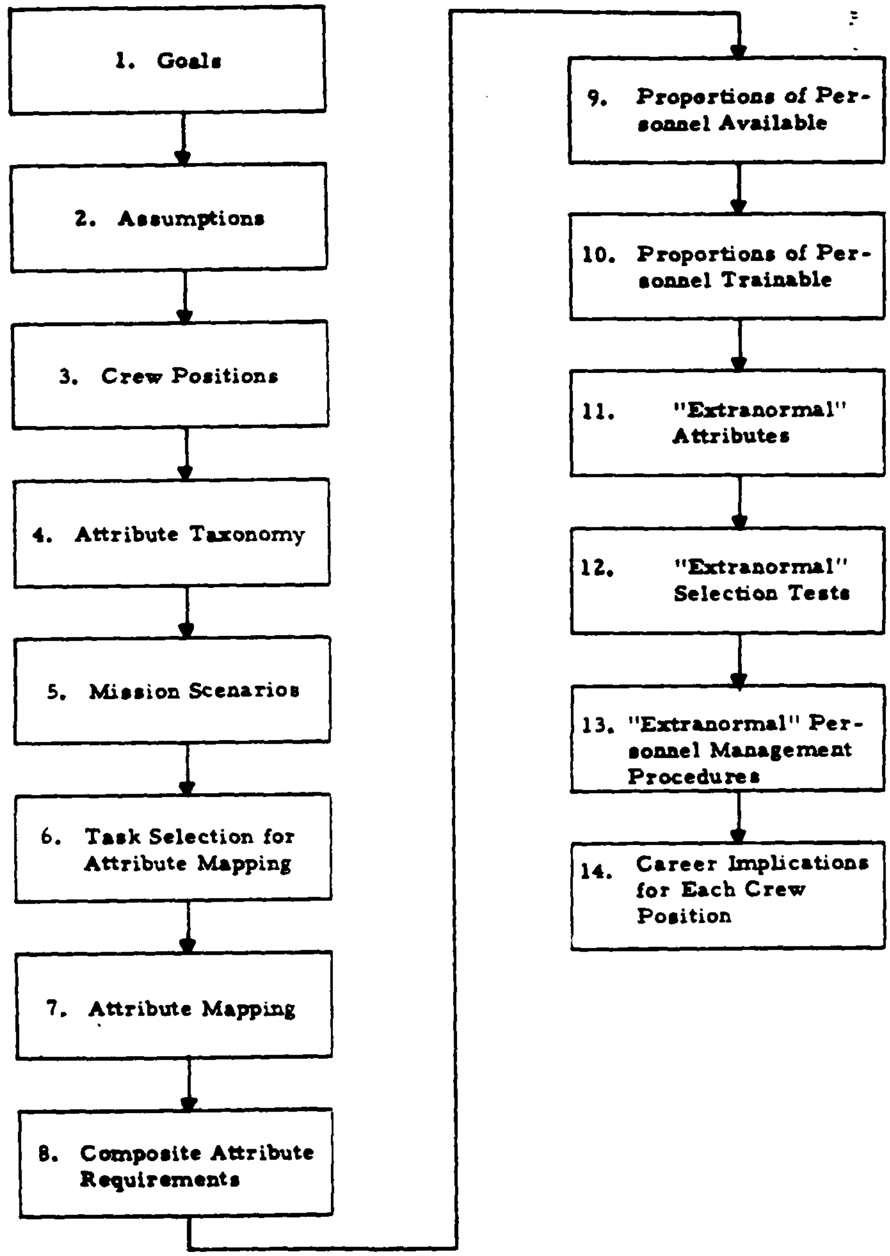

Figure 1. Analytic Methodology for Determining Extranormal IFV/CFV Personnel Attribute Requirements.

and efficient completion of the required work. First, the analysis was concerned only with unique or new tasks allocated to mounted crews in the Infantry and Cavalry Fighting Vehicles. Those tasks arise from the new weapons, equipment and operational conditions of these fighting vehicles as compared with existing vehicles such as the Armored Personnel Carrier (APC) used by infantry and tanks used by cavalry. The new devices and conditions include the two-man turret, the weapons (25mm cannon, coax 7.62 machine gun and TOW missile), the vision aids (day/night sight, night vision viewer, night vision goggles, vision blocks and associated firing ports), and the unique locations of crew members within the vehicle. The tactical conditions that have significant implications for extranormal attributes involve operations at night and with the vehicle in motion when employing the weapon system (except TOW). Finally, the analysis was conducted for a single vehicle at squad level, and for personnel in the mounted mode.

The equipment used and the tasks performed to accomplish the functions in the two vehicles (IFV/CFV) were determined to have no significant differential impact on extranormal crew attributes. Consequently, a single consolidated set of five (5) crew positions (Block 3) was defined for this analysis: Track Commander, Driver, Gunner, Firing Port Weapon Operator (IFV only) and Observer (CFV only). It was noted that the FPWO and Observer also function as Ammunition Loaders.

As work proceeded, reviews were made of previously completed crew task descriptions and analyses, and existing attribute taxonomies. With the help of individuals who are knowledgeable in the design and performance of the IFV/CFV, a taxonomy of personnel attributes (Block 4) was then developed. The crew task analyses had been completed previously by Dunlap and Associates, Inc. The existing attribute taxonomies were found in a systematic search of the technical literature, including computerized key word searches of the National Technical Information Service (NTIS) and Psychological Abstracts data bases. These data bases yielded a total of 465 citations of which 56 were judged to be relevant to the search topic. Expert knowledge of current IFV/CFV operations was provided by contractor staff members responsible for developing IFV/CFV task descriptions and mission scenarios, and by subject matter experts (SMEs) at Ft. Benning and Ft. Knox. Most of the attributes identified as appropriate to the IFV/CFV design and crew tasks were found in a comprehensive taxonomy study completed by Finley, et al. (1969) for the NASA Ames Research Center. The composite taxonomy is contained in Table 1. General definitions for these attributes were developed and are described in Appendix A. A set of system-specific definitions also was developed for the six critical attributes identified during the detailed task analysis. Those definitions are found in the next section of this report.

In anticipation of the need for a realistic exercising of crew member tasks, several mission scenarios (Block 5) were developed and analyzed to identify the functions and tasks being performed to accomplish those missions. Those scenarios appear in Appendix B. Crew member tasks are seen to be mapped against time and external events during the mission. Those tasks were then compared for similarity with known currently required tasks by Army personnel. Where the tasks appeared to require new or unique attributes, this was noted.

The next step in the analytical process was to define those tasks which have implications for extranormal attributes (Block 6). This was accomplished in several ways. First, a summary was made of tasks which are new to crew members proposed (MOS 11B and 19D) to operate the vehicles. Special attention was paid to those tasks which are performed during restricted visibility, in contact with the enemy, under time pressure and other stressful conditions. The criticality rating of tasks, as summarized by Lenzycki, et al. (1979), served as an important guide in identifying the conditions that were examined. Detailed task descriptions were reviewed for the selected tasks, revealing no unusual attribute requirements for the FPWO (IFV) and Observer (CFV), but several special attributes required for the crew positions of Track Commander, Gunner and Driver. The behavior and personality dimensions associated with performing each task were then identified, using the composite taxonomy of attributes. A separate analysis of tasks was performed for current Army personnel, based on 35 critical items in the Infantryman Skill Qualification Test (SQT 2). The attributes associated with those tasks described in SQT 2 were then compared with the ones identified earlier in the IFV/CFV tasks. Another comparison was made with tasks required of Infantry personnel currently using the Armored Personnel Carrier (APC). The comparisons helped to mitigate the analytical effort by identifying currently required attributes that could be eliminated from further consideration.

After completing the analyses and screening for unique requirements, three tasks, performed under varying conditions, emerged as having possible implications for extranormal attributes. They are:

Table 1. Working Taxonomy of Personnel Attributes

No.	Description
1	Static strength: arm-hand-shoulder emphasis
2	Dynamic strength: arms-flexor emphasis
3	Dynamic strength: arms-extensor emphasis
4	Dynamic strength: legs
5	Trunk strength
6	Gross body equilibrium
7	Balance-visual cues
8	Speed of limb movement: arms
9	Speed of limb movement: legs
10	Gross body coordination
11	Stamina/endurance
12	Verbal knowledge
13	Word fluency
14	Numerical ability
15	Concept fluency
16	General reasoning
17	Seeing implications and consequences (foresight)
18	Practical judgment
19	Intelligence
20	Arm-hand steadiness
21	Wrist-finger speed
22	Finger dexterity
23	Manual dexterity
24	Control precision
25	Multilimb coordination
26	Movement analysis
27	Movement prediction
28	Rate control
29	Acceleration control
30	Reaction time
31	Discrimination abilities
32	Perceptual speed
33	Time sharing
34	Closure abilities: speed of closure
35	Closure abilities: flexibility of closure

Table 1. Working Taxonomy of Personnel Attributes (continued)

No.	Description
36	Auditory identification abilities: auditory rhythm discrimination
37	Auditory identification abilities: auditory perceptual speed
38	Spatial abilities: spatial orientation
39	Spatial abilities: spatial visualization
40	Associate memory: rote memory
41	Associate memory: meaningful memory
42	Memory span: immediate memory
43	Memory span: integration I (large number of detailed rules)
44	Visual memory
45	Leadership
46	Closeness of interactions
47	Amount of interaction
48	Strength of interaction
49	Aggression reaction
50	Conformity and/or control reaction
51	Flexibility:rigidity reaction
52	Self control reaction
53	Subjectivity:objectivity reaction
54	Emotionality, sensitivity of reaction
55	Desired level of output
56	Desired type of output
57	Nighttime dynamic visual acuity
58	Motion-vibration tolerance
59	Eye-hand coordination
60	Time estimation
61	Body dimensions
62	Selective attention

- Track target while vehicle is in motion (including turret movement) under daytime and nighttime conditions. Recover balance and orientation, while firing weapons, when turret is moved unexpectedly by other turret crew member. (Gunner, Track Commander)

- Maintain adequate surveillance of external environment with aid of night vision viewer (image intensifier) during periods of low external visibility. (Driver)

- Maintain adequate surveillance of external environment with aid of integrated day/night sight (IR display) during periods of low external visibility. (Gunner and Track Commander)

The above three tasks were reviewed with respect to the attribute taxonomy. Potentially extranormal attributes were identified, and a procedure was developed for estimating the proportions of the personnel pool possessing those attributes. A final determination of "extranormal" attributes is based on the low availability of qualified individuals within the personnel pool (e.g., 50% or less of those in the pool satisfying each of the multiple cutoff criteria). The implications of extranormal attributes on selection, personnel management and career development were considered following the "extranormal" attribute determination. Details of the above steps (Blocks 7-14) comprise the balance of this report.

III. ATTRIBUTES WHICH MAY REQUIRE SELECTION PROCEDURES

The three IFV/CFV tasks and performance conditions previously noted as having possible extranormal implications were mapped against the taxonomy to identify their associated human attributes (Block 7). In the analyses, certain apparently unique requirements were carefully reviewed. For example, given the multiplicity, simultaneity and complexity of composite task requirements for turret and weapons control, special attention was paid to two attributes--Multilimb Coordination (No. 25) and Flexibility:Rigidity Reaction (No. 51).

Multilimb Coordination is required when the Gunner or Track Commander is tracking or holding on a target. The Gunner is required to track the target with the left hand and select the ordered weapon system and associated firing elements with the right hand. When the appropriate selections/switches have been activated, the Gunner is required to control the turret and selected weapon with both hands on the Gunner's control handle. The turret and turret weapons, which are linked mechanically and electrically, move together in azimuth. If targets or weapons are changed at the last moment, a new sequence of task elements must be substituted. This type of substitution requires a "flexibility of mind" more than an integrative or even coordinative sort of motor ability. A similar kind of Multilimb Coordination also is required of the Driver, as when steering the vehicle over a selected route and simultaneously selecting driving switches and controls (lights, brakes, etc.).

Although the required Multilimb Coordination ability may be viewed as a sequence of multiple steps, each of which is relatively simple, it does not necessarily pose unique requirements. Very similar types of coordinated control actions are required for the Driver position of the Armored Personnel Carrier (M113). The required ability for sequencing operations is considered trainable, so that the operator can reach a desired level of proficiency through practice. Likewise, the requirement for Flexibility has been found in the analysis to occur during the performance of numerous other infantry tasks and is not unique to the IFV/CFV (e.g., react to overhead and ground flares while moving and while negotiating obstacles; engage targets with an M203 grenade launcher and apply immediate action to reduce a stoppage; and engage multiple targets with an M72 A2 LAW and apply immediate action to correct a malfunction in the weapon).

As a result of this reasoning, neither Multilimb Coordination nor Flexibility:Rigidity Reaction was included in the final set of unique and potentially extranormal attributes. Another apparently unique requirement was also examined. This one pertained to the fact that the turret weapon systems (TOW missile, 25mm cannon and coax 7.62 machine gun) require operating procedures which differ from each other in various ways. Earlier MICV work suggested to some concerned individuals that: (1) the crew member who finds the ground mounted TOW to be easy to operate finds the cannon to be more difficult, and vice versa; and (2) the behaviors required to handle these two weapons are apparently quite different. During the course of this effort, it remained unclear as to the amount and type of training those MICV operators received prior to testing and the specific meanings of "easy" and "difficult" to operate. However, the more important point was that a comparison of operator reactions to the ground-mounted TOW and cannon is not a valid basis for drawing conclusions about operator reactions to those same weapons in their IFV/CFV mounted versions. Within the IFV/CFV turret, the same control is used for setting azimuth and elevation and the same computer-aided sight is employed with all three weapon systems. This is not true in comparing the separately ground-mounted TOW and MICV cannon. A reexamination was made of the "Engage Targets" function (No. 9)* and the operator control actions required during the conduct of fire for any of the three weapon systems. Though differences were found in overall procedures, the reexamination indicated that no significant differences exist in their underlying required attributes. More test data would be needed before one could accept the statement that different sets of attributes are required to control the different IFV/CFV turret-mounted weapons.

Finally, the review of tasks which are IFV/CFV specific and new to the Infantry/Armor inventory of crew tasks has led to the conclusion that the FPWO (IFV) and Observer (CFV) positions make no unusual personnel selection demands. However, if either of these two crew members are to be trained or crosstrained for Driver, Gunner or Track Commander positions, they will need to possess the "extranormal" attributes required for those positions, in addition to the normal attributes required by the Infantry or Cavalry for training in their own positions.

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*from Lenzycki, et al., 1978.

Those tasks and related attributes identified as new and potentially extranormal to Infantry/Cavalry personnel were mapped as shown in Table 2. The composite of unique attributes (Block 8) for the Track Commander and Gunner includes:

7. Balance--visual cues
28. Rate control
35. Closure abilities: flexibility of closure
38. Spatial abilities: spatial orientation
39. Spatial abilities: spatial visualization
57. Nighttime dynamic visual acuity

The Driver must possess the last three of those attributes (38, 39 and 57).

For purposes of this effort, system specific definitions for the aforenamed attributes were developed, providing clarifications beyond the general definitions found in Appendix A. Table 3 provides both system specific definitions and the more general ones from Appendix A. These definitions were used later to establish requirements for test instruments.

It should be noted that the individual attribute No. 39, "Spatial abilities: spatial visualization" may bear some similarity to one of the component tests in the Armed Services Vocational Aptitude Battery (ASVAB)--Space Perception (formerly known as Pattern Analysis). The Space Perception test consists of 70 questions, all of which are based upon folding cardboard patterns into boxes with special shapes or marked patterns. In the ASVAB, the Space Perception test is used in combination with three other tests (Arithmetic Reasoning, Trade Information, and Attention-to-Detail) to produce the composite score referred to as the Combat Scale. Besides not being used alone for selection purposes, the Space Perception test may not satisfactorily tap the required IFV/CFV crew member's ability to use infrared images to develop an accurate mental image of the external environment during periods of low visibility. It is likely that no available test directly measures that ability. However, some of the tests for Attribute 39 (listed in the next chapter) appear to provide better indications of how well an individual can construct and maintain a mental image of a scene based upon partial or distorted sensor information.

Table 2. Mapping of Tasks and Attributes Required for Performance

Task and Conditions	Crew Position	Unique Attributes
Track target while vehicle is in motion (including turret movement) under daytime and nighttime conditions. Recover balance and orientation, while firing weapons, when turret is moved unexpectedly by other turret crew member.	Track Commander Gunner	7. Balance--visual cues 28. Rate control
Maintain adequate surveillance of external environment with aid of night vision viewer (image intensifier) during periods of low external visibility.	Driver	38. Spatial abilities: spatial orientation 39. Spatial abilities: spatial visualization 57. Nighttime dynamic visual acuity
Maintain adequate surveillance of external environment with aid of integrated day/night sight (IR display) during periods of low external visibility.	Track Commander Gunner	35. Closure abilities: flexibility of closure 38. Spatial abilities: spatial orientation 39. Spatial abilities: spatial visualization 57. Nighttime dynamic visual acuity

Table 3. General and System-Specific Definitions for Unique Attributes

No. 7--Balance-visual cues

General: The ability to utilize visual cues to maintain balance under adverse conditions such as when cues from the equilibrium senses are absent, distorted, or subject to interference.

Specific: The ability to use visual cues to maintain balance when sudden vehicle or turret movements occur and temporarily interfere with equilibrium senses.

No. 28--Rate control

General: The ability to make continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving target or object.

Specific: The ability to maintain track of a moving target while in a moving vehicle, in part by controlling turret position, under high and low visibility conditions. (Track Commander/Gunner)

No. 35--Closure abilities: flexibility of closure

General: The ability to identify a previously specified stimulus configuration that is embedded in a more complex sensory field, possibly with reduced, altered or abstract visual cues.

Specific: The ability to identify targets using the infrared sensor display (night sight).

No. 38--Spatial abilities: spatial orientation

General: The ability to utilize cues from the equilibrium senses, visual senses or instruments to maintain a correct awareness of body orientation with respect to a specified reference object (e.g., the ground).

Table 3. General and System-Specific Definitions for Unique Attributes (continued)

Specific:	The ability to use the night vision viewer and body senses to maintain a correct awareness of IFV/CFV orientation within the external environment during periods of low external visibility. (Driver)
Specific:	The ability to use the integrated day/night sight and body senses to maintain a correct awareness of IFV/CFV orientation within the external environment during periods of low external visibility. (Track Commander and Gunner)

No. 39--Spatial abilities: spatial visualization

General:	The ability to utilize cues from the visual sense, other senses, or instruments to develop an accurate mental image of an object or group of objects within or outside of an environmental context.
Specific:	The ability to use the night vision viewer to develop an accurate mental image of the external environment (including targets) during periods of low external visibility. (Driver)
Specific:	The ability to use the integrated day/night sight to develop an accurate mental image of the external environment (including targets) during periods of low external visibility. (Track Commander and Gunner)

Table 3. General and System-Specific Definitions for Unique Attributes (continued)

<u>No. 57--Nighttime dynamic visual acuity</u>

General:	The ability to perceive the detail of moving objects at low levels of illumination.
Specific:	The ability to use the night vision viewer to detect targets (generally moving horizontally relative to the observer) during periods of low external visibility and with the vehicle in motion. (Driver)
Specific:	The ability to use the integrated day/night sight to detect targets (generally moving horizontally relative to the observer) during periods of low external visibility and with the vehicle in motion. (Track Commander and Gunner)

IV. CANDIDATE SELECTION PROCEDURES AND TOOLS

Using the system-specific definitions of unique attributes (Table 3) as a point of departure, this section describes requirements for test instruments to measure those attributes and identifies the test instruments considered to be reasonable measures of each attribute. Information is provided on the test publisher, manufacturer or researcher and its availability. A more complete listing of test instruments with normative curves, factor loading and/or reliability information (where available) is presented in Appendix C. Many of the test instruments are referenced in the comprehensive effort completed by Finley, et al. (1969); others are identified in the general literature or listed by Buros (1959, 1965 and 1972).

Attribute No. 7: Balance-visual cues

A test to measure this attribute would require the subject to maintain balance and orientation when visual information is provided and there is a disruption in the equilibrium senses. A study by Ambler and Guedry (1965) investigated the validity of a brief vestibular disorientation test. Their report describes a test which assesses the subject's reactions produced by certain head movements while seated in a rotating chair (Stille-Werner). Further information on the device and its availability might best be obtained by directly contacting one of the authors of the test study at the U.S. Naval Aerospace Medical Institute, Pensacola, Florida.

Attribute No. 28: Rate control

Tests to measure this attribute would require the subject to track a moving target while positioned on a moving platform. No tests were uncovered in the literature which provided a moving platform while requiring the subject to track a moving target. There were, however, a number of simpler tests identified which measure tracking ability. They include the following:

- Motor Judgment Test
- Two-Hand Coordination
- Rate Control Test
- Pursuit Confusion
- Multidimensional Pursuit
- Two-Hand Pursuit--Bank and Altitude

Fleishman (1958) was the principal researcher in the studies that describe and utilized the above tests.

Attribute No. 35: Closure abilities: flexibility of closure

Tests to measure flexibility of closure would require the subject to interpret imagery with reduced or altered visual cues, as in identifying targets based on a complex pattern of infrared pictorial signatures. A number of tests related to this attribute were identified, including:

Test	Author/Publisher
• Embedded Figures Test (printed) (also: Group Embedded Figures Test)	Consulting Psychologists Press, Inc. Palo Alto, California Cost: $3.00 per set
• Hidden Pictures (printed)	Office of Research Administration Room R-051 Educational Testing Service Princeton, New Jersey 08540 Cost: unlisted
• Concealed Figures: A Test of Flexibility of Closure (derived from the Gottschaldt Figures Test)	Industrial Relations Center University of Chicago 1225 East 60th Street Chicago, Illinois Cost: $2.00 per specimen set $4.00 per 20 tests

Attribute No. 38: Spatial abilities: spatial orientation

Tests for spatial orientation would require measuring the subject's ability to maintain a correct orientation awareness of self, vehicle and environment when cues from visual and equilibrium senses are provided. Several possible tests include:

Test	Author/Publisher
• Aerial Orientation	Parker and Fleishman, 1960
• Visualization of Maneuvers	Parker and Fleishman, 1960
• Spatial Orientation Test (Part 5 of Guilford-Zimmerman Aptitude Survey)	Sheridan Supply Co. P. O. Box 837 Beverly Hills, California

Attribute No. 39: Spatial abilities: spatial visualization

Tests to measure spatial visualization would require the subject to maintain a correct mental image of the external environment, especially of significant object locations and movements, using visual or other senses. The Pattern Analysis, or Space Perception, component of the Armed Services Vocational Aptitude Battery (ASVAB) provides a general measure for this aptitude. It is one of four components which comprise the composite Combat Score used to select Infantry personnel, and as such does not involve a cutoff score for selection on this attribute alone. Other tests to measure this attribute are:

Test	Author/Publisher
• Revised Minnesota Form Board Test	The Psychological Corporation Eastern Region 757 - 3rd Avenue New York, New York 10017 Cost: $1 per specimen set Hand Scoring edition: $3.00 per 25 sets, manual and scoring stencils Machine Scorable edition: $4.50 per 25 sets; $2.50 per 50 answer sheets; 70¢ per set of manual and scoring stencils
• Formation Visualization	Parker and Fleishman, 1960
• Stick and Rudder Test	Parker and Fleishman, 1960
• Paper Folding Test	Educational Testing Service Princeton, New Jersey 08540

There are a number of test instruments which measure all three attributes (Flexibility of Closure, Spatial Orientation and Spatial Visualization) or some combination thereof. See Appendix C for a listing of tests by combined attributes.

Attribute No. 57: Nighttime dynamic visual acuity

A test of this attribute would require the subject to detect and identify moving targets and other objects under low external visibility. Only one instrument was found which could be appropriate to measure this attribute. This is the Mark II Integrated Vision Testing Device referenced in Williams and Graf (1975) and Shinar (1977). The device includes eight vision tests: static acuity; dynamic acuity; detection, acquisition and interpretation; static acuity--low luminance; central movement in depth; angular movement; field; and static acuity with glare. This sophisticated device is being pilot-tested by the National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C., and the Project Director is Mr. Steve Versace.

Normative data were obtained for all of the tests referenced above and are summarized in Table 4. These data are for those populations tested which we believe most representative of the MOS 11B and MOS 19D personnel pool. Appendix C contains the normative data translated into standard cumulative distribution curves. By using "Probability Scale x 90 Divisions" graph paper, the normal distribution appears as a straight line. These distribution curves provide inputs to the computer simulation model for identifying the proportions of the personnel pool satisfying individual cutoff criteria for test-scores and underlying attributes (see Chapter V).

Table 4. Normative Data for Candidate Test Instruments

Attribute	Test	Sample Description	Sample Size (N)	Mean	Standard Deviation
7. Balance -- Visual Cues	Brief Vestibular Disorientation Test (Ambler and Guedry, 1965)	Naval aviation trainees	226	12.64	5.76
28. Rate Control	Motor Judgment Test (Fleishman, 1958)	Unselected basic trainee airmen	204	1.21	0.27
	Two Hand Coordination (Ibid.)	Unselected basic trainee airmen	204	0.93	0.35
	Rate Control Test (Ibid.)	Unselected basic trainee airmen	204	1.74	0.42
	Pursuit Confusion (Ibid.)	Unselected basic trainee airmen	204	1.58	0.58
	Multidimensional Pursuit Bank and Altitude (Ibid.)	Unselected basic trainee airmen	204	1.94	0.45
	Two Hand Pursuit (Ibid.)	Unselected basic trainee airmen	204	2.01	0.51
35. Closure Abilities: Flexibility of Closure	Embedded Figures Test (Witkin, Oltman, Raskin and Karp, 1971)	Five pooled male samples	336	50.87	31.62
	Group Embedded Figures Test (Ibid.)	Male college students	155	12.00	4.10
	Hidden Pictures Test (Derman, 1978)	11th - 12th Grade males	299	6.85	2.30
	Concealed Figures: A Test of Flexibility of Closure (Thurstone and Jeffrey, 1965)	Industrial Personnel (various)	5,236	64.50	28.50

Table 4. Normative Data for Candidate Test Instruments (continued)

Attribute	Test	Sample Description	Sample Size (N)	Mean	Standard Deviation
38. Spatial Abilities: Spatial Orientation	Aerial Orientation (Parker and Fleishman, 1960)	AFROTC students U. of Md. (Freshman, Sophmores)	203	5.03	1.93
	Visualization of Maneuvers (Ibid.)	AFROTC students U. of Md. (Freshman, Sophmores)	203	5.03	1.90
	Spatial Orientation Test (Guilford and Zimmerman, 1956)	College men (Freshman emphasis)	2,617 to 2,728	20.50	10.32
39. Spatial Abilities: Spatial Visualization	Revised Minnesota Form Board Test (Likert and Quasha, 1960)	Nine pooled male samples	4,768	39.31	10.39
	Formation Visualization (Parker and Fleishman, 1960)	AFROTC students U. of Md. (Freshman, Sophmores)	203	5.01	1.93
	Stick and Rudder Test (Ibid.)	AFROTC students U. of Md. (Freshman, Sophmores)	203	5.16	1.99
	Paper Folding Test (Derman, 1978)	Army Enlistees	82	10.40	3.30 est.
57. Nighttime Dynamic Visual Acuity	Central Movement in Depth (Small) (Shinar, 1977)	Male drivers under 35 years old	169	11.00	3.70
	Central Angular Movement (Ibid.)	Male drivers under 35 years old	169	11.30	5.00

V. ESTIMATING THE PROPORTION OF PERSONNEL POSSESSING SPECIFIED ATTRIBUTES

Having identified the jointly required attributes for IFV/CFV personnel, the next objective was to estimate the proportions of the personnel pool possessing the desired levels of those attributes (Block 9). The two key problems to be resolved in this process are: (1) the methodological one of how to address the effect of joint requirements on personnel pool availability; and (2) the lack of sufficient information to determine IFV/CFV personnel pool availability specifically. Problem (1) was resolved by developing a computer-based statistical model specifically for this effort. Problem (2) was treated first by making boundary estimates of availability, and second by using subject matter experts to help develop best estimates of model input parameters so that a reasonable estimation of personnel pool availability could be calculated.

The present Chapter (V) addresses Problem (1) by describing the development of the statistical model. The next Chapter (VI) addresses Problem (2) by first exercising the model to illustrate the boundaries and sensitivity of personnel availability estimates as a function of the model input parameters, and second, by exercising the model using the best estimates of model input parameters to calculate the required availability information. Chapter VI also describes how those best estimates were made.

The remaining paragraphs of this chapter describe the statistical model for estimating proportions of personnel possessing desired levels of jointly required attributes. The model was developed specifically for this effort and provides sufficient parameters to handle each of the variables and constraints that are currently felt to be relevant in the IFV/CFV personnel selection process. Output from the model consists of the joint distribution of the several identified candidate "extra-normal" attributes and the combination of these attributes into a single predicted job performance score. The model assumes that prior standard screening has assured that all other required attributes are possessed at adequate levels in all IFV/CFV crew trainees (thereby not affecting any joint probability calculation).

A. Background

Personnel selection formulas are typically developed as a combination of regression equations and multiple criteria cutoff schemes.

Regression may be thought of as developing a combined or total score across several personnel selection indices. The individual index scores (e.g., the scores for each test in a battery of tests) are weighted through multiple regression where the resulting total score is maximally related to job performance. Multiple cutoff selection schemes are used when a satisfactory score must be achieved on each one of the underlying indices. Night vision, for example, may be critical and deficiencies in this area cannot be made up by strengths on any of the other indices. In other words, if a prospective trainee does not possess at least some minimum level of night vision, he cannot adequately perform certain aspects of the specified job regardless of any other attributes he may possess and/or regardless of any projected training.

It is felt that the best approach is a combination of both schemes, since it appears that each of the identified attributes must be present in each prospective trainee at least to some minimum level, and that increases beyond the minimum may be reflected in increased overall job performance. This approach is compatible with schemes currently used by the Army.

Using such an approach requires two steps: first, the multiple cutoff scheme to eliminate the totally unqualified, and second, the regression approach to order the remaining candidates according to their ultimate likelihood of success.

B. Parameter Estimation

In the prior sections, it was reported that six potentially extranormal attributes (characteristics or abilities) are essential for adequate performance in the Track Commander and Gunner positions. Similarly, three attributes are essential for adequate performance in the Driver position. The parameters of a multiple cutoff scheme for six attributes (or three) are trivial if all six are uncorrelated (product moment $r = 0$) or perfectly correlated ($r = 1$) within the personnel pool. The parameters are much more complicated when any of the correlations deviate from 0 or 1. The following paragraphs present some of these considerations.

Uncorrelated ($r = 0$), Multiple Cutoff

For $r = 0$, a trainee's "score" for one attribute is unrelated to his score on any other attribute. To obtain the percentage of the personnel pool which will "pass" for all six scores, it is necessary only to multiply the percentages passing on each score. Thus, if 50% of the pool pass each cutoff (and 50% fail), then $(.50)^6$ or 1.6% will pass on all six (12.5% for all three). Similarly, if 90% pass each cutoff (and 10% fail), then $(.9)^6$ or 53% will pass on all six (72.9% for all three).

Perfectly Correlated (r = 1), Multiple Cutoff

When r = 1.0, a trainee's score on one attribute is the same as his or her score on every other attribute (on the basis of standard scores or percentiles). Thus, if the cutoff point on every attribute is 50%, then 50% will pass on the first attribute and the same 50% will pass on every other attribute. Similarly, if 90% pass on one attribute, then 90% will pass overall.

Imperfectly Correlated ($0 < r < 1$), Multiple Cutoff

The parameters for multiple cutoff are not trivial when two or more of the attributes are correlated at some level other than zero or one. Correlations, for instance, in the range of +.20 to +.60 are common and fully expected between several pairs of these attributes. The effect of these moderate positive correlations would be to raise the expected percentage passing above the r = 0 level (e.g., 1.6% in the first example), but below the r = 1 level (50.0% in the comparable perfectly correlated example).

C. Description of Developed Model

It was decided that the parameters for the imperfectly correlated situation could best be estimated through computer modeling using a Monte Carlo simulation. The model developed here allows the user to enter levels for the following variables:

- The number of attributes (six or three, in this case)
- The cutoff score for each attribute (variable, established by user for each attribute)
- Attribute intercorrelations (hypothesized or based on actual data; variable for each attribute pair)
- Attribute weight or loading with respect to job performance (for the multiple regression subroutine)

The model's output consists of the percent passing above cutoff on all six attributes; the percentage failing one or more attributes; and, the contribution made by each attribute to the overall pass-fail rate. By varying the number of attributes, cutoff scores and intercorrelations, the user can gauge the effects of personnel selection decisions on available manpower. For example, one set of cutoffs and correlations may show that 45% of available manpower are qualified for training. The user may then want to know the effect of changing the cutoff on attribute "X" from say 90% pass to 80% pass. Clearly, this will decrease the available pool. The model can simply be rerun after resetting the cutoff for attribute "X" and the expected decrease would be directly calculated. Similarly, a more reliable test instrument for attribute "X" could increase the intercorrelations and thus increase the available pool. Such effects could also be estimated by resetting and rerunning the model. The computer model, described in Appendix D, allows for inclusion of up to ten attributes (with expansion capability) with any set of independent cutoff scores, and any set of intercorrelations between attributes. The output is the percentage of personnel exceeding the multiple cutoff criteria on all attributes, on each attribute and on combinations of attributes. The model is also equipped to estimate the results of a multiple regression selection scheme with or without multiple cutoff. Specifically, the fourth available input variable is the strength of the relationship between each attribute and job performance. Attribute number one, for instance, could be "twice" as important to job performance (that is account for twice as much job performance variability) as attributes three or four. As such, attribute one would enter the model's regression subroutine with a weight of 2.0 whereas attributes three and four would carry weights of only 1.0. The model then produces predicted job performance scores utilizing input weights in linear regression for the "pass" group (i.e., pass all criteria), the "fail" group (i.e., fail one or more of the criteria) and for the combined pass and fail groups. This provision of the model allows the user to systematically examine the trade-offs between personnel selection based on multiple cutoff, multiple regression and selection schemes utilizing both approaches.

Table 5 contains the computer program specification. It describes three program stages to accomplish the required computations.

Table 5. Simulation Model Specification

Module 1:	Standard statistical package multivariate regression program		
Input:	(1)	Intercorrelation matrix for all predictor variables (and optionally, criterion variables) (all values estimated)	
Output:	(2)	Linear prediction equations	
Module 2:	Special-purpose Monte Carlo data generation and partial data analysis program (Fortran)		
Input:	(2)	above	
	(3)	desired number of cases*	
	(4)	"cutoff" criteria for all predictor variables	
	(5)	(optionally) weighted linear prediction equations for job performance criteria from predictor variables	
Output:	(6)	Printed output echoing the input values and showing:	
		(a)	intercorrelation matrix corresponding to Input (1) for the generated pseudo-data
		(b)	percent passing
		(c)	percent failing:
			- overall
			- for each predictor variable, total
			- for selected combinations of predictors

*The program simulates raw data by generating random normal numbers (one for each predictor for each "case") and adjusting these numbers so that they conform to the intercorrelation matrix parameters. It generates virtually any desired number of cases or subjects. One might wish, for example, to base exploratory runs on 1,000 to 5,000 generated raw data cases. Later runs, when greater sensitivity is desired, can be based on 10,000 or more generated raw data cases.

Table 5. Simulation Model Specification (continued)

(d) for each subgroup in 6 (b) and 6(c), the average, standard deviation, maximum value, and minimum value on each predictor (and criterion) variable

(7) (optional) pseudo-data file, including scores on each predictor (and, optionally, each estimated criterion) and whether or not each case passed the "cutoff" criteria

Module 3: Specially-written data analysis programs

Input: (7) above

Output: (8) as desired; may include cross-tabulations of predictor variables by pass/fail category, within-group correlations, or any other analysis requested by the user

VI. FINAL DETERMINATION OF EXTRANORMAL ATTRIBUTES

This chapter addresses the problem of developing sufficient model-input information specifically to determine IFV/CFV personnel pool availability. That, in turn, determines if any attribute can be considered to be extranormal. The first stage in this process was to apply the model in such a manner as to determine the boundaries and sensitivity of personnel availability estimates when model-input parameters were varied. That determination is described in Section A below. The second step of this process was to develop best estimates of the model-input parameters (described in Section B) and to apply those estimates to the model for the final calculations of personnel pool availability (described in Section C). The concluding section (D) provides a brief summary of this chapter.

A. Application of the Model to Determine Boundaries and Sensitivity

The model is intended to be used as a tool to estimate the impact of various personnel selection decisions on the available manpower pool. It will be most useful as data are obtained concerning the relationship between actual job performance and each of the candidate extranormal attributes within the actual available pool. Nevertheless, the model was run at this time in order to investigate the results across a wide range of selection alternatives.

Tables 6 through 9 present some of the results obtained when examining a range of selection alternatives. Attribute intercorrelations ranging from 0 to 1, and attribute cutoff scores ranging from the mean to -1.5 standard deviations were considered. Data in these tables are based on several different simulations of scores for 10,000 soldiers. As such, the percentages reported could vary as a function of the sampling error associated with an N of 10,000. Also, the simulation assumes that scores associated with each attribute are normally distributed. This assumption appears warranted given the available literature related to these attributes.

Each table attempts to provide a large amount of data. This allows for several side-by-side comparison to be made. The major components of each table are as follows:

Table 6. Zero-Correlation Calculations

Attribute Intercorrelation							Percent Failing on This Attribute Only Under Multiple Cutoff Criteria of (Standard Score):			
Attribute	7	28	35	38	39	57	-1.5	-1.0	-0.5	0.0
7	1	0	0	0	0	0	4.6	6.8	5.2	1.7
28	-	1	0	0	0	0	4.4	6.7	4.7	1.6
35	-	-	1	0	0	0	4.5	6.3	5.1	1.8
38	-	-	-	1	0	0	4.8	6.5	4.7	1.3
39	-	-	-	-	1	0	4.8	6.6	4.8	1.6
57	-	-	-	-	-	1	5.0*	6.6	4.9	1.6

Proportion Passing the Multiple Cutoff Criteria		-1.5	-1.0	-0.5	0.0
	TC/Gunner	66.3%	35.6%	11.7%	1.7%
	Driver	80.8%	59.5%	33.7%	13.2%

Average Correlation (Off Diagonal)		
	TC/Gunner	0.00
	Driver	0.00

*These entries may be interpreted for the TC/Gunner as follows: If the Attribute associated with this entry (No. 57 in this example) is dropped as a requirement, then the "Proportion Passing the Multiple Criteria" for TC/Gunner will increase by the indicated number of percentage points (e.g., 66.3% would become 71.3%). For Drivers, this increase would be at least as great as the entry number. Note that 5.0 percentage points is a larger proportion of its Fail group (33.7% in this example) than, say, 6.6 percentage points is of its Fail group in the -1.0 column.

Table 7. Low-Correlation Calculations

Attribute	Attribute Intercorrelation						Percent Failing on This Attribute Only Under Multiple Cutoff Criteria of (Standard Score):			
	7	28	35	38	39	57	-1.5	-1.0	-0.5	0.0
7	1	0	.2	.3	.3	.3	3.6	4.9	4.0	1.9
28	-	1	.3	.3	.3	0	3.8	5.2	5.2	2.7
35	-	-	1	.3	.4	0	3.1	4.5	3.6	1.8
38	-	-	-	1	.4	0	3.1	4.1	3.5	1.7
39	-	-	-	-	1	0	3.0	4.0	3.3	1.7
57	-	-	-	-	-	1	4.5	7.2	7.3	4.3

Proportion Passing the Multiple Cutoff Criteria		-1.5	-1.0	-0.5	0.0
	TC/Gunner	70.3%	44.6%	19.8%	5.7%
	Driver	81.9%	62.0%	37.2%	16.1%

Average Correlation (Off Diagonal)		
	TC/Gunner	0.21
	Driver	0.13

Table 8. Moderate-Correlation Calculations

Attribute	Attribute Intercorrelation						Percent Failing on This Attribute Only Under Multiple Cutoff Criteria of (Standard Score):			
	7	28	35	38	39	57	-1.5	-1.0	-0.5	0.0
7	1	0	.283	.424	.424	.424	2.5	4.3	3.7	1.8
28	-	1	.424	.424	.424	0	3.7	4.9	4.8	3.0
35	-	-	1	.424	.566	0	2.9	3.6	3.7	1.9
38	-	-	-	1	.566	0	2.5	3.4	3.0	1.5
39	-	-	-	-	1	0	2.0	3.0	2.4	1.1
57	-	-	-	-	-	1	4.7	6.9	7.6	5.3

Proportion Passing the Multiple Cutoff Criteria		-1.5	-1.0	-0.5	0.0
	TC/Gunner	72.7%	48.5%	24.1%	7.6%
	Driver	82.7%	63.5%	39.7%	17.2%

Average Correlation (Off Diagonal)		
	TC/Gunner	0.29
	Driver	0.19

Table 9. Moderate-High Correlation Calculations

Attribute	Attribute Intercorrelation						Percent Failing on This Attribute Only Under Multiple Cutoff Criteria of (Standard Score):			
	7	28	35	38	39	57	-1.5	-1.0	-0.5	0.0
7	1	.3	.4	.6	.6	.6	2.2	3.2	3.3	2.3
28	-	1	.6	.6	.6	.3	2.4	4.0	4.2	3.2
35	-	-	1	.6	.8	.3	2.0	2.8	2.8	1.8
38	-	-	-	1	.8	.3	1.5	2.4	2.1	1.5
39	-	-	-	-	1	.3	1.0	1.2	1.1	0.6
57	-	-	-	-	-	1	3.3	5.0	6.0	4.5

Proportion Passing the Multiple Cutoff Criteria		-1.5	-1.0	-0.5	0.0
	TC/Gunner	77.6%	57.0%	33.5%	15.2%
	Driver	84.9%	68.3%	45.9%	24.6%

Average Correlation (Off Diagonal)		
	TC/Gunner	0.49
	Driver	0.47

Table No. and Title

The four tables correspond to four levels of correlation between the six candidate "extranormal" attributes. Several runs were made assuming a zero correlation (Table 6), several more assuming low correlations (Table 7), moderate correlations (Table 8), and moderate to high correlations (Table 9). Table titles simply reflect these levels of correlation and comparisons across levels must be made across tables.

Attribute (first column)

The number, as assigned previously in the text, of each attribute.

Attribute Intercorrelations (next 6 columns)

These columns show the attribute by attribute intercorrelation matrix. By definition, the data entries on the diagonal are all equal to 1.0. Data entries above the diagonal are the attribute by attribute correlations and are entered by the user prior to running the simulation program. Items below the diagonal are not shown since they are merely the mirror image of the items above the diagonal (e.g., the correlation between #7 and #28 is the same as for #28 and #7).

Percent Failing on This Attribute Only etc.

The first row under this heading shows, in standard deviations, the cutoffs for a multiple cutoff selection strategy. They range from a standard deviation of -1.5 to 0.0. The -1.5 cutoff is relatively lenient since it means that anyone scoring higher than one and a half standard deviations below the mean on each attribute will pass. Alternatively, 0.0 is very strict since it means that, in order to pass, the simulated soldier must score at or above the mean on each attribute. The data entries under each column show the contribution of each attribute taken individually to the total pass/fail rate for the TC or Gunner. (For Driver data, see footnote, Table 6.) An entry of 4.6%, for instance means that if that attribute were dropped from the multiple cutoff scheme, the overall pass rate would be increased by an expected 4.6 percentage points. It should also be noted that in practice the cutoffs would be set individually for each attribute. Attribute number 7, for instance, might be set at -1.0, number 28 at -1.6, etc. The cutoffs are assigned by the user prior to running the simulation, and do not necessarily have to be the same across all other attributes though they are the same in these tables.

Proportion Passing the Multiple Cutoff Criteria

The next two rows of the tables show the percentage of simulated soldiers passing all six criteria for TC/Gunner and all three criteria for the Driver under the selected cutoff criteria.

Average Correlation (Off Diagonal)

The mean of the off diagonal correlation coefficients is given for all six attributes (TC/Gunner) and for those three attributes appropriate only for the Driver. These values are used later to develop a graphical relationship between "Percent Passing" and "Average Correlation," that is useful for rapidly approximating multiple cutoff effects without using the computer simulation model.

The tables depict a complex relationship between attribute correlation and multiple cutoff selection. First, as expected, the tables show that as the attribute by attribute correlations rise from zero to moderate-high the percentage passing all six increases. This increase is most noticeable under the 0.0 criterion for TC/Gunner. At the 0.0 criterion with zero attribute correlations, only 1.7% of the simulated soldiers passed. This rises to 5.7%, 7.6% and 15.2% on successive tables with increasing attribute by attribute correlations. The last table (Table 9), in particular, also shows the effects obtained on an individual attribute basis as the correlations rise. Attribute number 39, for instance, was entered as the attribute most highly correlated with the remaining attributes (.6, .6, .8, .8 and .3). As such, the individual contribution of number 39 to the overall pass/fail rate was the least (1.0%, 1.2%, 1.1% and 0.6% across the four criteria). In other words, this highly correlated attribute contributed very little, on its own, to the overall pass/fail rate. The two main points to be recognized in the complex correlation-cutoff relationships are: (1) an attribute that is highly correlated with the others will eliminate relatively few candidates all by itself, while an attribute relatively unrelated to the others will eliminate a comparatively large number of candidates; and (2) as the cutoff criteria become more strict (e.g., change from -1.5 to 0 standard deviations), fewer candidates are rejected on only one variable and more are rejected on combinations.

Not illustrated until the final application of the model (Section C of this chapter), are the complex relationships between the pass/fail rate from the multiple cutoff scheme and the predicted performance scores from the multiple regression scheme. Some of those relationships are addressed in that later section and in Appendix D. The predicted performance scores are particularly useful where lenient multiple cutoff criteria are adopted. Consider, for instance, the data in the -1.5 criterion column in the low correlation table (Table 7). Here, it can be seen that 70.3% of the soldiers pass all six multiple criteria leaving a relatively large pool of soldiers available for training. Additional TC/Gunner selection could be based on multiple regression (i.e., on the predicted performance score). Examination of the scores themselves, available from the simulation, can provide a good indication of the top 10%, 20%, 30%, etc., of soldiers to be finally selected for training. The user can examine the distribution of these finally selected soldiers with respect to each attribute and overall predicted performance.

A convenient method for approximating the results of varying multiple cutoff criteria is seen in Figure 2. For each set of multiple cutoff criteria used in Tables 6-9, a pair of straight lines approximates the relationship between the mean (or average) correlation off the diagonal (see tables) and the percent of personnel passing on all designated attributes. This device is presented as an additional tool for the analyst who may not wish to conduct a complete computer simulation for each interim change in cutoff criteria. However, it provides only an approximate relationship. Final values for the parameters of interest should still be obtained from the computer simulation.

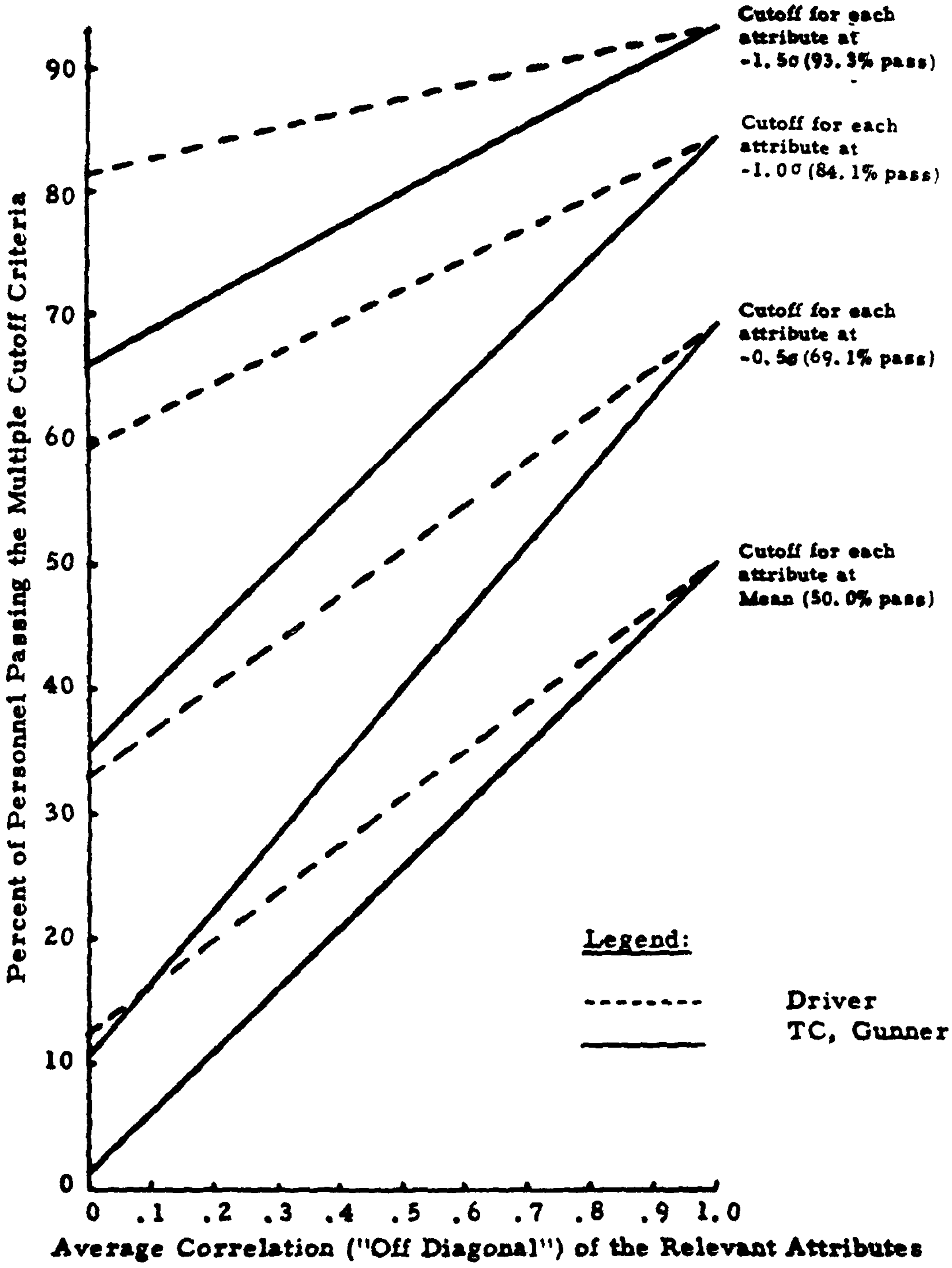


Figure 2. Approximate Relationship Between "Percent Passing" and "Average Correlation."

B. Estimation of Model Input Data

In order to exercise the computer-based simulation model so as to make a final determination of extranormal requirements, it was necessary to specify the levels of various parameters, including: (1) the correlations between tests of the six unique attributes; (2) the correlations between those attributes and performance in the TC, Gunner and Driver positions; and (3) the minimum cutoff criteria for those attributes to assure disqualification of individuals that are unquestionably deficient in these three crew positions. Table 10 and the following paragraphs summarize the estimation of those parameters.

The estimated correlations between tests of the six attributes are based on a review of published data reporting correlations between tests very similar to, if not exactly the same as, the tests identified herein. In particular, Parker and Fleishman (1960, Appendix D) provide a comprehensive set of intercorrelations for tests of about 50 variables. Some of those 50 variables are specifically related to the unique attributes of interest here, including: (1) none for Attribute 7 (Balance--visual cues); (2) motor judgment, two-hand coordination, rate control and pursuit confusion for Attribute 28 (Rate control); (3) none for Attribute 35 (Closure abilities: flexibility of closure); (4) aerial orientation, visualization of maneuvers and spatial orientation for Attribute 38 (Spatial abilities: spatial orientation); (5) formation visualization and stick and rudder orientation for Attribute 39 (Spatial abilities: spatial visualization); and (6) none for Attribute 57 (Nighttime dynamic visual acuity). Other variables correlated by Parker and Fleishman (1960) and Fleishman (1958) provide suggested levels of association by referring to tests somewhat similar to those of interest here, and by presenting additional correlation data and factor loadings of test variables on particular attributes. Using all of those available data as guidelines, the correlations between the attribute tests were estimated, as shown in Table 10, and they are considered to be realistic.

The estimated correlations between attribute tests and performance in the TC, Gunner and Driver positions relied entirely upon the informed judgments of subject matter experts. No reliable data were available to provide guidance for this estimate. The procedure for estimating these data involved independent assessment and subsequent consensus by the four project team members considered most knowlegable in this area. Brought together for this particular purpose, these subject matter experts (SMEs) were instructed as follows:

- Assume that all individuals who are unquestionably deficient in any of the three positions have been eliminated from the group.

- Using a correlation scale of 0 - 3 (corresponding to none, low, medium and high), estimate the degree to which you would expect job performance to improve as attribute test score improves.

- Record your estimates independently on the supplied form (similar to Table 10).

- As a group, discuss your estimates and the reasons for your choices. Then, make any modifications you wish to your estimates.

- Average the four SMEs' estimates, to provide a single estimate for each attribute's "correlation" with performance on each job. (These "correlations" are listed in Table 10.)

The estimated cutoff score for each attribute was derived in a manner similar to that listed above for the correlations. No specific guidance data were available for this estimate, either. Score distributions in the MOS 11B/19D populations were assumed to follow the data listed previously in Table 4 (Chapter IV) and plotted in the graphs of Appendix C. The SMEs were instructed to select a lenient cutoff score to eliminate only those individuals who are so lacking in the specific attribute that they are unquestionably deficient and should not be allowed to serve in the crew position under consideration. Each of the four SMEs made an independent estimate; those estimates were discussed, modifications were made; and, an average cutoff was estimated for each attribute with regard to each job. (These cutoff criteria are listed in Table 10.)

It can be noted now, on the basis of the cutoff criteria judgments, that none of the attribute level requirements is considered to be "extranormal." Cutoffs ranged from 10-25% as opposed to 50% or more. Since no validated criteria for cutoff can be specified for the prediction indices either, no unusually stringent selection requirement is now determined to exist. Since these conclusions are based on "best estimates," it remains for future testing and assessment of IFV/CFV TCs, Gunners and Drivers to collect the field data necessary to validate or modify the estimated model input parameters (Table 10).

Table 10. Estimated Computer Input Parameters

	Inter-Test Correlations					Selection Parameters			
						"Correlation" With Job Performance*		Cutoff Criteria (% rejects)	
	7.	28.	35.	38.	39.	TC/Gunner	Driver	TC/Gunner	Driver
57. Nighttime Dynamic Visual Acuity	.3	0	0	0	0	2.3	2.0	10	10
39. Spatial Abilities: Spatial Visualization	.3	.3	.4	.4	-	2.4	2.0	20	20
38. Spatial Abilities: Spatial Orientation	.3	.3	.3	-	-	2.3	2.4	15	20
35. Closure Abilities: Flexibility of Closure	.2	.3	-	-	-	2.9	n.a.	25	n.a.
28. Rate Control	0	-	-	-	-	2.9	n.a.	25	n.a.
7. Balance--Visual Cues	-	-	-	-	-	1.6	n.a.	10	n.a.

*0 = none
1 = low
2 = medium
3 = high

n.a. = not applicable

C. Final Application of the Model

The SME consensus correlations and cutoffs shown in Table 10 were used as input parameters to the computer model. Simulated scores were then generated for 10,000 TC/Gunner candidates and 10,000 Driver Candidates. Table 11 shows the resulting computed intercorrelations between the attribute test scores, across these simulated soldiers. It can be seen that while these obtained inter-test correlations do vary from the desired or input correlations, they are nevertheless quite similar. Table 11 also shows the correlations between the attributes and the "predicted job performance" scores, across all simulated soldiers. The "predicted job performance" scores for each soldier were formed from linear combinations of his attribute scores. The weights for the linear combinations were chosen through multiple regression procedures detailed in Appendix D (along with a full description of the simulation process). In this instance, the weights were chosen to reflect the comparative magnitude of the SME consensus judgments of the attribute-job performance correlations given in Table 10. Different weights were used for TC/Gunner as compared to Driver. Thus, separate "predicted job performance" scores were generated for each group. It can be seen that, except for scale factors reflecting the distinction between the so-called SME "correlations" of Table 10 and the statistically-derived correlations of Table 11, the simulation closely reproduced the differential impact of each attribute on job performance.

The simulation output showed that 4,138 of the 10,000 simulated soldiers (41.4%) passed the cutoff point on all six of the attributes. It also showed that 6,075 soldiers (60.8%) passed on all three of the attributes relevant to the Driver position. In other words, it is estimated that 41.4% of the manpower pool would qualify for training in the Track Commander and Gunner positions and 60.8% would qualify for the Driver position. These results assume that all training candidates have already qualified for MOS 11B or 19D, and they are based on current best estimates concerning additional requirements for operation of the IFV/CFV.

Table 12 shows the distribution by attribute of the pass versus fail rate. The first column of Table 12 shows the desired cutoff point as indicated by the subject matter experts. The second column shows the actual cutoff achieved by the model. These first two columns should be

Table 11. Correlation Values Obtained in Two Simulations

11a. TC/Gunner

	Inter-Test Correlations 7	28	35	38	39	Correlation With Job Performance
57	.299	-.009	.008	-.003	-.011	.499
39	.302	.301	.394	.396	--	.515
38	.307	.300	.299	--	--	.522
35	.206	.303	--	--	--	.676
28	.005	--	--	--	--	.656
7	--	--	--	--	--	.343

11b. Driver

	Inter-Test Correlations 38	39	Correlation With Job Performance
57	-.005	.003	.612
39	.397	--	.554
38	--	--	.735

Table 12. Pass/Fail By Attribute For TC/Gunner And Driver (From Model)

	Judged Cutoff	Simulation Data: Percent Failed	Simulation Data: Percent Failed (on this variable only)
TC/Gunner			
#57 Nighttime dynamic visual acuity	10%	10.2%	4.1%*
#39 Spatial abilities: visualization	20%	19.9%	4.8%
#38 Spatial abilities: orientation	15%	14.3%	3.0%
#35 Closure abilities: flexibility	25%	24.5%	7.4%
#28 Rate control	25%	24.6%	8.6%
# 7 Balance-- visual cues	10%	9.8%	2.2%
			Passed all six = 41.4%
Driver			
#57 Nighttime dynamic visual acuity	10%	9.8%	6.7%
#39 Spatial abilities: visualization	20%	20.1%	11.5%
#38 Spatial abilities: orientation	20%	19.9%	11.2%
			Passed all three = 60.8%

*Data can be read as: 10% was desired cutoff; 10.2% was actually achieved by the simulation; and of the 10.2%, 4.1% failed on this attribute and only this attribute (i.e., remaining 6.1% of the 10.2% also failed on some other attribute(s)).

identical and vary simply as a function of sampling error. The third column shows the percentage of soldiers who failed only on each specific attribute. Concerning the TC and Gunner positions, it can be seen from the data in the third column that Attribute #28, Rate control, contributed most to the overall pass/fail rate (8.6 percentage points), followed by Attributes #35, #39 and #57. Attributes #7 and #38 contributed little to the overall rate (2.2 and 3.0 percentage points respectively). As can be seen, an attribute's individual contribution to the overall rate is a function both of its cutoff point and its correlation with other attributes.

Essentially, the data in Table 12 show the basic results of the "best estimate" multiple cutoff personnel selection strategy. This strategy can be manipulated by raising or lowering the cutoffs for any individual attribute and thereby affecting the overall pass/fail rate. It is also possible to accept the multiple cutoff scheme as it stands and continue the personnel selection process using multiple regression. Table 13 provides an overview of the scores of these simulated soldiers on each attribute. Of primary interest here is the distribution of scores within the Pass group since it is these scores which will be combined into one predicted performance score to be used for additional selection under the multiple regression subroutine.

Concerning the TC/Gunner positions, it can be seen (Table 13) that the Pass group averages above the mean on each of the six attributes. This is hardly surprising since, by definition, the cutoff method eliminated the low end of each distribution from the Pass group. The scores are above the mean by about one half of one standard deviation for Attributes #39, #38, #35 and #28, somewhat less for Attributes #57 and #7. The same kind of Pass/Fail differences can be seen for the Driver simulation data also shown in Table 13.

As outlined above, this simulation has used linear regression procedures to combine the attribute scores into predicted job performance scores for each simulated soldier. Table 14 summarizes key results for two such linear combinations for TC/Gunner and for Driver. The first scores are based on the linear weights which reflect the SME consensus judgments (Tables 10 and 11, as discussed above).

The second scores are based on simply adding together all attribute scores (the "unit weight" situation). This latter procedure is

Table 13. Means And Standard Deviations For Individual Attribute Scores Within The Pass And Fail Groups

		#57 night vision	#39 visual-ization	#38 orien-tation	#35 closure	#28 rate control	#7 balance visual
TC/Gunner							
All soldiers	$\bar{z}$	.00*	-.01	.02	.00	.01	.01
N = 10,000	S.D.	1.01	.99	1.00	.99	1.00	1.00
Pass group	$\bar{z}$	.21	.51	.48	.54	.53	.35
n = 4,138	S.D.	.84	.78	.84	.76	.75	.85
Fail group	$\bar{z}$	-.15	-.38	-.30	-.39	-.37	-.23
n = 5,862	S.D.	1.08	.96	.98	.96	.98	1.02
Driver							
All Soldiers	$\bar{z}$	-.01	.00	.00			
N = 10,000	S.D.	1.00	1.00	1.00			
Pass group	$\bar{z}$	.19	.41	.42			
n = 6,075	S.D.	.85	.77	.76			
Fail group	$\bar{z}$	-.31	-.64	-.64			
n = 3,925	S.D.	1.13	.98	.98			

*Entries are in terms of standard, or "z" scores. The overall mean for each attribute should be approximately 0.0 with a standard deviation of 1.0.

Table 14. Predicted Performance for Pass/Fail Groups--
Means and Standard Deviations

		Predicted Performance	
TC/Gunner		Using the Judged Intercorrelations	Based on the Assumption of No Information About Any Intercorrelations*
All soldiers	$\bar{z}$	.01	.01
N = 10,000	S.D.	1.00	1.00
Pass Group	$\bar{z}$	.74	.75
n = 4,138	S.D.	.75	.70
Fail Group	$\bar{z}$	-.51	-.52
n = 5,862	S.D.	.82	.80
Driver			
All soldiers	$\bar{z}$	.00	.00
N = 10,000	S.D.	1.00	1.00
Pass Group	$\bar{z}$	.50	.53
n = 6,075	S.D.	.78	.77
Fail Group	$\bar{z}$	-.79	-.82
n = 3,925	S.D.	.79	.75

*This is the extreme position which assumes that the attributes are related to the criterion but nothing is known about any interrelationships. Under these assumptions the best estimate of job performance is an equal combination of the predictor attributes. This estimate was made in order to generate the data summarized in the second column.

somewhat crude, but is the most reasonable one under a particular set of circumstances. The use of unit weights is exactly appropriate after one has judged that a specific set of attributes (e.g., these six) is relevant to job performance and after one has decided he is unwilling to assume anything about differences between inter-attribute correlations or about differences in the correlations between the attributes and job performance.

Both procedures were used in this example to provide some feeling of the degree to which the expert judgments of attribute-performance correlation differences affect the accuracy of predicted job performance scores.

It can be seen that, on the average, the distinction between Pass/Fail groups due to the multiple attribute cutoff criteria yields a large predicted job performance difference. For both TC/Gunner and Driver expert judgment predictions, the average Pass group predicted performance is about 1.25 standard deviations above that for the Fail group.

The results for the second, unit weight, predictions are nearly equivalent. The differences in job performance predictions between the Pass and the Fail groups are still at least 1.25 standard deviations. A further indication of how equivalent the two predictions of job performance were in this simulation exercise is their intercorrelation. For TC/Gunner, the correlation between the two performance predictions was .921; for Driver, the analogous value was .977. This shows that the results are robust; while the expert judgments have probably increased the accuracy of the simulation and have certainly contributed to the understanding of the entire situation, the possibility of errors in their judgment does not markedly impact our confidence in the validity of the simulation.

Note that, as one would expect, the Pass/Fail differences in predicted performance scores are greater than the differences on any of the attributes alone. This would make these predicted performance scores a sensitive scale along which to select training candidates if the number needed was smaller than the entire Pass group. Further selection for either the TC/Gunner or Driver positions would be accomplished by simply taking the top "n" estimated performance scores and assigning these candiates for training. The fewer candidates selected, the higher their predicted performance mean score would be. The more candidates selected, the closer their mean would approximate the mean of the full Pass group.

D. Summary

In summary, this chapter has presented the results obtained when exercising the model in general, and when applying it to the "best estimate" input parameters as determined by available data and the judgments of subject matter experts. Those results were intended to help determine if any attribute has extranormal implications. An attribute would be designated as extranormal if an insufficient proportion of the personnel pool possesses, or can be trained to possess, that attribute (Blocks 9 and 10). For purposes of this investigation, the "insufficiency" criterion for an attribute was defined as being less than 50% of those individuals now assigned MOS 11B or 19D (Block 11). Since the Army does not ordinarily measure and select on the individual unique attributes identified in this study, criteria in the present study were based upon normative data published for other populations.

The requirement for expediency dictated the utilization of informed judgments to select and combine existing test data for exercising the model and producing the estimates sought in the present effort (Block 12). Where data were non-existent, best estimates by subject matter experts were used. These experts provided best estimate cutoff levels on each attribute for minimally acceptable TC/Gunner and Driver performance and they estimated the correlation between each attribute and job performance. For example, a best estimate was made (in the absence of actual, measured correlation data) for the minimum acceptable test level of each attribute. Those cutoffs ranged from the 10th percentile to the 25th percentile of the population, and thereby did not create extra-normal requirements in themselves. Attribute intercorrelations were estimated from available literature, when possible, and from subject matter experts. The final simulation results showed that 41.4% of the available manpower pool are currently estimated to be qualified for training for the Track Commander and Gunner positions and 60.8% are estimated to be qualified for the Driver position. Additional selection among the qualified soldiers was made possible by using the multiple regression portion of the model to calculate a predicted performance measure for each candidate. On this measure, the qualified group averaged one and-a quarter standard deviations above the unqualified group, and selections among top qualified personnel would yield even higher mean predicted performance. At the present stage of knowledge regarding IFV/CFV tasks and personnel attributes, no specific cutoff score can be set for the prediction index.

The conclusion remains that no extranormal requirement is now determined to exist. However, the noted attributes which are not now used individually for personnel selection, are recognized as being especially needed to perform the new or unique IFV/CFV tasks.

VII. PERSONNEL MANAGEMENT AND CAREER IMPLICATIONS

The preceding section of this report showed that the combination of attributes required for Track Commander, Gunner and Driver may impose some stringent requirements on the selection process. Recognizing that the present analysis relied on reasonable estimates for cutoff criteria and intercorrelations, and that further actual measurements of Army personnel may result in the identification of even more severe availability and selection problems, it is appropriate to consider next the potential impact such problems may have on management procedures and MOS career structures (Blocks 13 and 14). That information can be used by the Army in modifying or developing new personnel management and promotion procedures.

The analyses performed in this study identified only three tasks and three positions as having had potentially extranormal implications for MOS 11B and 19D personnel (see Table 2, Chapter III). No unusual personnel selection demands were identified for FPWO (IFV) and Observer (CFV) positions. If, however, these crew members are to be trained for Driver, Gunner or Track Commander positions, they should possess all unusual attributes required for those positions, in addition to the normal attributes required in the Infantry or Cavalry for training in the positions of FPWO or Observer.

Since crosstraining usually takes place at the unit level, it is recommended that the Unit Commander be provided with information about crew potential for each of his IFV/CFV personnel based on their screening test scores for all unusual attributes. The Unit Commander can use these scores for guidance along with any other criteria normally used in making crosstraining decisions and crew assignments.

The results of analyzing tasks and comparative requirements for each crew position plus the training planning information from the U.S. Army Infantry School (USAIS)(1978), have led to the following recommendations regarding training, crosstraining and career patterns:

a. All entry level IFV personnel should receive FPWO training, as currently planned (USAIS, 1978).

b. All entry level IFV/CFV personnel should receive Loader training, since any crew member in the squad compartment may be required to load or assist in loading the TOW, 25mm gun and the 7.62mm coax machine gun.

c. All IFV/CFV personnel should be screened to receive Driver or Gunner training, as currently planned (USAIS, 1978).

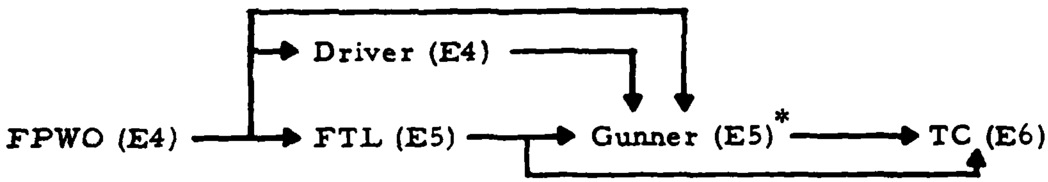
d. The Commander at the unit level should select institutionally trained personnel to crosstrain as Drivers, Gunners and Track Commanders based on their prior training, unique attribute measurements, other normally used attribute criteria and the Commander's own evaluation. This recommendation is intended to help maintain skill levels and crew assignment flexibility.

e. Gunners should be crosstrained as Track Commanders. For dismounted operations, the Gunner assumes the vehicle commander's role and, therefore, must be able to perform the duties and tasks of a Track Commander. In addition, this will facilitiate the performance of interactive tasks that are predominant in the turret.

f. Gunners and Fire Team Leaders should be of equal maximum rank so that either one having the required unique attributes may be promoted and trained as Track Commander (at present, the Gunner's maximum grade level is E4). The implication of this recommendation is that the Gunner in an IFV should not be required to become a Fire Team Leader before promotion to Track Commander (i.e., he should remain as a turret crew member to maintain turret proficiency). Furthermore, during IFV tactical operations, the Gunner has a command role of at least equal importance to the FTL (i.e., he is the Carrier Team Commander during dismounted operations) and, therefore, should have a rank commensurate with those responsibilities.

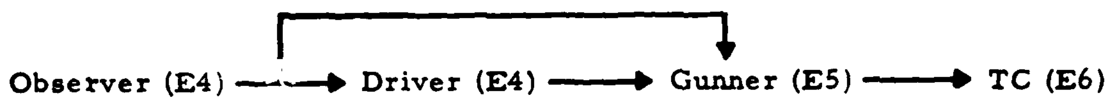
g. **The following career pathways are recommended for IFV and CFV crews:**

(1) <u>IFV:</u>



***At present the Gunner's maximum grade level is E4.**

(2) <u>CFV:</u>



VIII. CONCLUSIONS

A total of six attributes not presently used for personnel selection were found to be especially needed for IFV/CFV crew members. Although this analysis determined none of these personnel attributes to be extranormal, that finding was based upon best estimates of minimum required testing levels, normative data and attribute/job intercorrelations in the Army population. As such, it is recommended that more specific data be collected on the actual population of concern (MOS 11B and 19D), in order that the findings of this effort be either validated with greater confidence or modified, if necessary. In the absence of any further attribute analyses on the IFV/CFV personnel pool, researchers may use the results of the present effort with fair confidence that they reflect the true circumstances associated with personnel selection.

For the immediate future, it is recommended that crew trainees be tested on the six unique attributes, but that selection not be based on their scores. It is estimated that about 59% of the trainees for Track Commander or Gunner positions may score below the cutoff criteria established in this report on one or more of the six attributes. A smaller proportion (39%) of Driver trainees may score below the cutoff criteria on the three attributes found to be unique for that position. The entire trainee population should then be tested before and after training, and evaluated on training devices and on the job, in order to validate the norms and intercorrelations (between the attributes themselves and between attributes and job performance). Decisions for actual selection for crew training should be based only on those specific data. Close management of personnel, in terms of pre- and post-testing and associated performance evaluation, is recommended for the first several hundred individuals trained as IFV/CFV crew members. A reduction in the level of data collection can follow later, if desired.

Crosstraining and career structure analysis, based on a comparison of attributes and job descriptions, has shown that: candidates for Track Commander include the Gunner and IFV Fire Team Leader; candidates for Gunner include the Driver, CFV Observer, IFV Fire Team Leader and IFV Firing Port Weapon Operator; and candidates for Driver include the IFV Firing Port Weapon Operator and CFV Observer. These relationships are seen at the end ot Section VII.

Finally, it is recommended that the computer model, described in Chapter V and Appendix D, be employed whenever data become available and/or other options need to be evaluated.

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We are also indebted to Ms. Dorothy L. Finley and Mr. Harold C. Strasel of the U.S. Army Research Institute, Fort Benning Field Unit, for their constructive reviews and comments regarding the work performed and this final report.

APPENDIX A

Attribute Definitions for the Working Taxonomy

No. 1--Static strength: arm-hand-shoulder emphasis

The capacity to apply and maintain a force using the combined arm, hand and shoulder muscles, without moving the rest of the body or the object to which the force is applied.

No. 2--Dynamic strength: arms-flexor emphasis

The capacity to apply a force using the arms with elbow flexion (bending), and to move the object (to which the force is applied) at some measurable rate.

No. 3--Dynamic strength: arms-extensor emphasis

The capacity to apply a continuous force using the arms with elbow extension (straightening) and to move the object (to which the force is applied) at some measurable rate.

No. 4--Dynamic strength: legs

The capacity to apply a continuous force using the legs (in extension or flexion), and to move the body or an object (to which the force is applied) at some measurable rate.

No. 5--Trunk strength

The capacity to apply a force using the trunk muscles (back, stomach, etc., in any direction) with or without moving the body or an object (to which the force is applied).

No. 6--Gross body equilibrium

The ability to react to body motions, and to adjust body movement to maintain equilibrium under adverse conditions (dynamic equilibrium). The ability to maintain a fixed posture (static equilibrium).

No. 7--Balance-visual cues

The ability to utilize visual cues to maintain balance under adverse conditions such as when cues from the equilibrium senses are absent, distorted, or subject to interference.

No. 8--Speed of limb movement: arms

The rate at which one can make a gross, discrete movement of the arms where skill is not involved.

No. 9--Speed of limb movement: legs

The rate at which one can make a gross, discrete movement of the legs, where skill is not involved.

No. 10--Gross body coordination

The ability to coordinate the simultaneous actions of different parts of the body while making gross body movements.

No. 11--Stamina/endurance

The capacity to maintain maximal muscular efforts over long periods of time.

No. 12--Verbal knowledge

The degree to which one understands and can utilize written and spoken language.

No. 13--Word fluency

The degree to which one's speech flows coherently, smoothly and without effort.

No. 14--Numerical ability

The rapidity and accuracy with which one is able to complete number manipulations and computations.

No. 15--Concept fluency

The smoothness and ease with which more or less abstract thoughts and ideas are understood and expressed.

No. 16--General reasoning

The broad ability to grasp all kinds of systems that are conceived in terms of semantics or verbal concepts, including but not restricted to the understanding of problems of an arithmetical type.

No. 17--Seeing implications and consequences (foresight)

The ability to use existing cues to anticipate likely occurring events by imaging or employing symbolic representation.

No. 18--Practical judgment

The ability to use rational mental processes (such as association, recall, combining, references, concept formation and concept analysis) to form an opinion or evaluation or to develop a serviceable solution to a problem.

No. 19--Intelligence

The ability to understand and deal effectively with tasks involving abstractions or new situations.

No. 20--Arm-hand steadiness

The ability to make precise and steady arm-hand positioning movements where strength and speed are minimized.

No. 21--Wrist-finger speed

The rate at which one can make gross movements of the wrist and fingers, including pendular as well as rotary wrist motions.

No. 22--Finger dexterity

The ability to use one's fingers to make skillful, controlled manipulations of small objects.

No. 23--Manual dexterity

The ability to make skillful, well directed arm-hand movements in manipulating fairly large objects under speed conditions.

No. 24--Control precision

The ability to make fine, highly controlled adjustments of the large muscle groups in the arms or legs.

No. 25--Multilimb coordination

The ability to coordinate the movements of a number of limbs simultaneously.

No. 26--Movement analysis

The ability to analyze the velocity, acceleration and higher derivative characteristics of target motion.

No. 27--Movement prediction

The ability to mentally integrate target motion components to estimate future target position.

No. 28--Rate control

The ability to make continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving target or object.

No. 29--Acceleration control

The ability to control a dynamic system in which system acceleration is directly proportional to the force applied to the control.

No. 30--Reaction time

The time from receiving of a stimulus to the beginning of an action. Simple: the time required to make a single response to a single stimulus or signal. Complex: the time required to react when a discrimination must be made from among several stimuli.

No. 31--Discrimination abilities

The ability to accurately differentiate from among several stimuli in any one of the senses.

No. 32--Perceptual speed

The fastest rate at which one can correctly perceive individual stimuli in any of the senses.

No. 33--Time sharing

The ability to integrate or otherwise utilize information obtained by shifting between two or more channels of information.

No. 34--Closure abilities: speed of closure

The rate at which one is able to unify or organize an apparently disparate field into meaningful units.

No. 35--Closure abilities: flexibility of closure

The ability to identify a previously specified stimulus configuration that is embedded in a more complex sensory field, possibly with reduced, altered or abstract visual cues.

No. 36--Auditory identification abilities: auditory rhythm discrimination

The ability to differentiate different sounds on the basis of their individual rhythmical characteristics, and to associate individual rhythmical sounds with their originating sources.

No. 37--Auditory identification abilities: auditory perceptual speed

The rate at which one can accurately perceive and identify individual sounds.

No. 38--Spatial abilities: spatial orientation

The ability to utilize cues from the equilibrium senses, visual senses or instruments to maintain a correct wareness of body orientation with respect to a specified reference object (e.g, the ground).

No. 39--Spatial abilities: spatial visualization

The ability to utilize cues from the visual sense, other senses, or instruments to develop an accurate mental image of an object or group of objects within or outside of an environmental context.

No. 40--Associate memory: rote memory

The ability to accurately recall or reproduce learned material, without regard to meaning, by responding to one or more things with which it is associated.

No. 41--Associate memory: meaningful memory

The ability to accurately recall or reproduce the meaningful substance of learned material by responding to one or more things with which it is associated.

No. 42--Memory span: immediate memory

The number of simple items (e.g., numbers) that one is able to accurately recall or reproduce, immediately following a single presentation or impression.

No. 43--Memory span: Integration I (large number of detailed rules)

The number of detailed items (e.g., rules) for which one is able to accurately recall or reproduce the meaningful substance, immediately following a single presentation.

No. 44--Visual memory

The ability to accurately recall or reproduce a more or less complete representation of the attributes of an object or event once visually experienced but not now present to the senses, together with a recognition of its "pastness."

No. 45--Leadership

The ability to successfully exercise authority by appropriately initiating, guiding and controlling the actions or attitudes of others.

No. 46--Closeness of interactions

The degrees of attentiveness to others and self-revelation which characterize one's interpersonal communications and relationships.

No. 47--Amount of interaction

The frequency with which one participates in interpersonal communications and relationships during the conduct of work and personal activities.

No. 48--Strength of interaction

The degree to which one is assertive or reticent in getting needs met, expressing feelings and exercising rights.

No. 49--Aggression reaction

The tendency to display hostility in the pursuit of one's goals, sometimes resulting in hurting others or impinging on their rights.

No. 50--Conformity and/or control reaction

The tendency to need group agreement or support rather than to make decisions and take action independently.

No. 51--Flexibility:rigidity reaction

The tendency for one to be able or unable to readily change a set, a line of thinking, or a behavior in order to meet changing circumstances.

No. 52--Self-control reaction

The ability to guide one's own behavior, including the ability to suppress or inhibit impulsive or certain goal-seeking behavior for the sake of a more inclusive goal.

No. 53--Subjectivity:objectivity reaction

The tendency to perceive and respond to situations or individuals with or without personal bias.

No. 54--Emotionality, sensitivity of reaction

The ease and strength with which one responds emotionally to situations or individuals, including the degree of tension and anxiety exhibited, and the way in which defense mechanisms are utilized.

No. 55--Desired level of output

The degree of internal motivation to become actively involved in goal-seeking behavior.

No. 56--Desired type of output

The tendency toward responding to situations or individuals with characteristic behaviors, such as: bold or restrained; responsible or irresponsible; careful or careless; optimistic or pessimistic; and others.

No. 57--Nighttime dynamic visual acuity

The ability to perceive the detail of moving objects at low levels of illumination.

No. 58--Motion--vibration tolerance

The ability to experience no deleterious effects in performance, perception and other physiological and psychological attributes, as a result of being in an environment which is in continuous and varying linear and angular motion due to acceleration, jerk and their higher order derivatives.

No. 59--Eye-hand coordination

The ability to coordinate rapid and precise hand movements with features in the near visual field.

No. 60--Time estimation

The ability to accurately estimate various time intervals on the basis of unaided mental processes, such as by utilizing environmental cues, intuition, body rhythms and familiarity with known intervals between related events.

No. 61--Body dimensions

Bodily proportions and measurements (anthropometric data) with and without clothes.

No. 62--Selective attention

The ability to concentrate on the performance of a task in the presence of distracting stimulation external to the task or under monotonous conditions without significant loss in efficiency.

APPENDIX B

Scenarios Used For Analysis

Two scenarios of short engagement were developed in narrative format, along a time base, which highlight the tasks performed by the primary operators of the vehicle (Track Commander, Gunner, Driver). The roles of other crew members involve primarily monitoring and coordination activities. Though illustrated with IFV terminology, both scenarios are fire missions that can be applied to either IFV or CFV.

Mission Scenario #1 is a daylight offensive operation with the squad vehicle as the bounding element in a bounding overwatch in which contact with the enemy is expected. The scenario begins with a "Move Out" order from the platoon leader. Contact begins with a muzzle flash from an enemy weapon and continues with the bounding element responding with its primary weapon (25mm gun) while moving to a protected position. The scenario ends when the overwatching elements engage the enemy and the platoon leader announces that the target is suppressed.

Mission Scenario #2 is a night movement to a defensive position with the squad vehicle as the lead element in a traveling overwatch. The scenario begins with the Track Commander giving instructions to the Driver at a road junction. Contact is made when the Gunner detects a bright thermal image while conducting surveillance with the integrated day/night sight. An enemy tank is identified by the Gunner, confirmed by the Track Commander and a TOW missile engagement is ordered. The scenario ends with destruction of the enemy tank.

MISSION SCENARIO #1

MISSION SEGMENT: Offensive Operation: Squad is Bounding Element
Bounding Overwatch - Contact Expected

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
		INITIAL CONDITIONS - Platoon located at hill 450. Approaching hill 452. Mission - secure hill 452. - We are bounding element of 4 vehicle (IFV) platoon. - Daylight, contact expected. - Hill 452 is 1500M NE of 450. - Radio silence until contact. - Popped hatch mode on all vehicles. - Platoon (-) in overwatch on hill 450. - Initial bound to be 300m. - Vehicle prepared for move, turret weapons "battle sight." - TC has assigned sectors of surveillance to crew and general route to Driver.			
0:00	Platoon Leader Hand Signal	Receive hand signal to initiate bound			
0:03		Order "Driver left, move out" Observe turret indicator lights Select stabilization "On" Observe stabilization "On" indication	Announce "placing turret in motion" (IC) Observe turret indicator lights	Maneuver vehicle - - Depress foot brake - Release hand brake - Set driving range selector to "Drive" - Observe route of desired heading	Announce "turret deck clear" (FTL via IC) Observe assigned areas through vision blocks; FPWs at ready position (crew)
0:08		Observe assigned sector Maintain air surveillance	Squeeze palm switch and turn control handles to left Observe assigned surveillance area. Note turret reaching left sector limit	Announce "Moving Out" Release foot brake, depress throttle Maneuver vehicle to desired heading	(Continuous)

MISSION SCENARIO #1

MISSION SEGMENT: Offensive Operation: Squad is Bounding Element
Bounding Overwatch - Contact Expected

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
		Observe direction of movement and terrain Select and announce route changes to Driver → (continuous)	Turn control handle right → (continuous)	Maneuver vehicle in accordance with TC directions (continuous) (Vehicle moves about 200m)	
2:00	Muzzle Flash	Detect muzzle flash to right front in vicinity of hill 452			
2:01		Recognize target (mental process)			
2:02		Order hatches closed while closing own hatch.			
2:03		Grasp TC control handle, slew turret to vicinity of target. (May give verbal warning)	Observes/detects turret in TC override Closes hatch	Closes hatch, continues to observe type of terrain and continues to maneuver vehicle over selected route avoiding obstacles (trees, ditches, boulders, etc.)	
2:05		Observe target in alignment with vane sight	Observes target in unity window in day/night sight		
2:08		Order "Gunner, Battlesight, PC, direct front 1000 meters (estimates range)	Hears initial fire commands via IC and initiates response	Hears initial fire commands via IC	Hears initial fire commands via IC

MISSION SCENARIO #1

MISSION SEGMENT: Offensive Operation: Squad is Bounding Element
Bounding Overwatch - Contact Expected

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
2:10	Enemy Shell Impact	Observe shell impact direct front Announces, shell impact via IC	Shifts head and eye to day/night sight and observes target using 4X. Observes shell impact direct front. Hears TC's communication	Observe shell impact direct front. Hear TC's communication	Hears shell impact and TC's communication
2:11		Radios target information to overwatch element (as required) and observes target in TC day/night sight optical link	Moves gunner control handle to align target with optical reticle (continuous) and selects 12X on sigh[illegible]	Decides on required vehicle orientation with respect to target	
2:13		Verifies foe and orders "fire"	Identifies target as foe. Announces "foe."	Selects route offering best fighting position (mental process) and maneuvers vehicle accordingly	Maintain surveillance of assigned areas and monitor fire commands (continuous)
2:14		Continue to observe target in TC day/night sight optical link	Place master ARM/SAFE switch to ARM (right hand)	Maintains a steady platform during conduct of fire. Informs Gunner of any directional changes (as required)	
2:15	Enemy muzzle flash	Detect muzzle flash	Detect muzzle flash	Detect muzzle flash	
2:16	Platoon order to seek cover and concealment	Receives platoon order	Squeezes trigger Fires bursts Hears platoon order	Hears platoon order	Hears platoon order

MISSION SCENARIO #1

MISSION SEGMENT: Offensive Operation: Squad is Bounding Element
Bounding Overwatch - Contact Expected

TIME Min:Sec.	EXTERNAL	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
2:17		Order "Driver, left"	Tracks target	Maneuvers vehicle left	
2:21		Observes bursts with respect to target	Observes/senses bursts (visual/mental process)		
2:22		Advise Gunner of azimuth, elevation corrections (optional)	Applies corrections via gunner control handle and sight picture		
2:24		Order "Driver, straight"		Maneuvers vehicle straight ahead	
2:25	Enemy shell impact	Observe shell impact right rear	Squeeze trigger, fires bursts		Observe and report shell impact right rear
2:30		Observe own and overwatch element bursts on target	Observe own and overwatch bursts on target		
2:35	Platoon communication "target suppressed"	Receives communication	Hears communication	Hears communication	Hears communication

MISSION SCENARIO #2

MISSION SEGMENT: Night Movement to Defensive Position:
Squad is Lead Vehicle in Traveling Overwatch - Contact Possible

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
		INITIAL CONDITIONS - Platoon performing night march of 1000m to defensive position - Visibility limited due to overcast sky - Radio silence - March rate 15 mph - Squad vehicle is platoon lead vehicle - Surveillance areas have been assigned by squad leader - Platoon crossed SP at 2200 hours - Platoon has progressed approximately 300m - Vehicle approaching intersection Driver station prepared for night operation - Blackout drive - Night vision viewer installed (range 50m, FOV 45°) - Internal red lighting - Hatch popped - Engine running Gunner station prepared for night operation - Hatch popped - Integrated sight in night mode and 4X (range 2000m, FOV 6.6°) - Internal red lighting Track Commander station prepared for night operation - Turret power and stabilization on - Hatch popped - Night vision goggles on (range 50m, FOV 40° circular) - Internal red lighting Crew Compartment prepared for night operation - Internal red lighting - FPWs at "ready"			

MISSION SCENARIO #2

MISSION SEGMENT: Night Movement to Defensive Position:
Squad is Lead Vehicle in Traveling Overwatch - Contact Possible

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
0:00	Road junction 315 CP4	Observe CP4, order "Driver straight"	Maintains surveillance of assigned area while viewing through integrated sight, slews turret at slow rate (limited FOV) over assigned surveillance area	Observe CP4 in night vision viewer and maneuver vehicle accordingly (Vehicle moves 300m)	Monitoring Track Commander orders. Crew members 5 and 6 maintain visual contact with blackout markers of following vehicle. Report loss of visual contact to Track Commander,as required (via IC). (continuous)
0:50	Thermal image on right surveillance limit		Observe bright image on integrated sight and announce "Moving target, right limit, 1500 meters"		Monitor Gunner transmission and maintain "ready" to provide suppresive fire (continuous)
0:53		Removes goggles, observes target through sight repeater Orders "Driver stop" and hatches closed	Selects 12X on sight	Stops vehicle and closes hatch	
0:59		Close hatch	Close hatch		
1:03		Analyze target signature	Analyze target signature		
1:08			Identifies and announces target as "tank moving toward us"		

MISSION SCENARIO #2

MISSION SEGMENT: Night Movement to Defensive Position:
Squad is Lead Vehicle in Traveling Overwatch - Contact Possible

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
1:09		Verifies identification			
1:11		Reports target to platoon leader (via radio)			
1:16		Orders "Driver select and occupy a fighting position on the right"			Observes Platoon (-) stopped and reports to Track Commander (via IC)
1:21	Platoon order (via radio) "Engage target"	Receives platoon order and acknowledges	Hears platoon order Maintains surveillance of target	Maneuvers vehicle to the right, observes and selects fighting position through night vision viewer	
1:31		Orders "Gunner, missile, tank, right front, 1500 meters, Fire" Observes all indicators, Gunner actions and maintains surveillance of target	Set superelevation to TOW Select TOW launcher up Squeeze palm switches to erect launcher Depress TOW mode switch Move ARM/SAFE switch to ARM Depress missile #1 Observes all indicators Announces "On the way"	Responds to vehicle order and stops vehicle in selected fighting position	Hears and monitors fire command Maintain "ready"

MISSION SCENARIO #2

MISSION SEGMENT: Night Movement to Defensive Position:
Squad is Lead Vehicle in Traveling Overwatch - Contact Possible

TIME Min:Sec.	EXTERNAL SOURCE	TRACK COMMANDER	GUNNER	DRIVER	SQUAD AREA CREW (No. 4-6 FPWO's)
1:59		Observes thermal image of missile in flight	Squeezes trigger Tracks target by holding reticle on target signature Observes thermal image of missile in flight		
2:09		Observes bright thermal image of missile burst on target	Observes bright thermal image of missile burst on target	Observes missile flash	
2:14		Evaluates change in target thermal image through sight	Continues to track target signature		
2:17		Determines target destroyed			
2:18		Orders "Cease fire, return to battle sight"	Responds to order by: - Move ARM/SAFE switch to SAFE		
2:22		Report target destruction to Platoon headquarters (via radio)	- Lower TOW launcher - Select 4X on sight - Select battle sight ammunition - Resumes surveillance		

APPENDIX C

Supporting Data for Test Instruments

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
7. Balance-Visual Cues	Vestibular Disorentation Test	-	Ambler and Guedry, 1965	Report sent to COTR on 11/7/78. More information might be available from Guedry at Pensacola.
28. Rate Control	Motor Judgment Test	FL .40 rate control FL .40 control precision R = .76	Fleishman, 1958	(unknown)
	Two Hand Coordination	FL .32 rate control FL .25 rate control FL . 46 rate control FL .33 multilimb coordination	Fleishman, 1958	(unknown)
	Rate Control	FL .30 rate control FL .72 rate control FL .58 rate control FL .30 control precision FL .01 control precision FL .24 control precision FL .17 spatial orientation FL .47 spatial orientation FL .29 reaction time	Parker and Fleishman, 1960 (Finley et al. ref no. 189) Fleishman, 1958	(unknown)
	Pursuit Confusion--Time on Target (TOT) and Errors (E)	FL .37 TOT rate control FL .19 E rate control FL .12 TOT arm-hand steadiness FL .36 E arm-hand steadiness FL .24 TOT pursuit confusion doublet FL .31 E pursuit confusion doublet R = .82 TOT R = .84 E	Fleishman, 1958	(unknown)
	Multidimensional Pursuit (Bank and Altitude)	FL .37 rate control FL .32 response orientation R = .90	Fleishman, 1958	(unknown)

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
35.	Two-Hand Pursuit	FL = .37	Fleishman 1958	(unknown)
Closure Abilities: Flexibility of Closure	Gottschaldt Figures (printed) or Concealed Figures (revision of above)	FL .30 flexibility FL .41 of closure	Marron, 1953 (Finley et al. ref. no. 181)	Industrial Relations Center, University of Chicago, 1225 E. 60th Street, Chicago, Illinois Cost: $2 per specimen set, $4 per 20 tests
	Hidden Pictures (printed)	FL .47 flexibility of closure FL .40 R = .22	Marron, 1953; Frederiksen, 1965 (Finley et al. ref. no. 165)	Educational Testing Service, Princeton New Jersey or The Psychological Corporation, Eastern Region, 757 3rd Avenue, NY, NY 10017
	Embedded Figures (printed)	Corr .55 to .72 R for 17 yr males = .84 R *for* college males = .82 (manual)	Thornton et al., 1968 (Finley et al. ref. no. 198)	Consulting Psychologists Press, Inc. Palo Alto, CA Cost: $3 per set

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
38. Spatial Abilities: Spatial Orientation	Aerial Orientation (printed)	FL .52 spatial orientation R = .84	Parker and Fleishman, 1960	(unknown)
	Signal Interpretation (printed)	FL .45 spatial orientation FL .30 response orientation R = .77	Parker and Fleishman, 1960	(unknown)
	Spatial Orientation Test (Part 5 of Guilford-Zimmerman Aptitude Survey) (printed)	FL .35 spatial orientation FL .45 perceptual speed	Parker and Fleishman, 1960	Sheridan Supply Co. P.O. Box 837 Beverly Hills, CA Cost: $2.35 per specimen set 4¢ per IBM answer sheet for any one part 75¢ per scoring stencil for any one part 40¢ per manual
	Forced Landings	FL .29 spatial orientation	Parker and Fleishman, 1960	(unknown)
39. Spatial Abilities: Spatial Visualization	Mechanical Principles Test	FL .53, .40 visualization FL .52, .61 *mechanical* experience	Fleishman, 1957 (Finley et al., ref. no. 154) Parker et al., 1965 (Finley et al., ref. no. 190)	(unknown)
	Object Identification Test		Harris, W., 1967 (Finley et al., ref. no. 171)	Author: William Harris, 6780 Cortona Drive, Goleta, CA 93017
35. Flexibility of Closure; 38. Spatial Orientation;	Hidden Patterns (printed)	FL .44 flexibility of closure FL .51 spatial orientation FL .28 spatial visualization R = .87	Frederiksen, 1965	Educational Testing Service, Princeton, New Jersey Cost: $2.75 per 25 tests

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
39. Spatial Visualization	Form Board Test	FL .53 flexibility of closure FL .42 spatial orientation FL .45, .89 spatial visualization R = .81	Frederiksen, 1965 Frederiksen, 1966 (Finley et al., ref. no. 166) French et al., 1963 (Finley et al., ref. no. 168)	
	Revised Minnesota Paper Form Board Test	-	Buros, 1972	The Psychological Corp., Eastern Region, 757 3rd Avenue, NY, NY 10017 212 754-3500 Cost: hand scoring edition: $3 per 25 tests, manual and scoring stencils; machine scorable edition: $4.50 per 25 tests, $2.50 per 50 answer sheets, 70¢ per set of manual and scoring stencils
	Pattern Comprehension Test (printed)	FL .34, .31 spatial orientation FL .66, .60 spatial visualization	Fleishman, 1957	(unknown)
	Speed of Identification Test (printed)	FL .21, .37 spatial orientation FL .44, .38 spatial visualization	Fleishman, 1957	(unknown)
38. Spatial Orientation:	Formation Visualization (printed)	FL .33 spatial orientation FL .61 spatial visualization	Parker and Fleishman, 1960	(unknown)

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
39. Spatial Visualization	Visualization of Maneuvers (printed)	FL .46 spatial orientation FL .47 spatial visualization R = .87	Parker and Fleishman, 1960	(unknown)
	Stick and Rudder Orientation (printed)	FL .53 spatial orientation FL .57 spatial visualization R = .74	Parker and Fleishman, 1960	(unknown)
	Complex Coordination Test (apparatus)	FL .39, .10 spatial orientation FL .38, .10 spatial visualization R = .82	Fleishman, 1957 Fleishman, 1958 Parker, et al., 1965	(unknown) (unknown) (unknown)
	Paper Folding	FL .34 spatial orientation FL .36, .93 spatial visualization R = .84	Frederiksen, 1965 French et al., 1963	Educational Testing Service, Princeton, New Jersey Cost: $2 per 25 tests
38. Spatial Orientation; 39. Spatial Visualization	Choosing A Path	FL .61 spatial scanning FL .41 spatial orientation	Frederiksen, 1965 French et al., 1963	Educational Testing Service, Princeton, New Jersey Cost: $3.75 per 25 tests
	Surface Development Test	FL .46 spatial orientation FL .48 spatial visualization R = .90	Frederiksen, 1965 French et al., 1963	Educational Testing Service, Princeton, New Jersey Cost: $2.75 per 25 tests

Attribute	Tests Identified	Factor Loading/FL Reliability/R	Author/Source Other References	Availability
35. Flexibility of Closure; 39. Spatial Visualization	Hidden Figures/ Concealed Figures	FL .40 flexibility of closure FL .66 spatial visualization R = .72	Frederiksen, 1965	Educational Testing Service, Princeton, New Jersey Cost: $2.75 per 25 tests Industrial Relations Center, University of Chicago, 1225 E. 60th Street, Chicago, Illinois Cost: $1 per specimen set, $5 per 20 tests
	Gestalt Completion Test	FL .40 spatial visualization	Frederiksen, 1965 French et al., 1963	Educational Testing Service, Princeton, New Jersey Cost: $2.75 per 25 tests
	Concealed Words	FL .46 spatial visualization	Frederiksen, 1966	Educational Testing Service, Princeton, New Jersey Cost: $2.75 per 25 tests
	Mutilated Words	FL .38 spatial visualization FL .55 speed of closure	Fleishman, et al., 1958 (Finley et al., ref. no. 342)	(possibly) Educational Testing Service, Princeton, New Jersey
35. Flexibility of Closure; 38. Spatial Orientation	Cards Rotation Test	FL .43 flexibility of closure FL .53 spatial orientation	Frederiksen, 1965 Frederiksen, 1966 French et al., 1963	Educational Testing Service, Princeton, New Jersey Cost: $2 per 25 tests

Cumulative Distribution Curves for Test Scores Related to the Six Potentially Extranormal Attributes

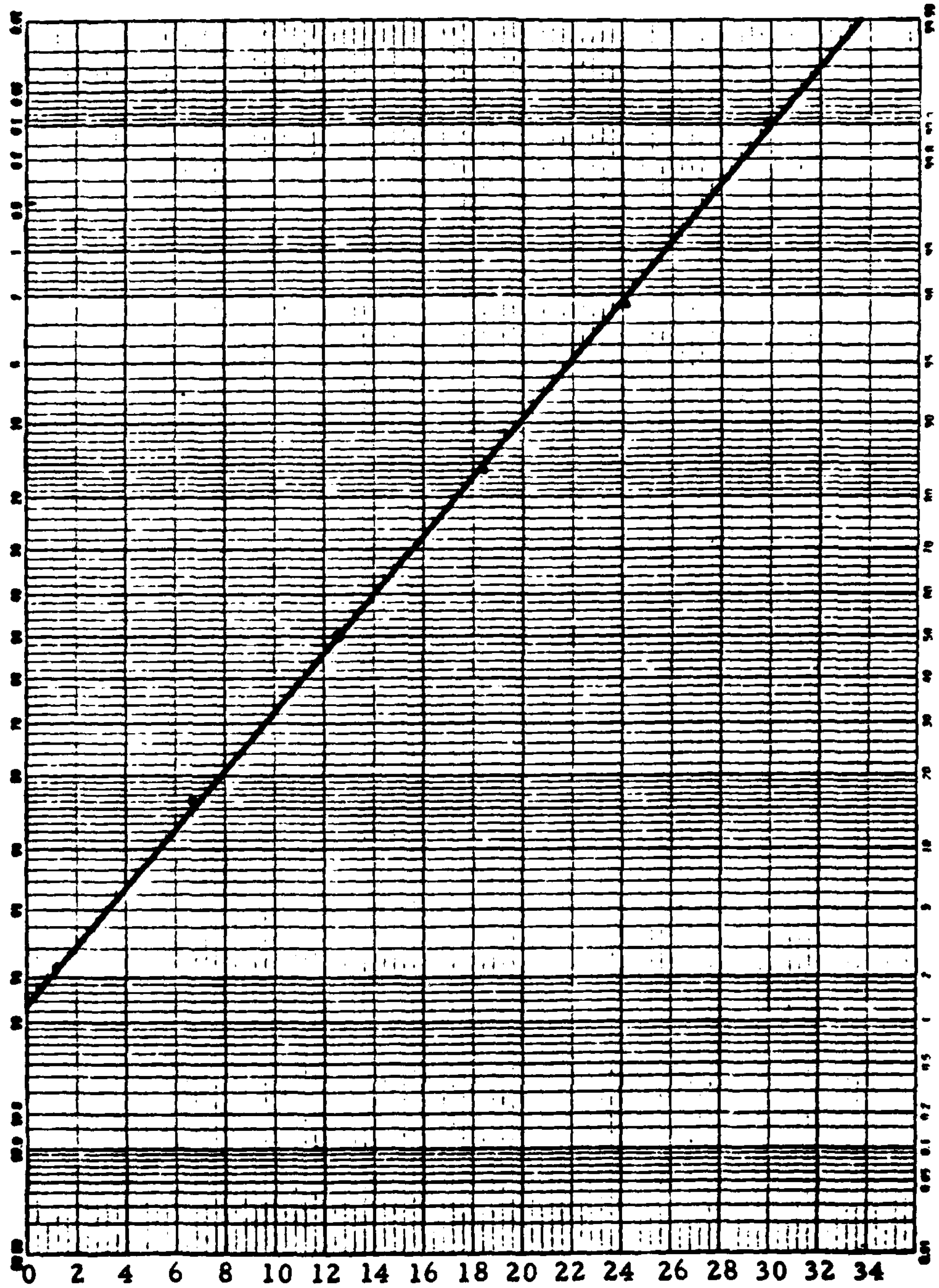
Note 1. These data use the means and standard deviations for those tests listed in Table 4 (found in the main body of this report). For purposes of preparing these curves, it was assumed that the data are normally distributed (but this may not be true in each case).

Note 2. The cumulative percentages associated with various departures from the mean are:

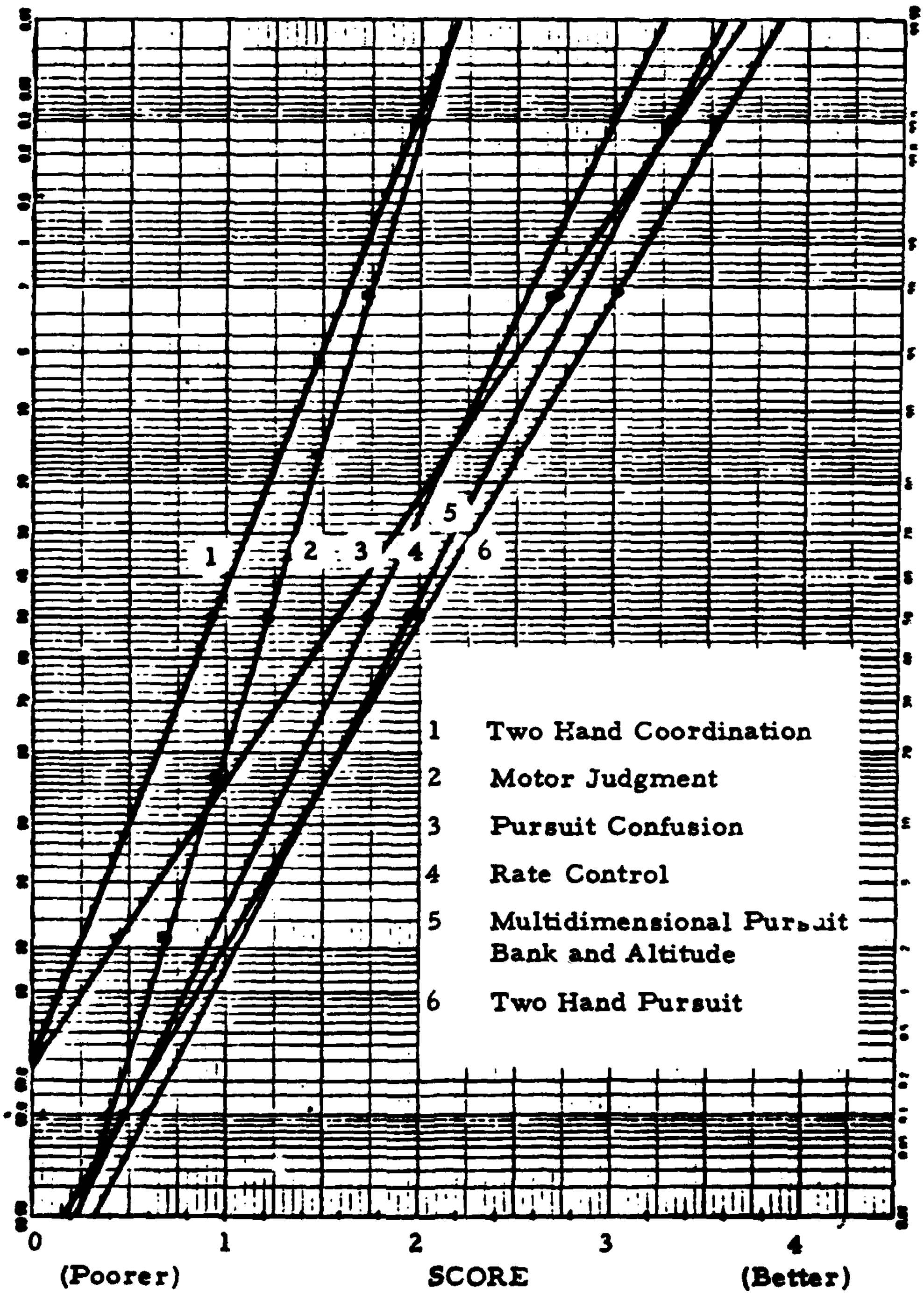
Departure in no. of standard deviations (Cutoff)	-3 σ	-2 σ	-1 σ	0 (Mean)	+1 σ	+2 σ	+3 σ
Cumulative percentage of the population below the cutoff	0.1%	2.3%	15.9%	50%	84.1%	97.7%	99.9%
Cumulative percentage of the population above the cutoff	99.9%	97.7%	84.1%	50%	15.9%	2.3%	0.1%

Note 3. For using the normative data in the computer-based model developed in this study, convert to a mean of 500 and a standard distribution of 100. Use the conversion formulas found in Appendix D, equations 13-18.

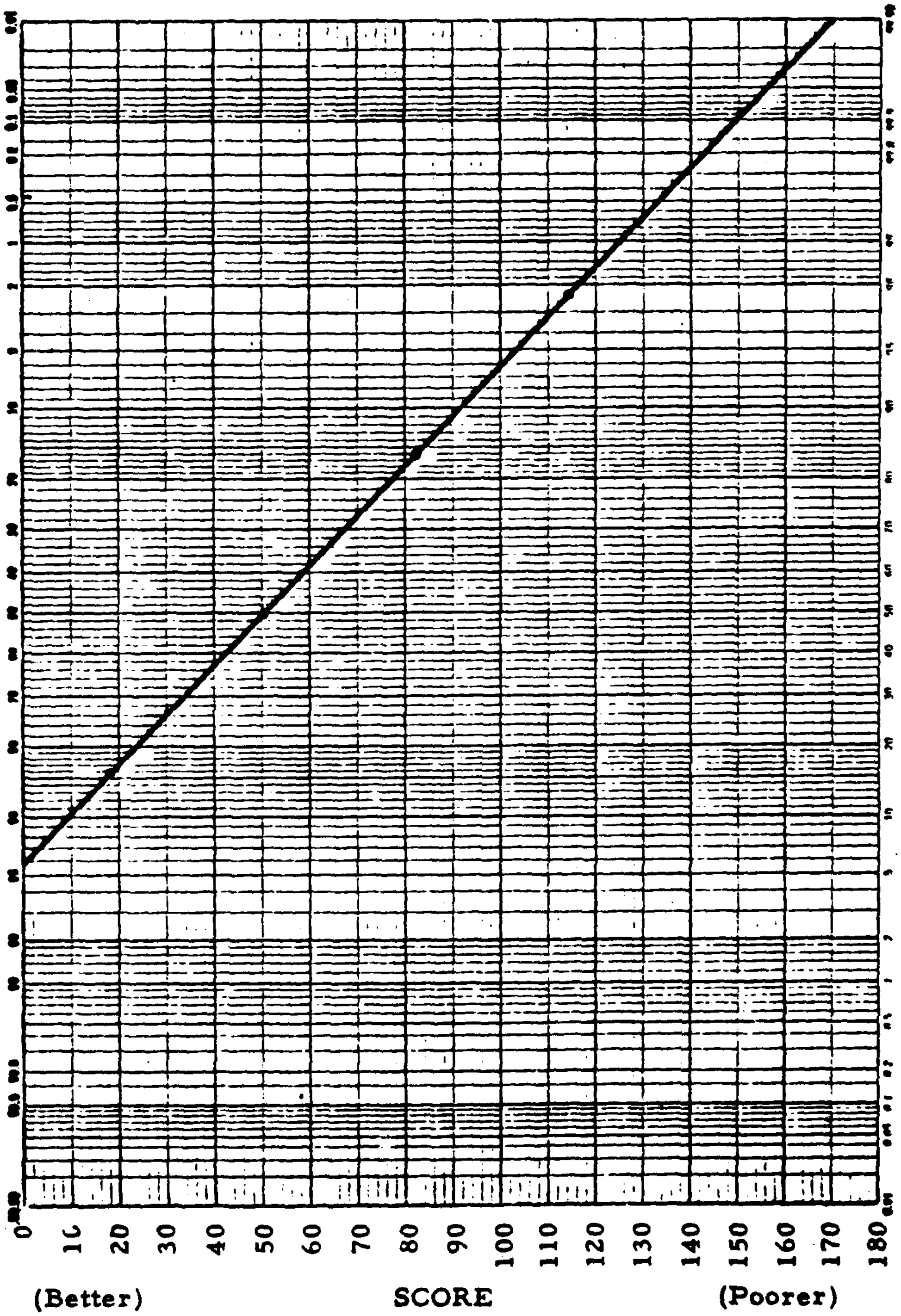
Attribute No. 7 - Balance--visual cues
Brief Vestibular Disorientation Test (BVDT)
(226 Naval aviation trainers)



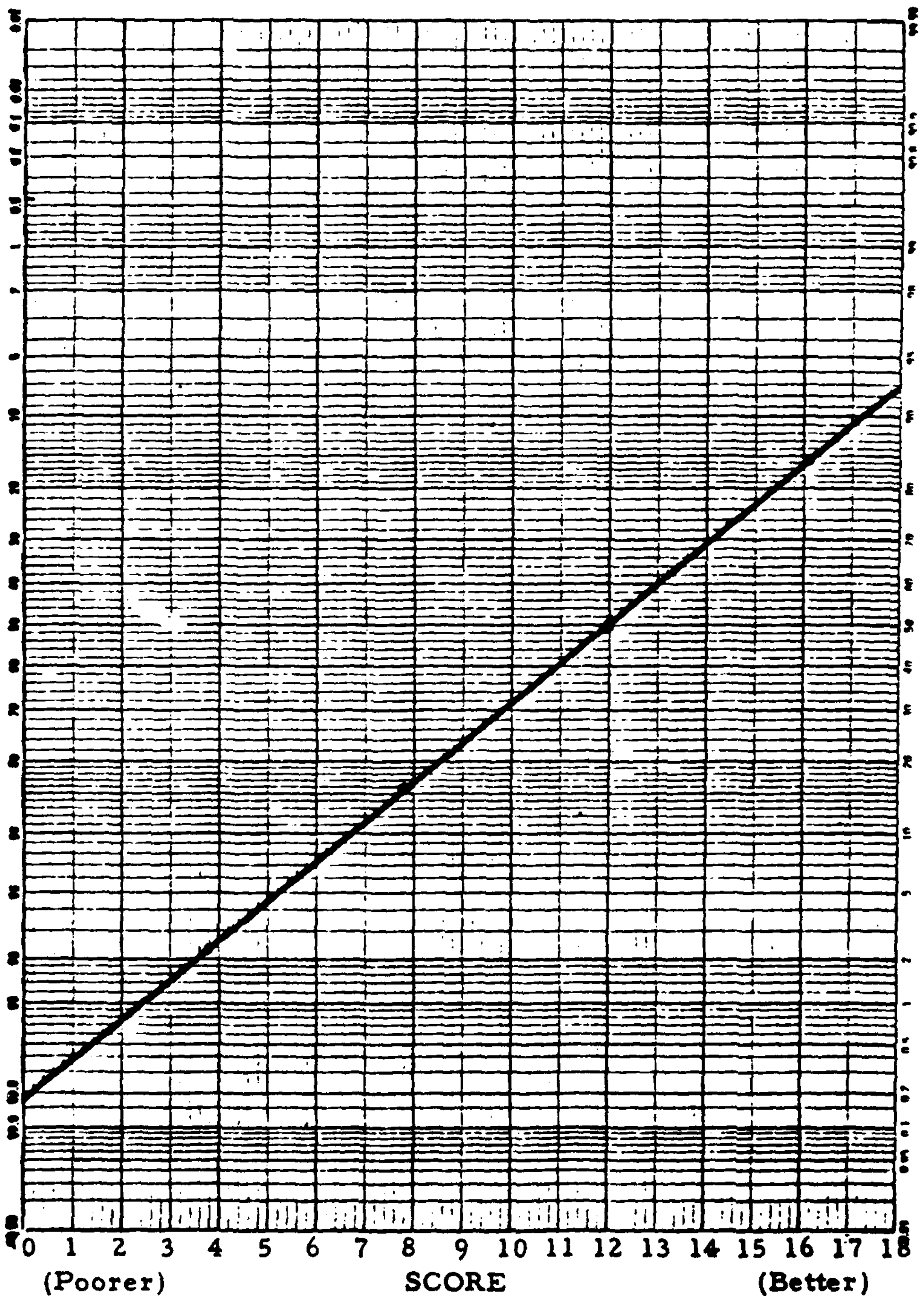
Attribute No. 28 - Rate control
Six Tests
(204 unselected basic trainee airmen; 1954)



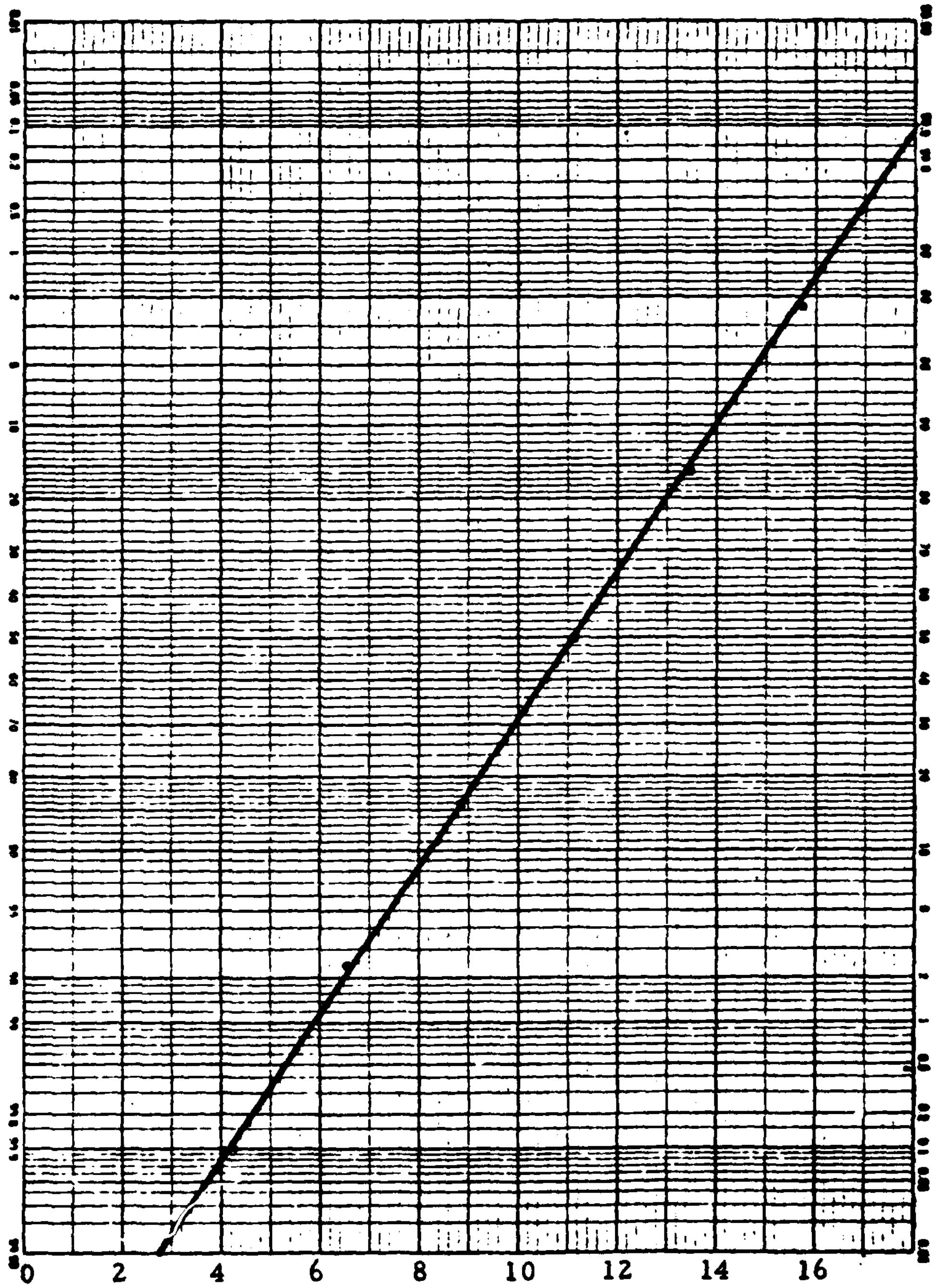
Attribute No. 35 - Closure abilities: flexibility of closure
Embedded Figures Test
(336 Males, 5 pooled samples)



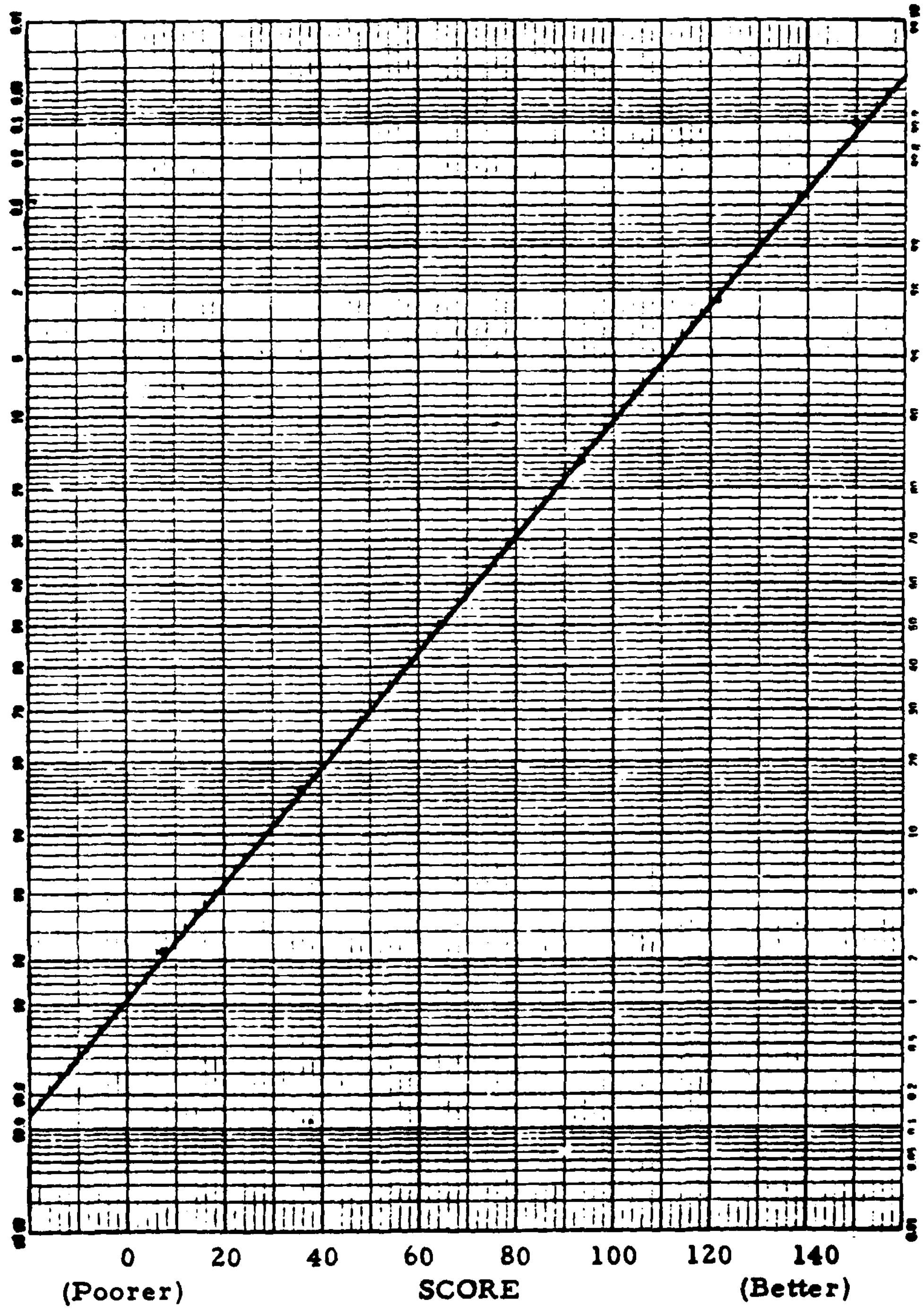
Attribute No. 35 - Closure abilities: flexibility of closure
Group Embedded Figures Test
(155 Males, Eastern Liberal Arts College)



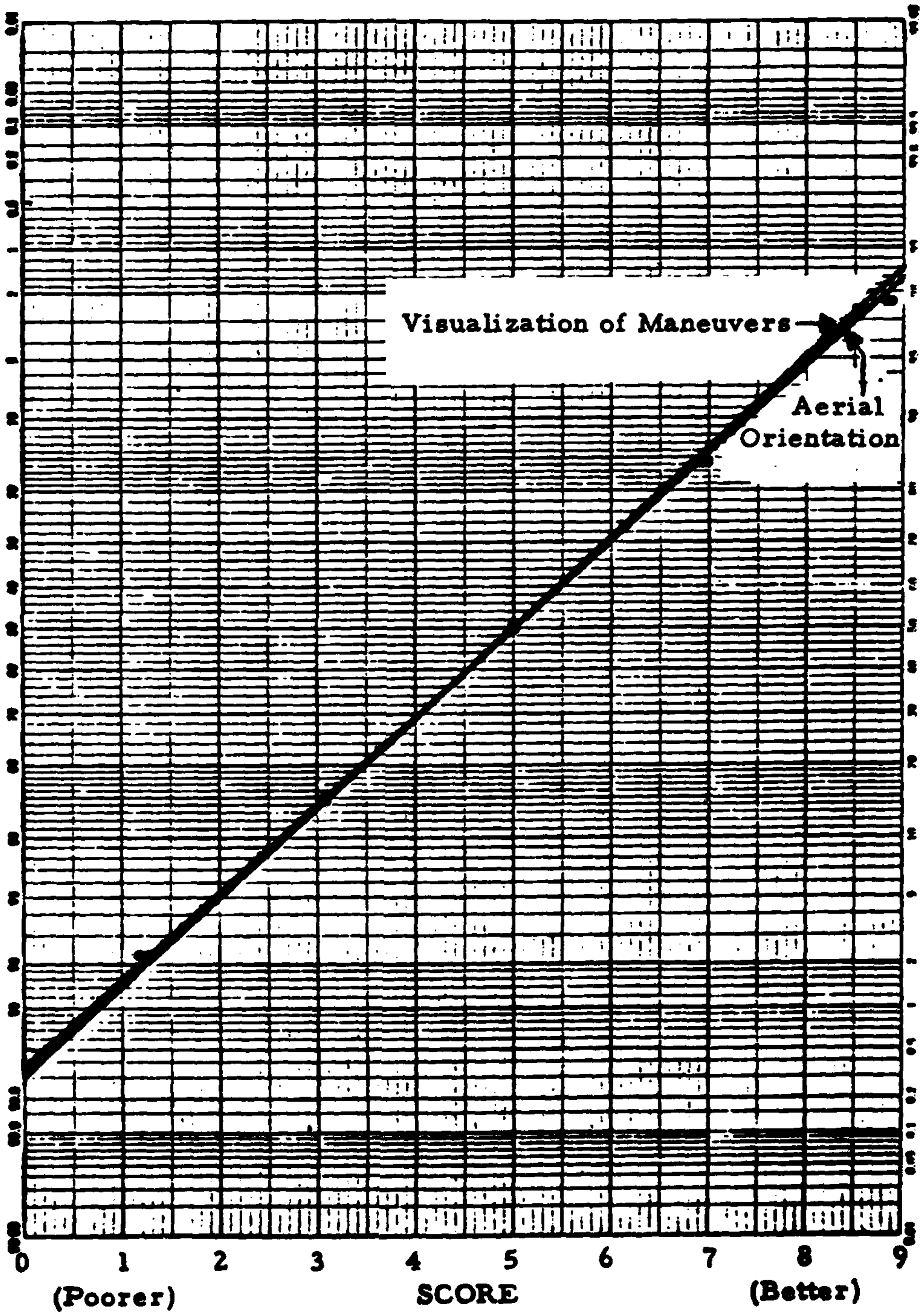
Attribute No. 35 - Closure abilities: flexibility of closure
Hidden Pictures Test
299 males, 11th - 12th grade)



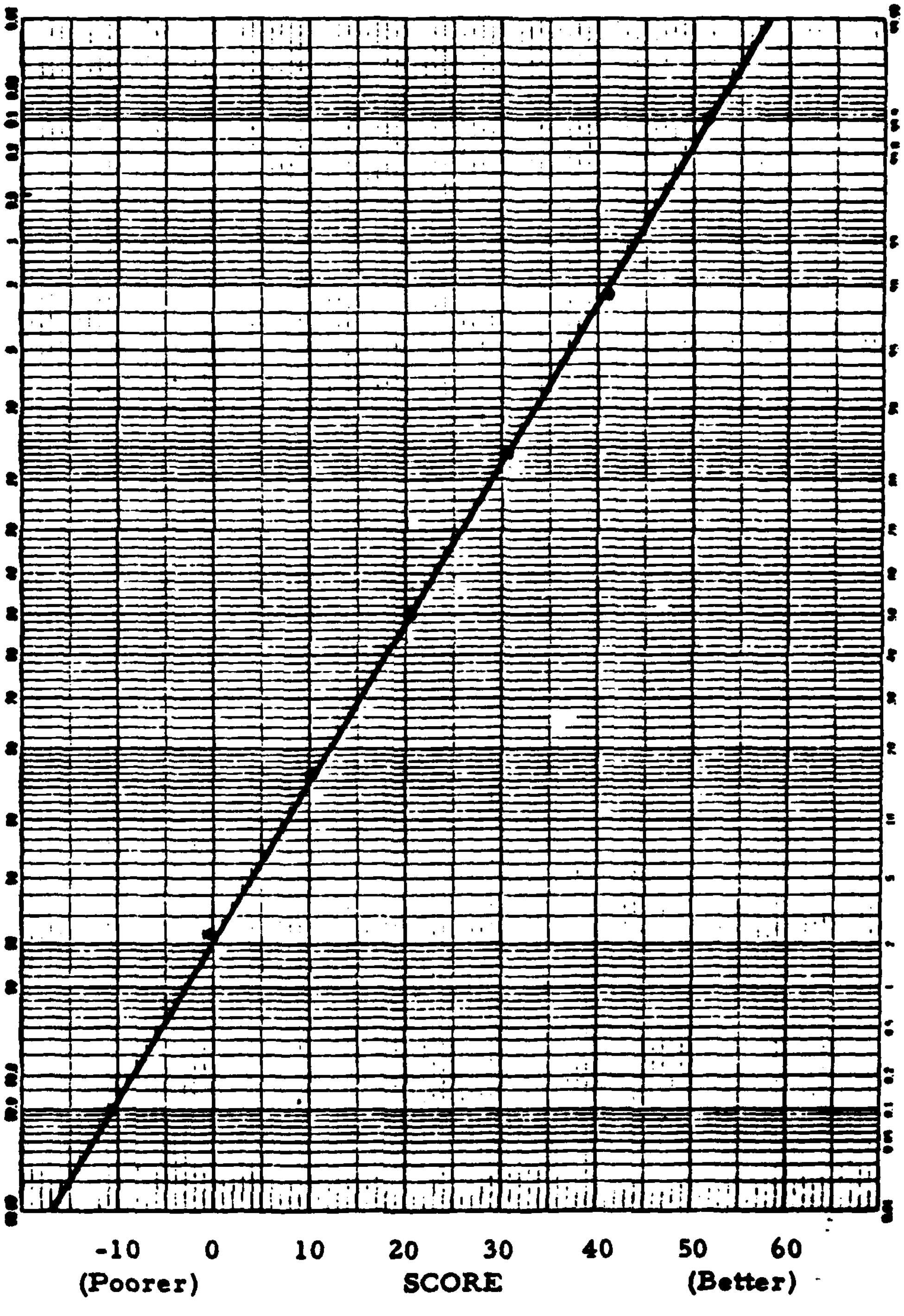
Attribute No. 35 - Closure abilities: flexibility of closure
Concealed Figures Test
(5,236 Industrial Workers)



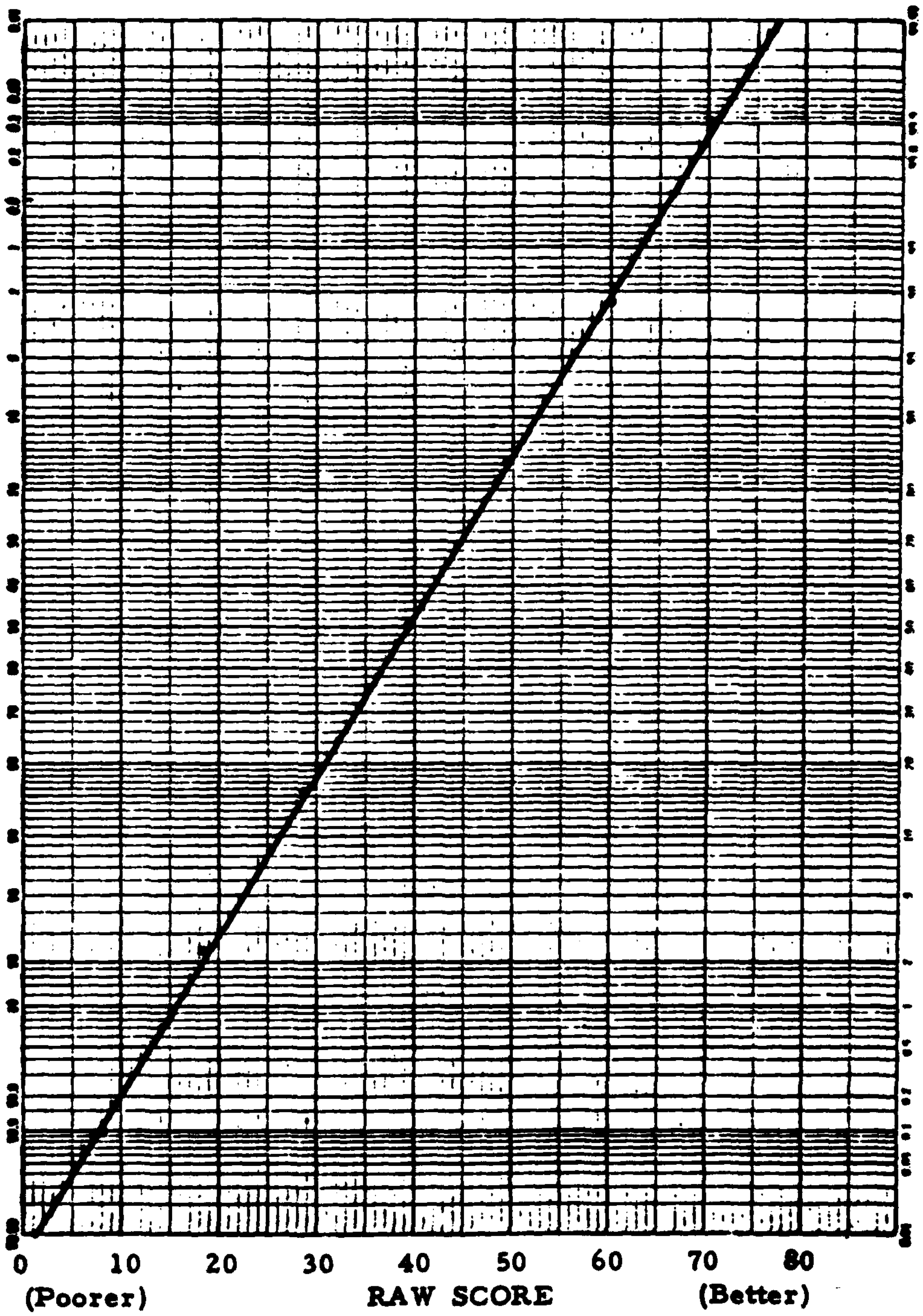
Attribute No. 38 - Spatial abilities: spatial orientation
Aerial Orientation Test; Visualization of Maneuvers Test
(203 male AFROTC Students)



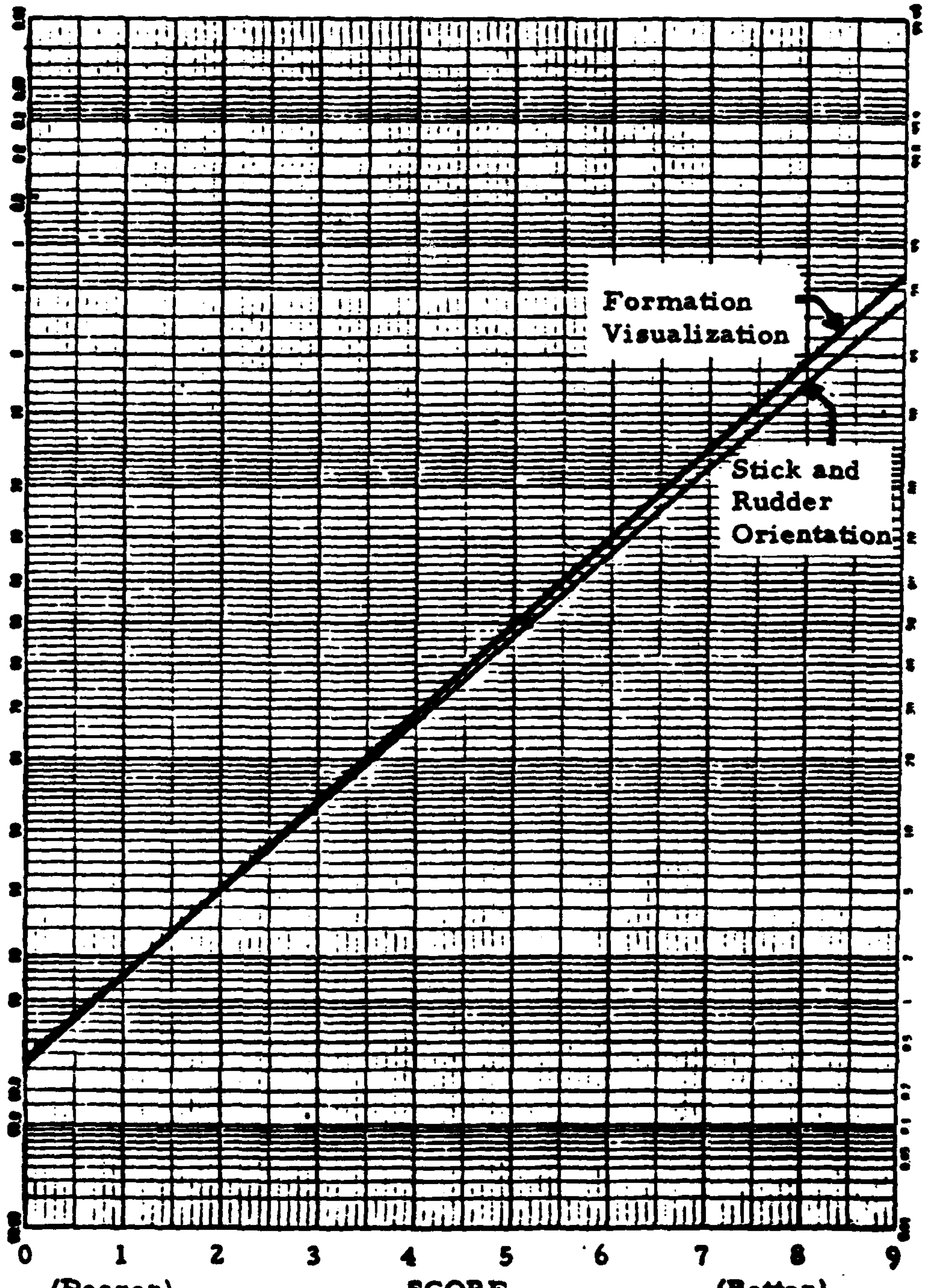
Attribute No. 38 - Spatial abilities: spatial orientation
Guilford-Zimmerman Aptitude Survey, Part V (Spatial Orientation)
(2,617 College Men)



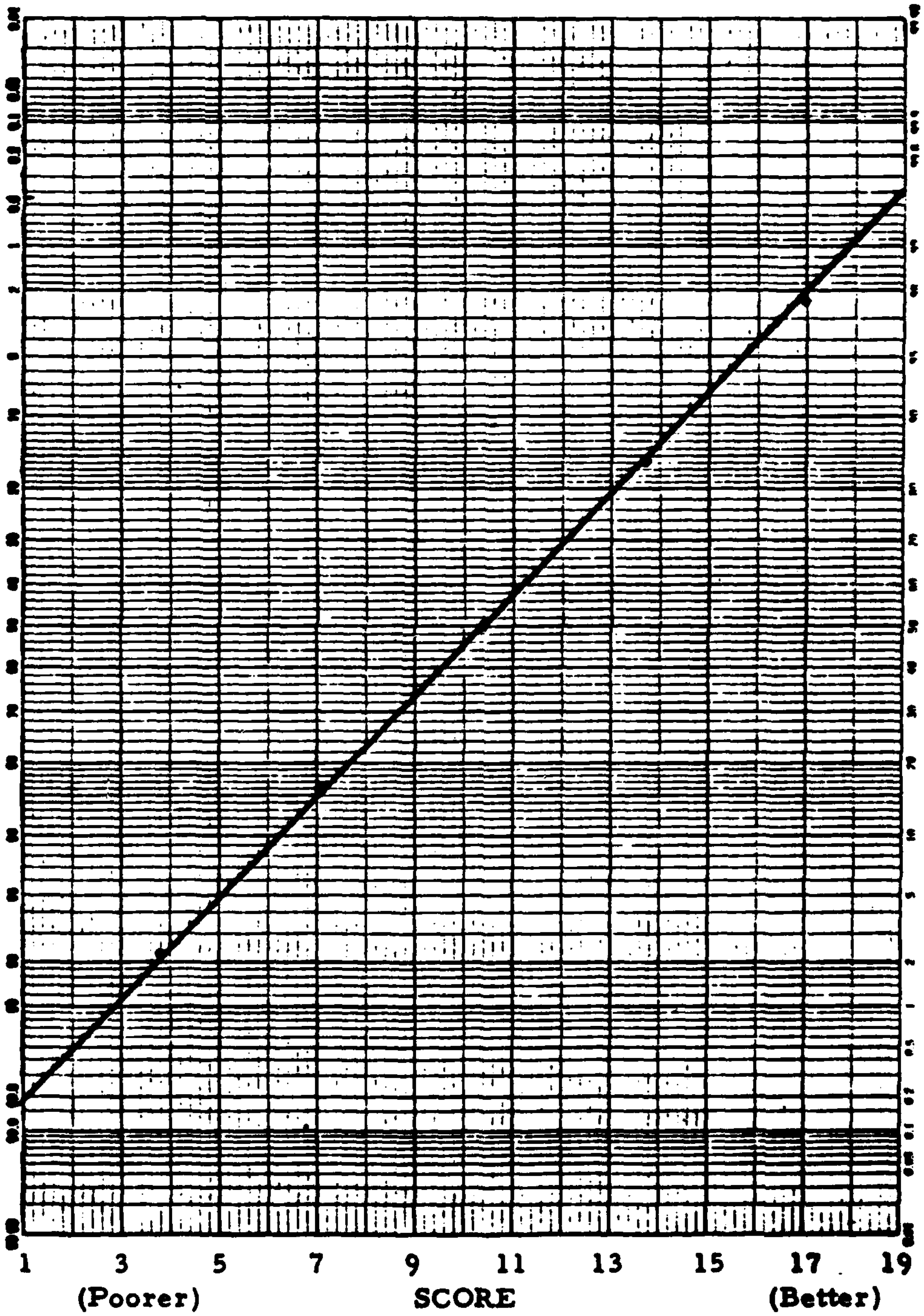
Attribute No. 39 - Spatial abilities: spatial visualization
Revised Minnesota Paper Form Board Test
(4,768 males, from 9 pooled male samples)



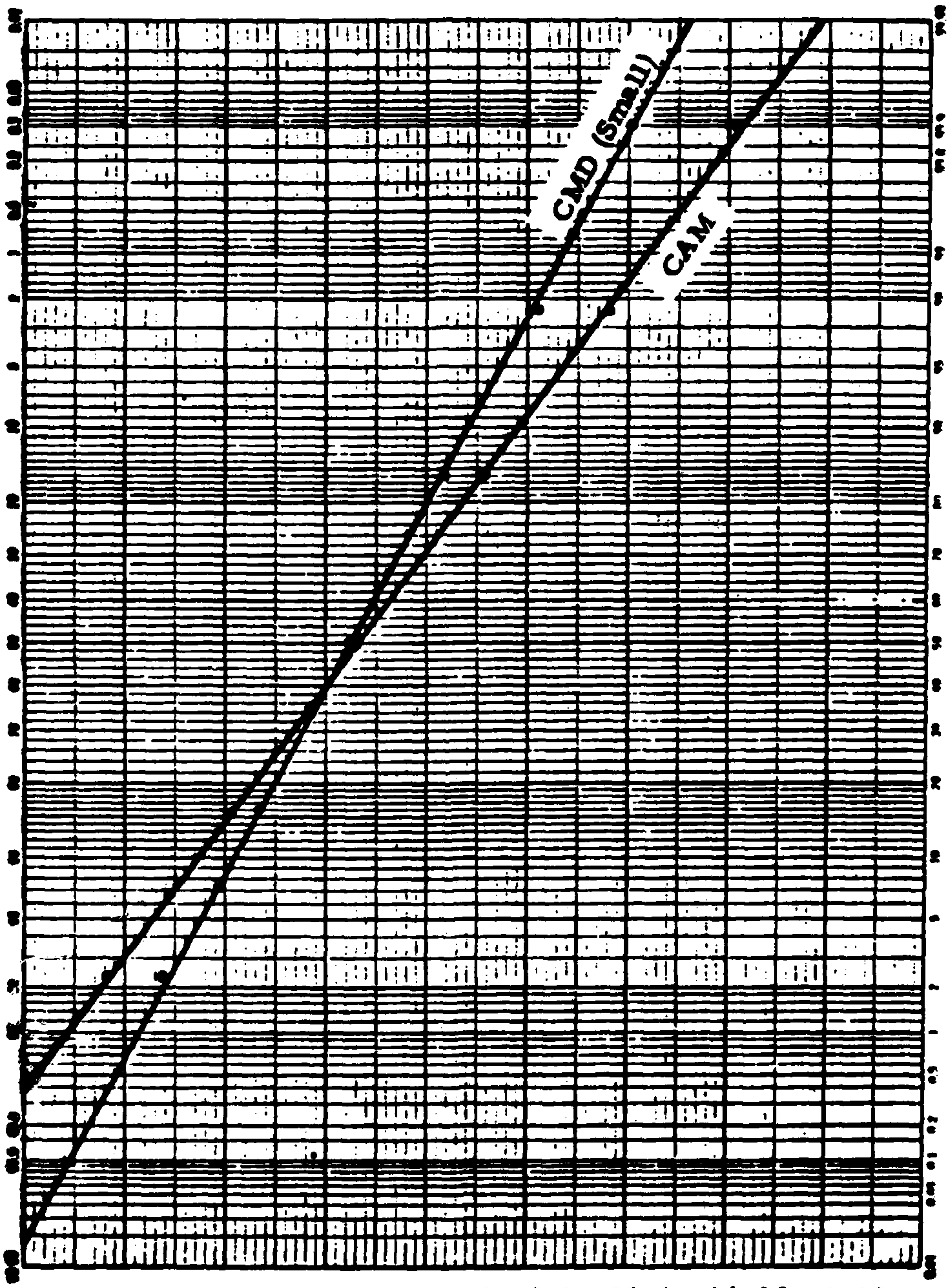
Attribute No. 39 - Spatial abilities: spatial visualization Formation Visualization Test and Stick-and-Rudder Orientation Test (203 male AFROTC Students)



Attribute No. 39 - Spatial abilities: spatial visualization
Paper Folding Test
(82 Army Enlistees)



Attribute No. 57 - Nighttime dynamic visual acuity
Mark II Tests: Central Movement in Depth (CMD) and
Central Angular Movement (CAM) (169 males)



APPENDIX D

The Simulation Model: Rationale, Computer Programs and Sample Runs

The task of estimating the proportion of personnel which will pass a selection procedure based on multiple personnel selection attribute values is deceptive. If the attributes are uncorrelated with each other or if the selection rule is simple and must be applied only once, the estimation is relatively straightforward and can be done conveniently using precise mathematical algorithms. If the attributes are related to each other less simply, and if several estimations must be made to deal with various possible situations, then the task of algorithmic estimation becomes arduous and requires careful and sophisticated work.

An alternative is computer simulation. This task is particularly well-suited to such an approach. Although the mathematical solution to the problem is complex, the processes underlying the situation are relatively simple. Repeatedly exercising these processes is easily performed by computer, and the output can be much more varied than simply the direct estimation of the proportion of personnel passing a selection criterion. Much more extensive and varied analyses can be performed because all aspects of the operation process are available. Also, once such a program has been set up, it is a simple matter to repeat the test for any variation of the input constraints.

Accordingly, a computer simulation procedure has been developed especially for this project. The remainder of this Appendix describes the simulation model rationale, the logic of the computer programs, the necessary input information and the scope of available output. The programs themselves are listed in Figures D-1 and D-4, sample inputs for the second program are presented in Figure D-5, and sample outputs are shown in Figures D-2, D-3, D-6 and D-7.

The Model

The model has been developed to handle a specific problem in personnel screening and selection, i.e.:

Given a number of personnel selection variables, such that

- each is normally distributed with known mean and standard deviation;
- the interrelationships between the variables are linear in nature, and
- the intercorrelations are known;

Develop scores on those variables for "simulated," or hypothetical, persons such that, for a large number of simulated cases,:

- The scores on each selection variable are approximately normally distributed and their means and standard deviations almost exactly correspond to the given values, and

- the intercorrelations between the variables are also very close to the given values.

(The closeness with which the observed data are required to meet the given conditions is a judgment issue; more exact correspondence makes the results of analyses more reliably applicable to the simulated situation, but high correspondence requires more simulated subjects which are costly to generate. In the simulation runs for this effort, we felt that simulating 10,000 subjects at once gave acceptable accuracy.)

This data generation process is the heart of the simulation model, and it proceeds in two steps:

1. Conversion of input parameters to useful data generation values. It is most natural for the model user to specify the interrelationships between variables in terms of an intercorrelation matrix. These values cannot be used in that form by the program which generates data, however. In the procedure used here, a multiple regression step converts the correlation matrix into linear combination coefficients which are used in the next step.

For example (in these examples, as in the program, variables are assumed to be normal, with means of zero and standard deviations of one), assume six screen variables with intercorrelations of:

	v_1	v_2	v_3	v_4	v_5	v_6	
v_1	1	r_{12}	r_{13}	r_{14}	r_{15}	r_{16}	
v_2	r_{12}	1	r_{23}	r_{24}	r_{25}	r_{26}	
v_3	r_{13}	r_{23}	1	r_{34}	r_{35}	r_{36}	(1)
v_4	r_{14}	r_{24}	r_{34}	1	r_{45}	r_{46}	
v_5	r_{15}	r_{25}	r_{35}	r_{45}	1	r_{56}	
v_6	r_{16}	r_{26}	r_{36}	r_{46}	r_{56}	1	

Then successive multiple regressions are performed to yield R^2 values and predictions formulas, i.e., regressions of v_2 on v_1; v_3 on v_2 and v_1; v_4 on v_3, v_2 and v_1; v_5 on v_4, v_3, v_2 and v_1; and v_6 on v_5, v_4, v_3, v_2, and v_1. The results of this step are:

$$R^2_{12} \text{ and } \hat{v}_2 = b_{12}v_1 \quad (2)$$

$$R^2_{3.12} \text{ and } \hat{v}_3 = b_{13}v_1 + b_{23}v_2 \quad (3)$$

$$R^2_{4.123} \text{ and } \hat{v}_4 = b_{14}v_1 + b_{24}v_2 + b_{34}v_3 \quad (4)$$

$$R^2_{5.1234} \text{ and } \hat{v}_5 = b_{15}v_1 + b_{25}v_2 + b_{35}v_3 + b_{45}v_4 \quad (5)$$

$$R^2_{6.12345} \text{ and } \hat{v}_6 = b_{16}v_1 + b_{26}v_2 + b_{36}v_3 + b_{46}v_4 + b_{56}v_5 \quad (6)$$

These formulas provide the basis for the generation of all the simulated data. Note that the formulas give estimates of successive variables from actual prior variables. In the generation process, the estimates must be expanded through the addition of random variance to bring their variance to unity.

In this simulation we have used the SPSS multiple regression capabilities to perform this step.* Any other procedure--another commercial computer package, specially written routines, or hand calculations--which provide the same information would be satisfactory.

2. Data generation. The generation of simulated data is the central and crucial step in the simulation. For actual soldiers, of course, the development of the attributes which show themselves in the screen variable scores occurs in parallel. The simulation generates the data in series, according to formulas of sequential dependence, based on the formula coefficients developed above.

For each iteration of data generation, i.e., for the development of scores on all selection variables for each simulated soldier, six pseudo-random normal numbers (n_1, n_2, ..., n_6) are generated and then combined by means of the prediction formulas to produce the simulated scores for each soldier:

$$v_1 = n_1 \tag{7}$$

$$v_2 = (1-R^2_{12})^{\frac{1}{2}} n_2 + b_{12}v_1 \tag{8}$$

$$v_3 = (1-R^2_{3.12})^{\frac{1}{2}} n_3 + b_{13}v_1 + b_{23}v_2 \tag{9}$$

$$v_4 = (1-R^2_{4.123})^{\frac{1}{2}} n_4 + b_{14}v_1 + b_{24}v_2 + b_{34}v_3 \tag{10}$$

$$v_5 = (1-R^2_{5.1234})^{\frac{1}{2}} n_5 + b_{15}v_1 + b_{25}v_2 + b_{35}v_3 + b_{45}v_4 \tag{11}$$

$$v_6 = (1-R^2_{6.12345})^{\frac{1}{2}} n_6 + b_{16}v_1 + b_{26}v_2 + b_{36}v_3 + b_{46}v_4 + b_{56}v_5 \tag{12}$$

---

*Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K. and Bent, D.H.: Statistical Package for the Social Sciences, Second Edition. New York: McGraw-Hill, 1975.

By this procedure, data are generated for each simulated soldier such that, overall, the correlations between the variables are nearly those of the original (i.e., "given") correlation matrix.

These data are generated as z scores, with means of about zero and standard deviations of about one. The scores could be left in this form or they could be converted to any scale desired. For the variables used in this simulation, the actual scale values have unique means and standard deviations, and for some of the scales lower values correspond to "better" scores. (They are shown in Table D-1.) To ease interpretation of the printout, we have chosen to present all scores on the same, relatively familiar scale in which all values are positive integers, with an overall mean of about 500 and a standard deviation of about 100. The scale is used for tests such as the SAT and CEEB college performance prediction tests and is thus widely known, and it combines the convenience of positive integers with three-digit precision. The formulas for this step are simple:

$$V_1 = 100v_1 + 500 \qquad (13)$$

$$V_2 = 100v_2 + 500 \qquad (14)$$

$$V_3 = 100v_3 + 500 \qquad (15)$$

$$V_4 = 100v_4 + 500 \qquad (16)$$

$$V_5 = 100v_5 + 500 \qquad (17)$$

$$V_6 = 100v_6 + 500 \qquad (18)$$

This step in the simulation is performed by a specially written Fortran program. It can preserve the data it has generated by writing it (on disk or tape) for analysis according to any desired procedure. Because the context of the simulation is personnel selection, some key analytical capabilities have been built into this program. The capabilities are applicable to both multiple cutoff and regression formula personnel selection schemes.

3. Multiple cutoff scheme. As part of the input to this program, it is possible to specify cutoffs for each selection variable. Based on the standard scale with mean 500 and standard deviation 100, for

Table D-1. Conversion Between Standard Scores and Actual Test Scores

		(Poorer)			SCORE		(Better)	
Attribute	Test	-3 σ	-2 σ	-1 σ	Mean (S. D.)	+1σ	+2σ	+3 σ
All	Standard	200		400	500 (100)	600	700	800
7	Brief Vestibular Disorientation	29.92	.16	18.40	12.64 (5.76)	6.88	1.12	- 4.64
28	Motor Judgment	0.40	0.67	0.94	1.21 (0.27)	1.48	1.75	2.02
28	Two-Hand Coordination	- 0.12	0.23	0.58	0.93 (0.35)	1.28	1.63	1.98
28	Rate Control	0.48	0.90	1.32	1.74 (0.42)	2.16	2.58	3.00
28	Pursuit Confusion	- 0.16	0.42	1.00	1.58 (0.58)	2.16	2.74	3.32
28	Multidimensional Pursuit	0.59	1.04	1.49	1.94 (0.45)	2.39	2.84	3.29
28	Two-Hand Pursuit	0.48	0.99	1.50	2.01 (0.51)	2.52	3.03	3.54
35	Embedded Figures	145.73	114.11	82.49	50.87 (31.62)	19.25	-12.37	-43.99
35	Group Embedded Figures	- 0.30	3.80	7.90	12.00 (4.10)	16.10	20.20	24.30

Table D-1. Converstion Between Standard Scores and Actual Test Scores (continued)

		(Poorer)			SCORE		(Better)	
Attribute	Test	-3σ	-2σ	-1σ	Mean (S.D.)	+1σ	+2σ	+3σ
35	Hidden Pictures	- 0.05	2.25	4.55	6.85 (2.30)	9.15	11.45	13.75
35	Concealed Figures	-21.00	7.50	36.00	64.50 (28.50)	93.00	121.50	150.00
38	Aerial Orientation	- 0.76	1.17	3.10	5.03 (1.93)	6.96	8.89	10.82
38	Visualization of Maneuvers	- 0.67	1.23	3.13	5.03 (1.90)	6.93	8.83	10.73
38	Spatial Orientation	-10.46	- 0.14	10.18	20.50 (10.32)	30.82	41.14	51.46
39	Revised Minnesota Form Board	8.14	18.53	28.92	39.31 (10.39)	49.70	60.09	70.48
39	Formation Visualization	- 0.78	1.15	3.08	5.01 (1.93)	6.94	8.87	10.80
39	Stick and Rudder	- 0.81	1.18	3.17	5.16 (1.99)	7.15	9.14	11.13
39	Paper Folding	0.50	3.80	7.10	10.40 (3.30)	13.70	17.00	20.30
57	Central Movement in Depth	22.10	18.40	14.70	11.00 (3.70)	7.30	3.60	- 0.10
57	Central Angular Movement	26.30	21.30	16.30	11.30 (5.00)	6.30	1.30	- 3.70

example, a cutoff value of 400 would reject all simulated soldiers scoring one or more standard deviations below average, or about 16% of the available manpower pool. A cutoff of 500 would reject about 50% of all candidates, i.e., those scoring at or below the mean.

The program tabulates the soldiers it simulates according to whether they pass all cutoffs or whether they fail to meet one or more of the criteria. This provides gross information about the overall proportion of the manpower pool which would remain after application of a multiple cutoff screen. It also provides detailed information on the impact of certain ones or combinations of variables included in the cutoff specification--it can answer, for example, questions like how many more soldiers would enter the available candidates pool if Variable X were not used to screen out candidates.

For each pass/fail subgroup, the program also summarizes the scores on the separate personnel selection variables--it provides, for each, the mean, standard deviation and minimum and maximum scores. This information can be valuable in evaluating the impact of selecting on one variable on the observed scores remaining for specific other variables.

4. Regression formulas. The multiple cutoff scheme is based on the rationale that low scores on certain selection variables mean that candidates cannot adequately perform the job. Regression formulas assume that candidates with higher scores on certain selection variables will perform their jobs better than candidates with lower scores. Both rationales may be appropriate in the same situation. In developing the analyses for this research, we have put both capabilities into the programs and have used both, particularly in Chapter VI.

The regression approach implies a predicted job performance variable created from a linear combination of the scores on each of the selection variables, with each score weighted according to its importance in the prediction. A general formula is:

$$p = \sum_{i=1}^{n} c_i v_i \quad . \qquad (19)$$

In this simulation, each prediction has been weighted to be on approximately the same scale of measurement as the selection variables:

$$P = 100(c_{11}v_1 + c_{12}v_2 + c_{13}v_3 + c_{14}v_4 + c_{15}v_5 + c_{16}v_6)/k_1 + 500$$

$$\text{where } k_1 = (c_{11}^2 + c_{12}^2 + c_{13}^2 + c_{14}^2 + c_{15}^2 + c_{16}^2)^{\frac{1}{2}} \quad (21)$$

That is, each prediction will have an expected mean of 500 and a standard deviation of about 100. (The standard deviation will not be expected to be exactly 100 because in the factor $100/k_1$, which adjusts the scale of the standard deviation of P, no correction is made for possibly non-zero correlations between the selection variables. To the extent that those correlations are positive, the standard deviation of the prediction will be greater than 100.

To develop the specific weights (here, $c_{11} \ldots c_{16}$) in the regression formula, one must have information on how the personnel selection variables are related to the criterion of job performance. Optimally, the weights should be derived through a multiple regression of known criterion (job performance) scores onto the scores for the selection variables.

In this simulation, the multiple regression producing these weights is run in Step 1, in the SPSS program. The weights so derived are then input to the Fortran program which produces prediction scores for each simulated soldier according to formulas 20 and 21 above.

The Fortran program treats these predicted job performance scores much the same as the selection variable scores. If the data for each soldier are written out for further analysis, the predicted criterion scores from the regression formulas are written out as well. Also, for each pass/fail subgroup, summary information (mean, standard deviation and minimum and maximum scores) are printed.

The Programs

The simulation model has been developed with the core as a Fortran program which actually generates the simulated data and performs the initial analyses. The main support program utilizes the facilities of SPSS to perform multiple regression functions. The programs have been run on a computer system based on a coupled IBM 360/75 and IBM 360/91 operating under IBM's ASP3 operating system.

The programs used are shown below in the order of their application. The data included are those which produced the runs discussed in Chapter VI.

Program 1. (SPSS)--The bulk of the program consists of the "Regression" statement, which generates the R^2 and b coefficients needed in Program 2 for generating data according to Formulas 7-12 so that the data will reflect the correlations in the matrix below the "Read Matrix" statements. Two examples of this program are shown in Figure D-1.

Each run of Program 1 requires two primary inputs. The first is the correlation matrix. The second is a request for one regression to be performed for each regression equation needed by Program 2. For example, in the case of the first program with six selection attributes, six equations like Formulas 7-12 above must be used (by Program 2) to generate properly interrelated selection variable scores for the simulated soldiers. Formula 7 has no unknown coefficients. Formulas 8-12 have unknown R^2 and b values; however, these are calculated by Program 1 according to the instructions shown on lines 18-22 in Figure D-1, first example.

A second set of coefficients is needed in this example as well, because two job performance predictions are being estimated, one for the Track Commander and Gunner together and one for the Driver. In Program 2, the c_{ij} weights of Formulas 20 and 21 must be provided, six weights for the first predictions and three for the latter. In order to best determine those weights, we have estimated the correlations between job performance and the personnel selection variables (see the first six values in lines 35 and 36 of Figure D-1) and we have requested the multiple regressions be performed which determine the regression weights for predicting job performance, for both job categories, from the relevant selection variables (lines 23 and 24 of Figure D-1, top example).

Printout for the examples in Figure D-1 is shown in Figures D-2 and D-3. SPSS has extensive and elaborate output presentations, and we have included only the parts most relevant to this discussion. The values in the printout which serve as input for Program 2 are circled for clarity.

When performing the full simulation process, one must run a separate version of Program 1 for each distinct correlation matrix to be simulated in order to develop the corresponding unique R^2 and b (and c) values which are key input to Program 2. Note in the examples included here that the correlation matrix of the second example is just

```
// JOB .ARISPSS,PRTY=0,REGION=250K
//*MAIN T=4,L=5,BIN=R1,ACHOLD=(R,1),CLASS=BATCH
//*FORMAT AC DDNAME=SYSMSG,PRINT=YES
//*FORMAT AC DDNAME=SYSPRINT,PRINT=YES
//*FORMAT AC DDNAME=FT06F001,PRINT=YES
// EXEC SPSS,TYPE=SPSSH
//GO.SYSIN DD *,DCB=BLKSIZE=2000
RUN NAME        ARI MONTE CARLO FOR IFV/CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENTS
VARIABLE LIST   VAR7,VAR28,VAR35,VAR38,VAR39,VAR57.CRIT1,CRIT2
INPUT MEDIUM    CARD
N OF CASES      10000
VAR LABELS      VAR7 BALANCE--VISUAL CUES/VAR28 RATE CONTROL/
                VAR35 FLEXIBILITY OF CLOSURE/VAR38 SPATIAL ORIENTATION/
                VAR39 SPATIAL VISUALIZATION/VAR57 NIGHT DYNAMIC VISUAL ACUITY/
                CRIT1 TRACK COMMANDER AND GUNNER, JOINT CRITERIA/
                CRIT2 DRIVER/
REGRESSION      VARIABLES=VAR7,VAR28,VAR35.VAR38.VAR39,VAR57,CRIT1,CRIT2/
                REGRESSION=VAR28 WITH VAR7 (2)/
                REGRESSION=VAR35 WITH VAR7,VAR28(2)/
                REGRESSION=VAR38 WITH VAR7,VAR28,VAR35(2)/
                REGRESSION=VAR39 WITH VAR7,VAR28,VAR35,VAR38(2)/
                REGRESSION=VAR57 WITH VAR7,VAR28,VAR35,VAR38,VAR39(2)/
                REGRESSION=CRIT1 WITH VAR7 TO VAR57(1)/
                REGRESSION=CRIT2 WITH VAR38 TO VAR57(1)/
OPTIONS         4
STATISTICS      1
READ MATRIX
1.0     0.0     0.2     0.3     0.3     0.3     0.2     0.0
0.0     1.0     0.3     0.3     0.3     0.0     0.4     0.0
0.2     0.3     1.0     0.3     0.4     0.0     0.4     0.0
0.3     0.3     0.3     1.0     0.4     0.0     0.3     0.25
0.3     0.3     0.4     0.4     1.0     0.0     0.3     0.2
0.3     0.0     0.0     0.0     0.0     1.0     0.3     0.2
0.2     0.4     0.4     0.3     0.3     0.3     1.0     0.2
0.0     0.0     0.0     0.25    0.2     0.2     0.2     1.0
FINISH
/*
```

Figure D-1. Two examples of Program 1 (SPSS).

```
// JOB ,ARISPSS,PRTY=0,REGION=250K
//*MAIN T=4,L=5,BIN=R1,ACHOLD=(R,1),CLASS=BATCH
//*FORMAT AC DDNAME=SYSMSG,PRINT=YES
//*FORMAT AC DDNAME=SYSPRINT,PRINT=YES
//*FORMAT AC DDNAME=FT06F001,PRINT=YES
// EXEC SPSS,TYPE=SPSSH
//GO.SYSIN DD *,DCB=BLKSIZE=2000
RUN NAME        ARI MONTE CARLO FOR GUNNER ONLY, STEP 1, RUN 6B--EXPERT JUDGMENTS
VARIABLE LIST   VAR38,VAR39,VAR57,CRIT2
INPUT MEDIUM    CARD
N OF CASES      10000
VAR LABELS      VAR38 SPATIAL ORIENTATION/
                VAR39 SPATIAL VISUALIZATION/VAR57 NIGHT DYNAMIC VISUAL ACUITY/
                CRIT2 DRIVER/
REGRESSION      VARIABLES=VAR38,VAR39,VAR57,CRIT2/
                REGRESSION=VAR39 WITH VAR38(2)/
                REGRESSION=VAR57 WITH VAR38,VAR39(2)/
                REGRESSION=CRIT2 WITH VAR38 TO VAR57(1)/
OPTIONS         4
STATISTICS      1
READ MATRIX
1.0       0.4       0.0       0.25
0.4       1.0       0.0       0.2
0.0       0.0       1.0       0.2
0.25      0.2       0.2       1.0
FINISH
/*
```

Figure D-1. Two examples of Program 1 (SPSS) (continued)

ARI MONTE CARLO FOR IFV-CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENT 04/17/79 PAGE 2

FILE NONAME (CREATION DATE = 04/17/79)

CORRELATION COEFFICIENTS

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	VAR7	VAR28	VAR35	VAR38	VAR39	VAR57	CRIT1	CRIT2
VAR7	1.00000	0.0	0.20000	0.30000	0.30000	0.30000	0.20000	0.0
VAR28	0.0	1.00000	0.30000	0.30000	0.30000	0.0	0.40000	0.0
VAR35	0.20000	0.30000	1.00000	0.30000	0.40000	0.0	0.40000	0.0
VAR38	0.30000	0.30000	0.30000	1.00000	0.40000	0.0	0.30000	0.25000
VAR39	0.30000	0.30000	0.40000	0.40000	1.00000	0.0	0.30000	0.20000
VAR57	0.30000	0.0	0.0	0.0	0.0	1.00000	0.30000	0.20000
CRIT1	0.20000	0.40000	0.40000	0.30000	0.30000	0.30000	1.00000	0.20000
CRIT2	0.0	0.0	0.0	0.25000	0.20000	0.20000	0.20000	1.00000

ARI MONTE CARLO FOR IFV-CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENT 04/17/79 PAGE 3

FILE NONAME (CREATION DATE = 04/17/79)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 1

DEPENDENT VARIABLE.. VAR28 RATE CONTROL

VARIABLE(S) ENTERED ON STEP NUMBER 1.. VAR7 BALANCE--VISUAL CUES

MULTIPLE R	0.0	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	0.0	REGRESSION	1.	0.0	0.0	0.0
ADJUSTED R SQUARE	-0.00010	RESIDUAL	9998.	9999.00000	1.00010	
STANDARD ERROR	1.00005					

---------- VARIABLES IN THE EQUATION ----------

VARIABLE	B	BETA	STD ERROR B	F
VAR7	0.0	0.0	0.01000	0.0
(CONSTANT)	0.0			

---------- VARIABLES NOT IN THE EQUATION ----------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

MAXIMUM STEP REACHED

Figure D-2. Selected output from first SPSS program, shown in Figure D-1.

AR[illegible]

FILE NONAME (CREATION DATE = 04/17/79)

* MULTIPLE REGRESSION * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 4

DEPENDENT VARIABLE.. VAR39 SPATIAL VISUALIZATION

VARIABLE(S) ENTERED ON STEP NUMBER 1.. VAR7 BALANCE--VISUAL CUES
VAR20 RATE CONTROL
VAR35 FLEXIBILITY OF CLOSURE
VAR38 SPATIAL ORIENTATION

MULTIPLE R	0.53967	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	0.29124	REGRESSION	4.	2912.14182	728.03545	1026.78989
ADJUSTED R SQUARE	0.29096	RESIDUAL	9995.	7086.85818	0.70904	
STANDARD ERROR	0.84205					

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
VAR7	0.1833060	0.18330	0.00897	417.936
VAR20	0.1584889	0.15849	0.00915	299.922
VAR35	0.2489506	0.24895	0.00917	736.399
VAR38	0.2227529	0.22275	0.00945	555.685
(CONSTANT)	0.0			

------------------ VARIABLES NOT IN THE EQUATION ------------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

ARI MONTE CARLO FOR IFV-CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENT 04/17/79 PAGE 11

FILE NONAME (CREATION DATE = 04/17/79)

* MULTIPLE REGRESSION * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 5

DEPENDENT VARIABLE.. VAR57 NIGHT DYNAMIC VISUAL ACUITY

VARIABLE(S) ENTERED ON STEP NUMBER 1.. VAR7 BALANCE--VISUAL CUES
VAR20 RATE CONTROL
VAR35 FLEXIBILITY OF CLOSURE
VAR38 SPATIAL ORIENTATION
VAR39 SPATIAL VISUALIZATION

MULTIPLE R	0.32619	ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
R SQUARE	0.10640	REGRESSION	5.	1063.87416	212.77483	237.99812
ADJUSTED R SQUARE	0.10595	RESIDUAL	9994.	8935.12584	0.89405	
STANDARD ERROR	0.94554					

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
VAR7	0.3946602	0.35466	0.01020	1189.951
VAR20	0.5769995D-01	0.05769	0.01043	30.815
VAR35	-0.3234700D-01	-0.03235	0.01067	9.184
VAR38	-0.8301300D-01	-0.08301	0.01090	57.982
VAR39	-0.7762212D-01	-0.07762	0.01123	47.760
(CONSTANT)	0.0			

------------------ VARIABLES NOT IN THE EQUATION ------------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

Figure D-2 (continued)

```
ARI MONTE CARLO FOR IFV-CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENT                04/17/79        PAGE    5

FILE    NONAME    (CREATION DATE = 04/17/79)

* * * * * * * * * * * * * * * * * * * * * * *   M U L T I P L E    R E G R E S S I O N   * * * * * * * * * * * * *   VARIABLE LIST  1
                                                                                                                    REGRESSION LIST  2

DEPENDENT VARIABLE..    VAR35     FLEXIBILITY OF CLOSURE

VARIABLE(S) ENTERED ON STEP NUMBER  1..    VAR7      BALANCE--VISUAL CUES
                                           VAR28     RATE CONTROL

MULTIPLE R            0.36056                ANALYSIS OF VARIANCE      DF      SUM OF SQUARES      MEAN SQUARE          F
R SQUARE              0.13000                REGRESSION                 2.       1299.87000         649.93500      746.90230
ADJUSTED R SQUARE     0.12983                RESIDUAL                9997.       8699.13000           0.87017
STANDARD ERROR        0.93283

---------------- VARIABLES IN THE EQUATION -----------------          ------------ VARIABLES NOT IN THE EQUATION ------------

VARIABLE            B            BETA      STD ERROR B        F            VARIABLE     BETA IN     PARTIAL   TOLERANCE        F

VAR7          0.2000000        0.20000      0.00933      459.632
VAR28         0.3000000        0.30000      0.00933     1034.172
(CONSTANT)    0.0

ALL VARIABLES ARE IN THE EQUATION
```

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```
ARI MONTE CARLO FOR IFV-CFV CREW, STEP 1, RUN 6--EXPERT JUDGMENT                04/17/79        PAGE    7

FILE    NONAME    (CREATION DATE = 04/17/79)

* * * * * * * * * * * * * * * * * * * * * * *   M U L T I P L E    R E G R E S S I O N   * * * * * * * * * * * * *   VARIABLE LIST  1
                                                                                                                    REGRESSION LIST  3

DEPENDENT VARIABLE..    VAR30     SPATIAL ORIENTATION

VARIABLE(S) ENTERED ON STEP NUMBER  1..    VAR7      BALANCE--VISUAL CUES
                                           VAR28     RATE CONTROL
                                           VAR35     FLEXIBILITY OF CLOSURE

MULTIPLE R            0.45372                ANALYSIS OF VARIANCE      DF      SUM OF SQUARES      MEAN SQUARE          F
R SQUARE              0.20586                REGRESSION                 3.       2058.41483         686.13828      863.74468
ADJUSTED R SQUARE     0.20562                RESIDUAL                9996.       7940.58517           0.79438
STANDARD ERROR        0.89128

---------------- VARIABLES IN THE EQUATION -----------------          ------------ VARIABLES NOT IN THE EQUATION ------------

VARIABLE            B            BETA      STD ERROR B        F            VARIABLE     BETA IN     PARTIAL   TOLERANCE        F

VAR7          0.2655172        0.26552      0.00912      848.386
VAR28         0.2482759        0.24828      0.00936      703.149
VAR35         0.1724138        0.17241      0.00956      325.532
(CONSTANT)    0.0

ALL VARIABLES ARE IN THE EQUATION
```

Figure D-2 (continued)

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FILE NONAME (CREATION DATE = 04/17/79)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 6

DEPENDENT VARIABLE.. CRIT1 TRACK COMMANDER AND GUNNER, JOINT CRITER

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
VAR28	RATE CONTROL	0.40000	0.16000	0.16000	0.40000	0.2670640	0.26706
VAR57	NIGHT DYNAMIC VISUAL ACUITY	0.50000	0.25000	0.09000	0.30000	0.2988352	0.29884
VAR35	FLEXIBILITY OF CLOSURE	0.57979	0.33615	0.08615	0.40000	0.2566851	0.25669
VAR38	SPATIAL ORIENTATION	0.59296	0.35161	0.01545	0.30000	0.1132733	0.11327
VAR39	SPATIAL VISUALIZATION	0.59613	0.35537	0.00376	0.30000	0.7049241D-01	0.07049
VAR7	BALANCE--VISUAL CUES	0.59613	0.35538	0.00001	0.20000	0.3882727D-02	0.00388
(CONSTANT)						0.0	

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FILE NONAME (CREATION DATE = 04/17/79)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 7

DEPENDENT VARIABLE.. CRIT2 DRIVER

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
VAR38	SPATIAL ORIENTATION	0.25000	0.06250	0.06250	0.25000	0.2023810	0.20238
VAR57	NIGHT DYNAMIC VISUAL ACUITY	0.32016	0.10250	0.04000	0.20000	0.2000000	0.20000
VAR39	SPATIAL VISUALIZATION	0.33824	0.11440	0.01190	0.20000	0.1190476	0.11905
(CONSTANT)						0.0	

Figure D-2 (continued)

```
ARI MONTE CARLO FOR GUNNER UALZ, STEP 1, RUN 6B--EXPERT JUDGMENT                  04/17/79        PAGE    2

FILE    NONAME    (CREATION DATE = 04/17/79)

CORRELATION COEFFICIENTS

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.


             VAR38      VAR39      VAR57      CRIT2

VAR38        1.00000    £.40000    0.0        0.25000
VAR39        0.40000    1.00000    0.0        0.20000
VAR57        0.0        8.0        1.00000    0.20000
CRIT2        0.25000    0.20000    0.20000    1.00000


ARI MONTE CARLO FOR GUNNER UALZ, STEP 1, RUN 6B--EXPERT JUDGMENT                  04/17/79        PAGE    3

FILE    NUNAME    (CREATION DATE = 04/17/79)

* * * * * * * * * * * * * * * * * * * * * * *   M U L T I P L E   R E G R E S S I O N   * * * * * * * * * * * * *   VARIABLE LIST    1
                                                                                                                  REGRESSION LIST  1
DEPENDENT VARIABLE..   VAR39     SPATIAL VISUALIZATION

VARIABLE(S) ENTERED ON STEP NUMBER  1..    VAR38     SPATIAL ORIENTATION

MULTIPLE R           0.40000          ANALYSIS OF VARIANCE     DF     SUM OF SQUARES     MEAN SQUARE          F
R SQUARE             0.16000          REGRESSION                1.        1599.84000     1599.84000     1904.38095
ADJUSTED R SQUARE    0.15992          RESIDUAL               9998.        8399.16000        0.84008
STANDARD ERROR       0.91686

------------------ VARIABLES IN THE EQUATION ------------------     ------------ VARIABLES NOT IN THE EQUATION ------------

VARIABLE             B          BETA      STD ERROR B        F       VARIABLE      BETA IN    PARTIAL   TOLERANCE      F

VAR38            0.40000000    0.40000    0.00917      1904.381
(CONSTANT)       0.0

MAXIMUM STEP REACHED
```

Figure D-3. Selected output from second SPSS program, shown in Figure D-1.

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FILE NONAME (CREATION DATE = 04/17/79)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 2

DEPENDENT VARIABLE.. VAR57 NIGHT DYNAMIC VISUAL ACUITY

VARIABLE(S) ENTERED ON STEP NUMBER 1.. VAR38 SPATIAL ORIENTATION
VAR39 SPATIAL VISUALIZATION

MULTIPLE R	0.0
R SQUARE	0.0
ADJUSTED R SQUARE	-0.00020
STANDARD ERROR	1.00010

ANALYSIS OF VARIANCE	DF	SUM OF SQUARES	MEAN SQUARE	F
REGRESSION	2.	0.0	0.0	0.0
RESIDUAL	9997.	9999.00000	1.00020	

------------------ VARIABLES IN THE EQUATION ------------------

VARIABLE	B	BETA	STD ERROR B	F
VAR38	0.0	0.0	0.01091	0.0
VAR39	0.0	0.0	0.01091	0.0
(CONSTANT)	0.0			

------------- VARIABLES NOT IN THE EQUATION -------------

VARIABLE	BETA IN	PARTIAL	TOLERANCE	F

ALL VARIABLES ARE IN THE EQUATION

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FILE NONAME (CREATION DATE = 04/17/79)

* M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * * * * VARIABLE LIST 1
REGRESSION LIST 3

DEPENDENT VARIABLE.. CRIT2 DRIVER

SUMMARY TABLE

VARIABLE		MULTIPLE R	R SQUARE	RSQ CHANGE	SIMPLE R	B	BETA
VAR38	SPATIAL ORIENTATION	0.25000	0.06250	0.06250	0.25000	0.2023810	0.20238
VAR57	NIGHT DYNAMIC VISUAL ACUITY	0.32016	0.10250	0.04000	0.20000	0.2000000	0.20000
VAR39	SPATIAL VISUALIZATION	0.33824	0.11440	0.01190	0.20000	0.1190476	0.11905
(CONSTANT)						0.0	

Figure D-3 (continued

a subset of the first matrix, and that we could have obtained all of the information needed for both runs by including the regression statements (lines 16-17 from the second example in Figure D-1) from the second in the first program. Note also that lines 24 (first example) and 18 (second example) ask for identical analyses; the corresponding results, the last output shown in Figure D-2 and the last in Figure D-3, are identical as they should be.

Program 2. (Fortran)--This program generates the scores on the screen and job performance variables according to the specifications of the input file. The program utilizes a subroutine from the IMSL subroutine library to generate the pseudo-random normal deviates from which the variable scores are produced.* Any other subroutine which generates normally-distributed pseudo-random numbers with an expected mean of zero and an expected standard deviation of one could be substituted.

The first output from the program is a listing of the input parameters and the intercorrelation matrix which was actually produced from the data generated in the simulation run. This is particularly useful because it provides immediate information on how well the output met the intended selection variable interrelationships. This is a major piece of evidence on how faithfully the simulation met its goals and provides a check on typographical errors in entering the regression coefficients which might otherwise escape detection.

The program divides the generated data into simulated soldiers who pass all screen criteria and those who fail on one or more of the criteria. The "failing" soldiers are separately analyzed according to which screen or screens they fail.

For each subgroup, average values are calculated for each screen variable and, if included in the simulation, each predicted performance variable. These values are reported in convenient tabular form along with variable standard deviations and maximum and minimum values.

At the user's option, this program will also write out all the generated data for subsequent analysis steps as desired. The program is written generally so that modifications to run the program to suit particular conditions are made in an input file rather than as changes to the program itself.

---

*International Mathematical and Statistical Libraries, Inc., Houston, Texas, 1975

The program source code is shown in Figure D-4, complete with control cards necessary for running under ASP3. The final dataset reference cards in lines 511-518 point to the input file (GO.FT21F001) shown in Figure D-5 and to two output files set to receive the generated data for subsequent analyses. (The input specifies two simulation runs to be performed and requests the first set of generated data to be written to GO.FT22F001 and the second to be written to GO.FT23F001.) The data analyses performed by this program are written to the normal Fortran output file and are reproduced, for this example, in Figures D-6 and D-7.

In Figure D-5, lines 1-16 specify all the input control information for the analysis shown in Figure D-6. Key features are:

- (line 2): specification of a simulation of 10,000 soldiers each with six selection variables and two predicted job performance criteria.
- (line 2): request for the generated data to be saved on GO.FT22F001.
- (lines 3-8): labels for six selection variables.
- (line 9): cutoff values, for the multiple cutoff scheme, for each of the six selection variables.
- (lines 10-14): regression coefficients-- R^2 and $\underline{b}$ values-- used to generate the selection variables with intercorrelations nearly matching those of Figure D-1. Note that these values are exactly the same as the circled values in Figure D-2, the SPSS output.
- (lines 15 and 16): weights for producing two predicted job performance scores for each soldier from his scores on the selection variables, along with brief labels. The weights were derived from two different lines of reasoning even though both scores are predictors of Track Commander and Gunner performance. The first formula

```
// JOB ,ARIFORT,PRTY=0,REGION=150K
//*MAIN T=10,L=15,BIN=R1,ACHOLD=(R,1),CLASS=NIGHT
//*FORMAT AC DDNAME=SYSMSG,PRINT=YES
//*FORMAT AC DDNAME=SYSPRINT,PRINT=YES
//*FORMAT AC DDNAME=SYSLOUT,PRINT=YES
//*FORMAT AC DDNAME=FT06F001,PRINT=YES
// EXEC FORTGCG,PARM.FORT='MAP'
//SYSIN DD *,DCB=BLKSIZE=2000
      DIMENSION SUM(20,199),SUMSQ(20,199),COEFFS(10,9),RVEC(10),VVEC(10)
      DIMENSION PWGTS(11,10),CORMAT(20,20)
      REAL*8 DLABEL(199),VLABEL(2,20),TITLE(10),PLABEL(2,10)
      INTEGER*2 MIN(20,199),MAX(20,199),ITAL(23),IVFAIL(10)
      INTEGER*2 HFMT(6),NFMT(10), HICUT
      INTEGER*4 NN(199),NCAS(10),NCUT(10),NOUT,IVVEC(20)
      DATA HFMT,NFMT /'( ','  ','I1',',2','OI','4)',' 1',' 2',
     1 ' 3',' 4',' 5',' 6',' 7',' 8',' 9','10'/
      REAL*8 DDLABE(69),DELABE(70),DFLABE(60)
      EQUIVALENCE (DDLABE(1),DLABEL(1)),(DELABE(1),DLABEL(70))
      EQUIVALENCE (DFLABE(1),DLABEL(140))
      INTEGER*4 JLABEL(9)
      DATA JLABEL /'VAR1','VAR2','VAR3','VAR4','VAR5',
     1 'VAR6','VAR7','VAR8','VAR9'/
      DATA DDLABE /'(TOTAL) ','ALL PASS','ALL FAIL','ALL V1  ',
     1'ALL V2  ','ALL V3  ','ALL V4  ','ALL V5  ','ALL V6  ',
     2 'ALL V7  ','ALL V8  ','ALL V9   ,'ALL V10 ','ONLY V1 ',
     3 'ONLY V2 ','ONLY V3 ','ONLY V4 ','ONLY V5 ','ONLY V6 ',
     4 'ONLY V7 ','ONLY V8 ','ONLY V9 ','ONLY V10','V1 & V2 ',
     5 'V1 & V3 ','V1 & V4 ','V1 & V5 ','V1 & V6 ','V1 & V7 ',
     6 'V1 & V8 ','V1 & V9 ','V1 & V10','V2 & V3 ','V2 & V4 ',
     7 'V2 & V5 ','V2 & V6 ','V2 & V7 ','V2 & V8 ','V2 & V9 ',
     8 'V2 & V10','V3 & V4 ','V3 & V5 ','V3 & V6 ','V3 & V7 ',
     9 'V3 & V8 ','V3 & V9 ','V3 & V10','V4 & V5 ','V4 & V6 ',
     1 'V4 & V7 ','V4 & V8 ','V4 & V9 ','V4 & V10','V5 & V6 ',
     2 'V5 & V7 ','V5 & V8 ','V5 & V9 ','V5 & V10','V6 & V7 ',
     3 'V6 & V8 ','V6 & V9 ','V6 & V10','V7 & V8 ','V7 & V9 ',
     4 'V7 & V10','V8 & V9 ','V8 & V10','V9 & V10','V1&V2&V3'/
      DATA DELABE
```

Figure D-4. Program 2, Fortran source code plus control cards.

```
     5/'V1&V2&V4','V1&V2&V5','V1&V2&V6','V1&V2&V7','V1&V2&V8',
     6 'V1&V2&V9','V1&V2,10','V1&V3&V4','V1&V3&V5','V1&V3&V6',
     7 'V1&V3&V7','V1&V3&V8','V1&V3&V9','V1&V3,10','V1&V4&V5',
     8 'V1&V4&V6','V1&V4&V7','V1&V4&V8','V1&V4&V9','V1&V4,10',
     9 'V1&V5&V6','V1&V5&V7','V1&V5&V8','V1&V5&V9','V1&V5,10',
     1 'V1&V6&V7','V1&V6&V8','V1&V6&V9','V1&V6,10','V1&V7&V8',
     2 'V1&V7&V9','V1&V7,10','V1&V8&V9','V1&V8,10','V1&V9,10',
     3 'V2&V3&V4','V2&V3&V5','V2&V3&V6','V2&V3&V7','V2&V3&V8',
     4 'V2&V3&V9','V2&V3,10','V2&V4&V5','V2&V4&V6','V2&V4&V7',
     5 'V2&V4&V8','V2&V4&V9','V2&V4,10','V2&V5&V6','V2&V5&V7',
     6 'V2&V5&V8','V2&V5&V9','V2&V5,10','V2&V6&V7','V2&V6&V8',
     7 'V2&V6&V9','V2&V6,10','V2&V7&V8','V2&V7&V9','V2&V7,10',
     8 'V2&V8&V9','V2&V8,10','V2&V9,10','V3&V4&V5','V3&V4&V6',
     9 'V3&V4&V7','V3&V4&V8','V3&V4&V9','V3&V4,10','V3&V5&V6'/
      DATA DFLABE /
     1 'V3&V5&V7','V3&V5&V8','V3&V5&V9','V3&V5,10','V3&V6&V7',
     2 'V3&V6&V8','V3&V6&V9','V3&V6,10','V3&V7&V8','V3&V7&V9',
     3 'V3&V7,10','V3&V8&V9','V3&V8,10','V3&V9,10','V4&V5&V6',
     4 'V4&V5&V7','V4&V5&V8','V4&V5&V9','V4&V5,10','V4&V6&V7',
     5 'V4&V6&V8','V4&V6&V9','V4&V6,10','V4&V7&V8','V4&V7&V9',
     6 'V4&V7,10','V4&V8&V9','V4&V8,10','V4&V9,10','V5&V6&V7',
     7 'V5&V6&V8','V5&V6&V9','V5&V6,10','V5&V7&V8','V5&V7&V9',
     8 'V5&V7,10','V5&V8&V9','V5&V8,10','V5&V9,10','V6&V7&V8',
     9 'V6&V7&V9','V6&V7,10','V6&V8&V9','V6&V8,10','V6&V9,10',
     1 'V7&V8&V9','V7&V8,10','V7&V9,10','V8&V9,10','4+ VARS ',
     2 'V1 IN 4+','V2 IN 4+','V3 IN 4+','V4 IN 4+','V5 IN 4+',
     3 'V6 IN 4+','V7 IN 4+','V8 IN 4+','V9 IN 4+','V10 IN4+'/
      ISEED = 1234567
C
C THE NEXT FIVE VALUES NEED RESETTING IF DATA ARE TO BE GENERATED
C ABOUT A MEAN OTHER THAN 500, A STANDARD DEVIATION OF 100,
C AND SCALE LOWER AND UPPER BOUNDS OF 0 AND 999.
C
```

Figure D-4 (continued)

```
      LOWCUT = 0
      HICUT = 999
      ZMEAN = 500.0
      IZMEAN = 500
      ZDEV = 100.0
      NPAGES = 0
C
C  BEGIN PROCESSING EACH NEW INPUT SPECIFICATION HERE
C
10    READ (21,1000,END=999) TITLE,NCASES,NVAR,NOUT,NPRED,INSEED
1000  FORMAT (10A8/I7,3I2,I10)
      IF (INSEED .GT. 0) ISEED=INSEED
      INSEED = ISEED
      HFMT(2) = NFMT(NVAR)
      READ (21,1010) ((VLABEL(I,J),I=1,2),J=1,NVAR)
1010  FORMAT (2A8)
      I=NVAR-1
      READ (21,1020) NCUT,((COEFFS(J,K),J=1,10),K=1,I)
1020  FORMAT (10I4/(10F8.8))
      IF (NPRED .LE. 0) GO TO 19
      DO 15 I = 1,NPRED
        READ (21,1025) (PWGTS(J,I),J=1,10),(PLABEL(J,I),J=1,2)
        VLABEL(1,NVAR+I) = PLABEL(1,I)
        VLABEL(2,NVAR+I) = PLABEL(2,I)
        PWGTS(11,I) = 0.0
1025  FORMAT (10F4.0,2A8)
C CALCULATE NORMALIZING VALUES FOR PREDICTIVE WEIGHTING EQUATIONS
        DO 14 J = 1,NVAR
14        PWGTS(11,I) = PWGTS(11,I) + PWGTS(J,I)**2
15      PWGTS(11,I) = SQRT(PWGTS(11,I))
C ZERO STUFF TO BE BLANKED
19    JOUT = NVAR + NPRED
      DO 20 I = 1,199
      NN(I) = 0
      DO 20 J = 1,JOUT
```

Figure D-4 (continued)

```
              MIN(J,I) = 1000
              MAX(J,I) = -1
              SUM(J,I) = 0.0
   20         SUMSQ(J,I) = 0.0
            DO 25 J=1,JOUT
              DO 25 K = 1,JOUT
   25       CORMAT(J,K) = 0.0
C ECHO INPUT SPECIFICATIONS TO FT06
            NPAGES=NPAGES+1
            WRITE (6,1100) NPAGES,TITLE
            WRITE (6,1030) NVAR,NCASES
 1030       FORMAT (/5X,'NUMBER OF VARIABLES =',I3/5X,
          2 'NUMBER OF SIMULATED SOLDIERS =',I7///15X,'VARIABLE LABEL',
          3 10X,'SELECTION'/40X,'CUTOFF'/)
            DO 30 I=1, NVAR
   30       WRITE (6,1040) I,(VLABEL(J,I), J=1,2), NCUT (I)
 1040       FORMAT(' VARIABLE',I3,' = ',A8,2X,A8,I11)
            JJJ = NVAR-1
            WRITE (6,1050) ZMEAN,ZDEV,(JLABEL(I),I=1,JJJ)
 1050       FORMAT(/' (ALL VARIABLES GENERATED WITH A MEAN OF ABOUT',F6.0,
          1 ' AND A STANDARD DEVIATION OF ABOUT',F6.0, )'///' ***** ',
          2'NORMALIZED INTERRELATIONS EQUATIONS'//3X,'VARIABLE ,T27,
          3 'P R E D I C T E D    B Y . . .'/4X,'NUMBER      R**2 ',9A9)
            WRITE(6,1111)
            DO 40 I=2,NVAR
            J=I-1
   40       WRITE(6,1060) I,(COEFFS(K,J),K=1,I)
 1060       FORMAT(I8,F14.5,F11.5,8F9.5)
            IF(NPRED.LE.0) GO TO 55
            WRITE (6,1070) (VLABEL(1,II),II=1,NVAR)
 1070       FORMAT (////' ***** WEIGHTED CRITERION PREDICTORS'//
          1 ' MATRIX OF WEIGHTS'//4X,'CRITERION',8X,10A11)
            WRITE (6,1080) (VLABEL(2,II),II=1,NVAR)
 1080       FORMAT (4X,'L A B E L',8X,10A11)
            DO 50 I=1,NPRED
   50       WRITE (6,1082) (PLABEL(J,I),J=1,2),(PWGTS(J,I),J=1,NVAR)
```

Figure D-4 (continued)

```
1082  FORMAT (/2A10,4X,10G11.4)
C DEVELOP CASE
55    WRITE (6,1085) INSEED
1085  FORMAT (//10X,'(PSEUDO-RANDOM NUMBER GENERATOR SEED VALUES:  ',
     1 'START =',I12)
      J=NVAR-1
      DO 60 I=1,J
60    COEFFS(1,I)=SQRT(1.0-COEFFS(1,I))
      ICASES=0
C
C FOR EACH CASE, CALCULATE ENOUGH RANDOM NORMAL NUMBERS (N(0,1))
C FOR "PREDICTOR" VARIABLES
C
100   CALL GGUN(ISEED,NVAR,RVEC)
      VVEC(1)=RVEC(1)
C CONVERT INDEPENDENT RAN-NORM-NUMBERS TO "PREDICTOR" VARIABLES--FLOATING PT
      DO 110 I=2,NVAR
      VVEC(I)=RVEC(I)*COEFFS(1,I-1)
      DO 110 J=2,I
110   VVEC(I)=VVEC(I)+VVEC(J-1)*COEFFS(J,I-1)
      NFAIL=0
C
C CONVERT FLOATING VALUES (MN = 0, SD = 1) TO INTEGER (MN = ZMEAN, SD = ZDEV)
C CONSTRAIN VALUES BETWEEN 0 AND 999, WITH 0 FOR ALL ORIGINALLY-NEGATIVE
C INTEGERS AND 999 FOR ALL INTEGERS ORIGINALLY 1000+.
C
C (THESE BOUNDS CORRESPOND TO "LOWCUT" AND "HICUT")
C
      DO 120 I=1,NVAR
      IVFAIL(I) = 0
      IVVEC(I)= IFIX(VVEC(I)*ZDEV+ZMEAN + 0.5)
      IF(IVVEC(I).EQ.LOWCUT)IVVEC(I)=LOWCUT + 1
      IF(IVVEC(I).LT.LOWCUT)IVVEC(I)=LOWCUT
      IF(IVVEC(I).EQ.HICUT)IVVEC(I)=HICUT - 1
      IF(IVVEC(I).GT.HICUT)IVVEC(I)=HICUT
      IF(IVVEC(I).GE.NCUT(I)) GO TO 120
```

Figure D-4 (continued)

```
      NFAIL=NFAIL+1
      IVFAIL(I)=1
120   CONTINUE
      IF(NPRED.LE.0)GO TO 140
C
C TALLY PREDICTOR SCORES FROM FLOATING POINT VALUES SO THAT THEIR
C MEAN IS ABOUT ZMEAN AND THEIR STANDARD DEVIATION DIFFERS FROM
C ZDEV SYSTEMATICALLY, BASED ON THE INTERCORRELATIONS OF THE
C "PREDICTOR" VARIABLES AND THE SIGNS OF THE PREDICTOR WEIGHTS.
C
      DO 130 I=1,NPRED
      X=0.0
      DO 125 J=1,NVAR
125   X=X+VVEC(J)*PWGTS(J,I)
      X=X/PWGTS(11,I)
      IVVEC(NVAR+I)= IFIX((X*ZDEV)+ZMEAN + 0.5)
      IF(IVVEC(NVAR+I).EQ.LOWCUT)IVVEC(NVAR+I)=LOWCUT + 1
      IF(IVVEC(NVAR+I).LT.LOWCUT)IVVEC(NVAR+I)=LOWCUT
      IF(IVVEC(NVAR+I).EQ.HICUT)IVVEC(NVAR+I)=HICUT - 1
      IF(IVVEC(NVAR+I).GT.HICUT)IVVEC(NVAR+I)=HICUT
130   CONTINUE
C WRITE CASE IF DESIRED
140   IF(NOUT.GT.0) WRITE (NOUT,NFMT) (IVFAIL(I),I=1,NVAR),(IVVEC(I),
     2I=1,JOUT)
C UPDATE NN,SUM, AND SUMSQ,MIN,MAX INDICATOR
C -- UP TO 23 SLOTS IN THOSE VECTORS COULD POSSIBLY NEED UPDATING
      ITAL(1)=1
      DO 150 I=2,23
150   ITAL(I)=0
      IF(NFAIL-1)160,170,170
C PASSED EVERYTHING
160    ITAL(2)=2
      GO TO 280
C ALL FAILURES HERE
```

Figure D-4 (continued)

```
170   ITAL(2)=3
      JTAL=3
      DO 180 I=1,NVAR
      IF(IVFAIL(I).LE.0) GO TO 180
      ITAL(JTAL)=I+3
      JTAL=JTAL+1
      IF (NFAIL .GT. 1) GO TO 180
      ITAL(4)=I+13
      GO TO 280
180   CONTINUE
C 2 OR MORE FAILURES ARE LEFT
      IF(NFAIL-3) 190,220,260
C 2 FAILURES EXACTLY
190   K=24
      III=NVAR-1
      DO 210 I=1,III
      IF(IVFAIL(I).EQ.0)GO TO 210
      JJJ=I+1
      DO 200 J=JJJ,NVAR
      IF(IVFAIL(J).EQ.0) GO TO 200
      ITAL(JTAL)=K+J-I-1
      GO TO 280
200      CONTINUE
210   K=K+10-I
C 3 FAILURES EXACTLY
220   K=69
      III=NVAR-2
      DO 250 I=1,III
      IF(IVFAIL(I).EQ.0)GO TO 250
      JJJ=NVAR-1
      KKK=I+1
      DO 240 J=KKK,JJJ
      IF(IVFAIL(J).EQ.0)GO TO 240
      LLL=J+1
      DO 230 L=LLL,NVAR
      IF(IVFAIL(L).EQ.0) GO TO 230
```

Figure D-4 (continued)

```
      ITAL(JTAL)=K+L-J-1
      GO TO 280
230   CONTINUE
240   K=K+10-J
250   K=K+(10-I)*(9-I)/2
      GO TO 280
C 4 OR MORE FAILURES
260   ITAL(JTAL)=189
      JTAL=JTAL+1
      DO 270 I=1,NVAR
      IF(IVFAIL(I).LE.0)GO TO 270
      ITAL(JTAL)=189+I
      JTAL=JTAL+1
270   CONTINUE
C UPDATE NN,SUM,SUMSQ,MIN,MAX ARRAYS
280   DO 285 I=1,23
      IF(ITAL(I).LE.0)GO TO 290
      K=ITAL(I)
      NN(K)=NN(K)+1
      DO 285 J=1,JOUT
C (REMOVE NOMINAL MEAN TO MINIMIZE ROUNDING ERRORS WITH REAL*4)
      X=IVVEC(J)-IZMEAN
      SUM(J,K)=SUM(J,K)+X
      SUMSQ(J,K)=SUMSQ(J,K)+X**2
      L=IVVEC(J)
      IF(L.GT.MAX(J,K))MAX(J,K)=L
      IF(L.LT.MIN(J,K))MIN(J,K)=L
285   CONTINUE
290   ICASES=ICASES+1
C UPDATE CROSSPRODUCTS MATRIX
      DO 295 I = 1,JOUT
        X = IVVEC(I)-IZMEAN
        DO 295 J = 1,JOUT
        Y = IVVEC(J) - IZMEAN
295     CORMAT (I,J) = CORMAT(I,J) + X*Y
      IF(ICASES.LT.NCASES)GO TO 100
```

Figure D-4 (continued)

```
C ALL CASES GENERATED,OUTFILE COMPLETED IF DESIRED; PREPARE FOR
C FT06 SUMMARY OUTPUT
C
C CALCULATE CORRELATIONS AND OUTPUT THEM
C
300   AN = NCASES
      WRITE (6,1090) ISEED
1090  FORMAT (58X,'END =',I12,')')
      NPAGES = NPAGES+1
      WRITE (6,1100) NPAGES,TITLE
      WRITE (6,1091)
      IJ = 1
      JK = MIN0(10,JOUT)
302   WRITE (6,1092) (VLABEL(1,II),II=IJ,JK)
      WRITE (6,1092) (VLABEL(2,II),II=IJ,JK)
      DO 306 I = 1,JOUT
        X = SUM(I,1)
        Y = SQRT(SUMSQ(I,1)*AN-X**2)
        DO 304 J = IJ,JK
          CORMAT(I,J)= (AN*CORMAT(I,J)-X*SUM(J,1))
304       CORMAT(I,J) = CORMAT(I,J)/(Y*SQRT(AN*SUMSQ(J,1)-SUM(J,1)**2))
        WRITE (6,1095) VLABEL(1,I),(CORMAT(I,II),II=IJ,JK)
306     WRITE (6,1096) VLABEL(2,I)
      IF (JK .GE. JOUT) GO TO 308
      IJ = JK+1
      JK = JOUT
      NPAGES = NPAGES+1
      WRITE (6,1100) NPAGES, TITLE
      WRITE (6,1098)
       GO TO 302
1091  FORMAT (/' CORRELATION MATRIX FOR DATA GENERATED',
     1 ' IN SIMULATION'//)
1092  FORMAT (20X,A8,9(2X,A8))
1095  FORMAT (/4X,A8,F15.4,9F10.4)
1096  FORMAT (4X,A8)
1098  FORMAT (/' GENERATED CORRELATION MATRIX (CONTINUED)'//)
C
```

Figure D-4 (continued)

```
C CALCULATE ALL MEANS AND STANDARD DEVIATIONS
C
308   DO 320 I=1,199
      IF(NN(I).LT.1) GO TO 320
      IF (NN(I) .GT. 1) GO TO 315
      DO 310 J = 1,JOUT
310     SUM(J,I) = SUM(J,I)+ ZMEAN
      GO TO 320
315   X=NN(I)
      DO 318 J=1,JOUT
      Y=SUM(J,I)/X
      SUMSQ(J,I)=((SUMSQ(J,I)-SUM(J,I)*Y)/(X-1.0))
      IF (SUMSQ(J,I) .GT. 0.0) SUMSQ(J,I) = SQRT(SUMSQ(J,I))
318   SUM(J,I)=Y+ZMEAN
320   CONTINUE
C
C PRINT BULKY PART OF OUTPUT -- MEANS, STANDARD DEVIATIONS,
C MINIMA AND MAXIMA -- FOR EACH OF UP TO 199 PASS-FAIL POSSIBILITIES
C
      NPAGES=NPAGES+1
      WRITE(6,1100)NPAGES,TITLE
1100  FORMAT('1 D&A SIMULATION OF IFV/CFV CREW QUALIFICATIONS',
     1T100,'PAGE',I4//5X,10A8//)
      IJ=1
      JK=NVAR
      KL=1
      I=1
      JJ=0
      WRITE(6,1110)(VLABEL(1,II),II=1,NVAR)
1110  FORMAT (23X,'I N D E P E N D E N T   V A R I A B L E S . . .'
     1 //4X,'CASES',12X,10A10)
1111  FORMAT(' ')
      WRITE(6,1120) (VLABEL(2,II),II=1,NVAR)
1120  FORMAT(21X,10A10)
350   GO TO 900
```

Figure D-4 (continued)

```
360   I=I+1
      IF(I.LE.3)GO TO 350
      IF(NPRED.LE.0.OR.IJ.GT.1)GO TO 400
      WRITE(6,2222)
2222  FORMAT(///)
      IJ=NVAR+1
      JK=JOUT
      I=1
      JJ=0
      WRITE(6,1130)(PLABEL(1,II),II=1,NPRED)
      WRITE(6,1120) (PLABEL(2,II),II=1,NFRED)
      GO TO 350
1130  FORMAT(23X,'CRITERION PREDICTIONS . . .'//4X,'CASES',12X,10A10)
C WRITE "ALL FAIL" FOR EACH VARIABLE
400   IJ=1
      JK=NVAR
      KL=2
      I=4
      JJ = 50
1140  FORMAT (2X,'FAILED ON:',9X,10A10)
410   GO TO 900
420   I=I+1
      IF (I .LE. NVAR+3) GO TO 410
      IF (NPRED .LE. 0 .OR. IJ .GT. 1) GO TO 450
      JJ = 50
      IJ = NVAR+1
      JK = JOUT
      I=4
      GO TO 410
C WRITE "ONLY FAIL" FOR EACH VARIABLE
450   IJ=1
      JK=NVAR
      KL=3
      I=14
      JJ = 50
460   GO TO 900
```

Figure D-4 (continued)

```
470   I=I+1
      IF (I .LE. NVAR+13) GO TO 460
      IF (NPRED .LE. 0 .OR. IJ .GT. 1) GO TO 500
      JJ = 50
      IJ = NVAR+1
      JK = JOUT
      I=14
      GO TO 460
C WRITE 2-WAY FAILS
500   IJ=1
      JK=NVAR
      KL=4
505   KK=23
      JJ=50
        J=1
506     K=1
507   I=KK+K
      GO TO 900
530   K=K+1
      IF(K.LE.NVAR-J)GO TO 507
      KK=KK+10-J
      J=J+1
      IF(J.LE.NVAR-1)GO TO 506
      IF(NPRED.LE.0.OR.IJ.GT.1)GO TO 550
      IJ=NVAR+1
      JK=JOUT
      GO TO 505
C WRITE 3-WAY FAILS
550   IF(NVAR.LE.2)GO TO 800
      IJ=1
      JK=NVAR
      KL=5
560   KK=68
      JJ=50
      J=1
```

Figure D-4 (continued)

```
570   L=0
      K=J+1
580   M=1
585   I=L+KK+M
      GO TO 900
610   M=M+1
      IF(M.LE.NVAR-K)GO TO 585
      L=L+10-K
      K=K+1
      IF(K.LE.NVAR-1)GO TO 580
      KK=KK+(10-J)*(9-J)/2
      J=J+1
      IF(J.LE.NVAR-2)GO TO 570
      IF(NPRED.LE.0.OR.IJ.GT.1)GO TO 650
      IJ=NVAR+1
      JK=JOUT
      GO TO 560
C 4+WAY FAILS SUMMARY LINE
650   IF(NVAR.LE.3)GO TO 800
      JJ = 50
      I=189
      IJ=1
      JK=NVAR
      KL=6
      GO TO 900
660   IF(NPRED.LE.0)GO TO 700
      IJ=NVAR+1
      JK=JOUT
      KL=7
      WRITE (6,2222)
      WRITE(6,1130)(PLABEL(1,II),II=1,NPRED)
      WRITE(6,1140)(PLABEL(2,II),II=1,NPRED)
      GO TO 900
C 4+ WAY FAILS, INDIVIDUAL VARS
```

Figure D-4 (continued)

```
700   IJ=1
      JK=NVAR
      KL=8
702   I=190
      JJ = 50
705   GO TO 900
730   I=I+1
      IF(I.LE.189+NVAR)GO TO 705
      IF(NPRED.LE.0.OR.IJ.GT.1)GO TO 800
      IJ=NVAR+1
      JK=JOUT
      GO TO 702
C DONE WITH THIS SIMULATION GENERATION
800   GO TO 10
C SUBPIECE-PRINT VALS FOR ONE CATEGORY
900   IF (JJ .LT. 48) GO TO 905
      JJ = 0
      NPAGES = NPAGES+1
      WRITE (6,1100) NPAGES,TITLE
      IF (IJ .GT. 1) GO TO 902
      WRITE (6,1110) (VLABEL(1,II),II=1,NVAR)
      GO TO 904
902   WRITE (6,1130) (PLABEL(1,II),II=1,NPRED)
904   WRITE (6,1140) (VLABEL(2,II),II=IJ,JK)
905   IF (NN(I)-1)910,920,930
C NOTHING HERE
910   WRITE(6,1910)DLABEL(I)
      JJ = JJ+2
      GO TO 940
1910  FORMAT('0   ',A8,' (N=0)')
C ONLY ONE VALUE
920   WRITE(6,1920)DLABEL(I),(SUM(II,I),II=IJ,JK)
      WRITE(6,1921)
      JJ = JJ+3
      GO TO 940
```

Figure D-4 (continued)

```
1920  FORMAT('0    ',A8,'    VALUE',F8.0,9F10.0)
1921  FORMAT(5X,'(N = 1)')
C MORE THAN ONE SCORE IN THIS CATEGORY
930   WRITE(6,1930)DLABEL(I),(SUM(II,I),II=IJ,JK)
1930  FORMAT('0    ',A8,'     MEAN',10F10.2)
      WRITE(6,1940)(SUMSQ(II,I),II=IJ,JK)
1940  FORMAT(14X,'ST.DEV.',F9.2,9F10.2)
      WRITE(6,1950)NN(I),(MIN(II,I),II=IJ,JK)
1950  FORMAT(4X,'N =',I6,4X,'MIN',I7,9I10)
      WRITE(6,1960)(MAX(II,I),II=IJ,JK)
1960  FORMAT(17X,'MAX',I7,9I10)
      JJ = JJ+5
940   GO TO(360,420,470,530,610,660,700,730     ),KL
999   STOP
      END
//GO.FT21F001 DD DSN=WYL.OM.WAL.ARIFORT.DAT,VOL=SER=DCU115,
// UNIT=2314,DISP=SHR
//GO.FT22F001 DD DSN=WYL.OM.WAL.ARIDAT6,VOL=SER=DCU308,
// DISP=(,KEEP),SPACE=(TRK,(10,10),RLSE),
// DCB=(RECFM=FB,LRECL=38,BLKSIZE=3152)
//GO.FT23F001 DD DSN=WYL.OM.WAL.ARIDAT3,VOL=SER=DCU308,
// DISP=(,KEEP),SPACE=(TRK,(5,5),RLSE),
// DCB=(RECFM=FB,LRECL=23,BLKSIZE=3151)
```

Figure D-4 (continued)

```
RUN B 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS
  100000622021119467382
7:BALNCE-VIS CUE
28: RATECONTROL
35: FLEXOF CLOSR
38:SPATLOR'NTATN
39:SPATLVISLZATN
57:NIGHTDYN VISN
 372 433 433 396 416 372
0.0     0.0
0.13    0.2     0.3
.20586  .26552  .24828  .17241
.29124  .18338  .15849  .24895  .22275
.10640  .35466  .05789  -.03235 -.08301 -.07762
   0    6    6    3    2    7                COMD/GNRCOMPUTED
   1    1    1    1    1    1                COMD/GNRUNIT WGT
RUN B 6B, PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)
  10000032302
38:SPATLOR'NTATN
39:SPATLVISLZATN
57:NIGHTDYN VISN
 416 416 372
0.16    0.4
0.0     0.0     0.0
   2    1    2                             DRIVER--COMPUTED
   1    1    1                             DRIVER--UNIT WGT
```

Figure D-5. Sample input specification for Program 2.

(weights of 0, 6, 6, 3, 2 and 7) comes from the multiple regression performed in Program 1 and shown in the "page 16" portion of Figure D-2. The b weights calculated there are .0039, .268, .257, .113, .0705 and .299, respectively. The weights could have been entered in that form with essentially no change in the predicted scores since the Fortran program adjusts for differences in the scale of the weights. To avoid introducing a false sense of precision to the estimation procedure, however, we converted the decimal weights to integers by dividing each by about .04 and rounding the result to the nearest integer. The rounding process will introduce a very slight shift in the resulting predicted values, but the discrepancy is negligible. Note that Variable 7 is effectively omitted from the regression weights even though it was given a significantly non-zero relationship with the criterion in the original correlation matrix (r = .2). This is due to the pattern of correlations between other variables and Variable 7 and the criterion. As would be expected, the criterion produced by these weights still does correlate positively with Variable 7, as shown in Figure D-6.

The second weights, all 1, are based on a simple argument: experts decided that all six selection variables are important to job performance. Rather than attempt to assign some variables more important than others, take the initial judgment and assign equal weights to all. While we would not defend this rationale as optimum, it is interesting to note that the two predictors of job performance were nearly equivalent (r = .92).

Lines 17 - 26 show similar specifications for the simulation for the Driver alone, using only three selection variables. The analysis based on the simulation from those specifications is shown in Figure D-7.

The next paragraphs describe the output features shown in Figure D-6 (Figure D-7 is similar). (Page references are to those printed by the computer as part of the output.)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

NUMBER OF VARIABLES = 6
NUMBER OF SIMULATED SOLDIERS = 10000

	VARIABLE LABEL		SELECTION CUTOFF
VARIABLE 1 =	7:BALNCE	-VIS CUE	372
VARIABLE 2 =	20: RATE	CONTROL	413
VARIABLE 3 =	35: FLEX	OF CLOSR	433
VARIABLE 4 =	38:SPATL	ORIENTATN	396
VARIABLE 5 =	39:SPATL	VISLZATN	416
VARIABLE 6 =	57:NIGHT	DYN VISN	372

(ALL VARIABLES GENERATED WITH A MEAN OF ABOUT 500. AND A STANDARD DEVIATION OF ABOUT 100.)

***** NORMALIZED INTERRELATIONS EQUATIONS

VARIABLE NUMBER	R**2	P R E D I C T E D B Y . . . VAR1	VAR2	VAR3	VAR4	VAR5
2	0.0	0.0				
3	0.13000	0.20000	0.30000			
4	0.20586	0.26552	0.24828	0.17241		
5	0.29124	0.18338	0.15849	0.24895	0.22275	
6	0.10640	0.35466	0.05789	-0.03235	-0.08301	-0.07762

***** WEIGHTED CRITERION PREDICTORS

MATRIX OF WEIGHTS

CRITERION L A B E L	7:BALNCE -VIS CUE	20: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL ORIENTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
COMD/GNR COMPUTED	0.0	8.000	6.000	3.000	2.000	7.000
COMD/GNR. UNIT WGT	1.000	1.000	1.000	1.000	1.000	1.000

(PSEUDO-RANDOM NUMBER GENERATOR SEED VALUES: START = 1119467382
END = 1212651781

Figure D-6. Program 2 sample output, TrackCommander/Gunner simulation.

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CORRELATION MATRIX FOR DATA GENERATED IN SIMULATION

	7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN	COMD/GNR COMPUTED	COMD/GNR UNIT WGT
7:BALNCE -VIS CUE	1.0000	-0.0048	0.2059	0.3069	0.3020	0.2989	0.3431	0.6046
28: RATE CONTROL	-0.0048	1.0000	0.3033	0.2996	0.3006	-0.0090	0.6558	0.5412
35: FLEX OF CLOSR	0.2059	0.3033	1.0000	0.2994	0.3938	0.0084	0.6758	0.6318
38:SPATL OR'NTATN	0.3069	0.2996	0.2994	1.0000	0.3956	-0.0027	0.5220	0.6588
39:SPATL VISLZATN	0.3020	0.3006	0.3938	0.3956	1.0000	-0.0106	0.5147	0.6807
57:NIGHT DYN VISN	0.2989	-0.0090	0.0084	-0.0027	-0.0106	1.0000	0.4991	0.3712
COMD/GNR COMPUTED	0.3431	0.6558	0.6758	0.5220	0.5147	0.4991	1.0000	0.9208
COMD/GNR UNIT WGT	0.6046	0.5412	0.6318	0.6588	0.6807	0.3712	0.9208	1.0000

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

INDEPENDENT VARIABLES . . .

CASES		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL ORIENTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
(TOTAL)	MEAN	501.23	500.54	499.70	502.02	498.58	500.35
	ST.DEV.	99.52	99.73	99.11	99.98	99.04	100.75
N = 10000	MIN	137	128	146	140	135	80
	MAX	876	879	864	874	873	881
ALL PASS	MEAN	535.48	553.29	554.05	547.63	550.71	521.43
	ST.DEV.	85.38	76.94	75.94	84.09	78.02	84.41
N = 4138	MIN	372	433	433	396	416	372
	MAX	876	879	864	874	852	881
ALL FAIL	MEAN	477.04	463.30	461.36	469.82	461.78	485.48
	ST.DEV.	101.68	98.26	95.55	97.77	95.74	108.42
N = 5862	MIN	137	128	146	140	135	80
	MAX	856	856	861	834	873	837

CRITERION PREDICTIONS . . .

CASES		COMD/GNR COMPUTED	COMD/GNR UNIT WGT
(TOTAL)	MEAN	500.61	500.98
	ST.DEV.	121.41	141.91
N = 10000	MIN	63	18
	MAX	917	980
ALL PASS	MEAN	589.69	607.20
	ST.DEV.	90.64	104.52
N = 4138	MIN	362	333
	MAX	917	980
ALL FAIL	MEAN	437.73	426.00
	ST.DEV.	98.96	114.27
N = 5862	MIN	63	18
	MAX	835	861

Figure D-6 (continued)

DCA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	51:NIGHT DYN VISN
ALL V1	MEAN	324.28	500.21	465.66	448.52	442.66	444.92
	ST.DEV.	41.16	98.78	98.87	96.46	93.11	97.98
N = 983	MIN	137	160	146	157	184	80
	MAX	371	767	804	767	691	719
ALL V2	MEAN	500.50	372.53	461.80	463.78	460.05	502.43
	ST.DEV.	99.04	49.98	93.76	94.81	96.92	100.69
N = 2462	MIN	161	128	146	148	135	146
	MAX	837	432	768	806	774	837
ALL V3	MEAN	474.96	461.56	372.39	462.86	448.47	498.86
	ST.DEV.	98.47	96.72	47.99	95.32	93.30	101.49
N = 2453	MIN	155	128	146	148	155	80
	MAX	854	776	432	787	873	837
ALL V4	MEAN	456.60	455.76	453.55	349.68	436.80	503.19
	ST.DEV.	97.02	96.05	94.60	44.18	92.67	102.94
N = 1430	MIN	155	128	158	148	135	132
	MAX	753	795	843	395	743	837
ALL V5	MEAN	459.56	457.17	445.50	447.30	359.85	501.64
	ST.DEV.	95.71	96.10	93.44	89.27	47.37	99.03
N = 1993	MIN	157	128	146	148	135	216
	MAX	741	856	763	739	415	799
ALL V6	MEAN	449.42	501.75	497.63	502.92	499.02	323.86
	ST.DEV.	96.16	99.30	98.23	104.28	99.84	41.00
N = 1020	MIN	170	160	200	158	181	80
	MAX	837	798	861	834	796	371

Figure D-6 (continued)

DCA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CMD/GNR COMPUTED	CMD/GNR UNIT WGT
ALL V1	MEAN	425.75	347.40
	ST.DEV.	115.43	117.63
N = 983	MIN	73	18
	MAX	773	721
ALL V2	MEAN	399.32	402.47
	ST.DEV.	97.61	123.12
N = 2461	MIN	63	18
	MAX	724	798
ALL V3	MEAN	396.71	385.31
	ST.DEV.	96.59	116.87
N = 2453	MIN	63	18
	MAX	710	788
ALL V4	MEAN	406.00	357.75
	ST.DEV.	106.89	115.64
N = 1630	MIN	73	18
	MAX	738	743
ALL V5	MEAN	412.66	365.65
	ST.DEV.	108.49	112.87
N = 1993	MIN	63	18
	MAX	835	781
ALL V6	MEAN	393.75	* 407.98
	ST.DEV.	106.72	133.71
N = 1020	MIN	63	18
	MAX	747	861

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
ONLY V1	MEAN	331.14	557.29	541.92	510.32	515.34	481.22
	ST.DEV.	36.56	73.23	69.57	74.07	63.96	72.31
N = 219	MIN	137	436	434	396	417	372
	MAX	371	767	804	767	691	717
ONLY V2	MEAN	545.34	380.34	525.88	518.28	524.24	521.99
	ST.DEV.	85.64	44.96	61.96	73.11	67.31	84.70
N = 855	MIN	372	134	433	396	416	372
	MAX	820	432	768	806	774	833
ONLY V3	MEAN	513.58	524.26	382.44	518.52	513.12	522.63
	ST.DEV.	81.36	63.42	39.03	75.72	65.26	83.82
N = 745	MIN	372	433	220	396	416	372
	MAX	854	776	432	787	873	826
ONLY V4	MEAN	507.11	523.28	531.08	356.65	511.83	536.21
	ST.DEV.	77.67	64.14	65.14	37.26	63.31	89.88
N = 304	MIN	372	433	433	152	416	373
	MAX	753	763	843	395	743	809
ONLY V5	MEAN	496.99	525.36	519.99	506.86	374.14	528.85
	ST.DEV.	72.54	66.44	60.68	65.93	35.55	82.76
N = 485	MIN	372	433	433	396	213	372
	MAX	741	856	741	739	415	765
ONLY V6	MEAN	493.92	558.11	555.39	557.76	554.20	320.69
	ST.DEV.	74.30	73.63	74.34	85.94	80.01	41.53
N = 408	MIN	372	434	433	397	417	114
	MAX	719	798	861	834	796	371

Figure D-6 (continued)

DSA SIMULATION OF IFV/CFV CREW QUALIFICATIONS PAGE 7

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CDMD/GNR COMPUTED	COMD/GNR UNIT WGT
ONLY V1	MEAN	545.66	474.38
	ST.DEV.	92.61	80.53
N = 219	MIN	363	270
	MAX	773	721
ONLY V2	MEAN	473.64	506.57
	ST.DEV.	70.50	85.03
N = 855	MIN	241	285
	MAX	724	798
ONLY V3	MEAN	472.38	489.60
	ST.DEV.	68.31	80.00
N = 745	MIN	291	306
	MAX	710	788
ONLY V4	MEAN	514.44	485.34
	ST.DEV.	78.90	81.73
N = 306	MIN	352	292
	MAX	729	743
ONLY V5	MEAN	520.45	479.63
	ST.DEV.	76.76	76.08
N = 485	MIN	338	248
	MAX	835	781
ONLY V6	MEAN	474.73	516.36
	ST.DEV.	75.96	93.55
N = 408	MIN	271	308
	MAX	747	861

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLUSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
V1 & V2	MEAN	342.80	382.27	508.77	495.47	508.17	457.73
	ST.DEV.	30.80	42.05	51.17	52.21	47.00	65.07
N = 30	MIN	264	278	434	421	426	372
	MAX	370	430	645	574	614	615
V1 & V3	MEAN	329.07	545.15	379.14	488.22	485.69	480.34
	ST.DEV.	40.02	64.23	39.67	65.09	52.37	78.13
N = 80	MIN	159	439	276	397	417	375
	MAX	371	717	432	657	637	669
V1 & V4	MEAN	324.27	535.65	520.61	345.45	486.78	466.94
	ST.DEV.	37.86	69.64	66.23	45.78	48.93	65.83
N = 49	MIN	228	437	433	200	420	376
	MAX	371	685	687	395	649	625
V1 & V5	MEAN	326.65	527.44	513.13	485.27	374.56	494.21
	ST.DEV.	42.93	62.79	69.20	56.60	38.72	80.83
N = 71	MIN	186	433	435	396	232	379
	MAX	371	695	763	621	415	716
V1 & V6	MEAN	326.44	568.42	542.64	517.56	525.76	321.50
	ST.DEV.	38.69	71.71	63.73	74.15	62.81	40.63
N = 84	MIN	170	441	434	407	422	158
	MAX	371	731	697	703	678	369
V2 & V3	MEAN	525.74	370.89	375.55	498.31	497.36	529.09
	ST.DEV.	81.36	48.47	48.02	66.02	63.24	84.78
N = 322	MIN	375	198	181	398	416	373
	MAX	749	432	432	735	686	775
V2 & V4	MEAN	512.77	371.05	516.49	349.78	492.06	534.54
	ST.DEV.	72.53	50.44	59.54	37.38	58.86	87.77
N = 156	MIN	381	191	434	210	416	373
	MAX	735	432	692	395	682	749
V2 & V5	MEAN	506.18	366.48	505.18	479.41	368.16	523.40
	ST.DEV.	76.11	46.61	57.55	58.67	41.91	78.84
N = 212	MIN	372	193	433	398	207	374
	MAX	719	431	698	663	415	777
V2 & V6	MEAN	498.07	381.73	527.40	529.74	539.91	328.38
	ST.DEV.	83.22	41.33	67.89	79.47	75.68	33.00
N = 85	MIN	375	256	434	401	418	173
	MAX	837	431	707	756	774	371
V3 & V4	MEAN	476.44	496.81	379.64	350.95	479.36	525.43
	ST.DEV.	69.94	54.96	39.14	42.43	54.16	81.63
N = 131	MIN	375	433	277	193	416	378
	MAX	643	723	432	395	662	785

Figure D-6 (continued)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLUSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
V3 & V5	MEAN	490.44	505.22	364.10	489.56	362.00	524.27
	ST.DEV.	74.48	55.06	50.84	60.55	43.85	86.74
N = 224	MIN	372	433	195	396	227	373
	MAX	699	758	432	678	415	799
V3 & V6	MEAN	492.99	519.28	385.49	538.95	507.73	324.12
	ST.DEV.	76.19	59.24	40.07	81.57	59.10	37.46
N = 74	MIN	372	433	276	407	417	209
	MAX	707	671	432	757	661	370
V4 & V5	MEAN	476.96	522.35	497.90	351.45	357.58	514.25
	ST.DEV.	67.34	69.51	51.20	36.10	49.67	86.66
N = 98	MIN	373	433	433	223	180	375
	MAX	690	795	652	395	415	799
V4 & V6	MEAN	466.18	523.79	540.93	360.57	516.82	335.11
	ST.DEV.	58.22	54.89	62.11	35.02	68.20	46.13
N = 28	MIN	382	453	454	255	421	169
	MAX	600	671	782	395	667	371
V5 & V6	MEAN	470.09	519.53	508.85	488.85	369.71	331.06
	ST.DEV.	54.07	63.19	49.37	68.77	49.63	34.50
N = 34	MIN	372	434	433	404	254	222
	MAX	563	681	619	717	415	371

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:			CMD/GNR COMPUTED	CMD/GNR UNIT WGT
V1 & V2		MEAN	418.07	375.47
		ST.DEV.	49.63	46.35
N =	30	MIN	333	293
		MAX	506	464
V1 & V3		MEAN	443.32	380.64
		ST.DEV.	68.25	64.46
N =	80	MIN	308	220
		MAX	592	513
V1 & V4		MEAN	466.83	369.22
		ST.DEV.	64.73	57.47
N =	49	MIN	311	225
		MAX	610	465
V1 & V5		MEAN	492.13	386.21
		ST.DEV.	85.59	73.71
N =	71	MIN	372	247
		MAX	727	599
V1 & V6		MEAN	458.64	419.27
		ST.DEV.	68.05	68.73
N =	84	MIN	320	283
		MAX	633	601
V2 & V3		MEAN	385.29	417.09
		ST.DEV.	67.30	75.35
N =	322	MIN	218	229
		MAX	590	664
V2 & V4		MEAN	422.30	408.85
		ST.DEV.	69.96	66.65
N =	156	MIN	251	248
		MAX	623	627
V2 & V5		MEAN	419.49	397.42
		ST.DEV.	67.23	71.54
N =	212	MIN	238	217
		MAX	610	620
V2 & V6		MEAN	363.73	420.49
		ST.DEV.	54.96	89.97
N =	85	MIN	208	226
		MAX	496	657
V3 & V4		MEAN	409.13	381.02
		ST.DEV.	64.86	64.92
N =	131	MIN	256	209
		MAX	599	551

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CMD/GNR COMPUTED	CMD/GNR UNIT WGT
V3 & V5	MEAN	420.41	392.04
	ST.DEV.	72.12	76.78
N = 224	MIN	249	226
	MAX	650	630
V3 & V6	MEAN	355.68	405.49
	ST.DEV.	55.12	72.82
N = 74	MIN	256	247
	MAX	570	607
V4 & V5	MEAN	455.98	385.90
	ST.DEV.	75.75	73.16
N = 98	MIN	331	219
	MAX	738	663
V4 & V6	MEAN	400.57	395.25
	ST.DEV.	39.52	49.48
N = 28	MIN	326	311
	MAX	472	520
V5 & V6	MEAN	387.18	372.62
	ST.DEV.	50.01	46.35
N = 34	MIN	261	236
	MAX	507	468

Figure D-6 (continued)

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
VI&V2&V3	MEAN	326.68	356.86	367.91	456.91	487.14	470.36
	ST.DEV.	34.70	55.54	60.08	42.98	45.47	70.66
N = 22	MIN	269	229	226	397	417	384
	MAX	371	427	429	586	582	646
VI&V2&V4	MEAN	321.36	391.50	520.93	358.79	496.93	488.14
	ST.DEV.	37.52	37.87	38.25	32.78	62.25	58.38
N = 14	MIN	246	304	433	273	417	382
	MAX	371	427	577	394	597	592
VI&V2&V5	MEAN	320.42	371.29	506.13	490.92	352.83	490.42
	ST.DEV.	49.83	64.68	62.82	60.62	49.69	98.47
N = 24	MIN	161	211	441	409	248	380
	MAX	366	430	655	682	405	719
VI&V2&V6	MEAN	298.09	392.00	523.45	469.73	479.09	317.09
	ST.DEV.	47.11	43.65	57.35	68.87	48.07	64.93
N = 11	MIN	212	280	457	407	420	146
	MAX	362	431	640	610	557	371
VI&V3&V4	MEAN	306.91	558.50	375.36	339.09	478.00	483.09
	ST.DEV.	46.41	79.56	52.66	51.95	43.46	62.43
N = 22	MIN	155	440	195	227	417	400
	MAX	369	722	431	395	588	608
VI&V3&V5	MEAN	314.38	526.36	358.50	486.77	348.61	467.13
	ST.DEV.	50.48	68.13	57.11	62.13	46.87	68.82
N = 56	MIN	165	437	233	396	198	372
	MAX	371	696	431	662	415	621
VI&V3&V6	MEAN	300.90	517.19	378.67	488.76	493.38	285.24
	ST.DEV.	58.57	50.38	51.74	55.93	55.78	78.84
N = 21	MIN	176	433	245	400	425	90
	MAX	366	625	430	621	621	367
VI&V4&V5	MEAN	322.18	518.76	475.39	336.97	356.16	492.95
	ST.DEV.	45.70	57.61	35.98	46.40	43.49	76.49
N = 38	MIN	157	436	434	249	223	388
	MAX	368	664	564	393	412	681
VI&V4&V6	MEAN	301.87	537.73	521.73	356.00	463.47	317.27
	ST.DEV.	43.04	76.37	60.84	30.80	32.21	58.27
N = 15	MIN	241	433	444	290	416	132
	MAX	360	655	611	393	533	368
VI&V5&V6	MEAN	325.39	519.00	516.61	489.17	363.28	326.61
	ST.DEV.	35.50	58.03	54.93	49.70	38.49	28.13
N = 18	MIN	249	441	436	400	242	260
	MAX	367	660	609	564	411	371

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CASES FAILED ON:		INDEPENDENT VARIABLES . . . 7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
V2&V3&V4	MEAN	485.29	367.62	366.49	349.63	481.05	526.23
	ST.DEV.	78.05	57.22	46.81	39.65	50.25	95.99
N = 84	MIN	372	213	203	201	416	377
	MAX	672	432	432	394	647	837
V2&V3&V5	MEAN	502.59	364.25	365.28	475.47	354.94	526.10
	ST.DEV.	74.16	57.86	51.26	53.02	50.63	83.39
N = 191	MIN	375	169	181	396	142	372
	MAX	705	432	432	672	415	749
V2&V3&V6	MEAN	484.00	368.26	380.84	492.66	494.08	334.63
	ST.DEV.	56.78	54.11	43.46	62.49	57.38	29.85
N = 38	MIN	376	211	246	398	417	267
	MAX	632	431	427	614	630	371
V2&V4&V5	MEAN	507.29	364.92	498.17	345.75	350.00	535.5C
	ST.DEV.	73.82	52.12	54.33	42.12	51.76	91.45
N = 76	MIN	378	228	433	204	213	373
	MAX	710	432	639	395	415	767
V2&V4&V6	MEAN	441.55	361.45	498.36	336.09	498.82	320.00
	ST.DEV.	42.18	59.87	36.86	39.41	64.18	46.05
N = 11	MIN	387	258	448	255	416	209
	MAX	519	423	573	385	599	365
V2&V5&V6	MEAN	492.90	364.95	518.71	507.71	371.43	328.81
	ST.DEV.	72.36	41.2C	69.74	64.27	32.44	36.96
N = 21	MIN	377	274	435	406	279	244
	MAX	652	426	702	634	413	371
V3&V4&V5	MEAN	476.32	510.1E	355.70	341.10	353.54	544.11
	ST.DEV.	67.25	58.14	54.91	45.41	41.46	77.83
N = 81	MIN	374	435	217	161	219	387
	MAX	618	692	432	395	415	736
V3&V4&V6	MEAN	442.81	512.CC	364.00	337.63	513.06	342.50
	ST.DEV.	56.36	65.91	47.49	55.77	73.86	25.90
N = 16	MIN	384	433	247	177	421	281
	MAX	572	650	426	395	685	367
V3&V5&V6	MEAN	450.68	485.92	376.52	479.00	363.20	337.36
	ST.DEV.	53.48	55.87	44.88	71.45	57.08	36.59
N = 25	MIN	375	433	280	397	181	249
	MAX	595	623	432	641	415	371
V4&V5&V6	MEAN	473.80	481.80	537.00	385.00	379.00	315.60
	ST.DEV.	85.55	33.64	47.40	7.78	23.47	48.84
N = 5	MIN	387	433	495	375	346	238
	MAX	604	515	616	394	404	363

Figure D-6 (continued)

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:		COMD/GNR COMPUTED	COMD/GNR UNIT WGT
VIEV2EV3	MEAN	326.00	281.73
	ST.DEV.	74.29	60.46
N = 22	MIN	172	129
	MAX	448	364
VIEV2EV4	MEAN	410.21	327.57
	ST.DEV.	39.69	46.81
N = 14	MIN	316	215
	MAX	472	411
VIEV2EV5	MEAN	402.83	308.96
	ST.DEV.	77.94	71.80
N = 24	MIN	313	172
	MAX	605	486
VIEV2EV6	MEAN	333.91	287.18
	ST.DEV.	67.18	69.43
N = 11	MIN	229	187
	MAX	459	421
VIEV3EV4	MEAN	409.91	312.41
	ST.DEV.	71.28	62.72
N = 22	MIN	299	224
	MAX	540	422
VIEV3EV5	MEAN	390.88	296.63
	ST.DEV.	72.50	66.74
N = 56	MIN	264	138
	MAX	552	452
VIEV3EV6	MEAN	312.14	281.19
	ST.DEV.	54.38	60.90
N = 21	MIN	185	193
	MAX	413	402
VIEV4EV5	MEAN	425.61	296.89
	ST.DEV.	63.50	53.38
N = 38	MIN	305	188
	MAX	571	418
VIEV4EV6	MEAN	376.67	294.93
	ST.DEV.	50.42	45.34
N = 15	MIN	295	202
	MAX	489	378
VIEV5EV6	MEAN	387.22	312.22
	ST.DEV.	45.45	46.47
N = 18	MIN	316	235
	MAX	501	397

Figure D-6 (continued)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A, PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CMD/GNR COMPUTED	CMD/GNR UNIT WGT
V2&V3&V4	MEAN	335.83	327.01
	ST.DEV.	74.42	79.43
N = 84	MIN	165	153
	MAX	556	587
V2&V3&V5	MEAN	344.17	332.05
	ST.DEV.	71.83	72.73
N = 191	MIN	123	72
	MAX	521	516
V2&V3&V6	MEAN	267.00	318.18
	ST.DEV.	44.22	55.13
N = 38	MIN	170	229
	MAX	357	437
V2&V4&V5	MEAN	384.63	337.38
	ST.DEV.	67.64	73.30
N = 76	MIN	260	202
	MAX	612	575
V2&V4&V6	MEAN	275.73	278.09
	ST.DEV.	46.22	48.38
N = 11	MIN	203	197
	MAX	337	352
V2&V5&V6	MEAN	315.86	330.43
	ST.DEV.	45.24	58.39
N = 21	MIN	220	212
	MAX	400	423
V3&V4&V5	MEAN	390.56	328.91
	ST.DEV.	69.69	71.93
N = 81	MIN	213	115
	MAX	550	478
V3&V4&V6	MEAN	300.69	300.88
	ST.DEV.	46.61	53.44
N = 16	MIN	216	187
	MAX	367	402
V3&V5&V6	MEAN	301.40	293.04
	ST.DEV.	39.02	51.12
N = 25	MIN	236	179
	MAX	400	397
V4&V5&V6	MEAN	347.40	325.20
	ST.DEV.	32.39	56.69
N = 5	MIN	320	279
	MAX	399	426

Figure D-6 (continued)

UGA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
4+ VARS	MEAN	389.37	390.80	376.05	356.46	353.02	450.49
	ST.DEV.	92.53	81.41	73.86	75.34	72.06	113.73
N = 379	MIN	183	128	146	148	135	216
	MAX	710	711	604	584	707	732

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CUMD/GNR COMPUTED	CUMD/GNR UNIT WGT
4+ VARS	MEAN	286.62	220.84
	ST.DEV.	77.35	73.24
N = 379	MIN	63	18
	MAX	695	431

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENTS

I N D E P E N D E N T V A R I A B L E S . . .

CASES FAILED ON:		7:BALNCE -VIS CUE	28: RATE CONTROL	35: FLEX OF CLOSR	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT OVN VISN
V1 IN 4+	MEAN	321.41	415.50	388.39	365.55	357.55	431.77
	ST.DEV.	39.94	87.65	82.39	83.36	71.43	106.67
N = 209	MIN	183	160	146	157	184	216
	MAX	371	711	604	576	603	690
V2 IN 4+	MEAN	403.54	363.50	374.19	356.41	354.64	462.29
	ST.DEV.	94.52	56.84	74.65	76.58	73.79	112.89
N = 309	MIN	183	128	146	148	135	225
	MAX	710	432	571	584	707	732
V3 IN 4+	MEAN	399.19	390.41	355.21	358.63	353.12	457.27
	ST.DEV.	95.82	82.97	57.50	74.29	74.81	113.32
N = 321	MIN	183	128	146	148	135	216
	MAX	710	711	432	584	707	732
V4 IN 4+	MEAN	398.86	389.19	379.07	329.71	354.00	467.45
	ST.DEV.	94.88	81.64	73.96	53.90	72.96	112.03
N = 302	MIN	183	128	158	148	135	216
	MAX	710	711	604	395	707	732
V5 IN 4+	MEAN	393.06	391.84	375.72	358.91	336.87	459.33
	ST.DEV.	93.02	82.62	75.32	73.10	57.46	111.80
N = 334	MIN	183	128	146	148	135	216
	MAX	710	711	604	584	415	732
V6 IN 4+	MEAN	375.51	414.00	396.76	383.72	379.77	327.00
	ST.DEV.	79.67	85.45	75.42	84.57	77.78	36.14
N = 426	MIN	196	160	200	158	186	216
	MAX	602	686	604	584	707	371

Figure D-6 (continued)

RUN # 6A. PREDICT JOINT COMMANDER/GUNNER BASED ON EXPERT JUDGMENT,

CRITERION PREDICTIONS . . .

CASES FAILED ON:		CMD/GNR COMPUTED	CMD/GNR UNIT WGT
V1 IN 4+	MEAN	297.62	206.12
	ST.DEV.	77.37	70.55
N = 209	MIN	71	18
	MAX	495	370
V2 IN 4+	MEAN	278.97	220.18
	ST.DEV.	77.20	74.89
N = 309	MIN	63	18
	MAX	495	431
V3 IN 4+	MEAN	280.31	219.88
	ST.DEV.	77.15	75.69
N = 321	MIN	63	18
	MAX	473	431
V4 IN 4+	MEAN	290.84	221.71
	ST.DEV.	78.53	76.07
N = 302	MIN	73	18
	MAX	495	431
V5 IN 4+	MEAN	290.17	220.63
	ST.DEV.	78.10	74.60
N = 334	MIN	63	18
	MAX	495	431
V6 IN 4+	MEAN	246.44	204.75
	ST.DEV.	63.38	65.11
N = 126	MIN	63	18
	MAX	441	386

Figure D-6 (continued)

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DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS                                   PAGE 19

   RUN # 68, PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)


   NUMBER OF VARIABLES =  3
   NUMBER OF SIMULATED SOLDIERS =  10000

             VARIABLE LABEL           SELECTION
                                        CUTOFF

VARIABLE  1 = 38:SPATL  OR'NTATN         416
VARIABLE  2 = 39:SPATL  VISLZATN         416
VARIABLE  3 = 57:NIGHT  DYN VISN         372

(ALL VARIABLES GENERATED WITH A MEAN OF ABOUT  500. AND A STANDARD DEVIATION OF ABOUT  100.)

***** NORMALIZED INTERRELATIONS EQUATIONS

 VARIABLE                     P R E D I C T E D    B Y . . .
  NUMBER        R**2          VAR1      VAR2

    2          0.16000        0.40000
    3          0.0            0.0       0.0



***** WEIGHTED CRITERION PREDICTORS

MATRIX OF WEIGHTS

  CRITERION               38:SPATL   39:SPATL   57:NIGHT
  L A B E L               OR'NTATN   VISLZATN   DYN VISN

 DRIVER--  COMPUTED        2.000      1.000      2.000

 DRIVER--  UNIT WGT        1.000      1.000      1.000

      (PSEUDO-RANDOM NUMBER GENERATOR SEED VALUES:  START =   121265178
                                                     END =  2143610722)
```

Figure D-7. Program 2 sample output, Driver simulation.

RUN # 6B. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

CORRELATION MATRIX FOR DATA GENERATED IN SIMULATION

	38:SPATL OR'NTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN	DRIVER-- COMPUTED	DRIVER-- UNIT WGT
38:SPATL OR'NTATN	1.0000	0.3973	-0.0049	0.7350	0.7154
39:SPATL VISLZATN	0.3973	1.0000	0.0030	0.5544	0.7194
57:NIGHT DYN VISN	-0.0049	0.0030	1.0000	0.6122	0.5115
DRIVER-- COMPUTED	0.7350	0.5544	0.6122	1.0000	0.9767
DRIVER-- UNIT WGT	0.7156	0.7194	0.5115	0.9767	1.0000

Figure D-7 (continued)

OEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 60. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

I N D E P E N D E N T   V A R I A B L E S . . .

CASES		38:SPATL ORIENTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
(TOTAL)	MEAN	500.42	500.01	499.29
	ST.DEV.	100.12	100.12	95.91
N = 10000	MIN	[illegible]	110	64
	MAX	[illegible]	917	904
ALL PASS	MEAN	542.14	541.36	518.82
	ST.DEV.	76.22	76.96	85.30
N = 6075	MIN	416	416	372
	MAX	896	917	855
ALL FAIL	MEAN	435.85	436.00	469.07
	ST.DEV.	98.41	98.12	112.56
N = 3925	MIN	130	110	64
	MAX	792	906	904

CRITERION PREDICTIONS . . .

CASES		DRIVER-- COMPUTED	DRIVER-- UNIT WGT
(TOTAL)	MEAN	499.81	499.85
	ST.DEV.	108.38	112.49
N = 10000	MIN	117	85
	MAX	886	916
ALL PASS	MEAN	554.43	559.08
	ST.DEV.	86.36	85.71
N = 6075	MIN	353	350
	MAX	886	916
ALL FAIL	MEAN	415.29	408.17
	ST.DEV.	84.56	83.86
N = 3925	MIN	117	85
	MAX	718	682

Figure D-7 (continued)

DCA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6B. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED UN:		33:SPATL ORIENTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
ALL V1	MEAN	358.62	445.74	498.30
	ST.DEV.	48.02	91.71	99.06
N = 1989	MIN	130	110	146
	MAX	615	716	864
ALL V2	MEAN	443.85	360.07	497.97
	ST.DEV.	93.93	46.95	95.93
N = 2012	MIN	133	110	146
	MAX	789	615	904
ALL V3	MEAN	503.02	502.37	324.55
	ST.DEV.	101.79	101.93	42.24
N = 976	MIN	186	128	64
	MAX	796	906	371

DCA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6B. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

CRITERION PREDICTIONS . . .

CASES FAILED UN:		DRIVER-- COMPUTED	DRIVER-- UNIT WGT
ALL V1	MEAN	386.54	386.08
	ST.DEV.	92.31	86.61
N = 1989	MIN	112	85
	MAX	694	674
ALL V2	MEAN	414.57	385.64
	ST.DEV.	92.65	85.06
N = 2012	MIN	112	85
	MAX	718	662
ALL V3	MEAN	385.85	401.84
	ST.DEV.	91.36	101.11
N = 976	MIN	112	89
	MAX	639	682

Figure D-7 (continued)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6B. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		38:SPATL ORIENTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
ONLY V1	MEAN	364.72	501.38	519.38
	ST.DEV.	42.96	60.37	87.06
N = 1125	MIN	130	416	372
	MAX	415	716	864
ONLY V2	MEAN	499.34	364.78	517.10
	ST.DEV.	60.14	44.16	84.13
N = 1150	MIN	416	177	372
	MAX	788	415	904
ONLY V3	MEAN	543.58	542.60	323.75
	ST.DEV.	76.30	80.67	42.58
N = 667	MIN	421	416	64
	MAX	796	906	371

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS

RUN # 6B. PREDIC. DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

CRITERION PREDICTIONS . . .

CASES FAILED ON:		DRIVER-- COMPUTED	DRIVER-- UNIT WGT
ONLY V1	MEAN	423.21	433.90
	ST.DEV.	69.01	67.20
N = 1125	MIN	211	227
	MAX	694	674
ONLY V2	MEAN	465.89	431.43
	ST.DEV.	70.91	65.90
N = 1150	MIN	278	224
	MAX	718	662
ONLY V3	MEAN	425.77	448.02
	ST.DEV.	70.21	77.15
N = 667	MIN	155	194
	MAX	639	682

Figure D-7 (continued)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS　　　　PAGE 26

RUN # 68. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		38:SPATL ORNTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
V1 & V2	MEAN	348.95	352.30	512.39
	ST.DEV.	52.51	49.63	78.87
N = 676	MIN	133	110	374
	MAX	415	415	748
V1 & V3	MEAN	370.12	503.13	321.72
	ST.DEV.	43.47	56.76	46.00
N = 121	MIN	242	416	147
	MAX	415	670	371
V2 & V3	MEAN	509.14	364.08	330.79
	ST.DEV.	65.70	48.75	37.42
N = 119	MIN	418	128	209
	MAX	700	415	371

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS　　　　PAGE 27

RUN # 68. PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

CRITERION PREDICTIONS . . .

CASES FAILED ON:		DRIVER-- COMPUTED	DRIVER-- UNIT WGT
V1 & V2	MEAN	358.34	334.65
	ST.DEV.	64.00	61.29
N = 676	MIN	124	85
	MAX	550	514
V1 & V3	MEAN	295.59	323.91
	ST.DEV.	49.20	52.41
N = 121	MIN	126	152
	MAX	379	430
V2 & V3	MEAN	347.95	329.13
	ST.DEV.	53.31	53.63
N = 119	MIN	278	193
	MAX	482	460

Figure D-7 (continued)

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS PAGE 28

RUN # 6B, PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

I N D E P E N D E N T   V A R I A B L E S . . .

CASES FAILED ON:		38:SPATL ORNTATN	39:SPATL VISLZATN	57:NIGHT DYN VISN
VIEV2EV3	MEAN	333.43	350.64	326.54
	ST.DEV.	62.52	52.8E	39.87
N = 69	MIN	184	198	146
	MAX	415	414	371

DEA SIMULATION OF IFV/CFV CREW QUALIFICATIONS PAGE 29

RUN # 6B, PREDICT DRIVER FROM EXPERT JUDGMENTS (3 ATTRIBUTES RELEVANT)

CRITERION PREDICTIONS . . .

CASES FAILED ON:		DRIVER-- COMPUTED	DRIVER-- UNIT WGT
VIEV2EV3	MEAN	223.55	217.49
	ST.DEV.	53.10	54.69
N = 69	MIN	112	89
	MAX	315	313

Figure D-7 (continued)

- Page 1 - repeats the input specifications so that the output can always be limited to its input constraints. Note that the start/finish values of the pseudo-random number generator "seed" - the number permitted by the subroutine to provide the "chance" aspects of the simulation - are printed so that any specific run may be reproduced exactly if ever necessary. The initial value of 1,119,467,382 was specified on input, in line 2 of Figure D-5.

- Page 2 - the actual correlation matrix between all the variables produced in this simulation run. These values should be compared with the matrix used as input to Program 1 (Figure D-1, lines 28-35 are relevant here). Two comparisons should be made:

  - The intercorrelations between the personnel selection variables should be almost exactly the same in input and output. (Here all but one are within ± .01, with the direction of error seemingly random.) If these values do not match very well, it is likely that an error has been made transcribing R^2 or <u>b</u> values from Program 1 output to Program 2 input.

  - The correlations between "criterion predictions" developed from Program 1 regression weights and the selection variables should be <u>higher</u> than those input to Program 1 but should show the same pattern. Here for example:

<u>input</u>:	.2	.4	.4	.3	.3	.3
<u>output</u>:	.34	.66	.68	.52	.51	.50

    The input values are all about 0.6 times the output values. (Some minor discrepancy from a perfect ratio is reasonable because the weights used were rounded rather than exact values.)

This ratio, 0.6 here and about .35 in the analysis in Figure D-7, should be about the same as the final Multiple R value in the regression producing the weights. The corresponding Multiple R values are marked on the last page of Figure D-2; they are .596 and .338.

- Page 3 - Along the leftmost column are the labels for the pass/fail subgroups and the number of simulated soldiers in each group. ("All Pass" means all soldiers whose scores were above the cutoff on every selection variable; "All Fail" are the other simulated soldiers.)

  To the right of this column are summary statistics for the scores on the selection variables ("Independent Variables") and the predicted job performance variables ("Criterion Predictions") for the simulated soldiers in each subgroup. This format is followed through the rest of the printout.

- Pages 4 - 15 The subjects who failed to pass all the cutoffs are broken into subgroups based on their exact failure pattern. Analysis of these pages can yield information on increases or decreases in the numbers of acceptable candidates caused by specific changes in cutoff criteria.

  - Pages 4, 5- Subgroups are based on all subjects failing each variable separately - i.e., without regard to whether or not they passed or failed the other variables. These numbers provide direct interpretation and verification of the cutoff numbers - e.g., a cutoff of 372 rejects about 10% of all candidates, one of 433 rejects about 25%, etc.

  - Pages 6, 7- Subgroups are based on subjects failing each variable <u>and</u> passing all the other selection variables. In this case, eliminating V1 (i.e., Var 7:Balance-Visual Cues) would increase the acceptable pool by only about 2%, eliminating V2 would swell the pool by about 8.5%.

- Pages 8-15 - Subgroups are based on subjects failing pairs or triads of selection variables but passing the rest. The interpretation of these numbers is similar to those of Pages 6 and 7, though their overall importance is lower.

- Pages 16-18- These pages summarize the scores for subjects who simultaneously fail to score above four or more selection variable cutoffs.

Using the Simulation Programs*

1. The first key input to the simulation programs is the specification of the personnel selection variables: the number of them and their interrelationship, in terms of a correlation matrix. Ideally, these values should be those empirically determined. At this point in the research, however, the values are estimated from a variety of sources of information. One benefit to the simulation process is the ability to test several plausible sets of variables and correlation matrices, including extreme matrix values to describe the bounds of conditions which may be found in the subsequent field experiences.

This input forms the basis of Program 1 (Figure D-1). The example shown above shows six screen variables (VAR7, VAR28, VAR35, VAR38, VAR39 and VAR57). The full program specification includes:

---

*For the SPSS program, the emphasis in this discussion is placed on the logic of the steps involved. For details of statement creation, formats and other language-specific factors, the reader is referred to the user's guide referenced above. While some familiarity with SPSS is required for any applications beyond a direct copy of what is presented here, we feel that the user can determine exactly how much familiarity is needed and can best obtain it through referencing the user's guide.

a) The correlation matrix (lines 28 - 36)

b) Successive regression statements (lines 17 - 24), especially:

VAR28 predicted from VAR7
VAR35 predicted from VAR7 and VAR28
VAR38 predicted from VAR7, VAR28 and VAR35
VAR39 predicted from VAR7, VAR28, VAR35 and VAR38
VAR57 predicted from VAR7, VAR28, VAR35, VAR38 and VAR39

In addition, the illustrated program includes two criterion variables. Their estimated correlations with the selection variables were included along with requests for the multiple regression of the criteria on the selection variables. The resulting weights were included in the running of Program 2.

2. The input to Program 2 is based on the prediction equations developed by Program 1 and the specification of several procedural details necessary to program operation. (The program was listed above in Figure D-4 and sample input for the program was shown in Figure D-5.) The input file is defined, in this system, as FT21F001, and includes:

Card 1: Title for the program output

Card 2:

Cols. 1-7: NSUBJ, the number of soldiers to be simulated (here 10,000)

Cols. 8-9: NVAR, the number of screen variables (up to 10 permitted)

Cols. 11-12: NOUT; if non-zero, the output file designation (e.g., 22 for FT22F001) for the simulated soldier data. If zero, the individual soldier data are not to be saved for possible further analysis.

Cols. 13-14: NPRED, the number of additional "criterion" variables in the program run (none required; up to 10 permitted)

Cols. 15-24: ISEED. The pseudo-random number generator works by successively modifying a kern l, or seed number. If ISEED is specified as a positive integer, it is used as the initial kernel value to allow the program to generate a unique series of numbers. If ISEED is not specified, a value contained in the program is used to generate an adequate series of pseudo-random numbers. (ISEED must be less than 2^{31}.)

Card 3: Cols. 1-8 and 9-16 contain a label for the first screen variable.

Card 4 to (NVAR + 2): labels for the remaining screen variables, as Card 3

Card (NVAR + 3): (in 10I4 format) The cutoff values for the NVAR screen variables. The first example in Figure D-5 gives cutoffs of 372, 433, 433, 396, 416 and 372 again. Since the variables are generated about a mean of 500 and a standard deviation of 100, the value 400 corresponds to a cutoff of -1σ, meaning that about 84% of all simulated subjects meet or exceed the cutoff of 400 on that variable. A value of 0 would lead to the acceptance of all subjects, i.e., the variable would be excluded from the screening process. For the values in the example above, the rejected subjects would be about 10%, 25%, 25%, 15%, 20% and 10% respectively.

Cards (NVAR + 4 to (2(NVAR) + 2): (in 10F8.8 format) The values derived from the running of Program 1 so that the generated data will reflect the inter-variable dependency shown in the correlation matrix input to Program 1.

The values on the first of these cards comes from the prediction of the second variable (e.g., VAR28) from the first variable (e.g., VAR7). The values on the second card come from the prediction of the third selection variable (e.g., VAR35) from the first two (e.g., VAR7 and VAR28). The values on the other cards are similarly derived.

The first value on any card is the "R SQUARE" value for the indicated regression. The second value is the "B" weight for the first variable (e.g., VAR7). The third value is the "B" weight for the second variable (e.g., VAR28) in the second and subsequent cards of this type. Additional values for the "B" weights for the third, fourth and (in this example) fifth selection variables follow.

For the values shown in the first example in Figure D-5, refer to the circled values in Figure D-2.

Cards (2(NVAR) + 3) to (2(NVAR + 1) + NPRED)*: If there are any additional "criterion," or job performance, variables to be generated (i.e., NPRED > 0), they are specified on these cards, one for each additional variable. The specification takes two parts: the list of weights by which the selection variable scores are to be combined to form the performance variable score, and the label by which the variable is identified in the printout.

Cols. 1-4: The weight given to the first selection variable score. (All weights are F4.0 . Fractional weights are allowed if the decimal point is punched, but integer values are almost always adequately precise and have been used in the accompanying examples.)

Cols. 5-8, 9-12, ..., 37-40: Weights for the other selection variables. Taken together, these weights correspond to the "c_{ij}" values of Formula 20. Weights for nonexistent selection variables are ignored.

---

*Optional. If NPRED=0 then no cards are used.

The weights receive proportional weight in the final variable score, as indicated by Formulas 20 and 21. In the example in line 15 of Figure D-5, the weights could have been doubled (to 0, 12, 12, 6,4 and 14) with no effect on the calculated scores.

Cols. 41-48 and 49-56: The label for the predicted performance variable defined by the weights in Columns 1-40.

As suggested by the example of Figure D-5, more than one simulation exercise can be carried out in a single program run. If this is done, and the simultated output from more than one run is to be retained for subsequent analysis, care must be taken that the data be saved in separate output files. This is done by making sure that the non-zero values of NOUT are distinct and that each refers to a properly defined output file (e.g., lines 513-518 in Figure D-4).

If produced, the output file of simulated soldier data includes a single record for each soldier, organized as follows:

Col. 1 to NVAR: Each column indicates whether or not the soldier failed to meet or pass the cutoff level for one of the personnel selection variables. "0" corresponds to pass, "1" means failure. For example,

010100

in Columns 1-6 means that this simulated soldier fell below the cutoff value for Variables 2 and 4 ("VAR28" and "VAR38" in our example) but scored at or above the cutoff for the other selection variables.

Col. NVAR + 1 to NVAR + 4: The actual score on the first selection variable, as an integer between 0 (zero) and 999. In confining scores to this interval on all generated variables, we have followed this convention: Actual scores of 0 or 999 are converted to 1 or 998; all negative scores are reported as 0 and all scores of 1000 or more are reported as 999.

The scores being affected are those more than five standard deviations from the mean; in our tests, this "truncation" has only been employed on predicted job performance variables and only extremely rarely (about once per 10,000 scores). Thus the effect of this convention on the data is negligible.

Col. NVAR + 5 to 5(NVAR): In four-column chunks, the scores for the remaining selection variables in order.

Col. 5 (NVAR) + 1 to 5(NVAR) + 4 (NPRED): Also in four-column chunks, the scores for any "criterion", or predicted job performance, variables included in the analysis.

Thus, for the examples shown, simulated soldier data would take up 38 columns: 1-6 for pass/fail indicators, 7-30 for scores on the six selection variables and 31-38 for scores on the two additional variables.

APPENDIX E

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