DOCUMENT RESUME

ED 172 018 IR 021 984

AUTHOR	Moore, Samuel B.; And Others
TITLE	Air Combat Training: Good Stick Index Validation. Final Report for Period 3 April 1978-1 April 1979.
INSTITUTION	Vought Corp., Dallas, Tex.
SPONS AGENCY	Air Force Human Resources Lab., Brooks AFB, Texas.
REPORT NO	AFHRL-TR-79-15
PUB DATE	Jun 79
CONTRACT	F34601-77-A-0176
NOTE	165p.; Not available in hard copy due to light print
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Aircraft Pilots; *Flight Training; Measurement Techniques; Military Training; *Simulators; Statistical Analysis; *Tables (Data); *Task Performance
IDENTIFIERS	Air Force; *Good Stick Index; United States

ABSTRACT

A study was conducted to investigate and statistically validate a performance measuring system (the Good Stick Index) in the Tactical Air Command Combat Engagement Simulator I (TAC ACES I) Air Combat Maneuvering (ACM) training program. The study utilized a twelve-week sample of eighty-nine student pilots to statistically validate the Good Stick Index (GSI) as an objective measure of pilot air combat skill, to compare GSI measures to the subjective judgment of ACM skill made by instructor pilots, to investigate improvements as a measure of ACM skill, and to evaluate GSI's utility as a training aid. (GSI utilizes four parameters as indicators of air combat skill: time in gun firing envelope, average mil error, offensive/ defensive time, and time to first kill.) It was concluded from analysis of the data that the GSI was a measure of ACM skill with contributory parameters consistent with intuitive expert opinion and with an acceptable level of accurate assessment of skill in the simulator. The GSI score was judged to be useful in evaluating individual and group learning within training programs in ACM. The individual parameters comprising the GSI were found usable as teaching guides. (JH)

AFHRL-TR-79-15

AIR FORCE

HUMAN RESOURCES LABORATORY

ED172018

AIR COMBAT TRAINING: GOOD STICK INDEX VALIDATION

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June 1979
Final Report for Period 3 April 1978 – 1 April 1979

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This final report was submitted [illegible] Corporation, P.O. Box 225907, Dallas, Texas 752[illegible] contract F[illegible]-601-77-A-0176, project 1123, with Flying Training Division, Air Force Human Resources Laboratory (AFSC), Williams Air Force Base, Arizona 85224. Mr. Robert E. Coward [illegible] contract monitor for the Laboratory.

This report has been reviewed [illegible] Information Office (OI) and is releasable to the National [illegible] Information Service (NTIS). At NTIS, it will be available [illegible] general public [illegible] foreign nations.

This technical report has been reviewed and is approved for publication.

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Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
AFHRL-TR-79-..

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
AIR COMBAT TRAINING: GOOD STICK INDEX VALIDATION

5. TYPE OF REPORT & PERIOD COVERED
Final
3 April 1978 – April 1979

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Samuel B. Moore
Walker G. Madison
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Robert E. Howard

8. CONTRACT OR GRANT NUMBER(s)
F34601-77-A-0

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Vought Corporation
P.O. Box 225907
Dallas, Texas 75265

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
62205F
[illegible]

11. CONTROLLING OFFICE NAME AND ADDRESS
HQ Air Force Human Resources Laboratory (AFSC)
Brooks Air Force, Texas 78235

12. REPORT DATE
June 1979

13. NUMBER OF PAGES
[illegible]

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Flying Training Division
Air Force Human Resources Laboratory
Williams Air Force Base, Arizona 85224

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Air Combat Maneuvering (ACM) training objective performance measures
automated performance measurement
flight simulators
flying training
pilot performance measurement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Good Stick Index validation study statistically [illegible] an empirically derived measure of pilot proficiency in an air combat simulator. Statistical methods, including [illegible] and discriminant analyses, were used to evaluate GSI scores as predictors of student free-engagement performances in the TAC ACES I simulator training program. Statistically derived performance predictors are [illegible] from objectively measured parameters recorded during simulator training. The effect of inclusion of student [illegible] demographic data with the objective data is investigated. Edumetric and psychometric data are presented as [illegible] skill development.

Results of the study yield performance predictors for four [illegible] within each TAC ACES class; (a) winners, (b) winners or runners-up, (c) upper-half winners, and (d) [illegible] quartile ranking. The empirically derived

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20 Continue

measure shows a probability of winner prediction of 25 percent, whereas the statistically derived optimal measure shows a probability of winner prediction of 80 percent. The reliability of the performance predictors is assessed. Potential utilization and limitations of the Good Stick Index are addressed.

SUMMARY

Approach

A study was conducted to investigate and statistically validate a performance measuring system in the Tactical Air Command Air Combat Engagement Simulator I air combat maneuvering (ACM) training program at Vought Corporation, Dallas, Texas. The study utilized a 12 week sample of 89 student pilots in an experiment to statistically validate an objective performance measure of air combat skill, compare the objective measure to the subjective judgement of ACM skill made by instructor pilots, to investigate improvements as a measure of ACM skill, and to evaluate its utility as a training aid.

Statistical methodologies of ridge regression and discriminant analyses were employed to assess the quantitative and qualitative characteristics of the measure of ACM skill in the simulator.

Background

A scoring system termed the Good Stick Index (GSI) is used as an indicator of pilot air combat skill in the TAC ACES I simulator training program. The GSI was developed jointly by the Tactical Air Command and the Vought Corporation utilizing four subjectively chosen and equally weighted parameters which to the experienced pilot are intuitive indicators of air combat skill. The four parameters are 1) time in gun firing envelope, 2) average mil error, 3) offensive/defensive time, and 4) time to first kill - objective measures obtained during student pilot scoring sessions against programmed target maneuvers. The TAC ACES I

training pr[illegible]ram is [illegible] by a one-on-one free engagement tournament where [illegible] student pilot is matched against another. T[illegible] turkey shoot tournament is a double elimination event [illegible] must [illegible] two engagements to be eliminated) resulting in a single winner.

The GSI score, [illegible] as a predictor of turkey shoot placement, [illegible] pre[illegible] the winner at greater than random frequency.

Specifics

The GSI [illegible] study was conducted to statistically validate the GSI as predictor of turkey shoot winner, investigate improvement [illegible] GSI by varying the weighting of each of the four parameters, and introducing additional parameters as candidates for an improved predictor of turkey shoot winner. The validated GSI was compared with the turkey shoot student placement predictions of the instructor pilot to assess its agreement with expert opinion.

In order to better evaluate the potential utility of the GSI, four groupings of turkey shoot placements in each class of eight students were investigated;

1) Winners

2) Winners and Runners-Up (Finalists)

3) Upper-Half (Semi-Finalists)

4) [illegible]artile Rankings.

Data used in the study were collected during the 12 class (12 week) sample from 3 April 1978 through 23 June 1978. These data were objective measures of performance in the simulator, demographic (background) data obtained by student questionnaire, and instructor pilots' predictions of turkey shoot placement of students within each class. The objective measures were obtained from scoring sessions on Mondays, immediately after briefing and hands-on familiarization and on Fridays just prior to the turkey shoot exercise. In four of the classes, an additional scoring session was held on Wednesdays to better assess learning trends in the simulator.

The TAC ACES I training syllabus was consistent throughout the experiment as attested to by the Chief Instructor Pilot. Instructor pilots provided individual instruction to each student, concentrating in areas of recognized deficiencies. The students were aware of the scoring sessions, but were unaware of the intended use of the acquired data.

Results

The first statistical analysis performed determined the prediction capability of the equally weighted, four-parameter GSI score obtained in Friday scoring sessions. The results were compared to the subjective student turkey shoot rank predictions of the instructor pilots. The analysis showed the GSI score, using Friday only data, to predict the turkey shoot winner with a 25 percent probability (one in four). There was no statistical difference between the GSI and the instructor pilot prediction capabilities.

A second analysis summed the GSI score obtained on Friday to the GSI score obtained on Monday and optimally weighted the combined score. A significant increase in probability of correct turkey shoot placement was observed at about 66 percent (two in three).

A third analysis used the four individual parameters of each GSI score for Monday and Friday (a total of eight terms) and optimally weighted each individual parameter. The results increased the prediction of turkey shoot placement to about 75 percent (three in four), the best prediction which could be obtained with the four parameters intuitively chosen as indicators of ACM skill.

In the fourth statistical analysis, a set of 40 objective measures taken during each scoring session were introduced to the discriminant model as potential predictor candidates. Included in the data set were the four parameters in the original and improved GSI score. The analysis derived an optimal predictor with about 80 percent probability of correct turkey shoot placement. Further, a set of 12 subjectively chosen demographic (background) data obtained from student questionnaires introduced as potential contributor candidates in the expanded list of candidates. The probability of correct turkey shoot placement remained about 80 percent -- however, background parameters of total time in fighter aircraft, time in the F-4 aircraft, and the number of sorties flown in the last thirty days, replaced three of the terms in the optimal objective predictor score. This result reinforces the predictor model as a measure of pilot ACM skill.

The statistically validated GSI was used in the final analysis to obtain a measure of learning trends in the simulator. A third scoring session on Wednesday, in addition to the Monday and Friday data, enabled an evaluation of skill development in the simulator over the week's training period. A quadratic fit through the means of individual scores obtained on the three days showed definite positive group learning (edumetric trend). The distribution of individual scores was seen to converge, or group closer together, from Monday to Friday. The slope of the quadratic fit approached zero on Friday, which indicates that one week's training in the simulator was optimal for the classes subjected to the investigation.

Conclusions

The overall analyses in the study showed the GSI to be a measure of ACM skill with contributing parameters consistent with intuitive expert opinion and with an acceptable level of accurate assessment of skill in the simulator. The GSI score is shown to be useful in evaluating individual and group learning within training programs in ACM, and the individual parameters comprising the GSI score can be used as teaching guides.

A recommendation is made to utilize the algorithms and similar techniques and methodologies as presented in this study to derive performance measurement systems for the Simulator for Air-to-Air Combat at Luke AFB and the Air Combat Maneuvering Instrumentation (ACMI) Range at Nellis AFB. When an objective performance measure can be obtained for ACM in the air, then an objective measure of transfer of training between the simulator and the aircraft can be ascertained.

Applications of the techniques of the study can also be applied to other ACM simulators and other types of flight simulators to achieve like measures of skill in a variety of flying tasks.

PREFACE

This report documents the tasks performed under contract F34601-77-A-0176-KW01, the Good Stick Index Validation Study. The Vought Corporation, Dallas, Texas, has been under contract with the USAF Tactical Air Command (TAC) to furnish the Air Combat Engagement Simulator (ACES) facility in support of TAC air combat training during the data collection phase of this study. A pilot performance scoring system, the Good Stick Index (GSI), was developed earlier for the purpose of predicting relative performance of student pilots in a free engagement competition within each class of eight pilots. Initially, four parameters of pilot performance were used to compute a GSI score for each pilot. These parameters were selected subjectively and were empirically weighted in the scoring equation. There had been no previous effort to statistically validate the predictive ability of the GSI equation.

The contractor wishes to acknowledge the technical guidance and assistance provided by Mr. Robert E. Coward, Contract Manager and Co-Author, Flying Training Division of the Air Force Human Resources Laboratory, and the program training, planning, and scheduling interface of TAC ACES I personnel provided by Lt. Col. John K. Sloan II of the Air Force Tactical Fighter Weapons Center.

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AIR COMBAT TRAINING:

GOOD STICK INDEX VALIDATION

I. INTRODUCTION

The Good Stick Index (GSI) is a numerical index devel-oped to measure student pilot proficiencies in simulated one-on-one air combat. The GSI, as originally formulated by the Vought Corporation, Dallas, Texas, consists of four objective performance parameters measured during USAF Tactical Air Command (TAC) Air Combat Engagement Simulator (ACES) I training.

The four parameters comprising the GSI were subjectively chosen and, from data obtained over many classes, empirically related to derive a predictor of the "winner" or "runner-up" in the double elimination one-on-one free engagement tournament held at the conclusion of each training session. This derived relationship appears to predict the winner or runner-up of the double elimination free engagement "turkey-shoot" with greater than random frequency.

This study investigates the predictive ability of the empirically derived relationship as a predictor of turkey shoot winner by utilizing statistical analysis methods. Further, the study derives, through statistical techniques, the optimal predictor indices using the original four subjectively chosen parameters and then derives optimal predictors from an expanded set of objective measures, which include the four parameters originally chosen.

These analyses were performed using data collected from 12 classes of students in an experiment representative of TAC ACES I training. Input data fidelity was assured by (a) certification that there was adherence to the training syllabus by the Instructor Pilots (IPs), (b) certification that there were no hardware anomalies, and (c) certification that there were no software anomalies unaccounted for during the control period.

Additional analyses were performed to obtain correlations of student pilot background data and IR subjective predictions of student ranking relative to GSI scores and actual turkey shoot rankings.

Four of the 12 classes in the experiment were structured to collect additional edumetric and psychometric parameters in order to obtain a greater measure of individual and group transfer of training in the simulator.

The optimal GSI predictors, as derived by statistical analyses of the experiment data, are evaluated as a predictor. Using previous class sessions as a data base to a limited degree, an assessment is made of actual turkey shoot prediction capability.

BACKGROUND

The TAC ACES I training program is conducted by the Tactical Air Command using the Vought Corporation fixed base air combat simulator (Figure 1). The program utilizes two F-4 configured cockpits with full instruments and weapon systems indicators necessary for air-to-air combat simulation in a functional mode. The software modeling is for F-4D and F-4E aircraft flight characteristic. In addition, a MIG 21 is modeled to provide training in dissimilar aircraft engagements.

Facility Description

The Vought Air Combat Simulator, Figure 1, consists of two cockpits, each situated within 16-foot-diameter spherical screens. Overhead projectors provide dynamic earth/sky horizon scenes and an image of the opponent's aircraft. The aircraft target is a high-resolution color image provided by the Opaque Target Optical Project System (OTOPS),

Figure 1. The Vought Air Combat Simulator

recently developed by Vought. Each pilot wears a g-suit and sits on a g-seat. As a pilot increases the load factor on his aircraft, his g-suit inflates and his g-seat deflates. The visual display dims as a function of g and time and finally blacks out, with the target image the last to go The g-seat also provides a buffet cue, beginning as a high frequency nibble, increasing in amplitude and decreasing in frequency as penetration into the buffet area occurs. Each cockpit is equipped with fire control switchology which reflects the F-4E, number 556 and subsequent, as modified by T.O. 1F-4E-556.

On-line firing and hit cues, engine, aircraft, and weapon sounds add to the realism of the simulated air combat, and a separate bullet model includes the time of flight. Weapon realism extends to the heat and radar missiles, too, as a miss will be scored if the aircraft target exceeds the missile turning/tracking capabilities before the time of flight has elapsed. A pilot scoring system called the GSI measures the relative air combat skills of the pilot.

A unique Instructor Pilot (IP) station that is mobile and that can be operated from alongside the cockpit provides the IP a matchless vantage point. The IP station provides complete control of the simulation, including operate, freeze or reset, replay, data recording, video recording, and options to record and play back preprogrammed or canned target trajectories. It also contains the engagement scene which can be recorded on video cassettes, along with the audio from both cockpits and the IP, for subsequent replay and debriefing.

Training Sessions

Typically, the TAC ACES I training session is scheduled for one week and consists of eight student pilots and three IPs. Each student accumulates a minimum of ten hours of classroom and hands-on training in air-to-air combat. Two student pilots train simultaneously in the dual dome two-cockpit facility. Each student pilot is normally instructed by an individual IP, but a single IP can instruct both pilots simultaneously. Training data are normally recorded while "flying" against a target with preprogrammed flightpaths. A kill is "scored" by guns, heat missile, radar missile, or ground strike.

The student pilot undergoes initial briefings and simulator familiarity sessions on the first day of the five days of training. After becoming familiar with the simulator characteristics through the hands-on session, the student is "scored" against a series of canned target maneuvers. The student's initial performance is recorded by computer and stored on magnetic tape.

The training progresses during the week in accord with the TAC ACES I training syllabus. The final day of training, the fifth day, consists of a second scoring session with each student pilot competing against canned target maneuvers as was initially done on the first day of training. The class training culminates by a double elimination competition, or turkey shoot, where each student competes against the others in one-on-one free engagements until eliminated or a winner is decided.

Background data are collected on each pilot undergoing TAC ACES I training. In addition, each student pilot is asked to subjectively evaluate the simulator performances in comparison to the actual aircraft. Subjective evaluations of the training effectiveness and potential improvements are also solicited. These data are recorded on appropriate questionnaire forms and transmitted to TAC, and copy remains on file at Vought.

Utilization of Data

The accumulated subjective critiques of the simulator performance and the training evaluations obtained from the student pilots and inputs from IPs are used both by TAC and Vought in evaluating potential improvements in the simulator and simulator training.

The objective measures of student pilot performance are used in obtaining the GSI to represent a measure of relative proficiency in air-to-air combat in the simulator. Student pilot background data are used to subjectively correlate a pilot's expected level of proficiency with that measured by the GSI.

Experiment Controls

The data were collected for a sample of 90 subjects during the period of this study, under concisely defined controlled conditions. The study was unique in the sense that the data had to be collected within and from the operational training environment. The collection of data under these conditions also had to be made on a minimum interface and non-interference basis with the ongoing TAC ACES I training program. This requirement precluded the application of experimental controls in a classical sense, as found in a laboratory experiment. As a result, other methods of control were developed to function within the restrictions imposed to provide some assurance as to the fidelity of the data collected and to minimize the effect of undesired variables. This was accomplished by briefing each new Chief IP (CIP) as to the mandatory adherence by IPs and students to the approved TAC ACES I Training Syllabus. A form was developed and completed after each training class, certifying to the adherence to the TAC ACES I Training Syllabus, fidelity of the air combat simulator performance, and performance accuracy of the software and computer hardware. Data collected from TAC ACES I students prior to this study did not have these controls.

The TAC ACES I students in the study were not aware of the GSI Validation Study and the purposes of data collection. Individual pilot performance data were collected on Monday and Friday of the training week and during the "Turkey Shoot" elimination contest, after completion of the formal training program. In addition, performance data were collected for four of the 12 classes on Wednesday of the training week. The students were also required to complete a background questionnaire and an end-of-course critique. The existing questionnaires were modified to obtain age group and combat experience data. The Chief Instructor Pilots (CIPs) for the TAC ACES program were required to predict each student's performance in the turkey shoot contest. As each class completed the formal training program, the CIP was required to rank-order that class of students as to their perceived standing at the completion of the turkey shoot elimination contest. Simulation or other training syllabus anomalies were also recorded as a part of the data collection task to aid in the identification of outliers in the data sets.

All of the student pilot performance data were recorded on magnetic tape. All other data from students' background, course critiques, and CIP rankings were recorded on forms adapted to or generated for the study. In addition, all of the student pilot performance data were produced on hard copy printouts for verification and preliminary analyses.

The forms developed and used in the study are included in Appendix B. The TAC ACES I Training Syllabus and the turkey shoot competition rules are included in Appendix C. Mathematical descriptions of the scoring computations for each weapon simulated in the study have been submitted to the Flying Training Division of the Air Force Human Resources Laboratory.

II. OBJECTIVES

Scope

The scope of this investigation is limited to the optimization and validation of the GSI system. The primary product is an assessment of the capabilities and limitations of the GSI scores as indicators of pilot Air Combat Maneuvering (ACM) skill and the determination of the utility of GSI scores as predictors of pilot performance in free-engagement turkey shoot competition.

Derivation of Optimal Models

The empirically derived GSI was statistically validated to its predictive capability by the use of statistical analysis techniques. An improved GSI predictor using the four subjectively selected parameters of the empirical GSI was obtained by discriminant analyses. A further improved GSI predictor was derived from the expanded list of available candidate predictor variables and variable selection techniques. These improved predictors were validated with data acquired from classes outside the experiment. Confidence intervals on the predictors were provided. Further, standardized discriminant functions were provided to identify the relative contribution of each parameter in the derived predictor equation(s). Student pilot background and subjective data obtained from questionnaire forms were input with objective data to obtain optimal predictor models.

Comparison With Expert Opinion

Subjective rankings of student pilots were obtained from Instructor Pilots and compared to the derived GSI predictors and the actual pilot rankings obtained from turkey shoot results. These interrelationships were described through the use of correlation and variance/covariance matrixes.

Correlation With Previous Data

Data from classes undergoing training prior to this experimental study were used on a random selected basis to obtain measures of GSI prediction accuracies. These investigations are necessarily limited to the GSI as determined from the four subjectively selected parameters, since other objective data were not on file.

Reliability of GSI Scores

The reliability of the GSI was determined by calculating confidence intervals of predictions of turkey shoot rank and corresponding confidence levels of the degree of certainty of the predicted value.

Edumetric and Psychometric Measurement

A measure of learning effects was obtained by statistically analyzing data from four classes specifically structured to obtain three scoring periods for each student pilot. Measures of individual and group learning were statistically derived as a function of time in training. These learning rates were compared to student pilot performance data.

III. ANALYSES

The GSI Score was computed from data acquired during the TAC ACES I training of each class, normally on Monday and Friday. During the GSI Validation Study, a third set of GSI data was collected on Wednesday for four of the 12 classes involved. GSI data are recorded nominally against five canned targets; generally, two of the five are cinetrack and the remaining three are head-on.

The equation defining GSI is,

$$GSI = 4.6\ (70-MILERR) + 0.86(PANG)+(O/D-35)+0.5(180-TTFK) \quad (1)$$

where:

- MIL ERR - average mil error over two cinetrack runs while R < 3,000 ft.
- PANG - average percentage of engagement time in pointing angle advantage, R < 3000 ft., over two cinetrack runs.
- O/D - average ratio of offensive to defensive time against the head-on targets. Offensive time is the time the target aircraft is in the front hemisphere of the piloted aircraft.
- TTFK - average time to first kill (seconds) from beginning of run until student achieves first kill against head-on targets with gun or heat missile.

The GSI Score itself is intended to have a possible range between zero and 1,000. Also, each of the four component scores was originally intended to contribute equally to the index itself. Scaling factors were adjusted from time to time as experience was gained and when an adjustment was considered appropriate. The equation for GSI given above contains the scaling factors used over the data collection period of this study. MIL ERR, PANG, O/D, and TTFK are referred to as the GSI component scores or component variables in this report.

Statistical Analysis of GSI Data

The statistical analysis of the basic Monday and Friday GSI scores and the four GSI component scores collected over the 12-class experimental period is presented in this section.

Histograms of the GSI scores and the four GSI component variables (part-scores) are provided in Figures 2 through 6. These show the general distributional shapes of each variable. The histograms for Monday and Friday for each score are provided on the same page to facilitate visual comparison. In general, the distributions improve from Monday to Friday (increase or decrease as appropriate) and the sample standard deviations become smaller.

Scatter diagrams for GSI and GSI component variables for both Monday and Friday are presented in Figures 7 through 11. The Y-variable used to construct these scatter diagrams is turkey shoot rank. Turkey shoot winners are ranked one, runners-up are ranked two, third eliminators always receive a rank of 5.5, and first eliminators are generally ranked 7.5. A visual examination of these scatter diagrams reveals no apparent trends.

Early in the analysis, a second candidate Y-variable was considered to be of possible interest. This was fractional wins, defined as the ratio of turkey shoot wins to the total number of engagements for a given student as indicated on the double elimination tree used to score the turkey shoots. Correlation coefficients of the four GSI component variables to turkey shoot rank and fractional wins for both Monday and Friday data are shown in Table 1. The presentation is constructed so that the correlation

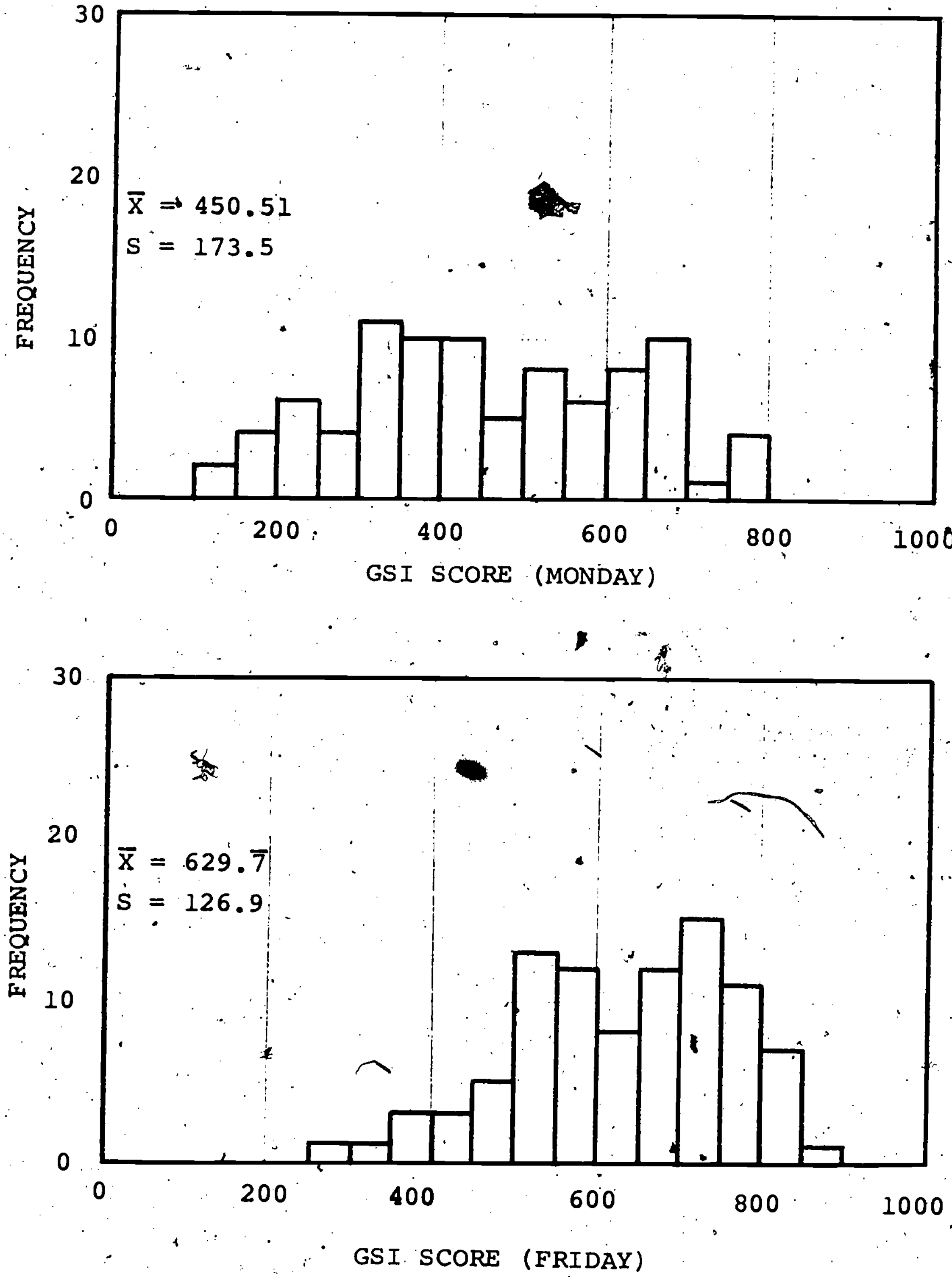
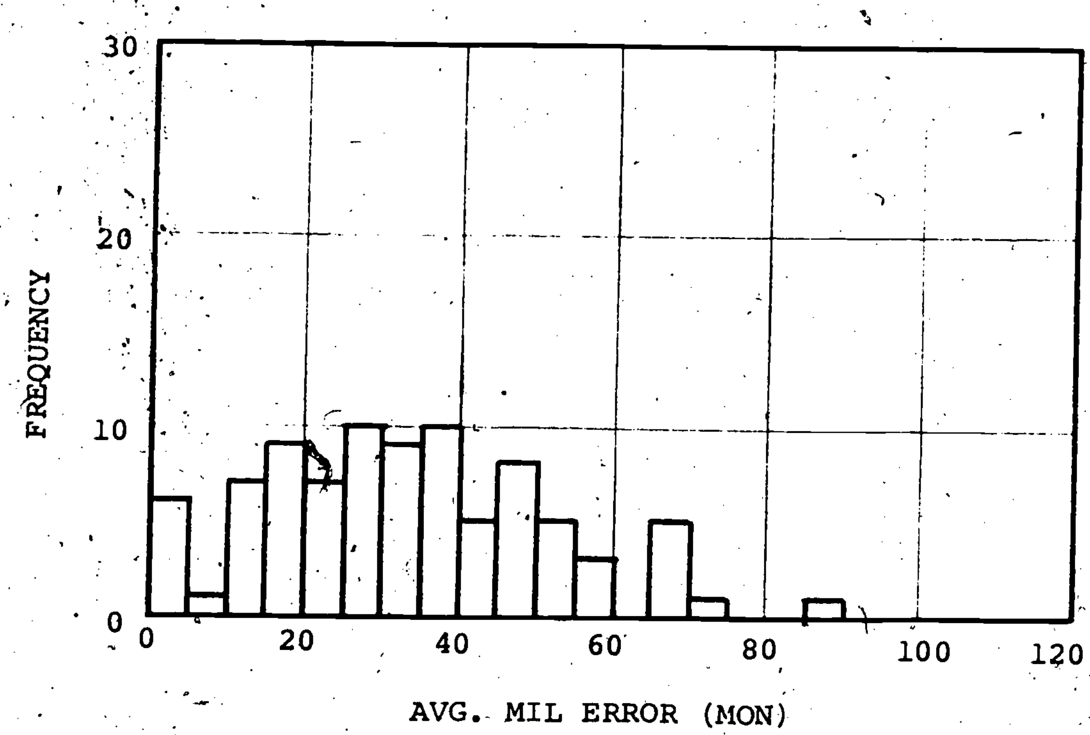


Figure 2. GSI Score Distributions



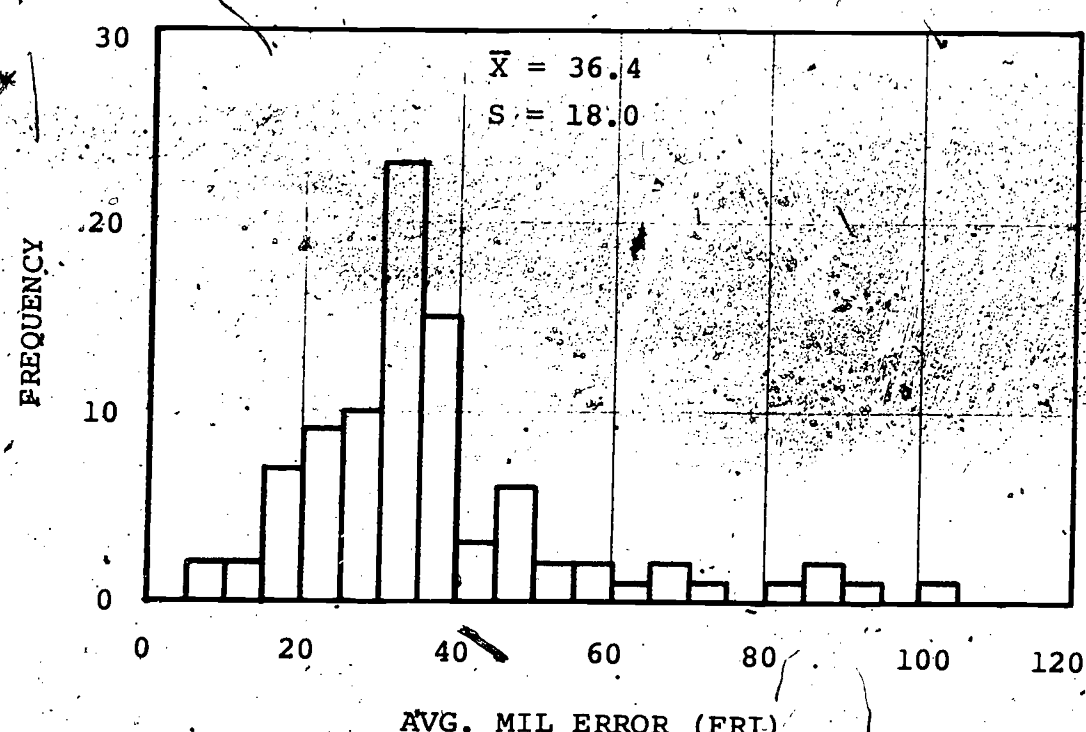


Figure 3. Mil Error Distributions

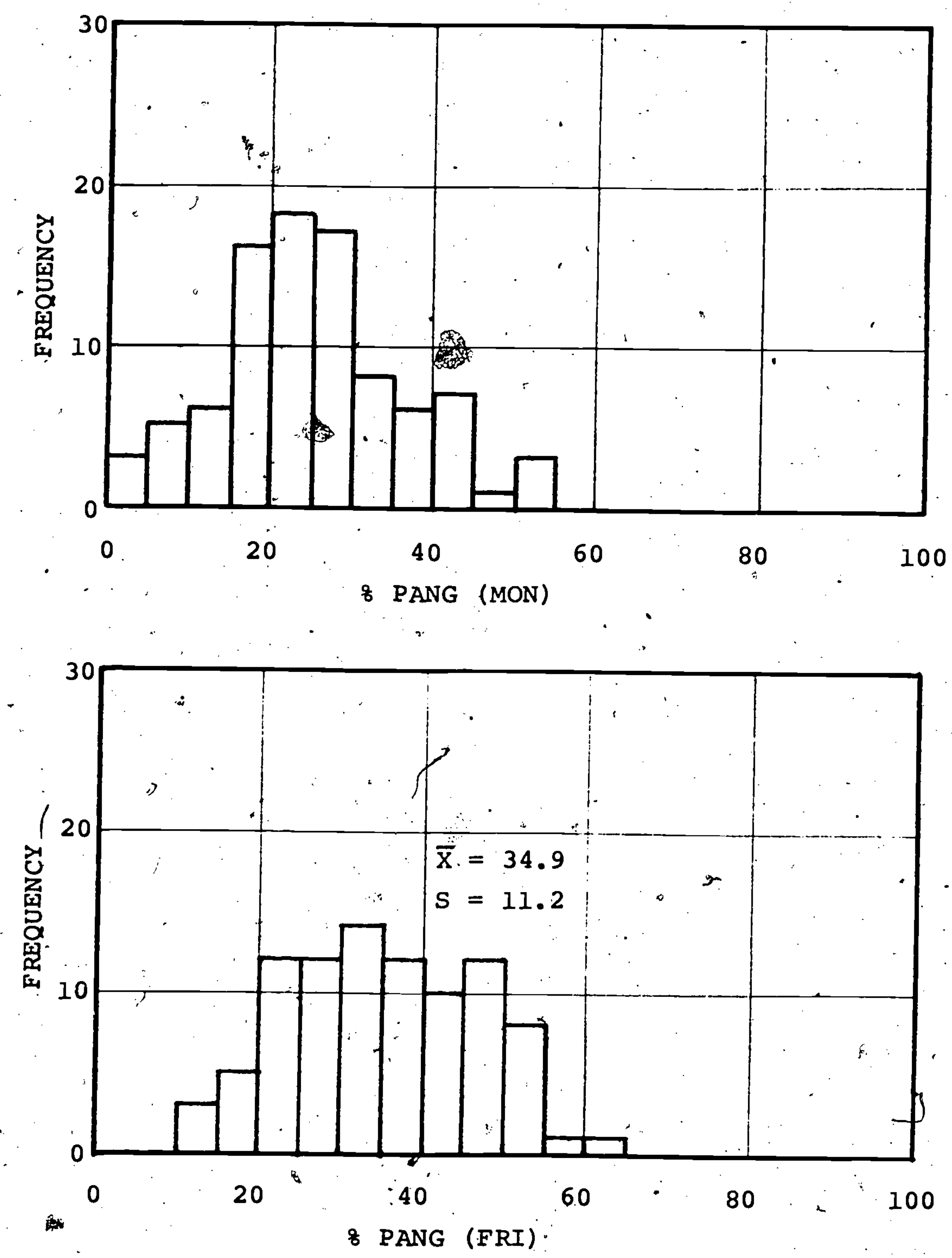
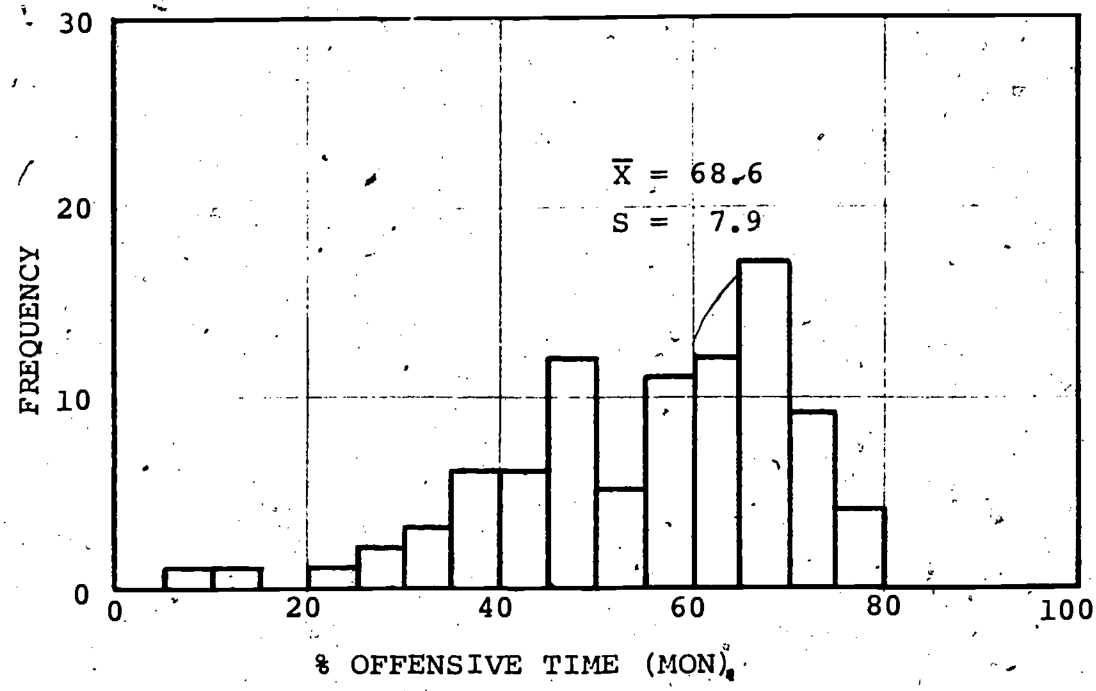


Figure 4. Percentage PANG (Time in Gun Envelope) Distribution



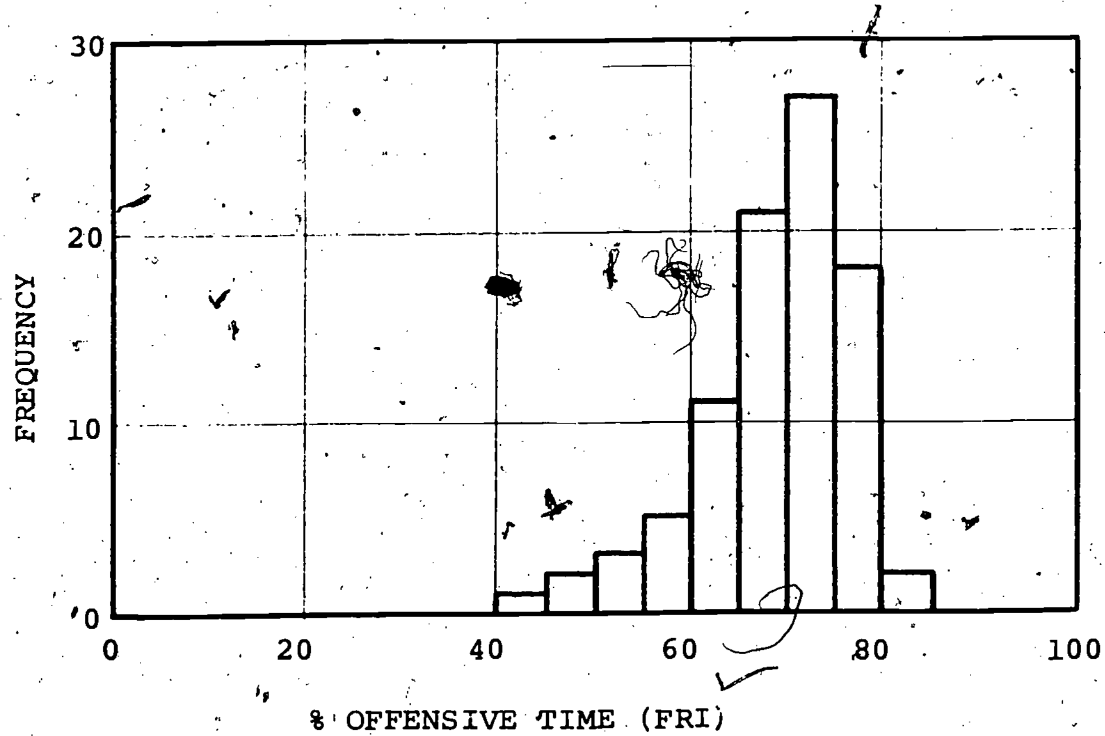
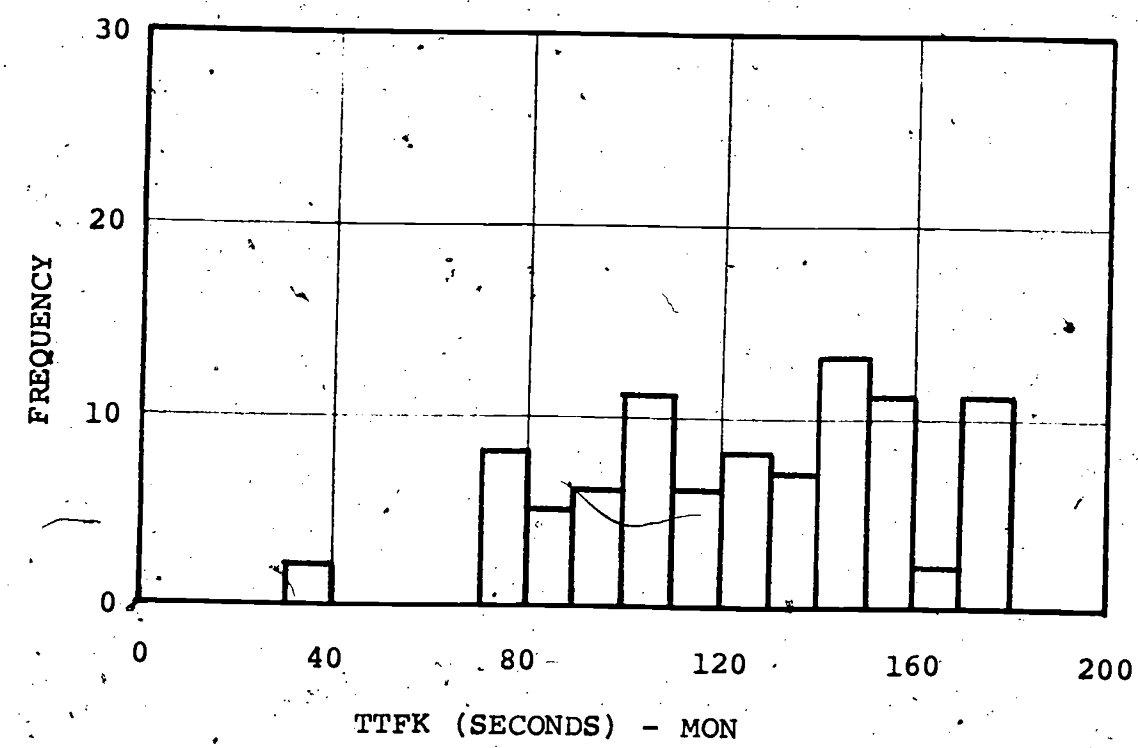


Figure 5. Distribution of Time in Offense Position



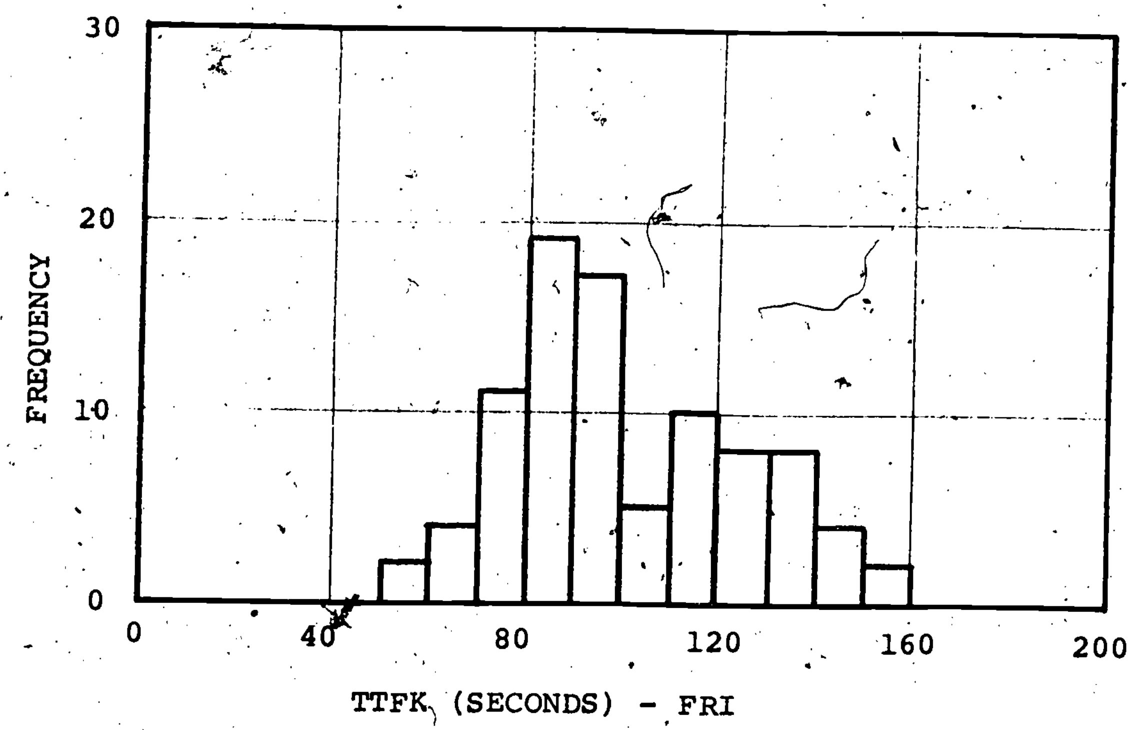


Figure 6. Time to First Kill Distribution.

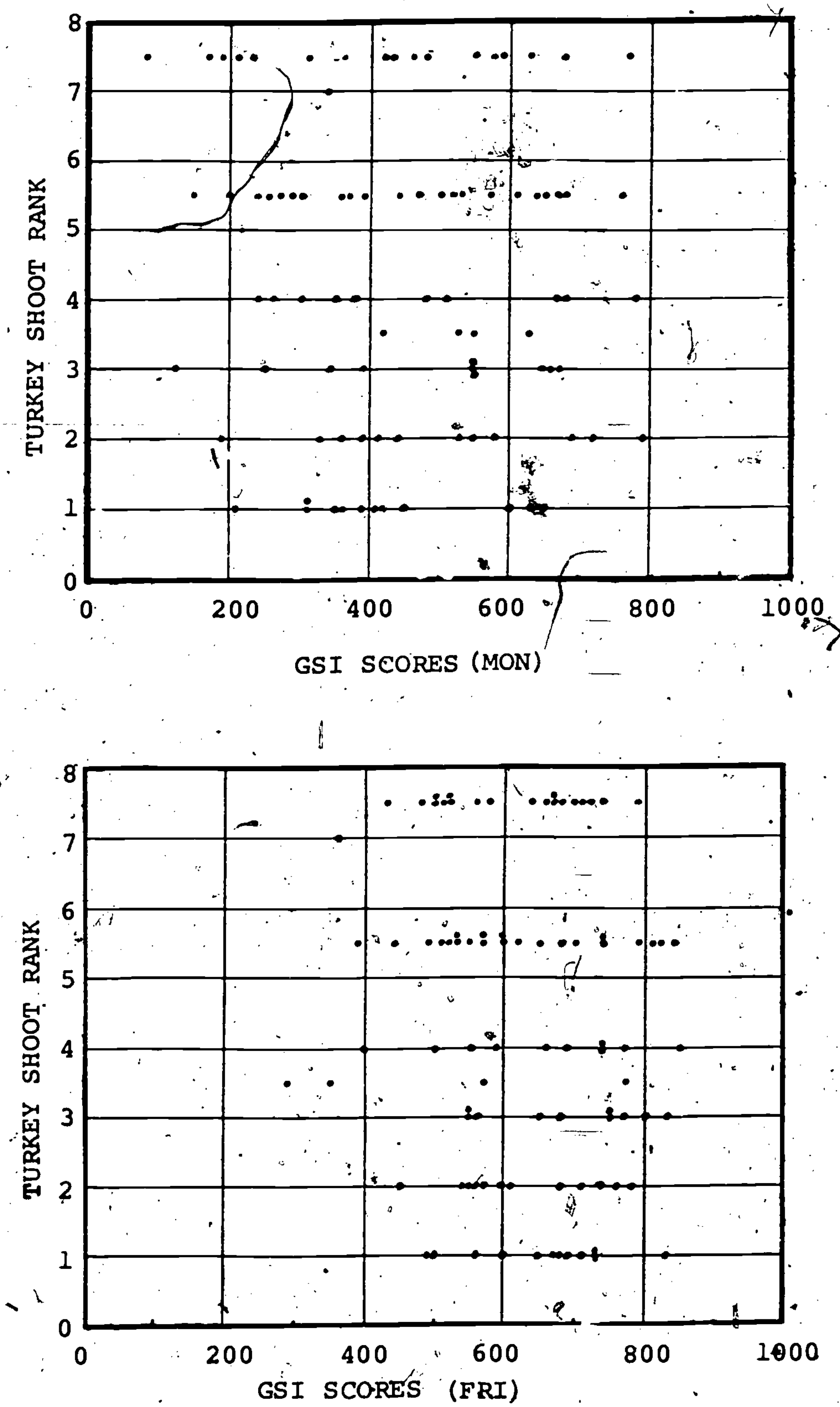
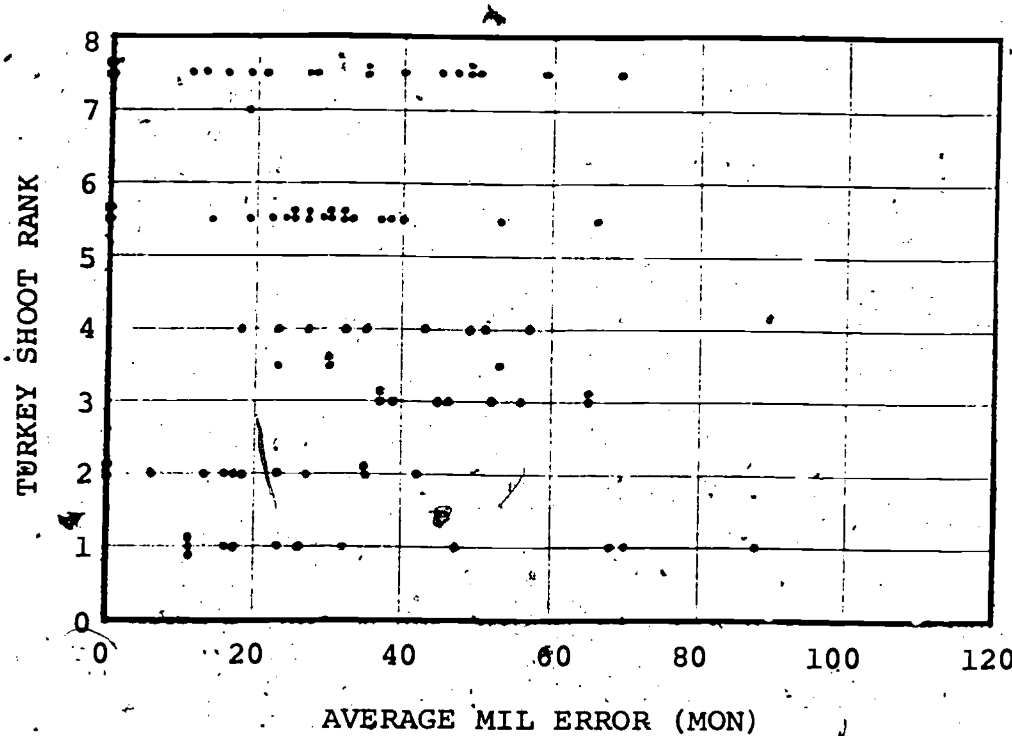


Figure 7. GSI Score vs. Turkey Shoot Rank Scatter Diagrams



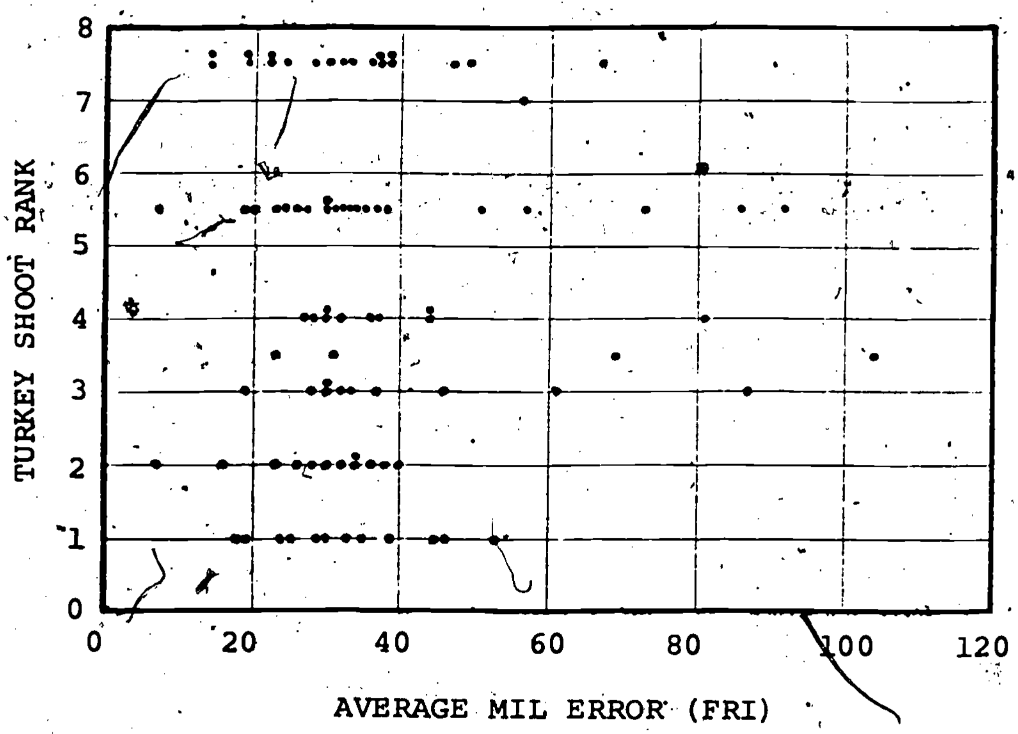


Figure 8. Mil Error vs. Turkey Shoot Rank Scatter Diagrams

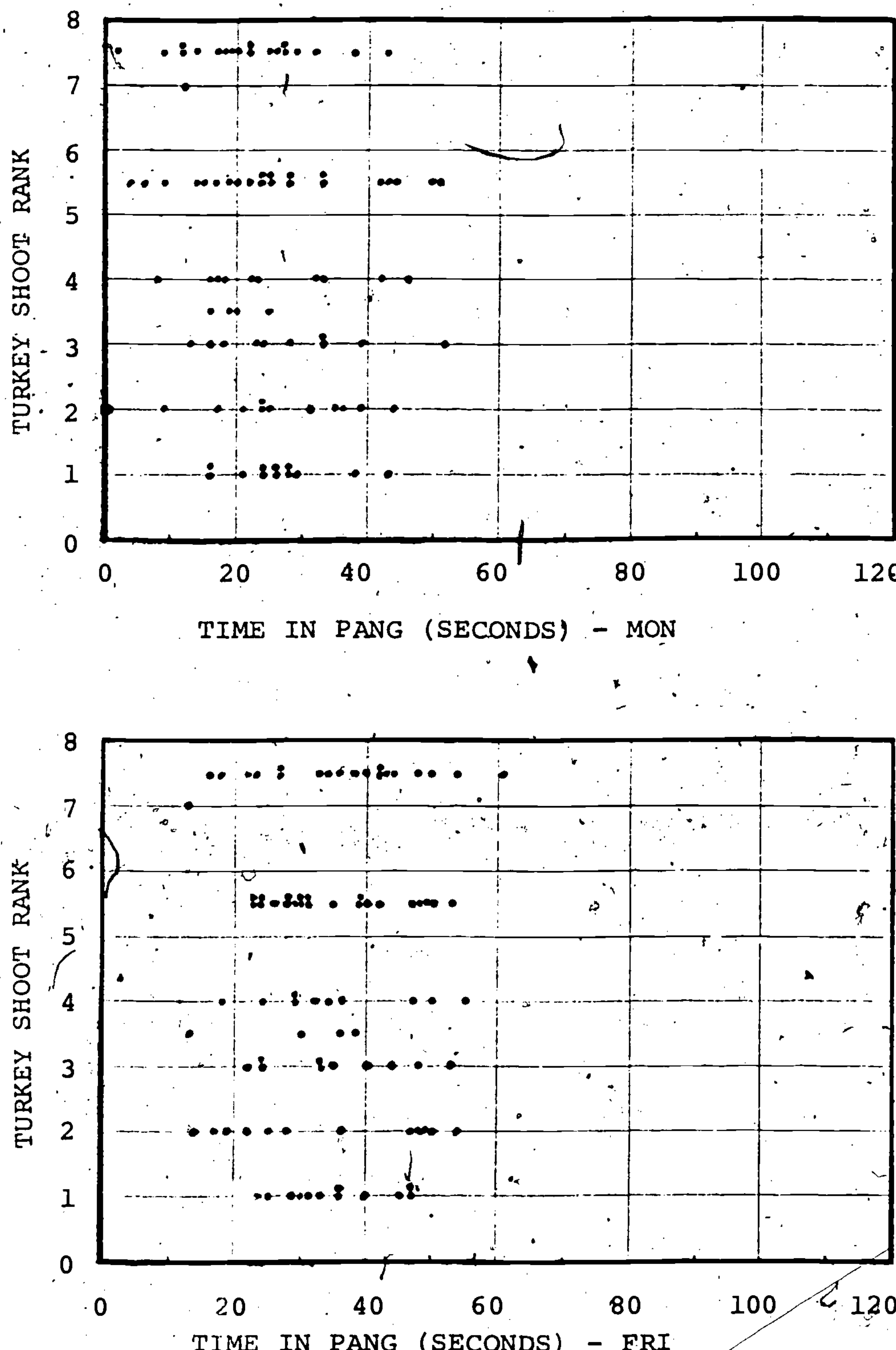


Figure 9. PANG vs. Turkey Shoot Rank Scatter Diagrams

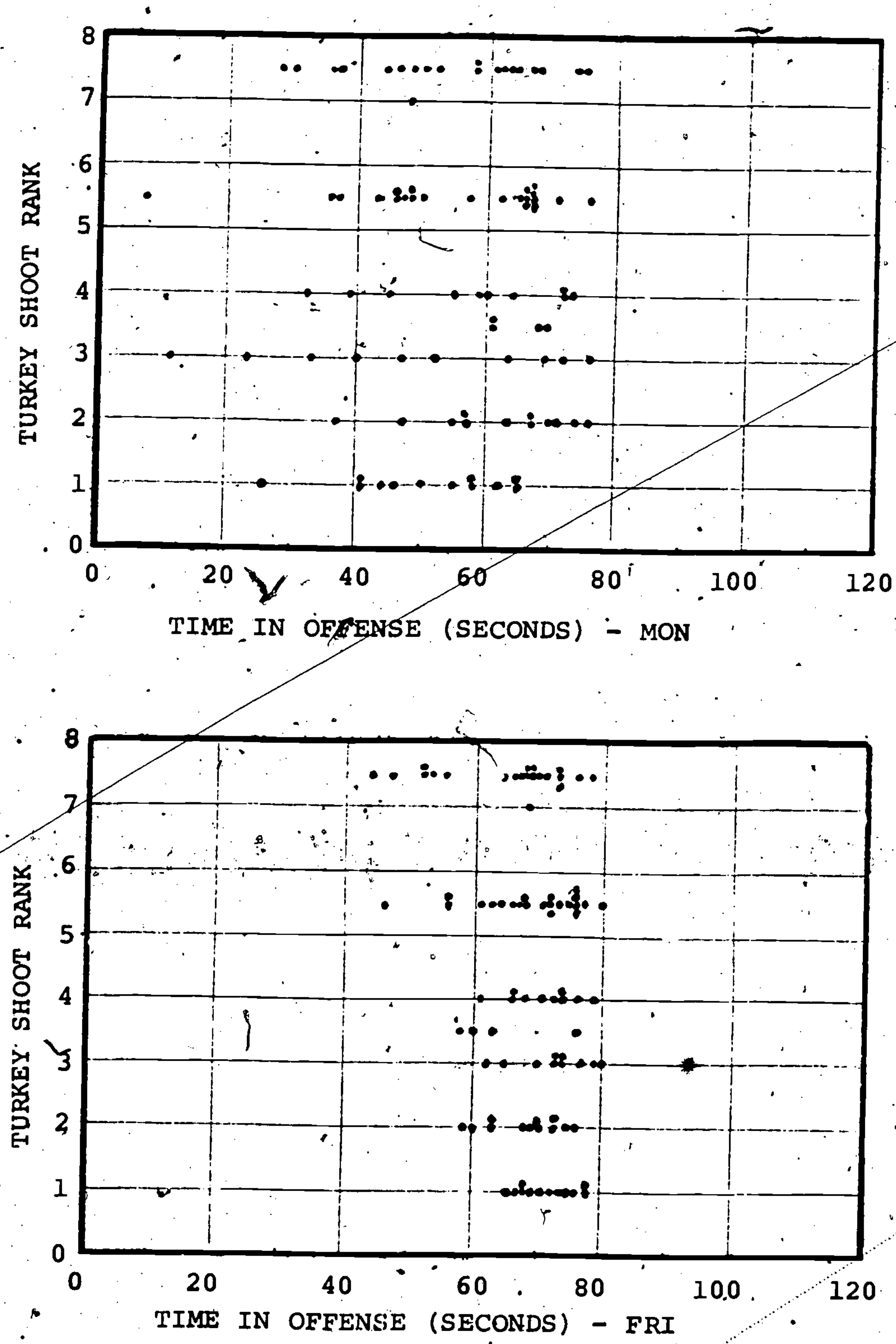
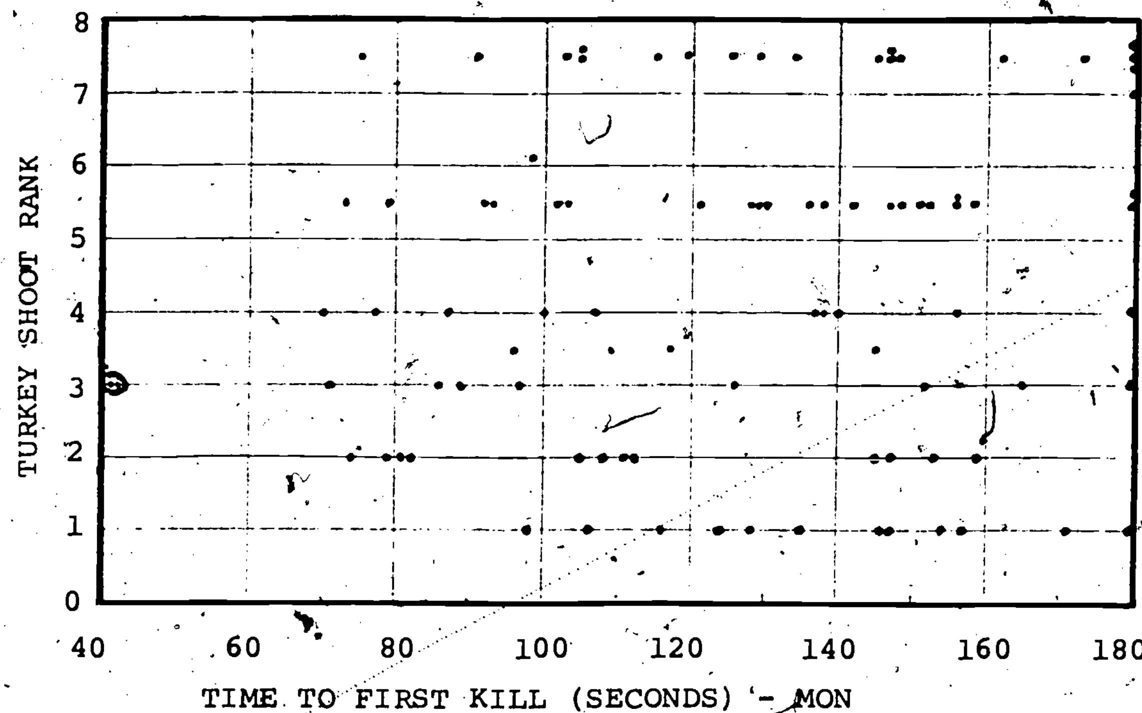


Figure 10. Percentage Offensive Time vs. Turkey Shoot Rank Scatter Diagrams



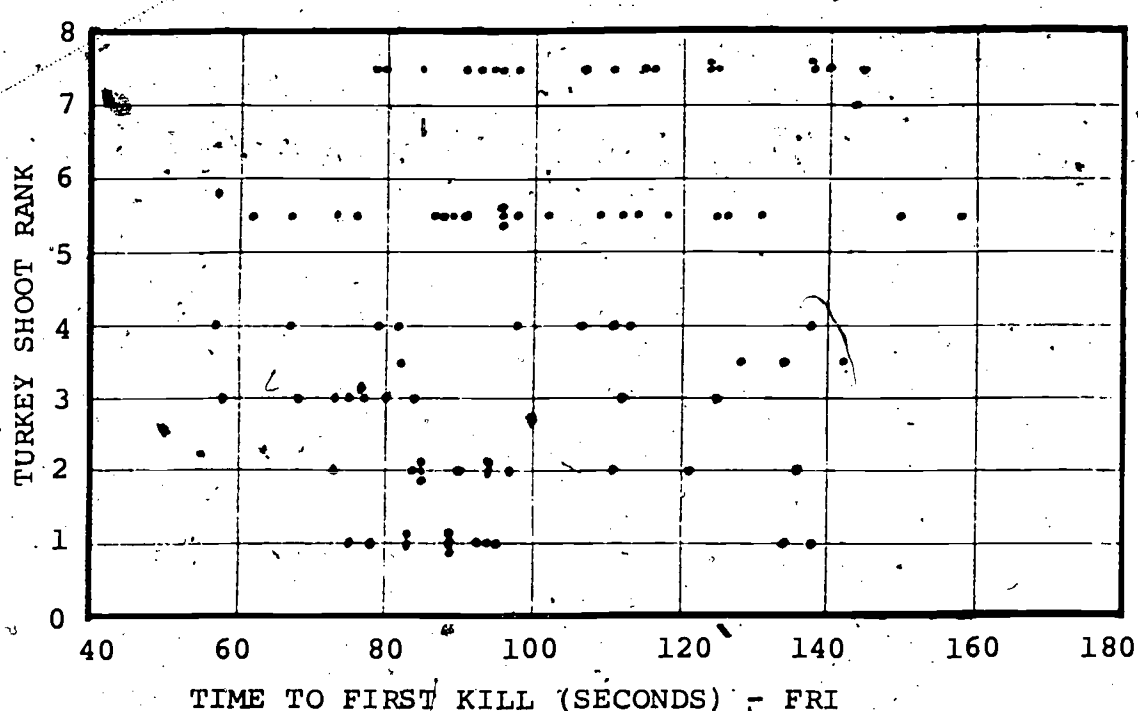


Figure 11. Time to First Kill vs. Turkey Shoot Rank Scatter Diagrams

TABLE 1 - GSI CORRELATION COEFFICIENTS

MONDAY

	T.S. RANK	AVG.MIL ERR	% PANG	% OFF TIME	TTFK
T.S. RANK	1	.1254	-.1318	-.0270	.1512
AVG.MIL.ERR.	.0200	1	-.0891	-.1915	.1650
% PANG	.0313	-.3071	1	.2107	-.2868
% OFF TIME	-.2761	-.0951	.0007	1	-.5430
TTFK	.2817	.0559	-.1557	-.6052	1

FRIDAY

MONDAY

	FRACT. WIN	AVG.MIL ERR	% PANG	% OFF TIME	TTFK
FRACT. WIN	1	-.1355	.1759	.0261	-.1218
AVG.MIL.ERR.	-.0083	1	-.0891	-.1915	.1650
% PANG	.0289	-.3071	1	.2107	-.2868
% OFF TIME	.2866	-.0951	.0007	1	-.5430
TTFK	-.2748	.0559	-.1557	-.6052	1

FRIDAY

coefficients for Monday data are shown above the main diagonal of each matrix and for Friday data are below the main diagonal. As can be seen, relatively strong correlations exist among the component variables indicating non-zero covariances and thus lack of independence, i.e., possible significant multicolinearities. Correlations between the component variables and turkey shoot rank and fractional wins are also seen to be very weak. Various regression analyses using appropriate variable selection techniques and ridge regression were also conducted as part of this study. Predictive capabilities of these regression models were found to be very poor. This is what might be expected in view of the scatter diagrams provided.

In an attempt to determine significant sources of variation within the data, five three-way analyses of variance were conducted for GSI and the four component variables. The three sources of variation investigated were

(a) variation between days (Monday and Friday),

(b) variation between turkey shoot ranks, and

(c) variation between the classes which contained eight students.

Table 2 shows the results of the analysis of the GSI scores. It was found that very significant differences exist between Monday and Friday GSI scores (The risk of error in saying a significant difference exists when in fact it does not is less than one percent), implying, of course, that if GSI measures group learning, a significant increase occurs over the five-day class period. This is discussed in detail in the section on edumetrics. The other significant source of variation (also significant at the one percent level) is between classes. It was preferred that significant differences between classes would not occur, as this

TABLE 2 - ANALYSIS OF VARIANCE - GSI SCORES

SOURCE OF VARIATION	SUM OF SQ.	DF	MEAN SQ.	F TEST
BETWEEN DAYS	997,335	1	997,335	51.1**
BETWEEN RANKS	58,630	3	19,543	1.00
BETWEEN CLASSES	655,204	8	81,900	4.20**
RESIDUAL	2,557,437	131	19,522	
TOTAL	4,268,606	143		

* significant at 5% level

** significant at 1% level

could tend to mask differences between ranks, as exhibited in the data, if they really existed. Conversely, it was desired that significant differences between GSI scores by rank should occur. These differences did not occur, and this provides evidence as to why the initial GSI score is a relatively poor predictor of turkey shoot rank. Figure 7, which shows scatter diagrams of GSI scores versus turkey shoot rank, provides graphic evidence as to why significant differences between GSI Score and rank do not exist, or at least, they cannot be detected from these data.

Tables 3 and 4 present the three-way analysis of variance tables for the GSI component variables. For the component variable average mil error, significant differences between ranks appear to exist at the 1 percent confidence level, but no difference is evident between days. A difference is detectable between classes at the 5 percent level.

For the component variable percent PANG, significant differences are evident at the 1 percent level. There is no evidence of significance for variation between ranks. For the component variable, offensive time, significance between days are detected at the 1 percent level. No differences appear to exist between ranks or classes. For the component variable TTFK, significant differences are detected at the 5 percent level between days and between ranks. Differences are not evident between classes. Table 5 summarizes the finding of the analyses of variance performed of the four GSI component variables.

TABLE 3 - GSI COMPONENT ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE - AVERAGE MIL ERROR

SOURCE OF VARIATION	SUM OF SQ.	DF	MEAN SQ.	F TEST
BETWEEN DAYS	152.11	1	152.11	.51
BETWEEN RANKS	4,567.06	3	1,522.35	5.15**
BETWEEN CLASSES	5,568.72	8	696.09	2.35*
RESIDUAL	38,764.33	131	295.91	
TOTAL	49,052.22	143		

ANALYSIS OF VARIANCE - % PANG

SOURCE OF VARIATION	SUM OF SQ.	DF	MEAN SQ.	F TEST
BETWEEN DAYS	2,871.17	1	2,871.17	24.5**
BETWEEN RANKS	356.08	3	118.69	1.01
BETWEEN CLASSES	4,114.25	8	514.28	4.38**
RESIDUAL	15,871.44	131	117.34	
TOTAL	22,712.94	143		

* significant at 5% level
** significant at 1% level

TABLE 4 - GSI COMPONENT ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE - % OFFENSIVE TIME

SOURCE OF VARIATION	SUM OF SQ.	DF	MEAN SQ.	F TEST
BETWEEN DAYS	6,696.69	1	6,696.69	47.2**
BETWEEN RANKS	274.25	3	91.42	.64
BETWEEN CLASSES	1,332.47	8	166.56	1.17
RESIDUAL	18,600.56	131	141.99	
TOTAL	26,903.97	143		

ANALYSIS OF VARIANCE - TIME TO FIRST KILL

SOURCE OF VARIATION	SUM OF SQ.	DF	MEAN SQ.	F TEST
BETWEEN DAYS	19,113.07	1	19,113.07	23.2**
BETWEEN RANKS	13,215.75	3	4,405.25	5.35**
BETWEEN CLASSES	10,873.01	8	1,359.13	1.65
RESIDUAL	107,942.50	131	823.99	
TOTAL	151,144.33	143		

* significant at 5% level
** significant at 1% level

TABLE 5 - SUMMARY OF RESULTS OF ANALYSIS OF VARIANCE OF GSI COMPONENT VARIABLES

SOURCE OF VARIATION	MIL ERR	% PANG	% O/D	TTFK
BETWEEN DAYS	-	**	**	**
BETWEEN RANKS	**	-	-	**
BETWEEN CLASSES	*	**	-	-

* significant at 5% level

** significant at 1% level

A Comparison of the GSI Predictor

This section presents a comparison of the best predictor using the GSI Score as defined at the beginning of the study with random selection and with CIP predictions (CIPPs) made just prior to the turkey shoot competition. Comparisons were made at four levels of detail as to the outcome of the turkey shoot (These levels of detail are carried throughout the remainder of the study). The four levels are defined as follows:

1. Four Groups - Proper placement into the proper turkey shoot quartile, i.e., 1 or 2 in the first group, 3-4 in the second group, 5-6 in the third group and 7-8 in the fourth group.
2. Upper Half of Class - Proper placement of students in the top four turkey shoot ranks in those ranks, i.e., 1, 2, 3, 3.5 or 4 in these ranks.
3. Winner and Runner-Up - Proper placement of the winner or runner-up in the winner/runner-up group.

4. Winner - Proper identification of the actual turkey shoot winner.

The results of this comparison are provided in Table 6. Note that CIPPs were not made for the first few classes of the experiment; thus, only 67 out of a possible 90 CIPPs were made. The random selection probabilities were determined under the assumption of independent random assignment of students to turkey shoot position. For example, there are eight possible assignments of outcome to the turkey shoot position. One of these positions is the winner position; another is the runner-up position; two are third eliminator positions, etc. Thus, the probability that a given student will be assigned the winner position, given that his assignment is at random and independent of all other assignments, is one out of eight or 12.5 percent. Similarly, if the grouping being considered is winner and/or runner-up, there are two out of eight possible assignments in this group. Therefore, under the same assumption, the probability that a given student will be assigned to the winner and runner-up grouping is two out of eight or 25 percent. Similar logic is used in determining the probabilities associated with the random assignments to the other two groups.

Four entries are provided for CIPP and GSI ranking predictors for each of the four groupings. These provide basic data on the actual predictions. For example, for CIPP and the "four groups" grouping, the CIPs properly placed 21 out of 67 predictions in the correct groupings (1-2, 3-4, 5-6, or 7-8); thus, 21 of 67 or 31.3 percent were correctly classified. Ninety-five percent confidence limits were calculated using these data and were determined

TABLE 6

A COMPARISON OF FRIDAY GSI RANK PREDICTIONS WITH CHIEF INSTRUCTOR PILOT (CIPP) AND RANDOM SELECTION

GROUPINGS		RANDOM SELECT.	CIPP	GSI RANKING (FRI.SCORE)
FOUR GROUPS (1-2,3-4, 5-6,7-8)	• NO. CORRECT PREDICT.	-	21	26
	• TOTAL NO. PREDICT.	-	67	90
	• % CORRECT PREDICT.	25%	31.3%	28.9%
	• 95% CONFIDENCE INT.	-	20.2-42.5	19.5-38.3
UPPER HALF OF CLASS (1,2,3-4)	• NO. CORRECT PREDICT.	-	24	27
	• TOTAL NO. PREDICT.	-	34	46
	• % CORRECT PREDICT.	50%	70.6%	58.7%
	• 95% CONFIDENCE INT.	-	55.2-85.9	44.5-72.9
WINNER & RUNNER-UP (1, 2)	• NO. CORRECT PREDICT.	-	6	9
	• TOTAL NO. PREDICT.	-	17	23
	• % CORRECT PREDICT.	25%	35.3%	39.1%
	• 95% CONFIDENCE INT.	-	12.6-58.0	19.2-59.1
WINNER (1)	• NO. CORRECT PREDICT.	-	1	3
	• TOTAL NO. PREDICT.	-	9	12
	• % CORRECT PREDICT.	12.5%	11.1%	25.0%
	• 95% CONFIDENCE INT.	-	0-31.6	0-49.5

to be 20.2 percent and 42.5 percent[1]. Thus, over the long run, 95 percent of the CIPPs can be expected to be between 20.2 and 42.5 percent correct. Similar information is provided for the other CIPP and the GSI ranking predictors.

Each CIPP and GSI ranking prediction was subjected to a test of the hypothesis that it is equal to or better than random selection[2]. The CIPP for the upper half of the turkey shoot was found to be significantly better than random selection at the 5 percent confidence level. The GSI ranking predictor was found to be significantly better than random selection for winner and runner-up also at the 5 percent confidence level. All other predictions were found not to be significantly different from random prediction at the 5 percent level. Table 7 provides the levels of significance at which differences would be assumed to exist.

TABLE 7 - APPROXIMATE RISK LEVEL AT WHICH DIFFERENCES CAN BE ASSUMED TO EXIST

GROUPINGS	CIPP	GSI RANKING
FOUR GROUPS	15%	18%
UPPER HALF	5%	13%
WINNER & RUNNER-UP	26%	5%
WINNER	36%	20%

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[1] Ostle & Mensing. Statistics in research, (3rd ed.). Ames: Iowa State University Press, 1975, 100-101.

[2] Ostle & Mensing. Statistics in research, (3rd ed.). Ames: Iowa State University Press, 1975, 129-133.

Thus, to this point in the analysis, it can be concluded that CIPPs can classify students as to whether or not they will finish in the upper half of the turkey shoot with about 55 to 86 percent accuracy while a simple GSI ranking scheme can correctly predict turkey shoot winners and runner-up classification about 39 percent of the time. For other predictions investigated, the two predictors appear to be no better than random selection. The data in Table 6 will be carried forward for comparison with more sophisticated predictors developed from the expanded data sets acquired from the master data base and through the use of discriminant analysis.

The Discriminant Analysis - A Discussion of the Analysis Performed

The GSI scores, the GSI component variables, the expanded set of candidate predictor variables, and the demographic data were subjected to a series of discriminant analyses using the sub-program DISCRIMINANT available as part of the SPSS package[3]. The capabilities of this program were useful in the development of predictor equations from the available data. The purpose of this analysis was to build optimal prediction models which predict "turkey shoot" rank from data collected during the 12 specified TAC ACES I classes. The models derived used the Wilks' Lambda variable selection criteria to select the best candidate predictor variables from those available. The models derived are optimal within the constraints of the analysis but are not necessarily maximal. A maximal predictor model could only be achieved if all possible models were considered.

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[3]Nie. Statistical Package for the Social Sciences (SPSS), (2nd ed.). New York: McGraw Hill, 1975, 434-462.

Discriminant analysis begins with the desire to statistically distinguish between two or more defined groups using information available from sample data. It was desired to predict turkey shoot winners using data collected by the simulator computer from each student during the normal course of his training and also from questionnaires. The groupings of interest were defined from turkey shoot rank. In a normal class of eight student pilots, there are always at least five distinguishable turkey shoot groupings. These are in order from most favorable to least favorable outcome: winner (1), runner-up (1), third eliminators (2), second eliminators (2), and first eliminators (2).

The primary objective of the analysis was to develop predictor algorithms for turkey shoot winners; therefore, the groupings considered were structured to investigate the level of detail at which winners could be predicted from available data. Winners can be defined in several ways. One winner class is the absolute winner or undefeated student in the turkey shoot. A second winner class is the winner and runner-up. This grouping scheme was used with some limited success in earlier Vought investigations which employed Friday GSI as the predictor variable. A third level of detail is the upper half of a class as determined by the turkey shoot competition. In all, four different grouping schemes were defined and investigated. These are as follows:

1. Winners (Group I) versus all others (Group II)
2. Winners and runners-up together (Group I) versus all others (Group II)
3. The upper half of the class (Group I; winners, runners-up, and third eliminators) versus the lower half of the class (Group II: second

eliminators and first eliminators).

4. Four Groupings (Group I: winners and runners-up; Group II: third eliminators; Group III: second eliminators; Group IV: first eliminators).

The analysis was conducted in four parts, each part being defined by the candidate predictor variable set to be used. The first analysis used only Monday and Friday GSI scores as candidate predictor variables. This analysis provided a measure of the best prediction capability of the GSI itself. Both the Monday and the Friday GSI scores were presented to DISCRIM as candidate predictor variables. Thus, DISCRIM was able to select one, the other, or both GSI scores. As it turned out in the three winner groupings investigated in the first analysis, both GSI scores were always included. The predictive capabilities determined here were then used as the baseline, or basis of comparison, for the other three analyses which followed.

The discriminant analysis considers more than just correct classification into the desired group. Two groups are defined, one group including the winners, and the other group including the non-winners. It is possible to correctly classify most of the true winners but incorrectly classify some relatively large number of non-winners as winners. It must be decided how many non-winners can be accepted in the winner group. This study found that by using indicators more complex than the GSI Score itself, it was possible not only to correctly classify "winners" a fairly large percent of the time, but also to greatly reduce the classification of non-winners into the winner group.

The analysis began with the empirically determined GSI scores as predictor variables. In the second analysis, the four component variables (or part scores) from which GSI is calculated were used instead of the GSI total scores. The DISCRIM program was then allowed to select from these eight component variables (four for Monday and four for Friday) the best predictor variables for each of the four classification schemes. The eight variables are defined in Table 8 which shows that DISCRIM was selective and never used all available data to define the optimal prediction (classification) equations.

Results of the Discriminant Analysis

The results of the four discriminant analyses are presented. Five pieces of information are provided for each discriminant grouping scheme:

1. A tabulation of group predicted membership versus actual group membership, using the 12-class sample considered in the study.

2. The basic optimal classification functions determined by the discriminant program. These are presented in tabular form. The classification functions are used to predict group membership. There is one classification function for each defined discriminant group. To classify a given sample (case), the value (score) for each classification function is calculated. The sample (case) is then classified into the group for which the classification function provides the highest score.

3. Standardized Discriminant Function(s) -- In this study, there is always one less discriminant function than the number of groups defined. In general, the discriminant functions can be thought of as the axes of a geometric space, and thus can be used to study the spatial

TABLE 8 - MONDAY AND FRIDAY GSI COMPONENT VARIABLES AND VARIABLE SELECTION BY DISCRIMINANT GROUP

VAR. DESIG.	GROUP I - Winners; GROUP II - Others	GROUP I - Winners & Runners-Up; GROUP II - Others	GROUP I - Winners, R.U., & 3rd Elim.; GROUP II - Others	GP. I - Win. & R.U.; GP. II - 3rd Elim.; GP. III - 2nd Elim.; GP. IV - 1st Elim.	VARIABLE DEFINITION
X1		X		X	AVERAGE MIL ERROR FOR FRIDAY
X2		X			PERCENT TIME IN PANG FOR FRIDAY
X3	X		X	X	PERCENT OFFENSIVE TIME FOR FRIDAY
X4		X	X		TIME TO FIRST KILL ON FRIDAY (SECONDS)
X5		X		X	AVERAGE MIL ERROR FOR MONDAY
X6					PERCENT TIME IN PANG FOR MONDAY
X7					PERCENT OFFENSIVE TIME FOR MONDAY
X8	X		X	X	TIME TO FIRST KILL ON MONDAY (SECONDS)

relationships among the groups. The standardized discriminant functions perform the same general functions as the standardized (beta) coefficients in regression analysis. These functions provide an easy reference as to the relative contribution of each of the selected discriminant predictor variables.

4. Unstandardized Discriminant Functions -- The unstandardized discriminant functions, like the standardized, are useful in the descriptive analysis of spatial relationships among the groups.

5. Canonical Correlation Coefficients of the Discriminant Function(s) -- The canonical correlation coefficient provides an indication of the relative capability of the associated discriminant function to separate data into correct groups. A value of one indicates perfect group separation capability; a value of zero indicates total inability to separate groups.

<u>The First Discriminant Analysis - Assessment of the GSI Scores as Turkey Shoot Placement Predictors</u>

The results of the first discriminant analysis are presented in Tables 9, 10, and 11, where Monday and Friday GSI scores are the predictor variables. While, in general, members of the first group are correctly classified on the order of 60 percent of the time, many non-first group students are classified incorrectly in the first group. The lack of discriminant power is evidenced by the low values of the canonical correlation coefficients of the respective discriminant functions, i.e., between 0.120 and 0.218.

TABLE 9 - GSI TURKEY SHOOT WINNER PREDICTIONS

PREDICTOR VARIABLES: Monday and Friday GSI Scores

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners	GPI	12	8 66.7%	4 33.3%
Turkey Shoot Non-Winners (Others)	GPII	78	34 43.6%	44 56.4%

57.8 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
FGSI	0.03907	0.03594	-0.96118	-0.00757
MGSI	0.00400	0.00581	0.75773	0.00437
CONSTANT	-13.77014	-12.55049	--	2.80178

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.140

TABLE 10 - GSI TURKEY SHOOT WINNER AND RUNNER-UP PREDICTIONS

PREDICTOR VARIABLES: Monday and Friday GSI Scores

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners & Runners Up	GPI	23	14 60.9%	9 39.1%
Third, Second, and First Eliminators (Others)	GPII	67	33 49.3%	34 50.7%

53.3 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
FGSI	0.03804	0.0396	0.96359	0.00759
MGSI	0.00596	0.00581	0.09485	0.00055
CONSTANT	-13.85377	-12.45815	--	-5.02757

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.120

TABLE 11 - GSI TURKEY SHOOT WINNERS, RUNNERS-UP AND THIRD ELIMINATOR PREDICTIONS (CLASS UPPER HALF)

PREDICTOR VARIABLES: Monday and Friday GSI Scores

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
T.S. Winners, Runners-Up and Third Eliminators	GPI	46	27 58.7%	19 41.3%
T.S. Second and First Eliminators	GPII	44	19 43.2%	25 56.8%

57.8 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
FGSI	0.03764	0.03587	0.49739	0.00392
MGSI	0.00759	0.00574	0.71398	0.00412
CONSTANT	-14.06189	-12.11746	--	-4.32199

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.218

The Second Discriminant Analysis - Statistical Derivia-tion of an Optimal Four Parameter Predictor - Derives Optimal Predictors Using the Same Four Parameters of the Empirically Derived GSI Scores

The results of the second discriminant analysis are presented in Tables 12, 13, 14, and 15. In this analysis, the eight GSI component variables (four for Monday GSI component scores and four for Friday GSI component scores) are used as candidate predictor variables (Table 8). The table for each group definition indicates the variables selected by DISCRIM. For example, X3 and X8 (Percent Offensive Time for Friday and Time to First Kill (TTFK) for Monday, respectively) were selected by DISCRIM for inclusion in the analysis where the 12 turkey shoot winners comprise the top discriminant group. The predictive capabilities of this analysis appear to be marginally better than in the GSI score analysis. The second analysis also investigated four groupings (quartile ranking) (Table 15). The standardized and unstandardized discriminant function coefficients are also presented in Table 15.

The Third Discriminant Analysis - Statistical Deriviation of Turkey Shoot Placement Predictor from an Expanded Objective Data Set

The results of the third discriminant analysis are presented in Tables 16, 17, 18, and 19. Candidate predictor variables were developed from the complete objective data set collected during the Monday and Friday GSI scoring session but previously not analyzed. The table for each group definition indicates the predictor variables selected for the given grouping scheme. The expanded set of candidate variables and their definitions are contained in Table 20. The canonical correlations of the discriminant

TABLE 12 - OPTIMAL FOUR PARAMETER TURKEY SHOOT WINNER PREDICTORS

PREDICTOR VARIABLES: Monday and Friday GSI Component Variables

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners	GPI	12	9 75.0%	3 25.0%
Turkey Shoot Non-Winners (Others)	GPII	78	32 41.0%	46 59.0%

61.1 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
X3	1.25471	1.18593	0.78341	0.09978
X8	0.14417	0.13060	0.69032	0.01968
Constant	-55.04846	-48.45673	--	-9.32037

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.226

TABLE 13 - OPTIMAL FOUR PARAMETER TURKEY SHOOT WINNER AND RUNNER-UP PREDICTOR

PREDICTOR VARIABLES: Monday and Friday GSI Component Variables

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners & Runners Up	GPI	23	15 65.2%	8 34.8%
Third, Second & First Eliminators (Others)	GPII	67	29 43.3%	38 56.7%

58.9 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
X1	0.17609	0.20701	-0.74791	-0.04149
X2	0.42651	0.45655	-0.45291	-0.04032
X4	0.19877	0.21484	-0.51216	-0.02157
X5	0.00750	0.01261	-0.42452	-0.00686
Constant	-19.45735	-23.34183	--	5.38022

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.301

TABLE 14 - OPTIMAL FOUR PARAMETER TURKEY SHOOT WINNER, RUNNER-UP & 3RD ELIMINATOR PRED. (UPPER HALF)

PREDICTOR VARIABLES: Monday and Friday GSI Component Variables

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
T.S. Winners, Runners Up & Third Eliminators	GPI	46	27 58.7%	19 41.3%
T.S. Second and First Eliminators	GPII	44	16 36.4%	28 63.6%

61.1 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
X3	2.23993	2.20200	0.37015	0.04714
X4	0.60083	0.61428	-0.39683	-0.01671
X8	0.04012	0.05417	-0.61199	-0.01745
Constant	-109.50150	-110.02942	--	0.64692

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.357

TABLE 15 - OPTIMAL FOUR PARAMETER QUARTILE RANK PREDICTORS

PREDICTOR VARIABLES: Monday and Friday GSI Component Variables						
ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP			
			GP I	GP II	GP III	GP IV
Turkey Shoot Winners & Runners Up	GP I	23	10 43.5%	5 21.7%	4 17.4%	4 17.4%
Turkey Shoot Third Eliminators	GP II	23	4 17.4%	13 56.5%	1 4.3%	5 21.7%
Turkey Shoot Second Eliminators	GP III	23	7 30.4%	4 17.4%	5 21.7%	7 30.4%
Turkey Shoot First Eliminators	GP IV	21	4 19.0%	3 14.3%	6 28.6%	8 38.1%

40.0 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS			
	GROUP I	GROUP II	GROUP III	GROUP IV
X1	0.14229	0.18733	0.16523	0.14452
X3	1.26789	1.27884	1.23831	1.17700
X5	0.01537	0.02250	0.01595	0.02180
X8	0.10084	0.08284	0.10708	0.10920
Constant	-53.39603	-53.99324	-52.95479	-48.69345

TABLE 15 (CONT.)

PREDICTOR VARIABLE SET: Monday and Friday GSI Component Variables

VARIABLE	DISCRIMINANT FUNCTION COEFFICIENTS STANDARDIZED			UNSTANDARDIZED		
	FCN. I	FCN. II	FCN. III	FCN. I	FCN. II	FCN. III
X1	-0.55611	0.45374	-0.70424	-0.03085	0.02517	-0.03907
X3	-0.51720	-0.54261	-0.05719	-0.06587	-0.06911	-0.00728
X5	-0.10805	0.60537	0.49927	-0.00175	0.00978	0.00806
X8	0.69680	-0.14693	-0.57239	0.01487	-0.00419	-0.01632
CONSTANT	--	--	--	3.21251	3.93242	3.63354
CANONICAL CORREL.	0.427	0.281	0.162			

TABLE 16 - EXPANDED OBJECTIVE PARAMETERS TURKEY SHOOT WINNER PREDICTORS

PREDICTOR VARIABLES: Expanded Data Set (Without Demographic Data)

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners	GPI	12	10 83.3%	2 16.7%
Turkey Shoot Non-Winners (Others)	GPII	77	9 11.7%	68 88.3%

87.6 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
M8	0.00575	0.00755	0.23698	-0.00063
M12	0.86869	0.82532	0.32092	0.01511
M16	1.58034	1.19862	0.15558	0.13295
M29	0.18453	0.23185	-0.21587	-0.01648
M32	0.02928	0.02361	0.82497	0.00197
F11	1.39074	0.61329	0.80084	0.27081
F18	0.05870	0.16967	-0.38896	-0.03865
F22	-0.10910	0.72217	-0.74215	-0.28957
F23	0.15750	0.09483	0.45025	0.02183
F27	4.35721	4.77215	-0.20194	-0.14455
F29	0.35718	0.31550	0.19126	0.01452
CONSTANT	-118.97914	-116.51265	---	-0.20297

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.617

TABLE 17 - EXPANDED OBJECTIVE PARAMETERS TURKEY SHOOT WINNER AND RUNNER-UP PREDICTORS

PREDICTOR VARIABLES: Expanded Data Set (Without Demographic Data)

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners and Runners-Up	GPI	23	19 82.6%	4 17.4%
Third, Second, and First Elimi-nators (Others)	GPII	66	16 24.2%	50 78.8%

77.5 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
M10	0.02022	0.02543	0.18801	-0.00302
M14	0.00224	0.00245	-0.19653	-0.00012
M24	0.38942	0.43126	-0.28432	-0.02427
M29	0.13310	0.17617	-0.32723	-0.02498
M32	-0.00597	-0.00758	0.39114	0.00094
F18	0.42068	0.51226	-0.53455	-0.05311
F27	5.90280	6.40625	-0.40832	-0.29227
F29	0.12566	0.05530	0.53757	0.04080
CONSTANT	-54.73753	-64.82437	--	6.15123

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.542

TABLE 18 - EXPANDED OBJECTIVE PARAMETERS TURKEY SHOOT WINNERS, RUNNERS-UP AND THIRD ELIMINATOR (UPPER HALF) PRED.

PREDICTOR VARIABLES: Expanded Data Set (Without Demographic Data

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
T.S. Winners, Runners-Up and Third Eliminators	GPI	46	36 78.3%	10 21.7%
T.S. Second and First Eliminators	GPII	43	10 23.3%	33 76.7%

77.5 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
M4	0.02266	0.02134	-0.22960	-0.00068
M20	0.51193	0.59123	0.27909	0.04063
M25	0.08904	0.05773	-0.37943	-0.01603
F1	20.40007	21.28377	0.30075	0.45352
F18	0.21914	0.31037	0.47031	0.04673
F25	0.12007	0.09632	-0.25523	-0.01216
F29	0.01772	-0.04312	-0.41056	-0.03116
F30	-0.56101	0.59603	0.30273	0.59262
CONSTANT	-126.35294	-131.05737	--	-2.39923

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.616

TABLE 19 - EXPANDED OBJECTIVE PARAMETERS QUARTILE RANK PREDICTORS

PREDICTOR VARIABLES: Expanded Data Set (Without Demographic Data)

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP			
			GP I	GP II	GP III	GP IV
Turkey Shoot Winners & Runners Up	GP I	23	14 60.9%	4 17.4%	2 8.7%	3 13.0%
Turkey Shoot Third Eliminators	GP II	23	4 17.4%	13 56.5%	3 13.0%	3 13.0%
Turkey Shoot Second Eliminators	GP III	23	5 21.7%	3 13.0%	12 52.2%	3 13.0%
Turkey Shoot First Eliminators	GP IV	20	1 5.0%	0 0.0%	2 10.0%	17 85.0%

62.9 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS			
	GROUP I	GROUP II	GROUP III	GROUP IV
M9	0.39080	0.43457	0.42527	0.32973
M11	-1.09244	-1.19695	-0.84949	-1.27048
M22	3.76039	3.83710	3.54577	4.03881
M25	0.05883	0.07826	0.04751	0.05261
M32	-0.00712	-0.00953	-0.00784	-0.00910
F1	23.15227	22.54955	23.13644	24.77510
F16	1.25992	1.56965	1.20116	1.61926
F18	0.38089	0.42928	0.49087	0.49089
F23	0.32194	0.29975	0.32001	0.28426
F25	0.23929	0.24372	0.21273	0.24954
F27	0.43905	1.20003	0.74263	0.40397
F29	-0.04349	-0.07499	-0.06826	-0.20159
CONSTANT	-134.68774	-140.15710	-139.95496	-147.62793

TABLE 19 (CONT.) - EXPANDED OBJECTIVE PARAMETERS QUARTILE RANK FUNCTION COEFFICIENTS

PREDICTOR VARIABLE SET: Expanded Data Set (Without Demographic Data)

VARIABLE	DISCRIMINANT FUNCTION COEFFICIENTS					
	STANDARDIZED			UNSTANDARDIZED		
	FCN. I	FCN. II	FCN. III	FCN. I	FCN. II	FCN. III
M9	0.29372	0.061509	0.50531	0.02840	0.00629	0.04886
M11	0.27379	0.72985	0.13650	0.07279	0.19405	0.03629
M22	-0.28484	-0.44215	-0.17302	-0.11116	-0.17255	-0.06752
M25	0.07615	-0.33074	0.24529	0.00322	-0.01398	0.01037
M32	0.21123	0.27740	0.52465	0.00051	0.00066	-0.00126
F1	-0.43789	0.08832	-0.47683	-0.66033	0.13319	-0.71904
F16	-0.22091	-0.35071	0.19407	-0.11332	-0.17990	0.09955
F18	-0.31037	0.38222	0.35250	-0.03084	0.03798	0.03503
F23	0.25134	0.20717	-0.12811	0.01219	0.01004	-0.00621
F25	-0.10654	-0.37477	-0.13307	-0.00508	-0.01786	-0.00634
F27	0.12900	-0.17522	0.77547	0.09234	-0.12542	0.55507
F29	0.72779	0.10283	0.10076	0.05524	0.00780	0.00765
CONSTANT	--	--	--	3.90265	-0.10029	-2.19164
CANONICAL CORREL.	0.647	0.529	0.440			

TABLE 20 - CANDIDATE OBJECTIVE PREDICTOR VARIABLES

DESIGNATION	DESCRIPTION
F29	HIT/MISS H-MISS SCORE HON (H*(H+M)/HON)
F12	*TIME TO FIRST KILL (SEC-AVG/HEAD-ON)
F17	TOTAL NO. HITS HON (HITS/HON)
F04	TOTAL FUEL USED (LBS. AVG/HEAD-ON)
F06	*PERCENT OFFENSIVE TIME (% AVG HD-ON)
F18	TOTAL TIME IN H-MIS ENV CTK (TIME/CTK)
F01	MAX G'S (MAX/SERIES)
F25	TOT. TIME IN GUN ENV. HON (TIME/HON)
M30	HIT/MISS R-MIS SCORE HON (H*(H+M)/HON)
M17	TOTAL NO. HITS HON (HITS/HON)
F09	TOTAL TIME SR LT 1500 (SEC-AVG/CTK)
M32	HIT/MISS GUN SCORE (H*TOTAL RDS/HON)
M12	*TIME TO FIRST KILL (SEC-AVG/HEAD-ON)
F27	G SPREAD HON (MAX G - MIN G)
F32	HIT/MISS GUN SCORE (H*TOTAL RDS/HON)
F08	TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
M13	*PERCENT TIME IN PANG (% AVG./CINETRACK)
F22	TIME TO GUN ENVELOPE CTK (TIME/CTK)
F23	TIME TO GUN ENVELOPE HON (TIME/HON)
F02	NO. TIMES OVER G (TOTAL SERIES)
M11	TIME TO PANG (SEC-AVG./CINETRACK)
M09	TOTAL TIME SR LT 1500 (SEC-AVG./CTK)
F31	HIT/MISS GUN SCORE (H*TOTAL RDS/CTK)
M10	*AVG. MILL ERROR SR LT 3000 (MILS-AVG./ CINETRACK)
M25	TOTAL TIME IN GUN ENV HON (TIME/HON)
M16	TOTAL NO. HITS CTK (HITS/CTK)
F11	TIME TO PANG (SEC-AVG./CINETRACK)
F30	HIT/MISS R-MISS SCORE HON (H*(H+M)/HON)
F20	TOT TIME IN R-MIS ENV CTK (TIME/CTK)
F19	TOT TIME IN H-MIS ENV HON (TIME/HON)
M22	TIME TO GUN ENV CTK (TIME/CTK)
M20	TOT. TIME IN R-MIS ENV CTK (TIME/CTK)
M29	HIT/MISS H-MISS SCORE HON (H*(H+M)/HON)
F03	TOTAL FUEL USED (LBS. AVG./CINETK)
F16	TOTAL NO. HITS CTK (HITS/CTK)
M24	TOT TIME IN GUN ENV CTK (TIME/CTK)
M04	TOTAL FUEL USED (LBS. AVG/HED-ON)
M14	DELTA ENERGY STATE CTK (INIT-END/CTK)
M08	TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
M31	HIT/MISS GUN SCORE (H * TOTAL RDS/CTK)

* Variables used to compute GSI scores.

TABLE 21 - EXPANDED OBJECTIVE PLUS DEMOGRAPHIC PARAMETERS
TURKEY SHOOT WINNER PREDICTORS

PREDICTOR VARIABLES: Expanded Set Including Demographic Data

ACTUAL GROUP MEMBERSHIP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
		GROUP I	GROUP II
Turkey Shoot Winners GPI	12	10 83.3%	2 16.7%
Turkey Shoot Non-Winners (Others) GPII	77	9 11.7%	68 88.3%

87.6 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
D5	- 0.00135	- 0.00016	0.26212	0.00041
M8	0.00331	0.00535	0.26502	0.00070
M29	- 0.09062	- 0.02737	0.[illegible]	0.02181
M32	0.00116	- 0.00296	[illegible]	-0.00142
F11	0.98447	0.157[illegible]	[illegible]	-0.28514
F16	0.64778	0.[illegible]	[illegible]	-0.08967
F18	0.[illegible]9583	[illegible]	[illegible]35913	0.03568
F22	0.26124	[illegible]	0.69227	0.27011
F23	0.120[illegible]	[illegible]062	-0.49723	-0.02411
F29	0.177[illegible]	0.14137	-0.16497	-0.01252
CONSTANT	-15.40078	-15.43945	--	-0.67260

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.620

TABLE 22 - EXPANDED OBJECTIVE PLUS DEMOGRAHIC PARAMETERS TURKEY SHOOT WINNER AND RUNNER-UP PREDICTORS

PREDICTOR VARIABLES: Expanded Data Set Including Demographic Data

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			GROUP I	GROUP II
Turkey Shoot Winners & Runners Up	GPI	23	19 82.6%	4 17.4%
Third, Second & First Eliminators (Others)	GPII	66	12 18.2%	54 81.8%

82.0 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
D5	- 0.00699	- 0.00557	0.35355	0.00055
D6	0.00329	0.00079	- 0.74499	- 0.00159
D7	0.02341	0.05347	0.42358	0.01171
M9	0.46854	0.52321	0.22037	0.02131
M10	0.00171	0.01239	0.25887	0.00416
M20	0.80229	0.91792	0.30951	0.04506
M29	0.04429	0.09930	0.28076	0.02144
M32	- 0.00274	- 0.00417	- 0.23232	- 0.00056
F11	0.64870	0.11529	0.61456	0.20782
F18	0.34346	0.43268	0.34989	0.03477
F22	0.57578	1.09963	0.52312	0.20411
F27	7.10480	7.60449	0.27220	0.19484
F29	0.13338	0.06650	- 0.44603	- 0.03385
F30	0.47268	1.56218	0.21687	0.42454
CONSTANT	-62.57329	-73.08694	--	- 4.45741

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.654

TABLE 23 - EXPANDED OBJECTIVE PLUS DEMOGRAPHIC PARAMETERS
TURKEY SHOOT WINNER, RUNNER-UP & 3RD ELIM. (UPPER HALF)

PREDICTOR VARIABLES: Expanded Data Set Including Demographic Data

ACTUAL GROUP MEMBERSHIP	NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
		GROUP I	GROUP II
T.S. Winners, Runners Up & Third Eliminators GPI	46	37 80.4%	9 19.6%
T.S. Second & First Eliminators GPII	43	7 16.3%	36 83.7%

82.0 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS		DISCRIMINANT FUNCTION COEFFICIENTS	
	GROUP I	GROUP II	STANDARDIZED	UNSTANDARDIZED
D11	0.00368	0.02656	0.27223	0.01065
M4	0.02228	0.02106	- 0.19296	- 0.00057
M20	0.52173	0.62508	0.33042	0.04811
M25	0.00378	- 0.03865	- 0.46721	- 0.01974
M29	0.33286	0.36408	0.19048	0.01454
F1	21.99968	23.02592	0.31727	0.47843
F11	1.48071	1.35444	- 0.17362	- 0.05871
F18	0.07518	0.17284	0.45738	0.04545
F25	0.21372	0.18771	- 0.25382	- 0.01209
F29	- 0.11230	- 0.19010	- 0.47705	- 0.03621
F30	0.21794	1.52132	0.30984	0.60653
CONSTANT	-139.34155	-144.61646	--	- 2.44321

CANONICAL CORRELATION OF DISCRIMINANT FUNCTION IS 0.642

TABLE 24 - EXPANDED OBJECTIVE PLUS DEMOGRAPHIC PARAMETERS QUARTILE RANK PREDICTORS

PREDICTOR VARIABLES: Expanded Data Set Including Demographic Data

ACTUAL GROUP MEMBERSHIP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP			
			GP I	GP II	GP III	GP IV
Turkey Shoot Winners & Runners Up	GP I	23	16 69.6%	3 13.0%	0 0.0%	4 17.4%
Turkey Shoot Third Eliminators	GP II	23	3 13.0%	14 60.9%	3 13.0%	3 13.0%
Turkey Shoot Second Eliminators	GP III	23	6 26.1%	2 8.7%	11 47.8%	4 17.4%
Turkey Shoot First Eliminators	GP IV	20	0 0.0%	2 10.0%	2 10.0%	16 80.0%

64.0 % OF CASES WERE CORRECTLY GROUPED

VARIABLE	CLASSIFICATION FUNCTION COEFFICIENTS			
	GROUP I	GROUP II	GROUP III	GROUP IV
D5	- 0.00053	0.00084	0.00077	0.00314
D6	- 0.00063	- 0.00389	0.00306	- 0.00544
M9	0.46314	0.48751	0.48939	0.40282
M10	0.00324	0.01468	0.00304	0.02122
M11	0.58092	0.61789	0.93229	0.51453
M12	0.65554	0.70357	0.67359	0.68348
M22	1.22072	1.11891	0.85281	1.35006
M25	0.34258	0.38840	0.34136	0.35504
F16	1.05453	1.29887	1.02676	1.37675
F18	0.25768	0.30279	0.35183	0.37553
F22	0.60374	0.65370	0.82041	0.42426
F23	0.008308	0.05169	0.07938	0.02629
F29	0.43946	0.40639	0.39330	0.28632
CONSTANT	-90.43753	-101.05052	-97.88803	-94.15775

TABLE 24 (CONT.)

PREDICTOR VARIABLE SET: Expanded Data Set Including Demographic Data

VARIABLE	DISCRIMINANT FUNCTION COEFFICIENTS: STANDARDIZED FCN. I	STANDARDIZED FCN. II	STANDARDIZED FCN. III	UNSTANDARDIZED FCN. I	UNSTANDARDIZED FCN. II	UNSTANDARDIZED FCN. III
D5	0.67724	0.06275	-0.08149	0.00106	0.00010	-0.00013
D6	-0.60936	-0.02166	0.59489	-0.00130	-0.00005	0.00127
M9	-0.22317	0.11192	-0.38708	-0.02158	0.01082	-0.03743
M10	0.33817	0.32989	-0.16183	0.00543	-0.00530	-0.00260
M11	-0.16161	0.78326	-0.39563	-0.0497	0.20825	-0.10519
M12	0.13758	-0.16675	-0.58128	0.00648	-0.00785	-0.02737
M22	0.16916	-0.50859	0.43156	0.06602	-0.19848	0.16842
M25	0.06428	-0.42895	-0.63271	0.00272	-0.01813	-0.02674
F16	0.19039	-0.24227	-0.13338	0.09766	-0.12428	-0.06842
F18	0.31104	0.35562	-0.14287	0.03091	0.03533	-0.01420
F22	-0.18372	0.32385	-0.31009	-0.07168	0.12636	-0.12099
F23	-0.35169	0.25426	0.12047	-0.01705	0.01233	0.00584
F29	-0.59790	-0.15839	-0.04538	-0.04538	-0.00796	-0.01202
CONSTANT	--	--	--	-0.23871	-0.59286	7.72996
CANONICAL						
CORREL.	0.679	0.518	0.450			

functions of the analyses have greatly increased over analogous functions in the previous analysis, indicating increased capability to discriminate between groups. This increased discriminant capability is at the cost of increased complexity in the number of variables required and the complexity of calculations. The classification functions provide optimal predictors for the objective data analyses in this study and include the best predictor variables consistent with the Wilks' Lambda variable selection criteria. The two-group analyses (Tables 16, 17, and 18) provide correct classification into the top group on the order of 80 percent; however, a fairly large number of non-Group I members are still being placed in these groups.

The Fourth Discriminant Analysis - Statistical Deriviation of a Turkey Shoot Placement Predictor Using Expanded Objective Parameters Plus Demographic Parameters as Candidate Variables

The results of the fourth discriminant analysis are presented in Tables 21, 22, 23, and 24. The analysis uses as candidate predictor variables all of the predictor variables reflected in the third analysis plus seven candidate demographic variables. These specific demographic candidate variables, Table 25, were available for all students; thus, no sample size reduction was required.

TABLE 25 - CANDIDATE DEMOGRAPHIC VARIABLES

DESIGNATION	DESCRIPTION
D4	TOTAL PILOT FLIGHT TIME (HOURS)
D5	TOTAL PILOT FIGHTER TIME
D6	TOTAL PILOT F-4 TIME (A/C & IP HOURS)
D7	TOTAL SORTIES LAST SIX MONTHS
D10	TOTAL BFM/ACM SORTIES
D11	BFM/ACM SORTIES LAST SIX MONTHS
D13	TIME SINCE LAST BFM/ACM (WEEKS)

The objective of the fourth analysis was to investigate the possibility of reduction of mis-classification of cases into Group I while maintaining comparable prediction rates. Comparison of the prediction results for the fourth analysis with those of the third indicate that the fourth analysis predictions were as good or better than the third analysis. Mis-classification into Group I was reduced in three of the four classifications, and correct classification into Group I was improved slightly in two of the four classifications. Evidence of this improved discrimination is provided by improvements (increases) in the canonical correlations of the discriminant functions.

In the first classification scheme (Group I - Turkey Shoot Winners, Group II - Other), the number of predictor variables required to maintain a constant correct classification rate was reduced from 11 to 10 by inclusion of demographic data.

Discussion of Third and Fourth Analyses

In the third analysis, over 80 predictor variables were available for consideration as candidates for the analysis. These variables were calculated using the master data base which Vought constructed during the first part of this study. These data include the expanded list of 12 variables which were required by the contract to be analyzed. An initial screening of the complete list was necessary to reduce the number of variables to an acceptable size. This screening was accomplished by correlating all variables with turkey shoot rank and then selecting the 40 variables from the list with the greatest correlation coefficients. The 40 candidate variables are presented in

Table 26 by rank as determined by the absolute values of the correlation coefficient (R). Variable designations are coded so as to indicate the class day on which each is collected. For example, F29 indicates that the variable value is collected on Friday (the "F" prefix indicates Friday), whereas M30 is a variable for which data are collected on Monday. Table 27 shows those objective variables which were selected by DISCRIM as the best turkey shoot rank predictors. In this table, the predictor variables are separated by day of data collection. The discriminant classification schemes by which each are used is also indicated. Use of this expanded list of candidate variables appears to have generally improved the winner prediction capability.

In the fourth analysis, a selected set of seven demographic variables were introduced. These were selected mainly on the basis of sample completeness, as it was not desired to reduce the sample size by excluding cases where incomplete data sets occurred. Non-quantitative data were also excluded. All objective variables selected in the third analysis were retained, but objective data considered in the third analysis but not selected were excluded. Table 28 defines the variables considered in the fourth analysis. Note that "D" is the variable prefix used to designate the demographic variables considered. As can be seen from the table, inclusion of the demographic data caused several Monday ("M" prefix) variables to be excluded. Also, as a result of the addition of demographic data in the analysis, certain other variable selection changes occurred.

TABLE 26 - CANDIDATE OBJECTIVE PREDICTORS RANKED BY CORRELATION COEFFICIENT WITH ACTUAL TURKEY SHOOT PLACEMENT

RANK	R	VAR	DEFINITION
1	-.4261	F29	HIT/MISS H-MISS SCORE HON (H*(H+M)/HON)
2	+.3168	F12	*TIME TO FIRST KILL (SEC-AVG/HEAD-ON)
3	-.3015	F17	TOTAL NO HITS HON (HITS/HON)
4	-.2981	F04	TOTAL FUEL USED (LBS. AVG/HEAD-ON)
5	-.2957	F06	*PERCENT OFFENSIVE TIME (% AVG HD-ON)
6	-.2784	F18	TOTAL TIME IN H-MIS ENV CTK (TIME/CTK)
7	+.2610	F01	MAX G'S (MAX/SERIES)
8	-.2548	F25	TOT. TIME IN GUN ENV HON (TIME/HON)
9	+.2475	M30	HIT/MISS R-MISS SCORE HON (H*(H+M)/HON)
10	-.2382	M17	TOTAL NO. HITS HON (HITS/HON)
11	-.2380	F09	TOTAL TIME SR LT 1500 (SEC-AVG/CTK)
12	-.2371	M32	HIT/MISS GUN SCORE (H*TOTAL RDS/HON)
13	+.2284	M12	*TIME TO FIRST KILL (SEC-AVG/HEAD-ON)
14	+.2000	F27	G SPREAD HON (MAX G - MIN G)
15	-.1988	F32	HIT/MISS GUN SCORE (H*TOTAL RDS/HON)
16	-.1931	F08	TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
17	-.1906	M13	*PERCENT TIME IN PANG (% AVG./CINETRACK)
18	+.1722	F22	TIME TO GUN ENVELOPE CTK (TIME/CTK)
19	-.1677	F23	TIME TO GUN ENVELOPE HON (TIME/HON)
20	+.1666	F02	NO. TIMES OVER G (TOTAL SERIES)
21	+.1654	M11	TIME TO PANG (SEC-AVG./CINETRACK)
22	-.1652	M09	TOTAL TIME SR LT 1500 (SEC-AVG./CTK)
23	-.1526	F31	HIT/MISS GUN SCORE (H*TOTAL RDS/CTK)
24	+.1518	M10	*AVG. MILL ERROR SR LT 3000 (MILS-AVG./ CINETRACK)
25	-.1485	M25	TOTAL TIME IN GUN ENV HON (TIME/HON)
26	-.1483	M16	TOTAL NO. HITS CTK (HITS/CTK)
27	+.1446	F11	TIME TO PANG (SEC-AVG./CINETRACK)
28	+.1437	F30	HIT/MISS R-MISS SCORE HON (H*(H+M)/HON)
29	+.1324	F20	TOT TIME IN R-MIS ENV CTK (TIME/CTK)
30	-.1297	F19	TOT TIME IN H-MIS ENV HON (TIME/HON)
31	+.1290	M22	TIME TO GUN ENV CTK (TIME/CTK)
32	+.1273	M20	TOT. TIME IN R-MIS ENV CTK (TIME/CTK)
33	-.1190	M29	HIT/MISS H-MISS SCORE HON (H*(H+M)/HON)
34	-.1172	F03	TOTAL FUEL USED (LBS. AVG./CINETK)
35	-.1111	F16	TOTAL NO. HITS CTK (HITS/CTK)
36	-.1108	M24	TOT TIME IN GUN ENV CTK (TIME/CTK)
37	-.0993	M04	TOTAL FUEL USED (LBS. AVG/HEAD-ON)
38	+.0908	M14	DELTA ENERGY STATE CTK (INIT-END/CTK)
39	-.0833	M08	TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
40	-.0804	M31	HIT/MISS GUN SCORE (H * TOTAL RDS/CTK)

* Variables used to compute GSI scores.

TABLE 27 - SELECTED OBJECTIVE DISCRIMINANT VARIABLES

VAR. DESIG.	WINNER VS OTHERS	WIN/R.U. VS OTHERS	UPPER 1/2 VS LOWER 1/2	FOUR GROUPS	VARIABLE DEFINITIONS
M4			X		TOTAL FUEL USED (LBS./AVG./HEAD-ON)
M8	X				TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
M9				X	TOTAL TIME SR LT 1500 (SEC-AVG./CINETRACK)
M10		X			AVG. MIL. ERROR SR LT 3000 (MILS-AVG./CINETRACK)
M11				X	TIME TO PANG (SEC-AVG./CINETRACK)
M12	X				TIME TO FIRST KILL (SEC-AVG./HEAD-ON)
M14		X			DELTA ENERGY STATE - CINETRACK (INT. - END/CTK)
M16	X				TOTAL NO. HITS - CINETRACK (HITS/CTK)
M20			X		TOTAL TIME IN R-MIS ENVELOPE - CTK (TIME/CTK)
M22				X	TIME TO GUN ENVELOPE - CINETRACK (TIME/CTK)
M24		X			TOTAL TIME IN GUN ENVELOPE - CTK (TIME/CTK)
M25			X	X	TOTAL TIME IN GUN ENVELOPE - HEAD-ON (TIME/H.ON)
M29	X	X			HIT/MISS HEAT - MIS. SCORE - H.ON (H*(H+M)/H.ON)
M32	X	X		X	HIT/MISS GUN SCORE (H*TOTAL RDS/H.ON)
F1			X	X	MAX G'S (MAX/SERIES)
F11	X				TIME TO PANG (SEC-AVG./CINETRACK)
F16				X	TOTAL NO. HITS CTK (HITS/CTK)
F18	X	X	X	X	TOTAL TIME IN H-MIS. ENV. CTK (TIME/CTK)
F22	X				TIME TO GUN ENVELOPE CTK (TIME/CTK)
F23	X			X	TIME TO GUN ENVELOPE H.ON (TIME/H.ON)
F25			X	X	TOTAL TIME IN GUN ENVELOPE H.ON (TIME/H.ON)
F27	X	X		X	G-SPREAD H.ON (MAX G-MIN G)
F29	X	X	X	X	HIT/MISS H-MIS SCORE H.ON (H*(H+M)/H.ON)
F30			X		HIT/MISS R-MIS SCORE H.ON (H*(H+M)/H.ON)

TABLE 28 - OBJECTIVE AND DEMOGRAPHIC DATA VARIABLES TURKEY SHOOT PLACEMENT PREDICTORS

VAR. DESIG.	WINNERS	WIN. & R.U.	UP 1/2 VS LO 1/2	FOUR GROUPS	VARIABLE DEFINITIONS
D4					TOTAL PILOT FLIGHT TIME (HOURS)
D5	X	X		X	TOTAL PILOT FIGHTER TIME (HOURS)
D6		X		X	TOTAL PILOT F-4 TIME (A/C & IP HOURS)
D7		X			TOTAL SORTIES LAST SIX MONTHS
D10					TOTAL BFM/ACM SORTIES
D11					BFM/ACM SORTIES LAST SIX MONTHS
D13					TIME SINCE LAST BFM/ACM (WEEKS)
M4			X		TOTAL FUEL USED (LBS, AVG./HEAD-ON)
M8	X				TOTAL ROUNDS FIRED (NO. TOTAL/HEAD-ON)
M9		X		X	TOTAL TIME SR.LT.1500 FT.(SEC.AVG.CTK)
M10		X		X	AVG. MIL ERROR SR. LT. 3000 FT. (MILS-AVG./CINETRACK)
M11				X	TIME TO PANG (SEC. AVG./CINETRACK)
M12				X	TIME TO FIRST KILL (SEC-AVG/HEAD-ON)
M14					DELTA ENERGY STATE - CTK (INT.-END/CTK)
M16					TOTAL NO. HITS - CINETRACK (HITS/CTK)
M20		X	X		TOTAL TIME IN R-MSL ENV.-CTK (TIME/CTK)
M22				X	TIME TO GUN ENVELOPE-CTK. (TIME/CTK)
M24					TOTAL TIME IN GUN ENV. - CTK (TIME/CTK)
M25			X	X	TOTAL TIME IN GUN ENV. - HEAD-ON (TIME/H-ON)
M29	X	X	X		HIT/MISS HEAT MIS. SCORE - H-ON (H*(H+M)/H-ON)
M32	X	X			HIT/MISS GUN SCORE (H*TOTAL ROS/H-ON)
F1			X		MAX G'S (MAX/SERIES)
F11	X	X	X		TIME TO PANG (SEC.-AVG./CINETRACK)
F16	X			X	TOTAL NO. HITS CINETRACK (HITS/CTK)
F18	X	X	X	X	TOTAL TIME IN H-MIS.ENV.CTK (TIME/CTK)
F22	X	X		X	TIME TO GUN ENVELOPE HON. (TIME/HON.)
F23	X			X	TIME TO GUN ENVELOPE HON. (TIME/HON.)
F25			X		TOTAL TIME IN GUN ENV. HON. (TIME/HON.)
F27		X			G-SPREAD HEAD-ON (MAX. G-MIN G OVER SERIES)
F29	X	X	X	X	HIT/MISS H-MIS SCORE HON (H*(H+M)/HON)
F30		X	X		HIT/MISS R-MIS SCORE HON (H*(H+M)/HON)

Comparison of Prediction Results

Table 29 summarizes the predictive capabilities of the major predictor models presented. The table also includes approximately 95 percent confidence limits on the prediction rates[4]. Note that the confidence limits are approximate and use the normal approximation to the binomial. This requires a relatively large sample size. For predictions of the winner (the last row of the table), sample size is nine or 12.

Tests of the Predictor Models

Given the predictor models developed using discriminant analysis, it is necessary to test these models using data collected outside the experimental data set. The purpose of these tests is to determine if the predictability of the developed models is retained using predictor variable data not used in the calculation of the parameters or in the selection of the predictor variables. In the analysis performed, there is evidence that the parameters selected are very sensitive to the particular data set used in their estimation and to the definition of the discriminant groups. The values of the parameter estimates are also probably quite sensitive to the data set used.

A very limited test analysis using data obtained prior to this study has been conducted on the predictor models developed from the first and second analysis defined previously. In the first analysis, Monday and Friday

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[4]Ostle and Mensing. Statistics in research, (3rd ed.). Ames: Iowa State University Press, 1975, 100-101.

GROUPINGS		RANDOM SELECTION	CIPP	GSI RANKING (FRI. SCORE)	DISCRIMINANT ANALYSIS: GSI SCORE (MON. & FRI.)	DISCRIMINANT ANALYSIS: GSI PRED. VAR.	DISCRIMINANT ANALYSIS: EXP. LIST	DISCRIMINANT ANALYSIS: EXP. LIST +DEM. VAR.
Four Groups (1-2, 3-4, 5-6, 7-8)	No. Correct Pred.	-	21	26		36	56	57
	Tot. No. Pred.	-	67	90		90	89	89
	% Correct Pred.	25%	31.3%	28.9%		40.0%	62.9%	69.3%
	95% Conf. Int.	-	20.2 - 42.5	19.5 - 38.3		29.9 - 50.1	52.9 - 73.0	54.1 - 74.0
Upper Half of Cla[illegible] (1, 2, [illegible]	No. Correct Pred.	-	24	27	27	27	36	37
	Tot. No. Pred.	-	34	46	46	46	46	46
	% Correct Pred.	50%	70.6%	58.7%	58.7%	58.7%	78.3%	80.4%
	95% Conf. Int.	-	55.2 - 85.9	44.5 - 72.9	44.5 - 72.9	44.5 - 72.9	66.3 - 90.2	69.0 - 91.9
Winner & Runner-Up (1, 2)	No. Correct Pred.	-	6	9	14	15	19	19
	Tot. No. Pred.	-	17	23	23	23	23	23
	% Correct Pred.	25%	35.3%	39.1%	60.9%	65.2%	82.6%	82.6%
	95% Conf. Int.	-	12.6 - 58.0	19.2 - 59.1	40.9 - 80.8	45.8 - 84.7	67.1 - 98.1	67.1 - 98.1
Winner (1)	No. Correct Pred.	-	1	3	8	9	10	10
	Tot. No. Pred.	-	9	12	12	12	12	12
	% Correct Pred.	12.5%	11.1%	25.0%	66.7%	75.0%	83.3%	83.3%
	95% Conf. Int.	-	0 - 31.6	0 - 49.5	40.0 - 93.3	50.5 - 99.5	62.2 - 100	62.2 - 100

TABLE 29- COMPARISON OF PREDICTION RESULTS

GSI scores were the predictor variables. In the second analysis, the predictor variables were selected Monday and Friday GSI component variables. No additional analysis has been conducted on outside data for the third and fourth analyses because it has been determined that the required data are not available and/or not available to the extent necessary for reduction to the master data base form.

Two other difficulties were also encountered in acquiring prior data for model testing. First, adjustments had been made in the weighting factors used in calculating GSI. These adjustments were not documented, and thus, a consistent set of historic GSI scores is not readily available. The second difficulty encountered pertains to the prior record keeping procedures on GSI component variables. The automated GSI component variable reporting forms were implemented beginning with TAC ACES I Class #7815. Thus, nominally, GSI component variable averages were not consistently recorded in a usable form prior to Class #7815. Further, Class #7816 had missing data for Monday GSI component variables. For Classes #7832 and #7833, two classes held after the study sample, it was determined that turkey-shoot compilations were conducted in an irregular manner; that is, certain competitions were terminated when two contestants were eliminated simultaneously by air-to-air collision. This practice preempted evaluation of turkey shoot results, using the method used previously in defining ranks. Thus, classification of results could not be determined using definitions defined for the discriminant predictor model.

The results of these data restrictions limit the analysis to four classes (7815, 7817, 7818, and 7819), totaling 30 students. It is also restricted to predictors using GSI and GSI component variables. This, of course, precludes evaluation at this time of the best predictor models; that is, those using the expanded data set and demographic data. Recommendations are made at the conclusion of this report that will alleviate these restrictions.

Evaluation of Predictor Models Using Monday and Friday GSI Scores

The first comparison conducted was for groupings where the top group was defined to be winners only and the second group contained all others. Figure 12 graphically shows the classification of the data from the original (experiment) data. The graph shows Monday GSI (MGSI) plotted versus Friday GSI (FGSI). The line shown is obtained by setting the Group I classification function equal to the Class II classification and solving for FGSI as a function of MGSI. All points above the line are placed in Group I (winners) while all points falling below the line fall in Group II (others). Figure 13 shows a similar plot of the test data using the same discriminant function developed from the experimental data. A statistical test of the null hypothesis that the proportion of correct classifications (P_E) using experiment data is equal to the proportion of correct classifications (P_T) using the test data was conducted, i.e., $H_O : P_E = P_T$ versus $H_1 : P_E \neq P_T$.[5] The null hypothesis is accepted at the 95 percent level.

Similar plots are presented (Figures 14, 15, 16, and 17) showing classifications of the experimental and test

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[5] Ostle and Mensing. Statistics in research, (3rd ed.). Ames: Iowa State University Press, 1975, 135-137.

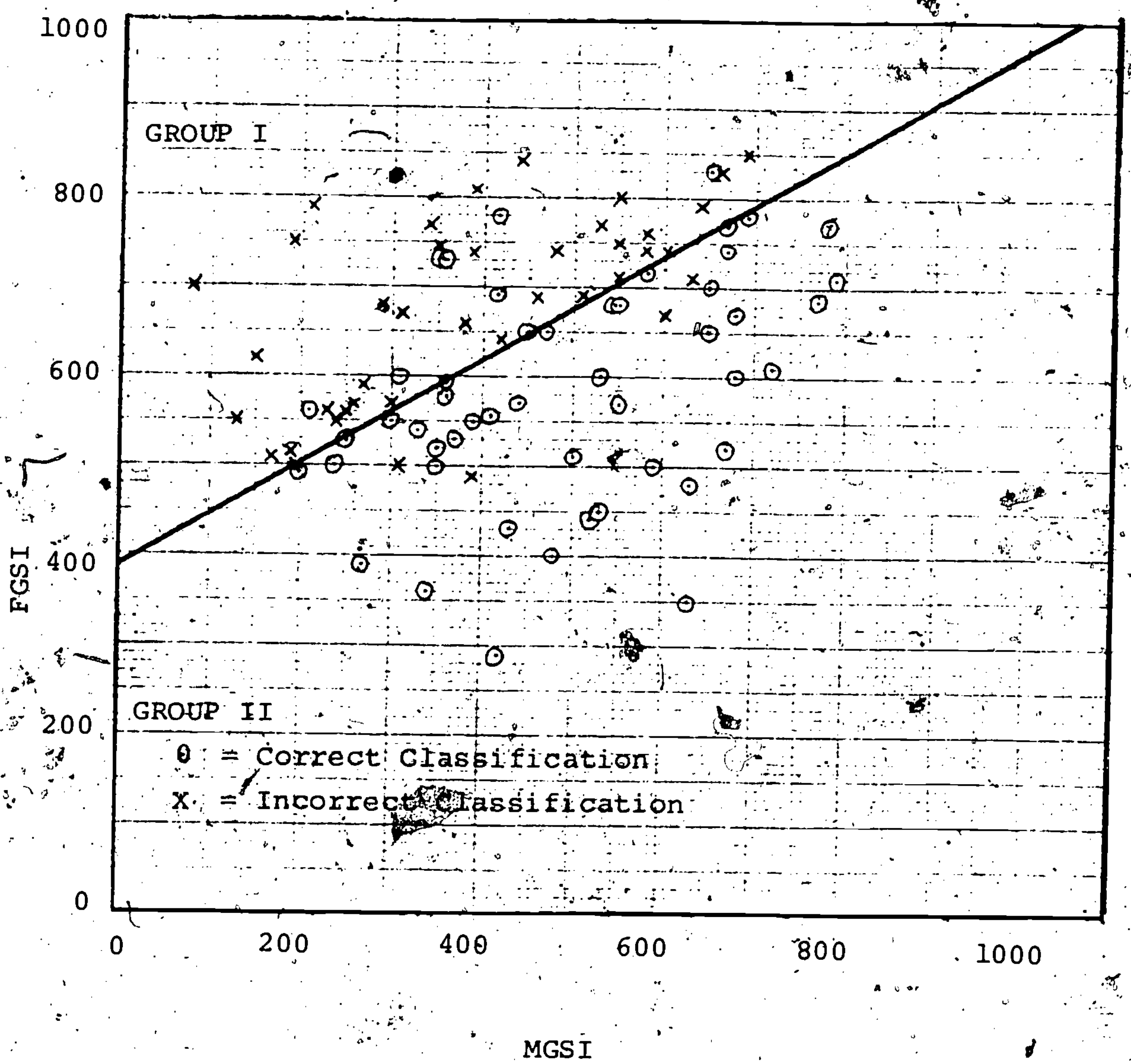

Figure 12. Classification diagram - experiment data (Group I = winners; Group II = others).

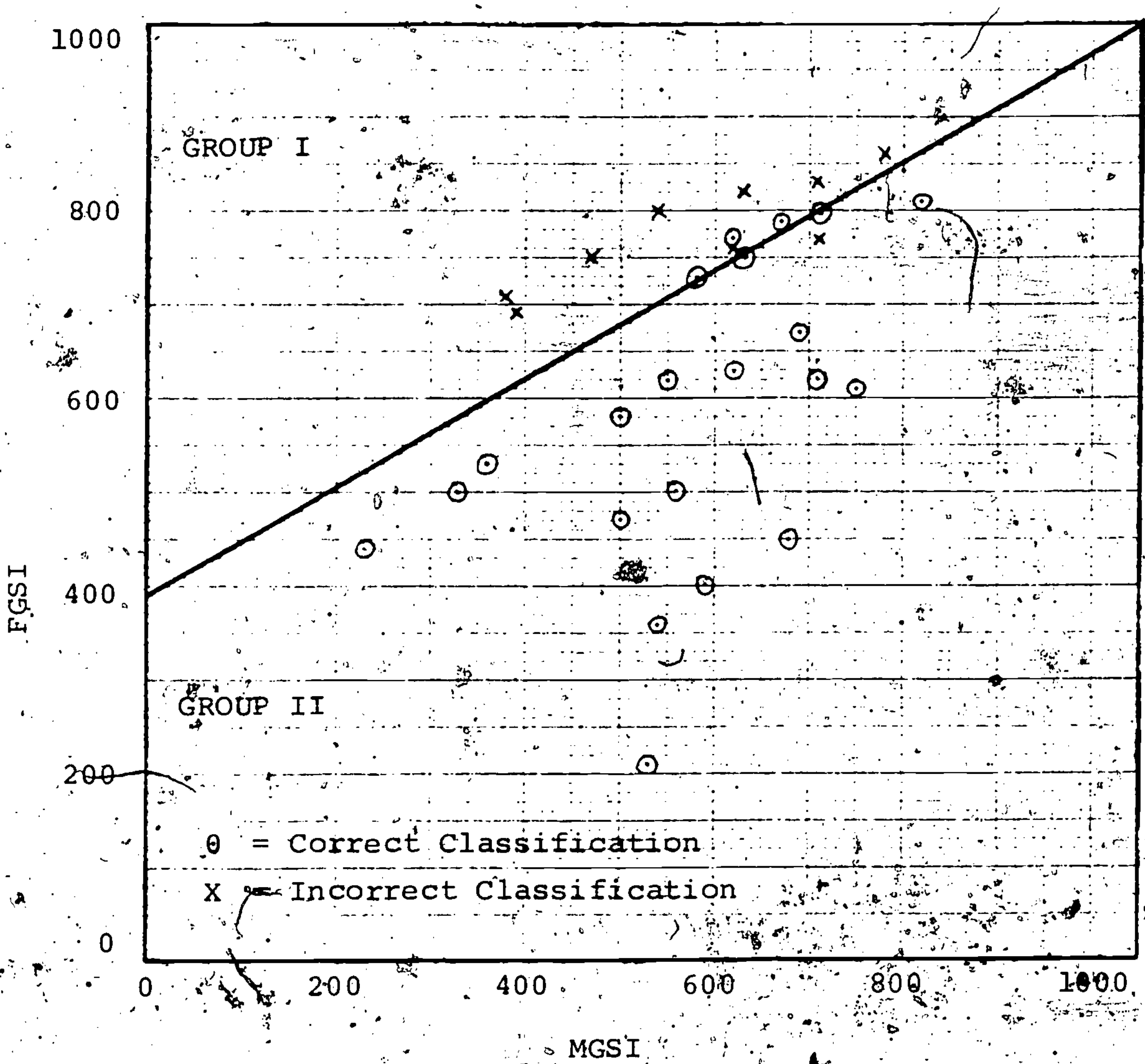

Figure 13. Classification diagram - test data
(Group I = winners; Group II = others).

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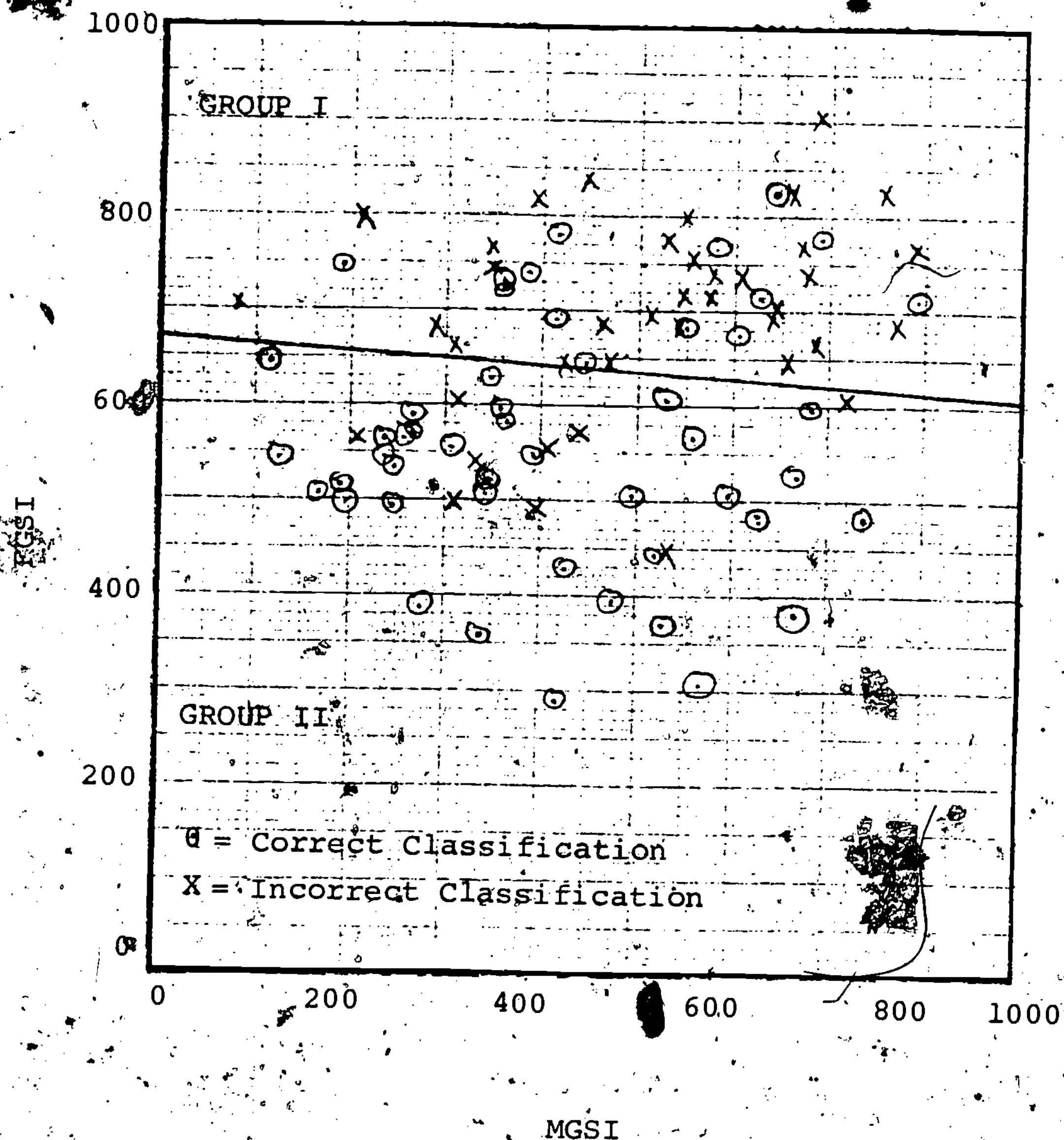

Figure 14. Classification diagram - experiment data (Group I = winners and runners-up; Group II = others).

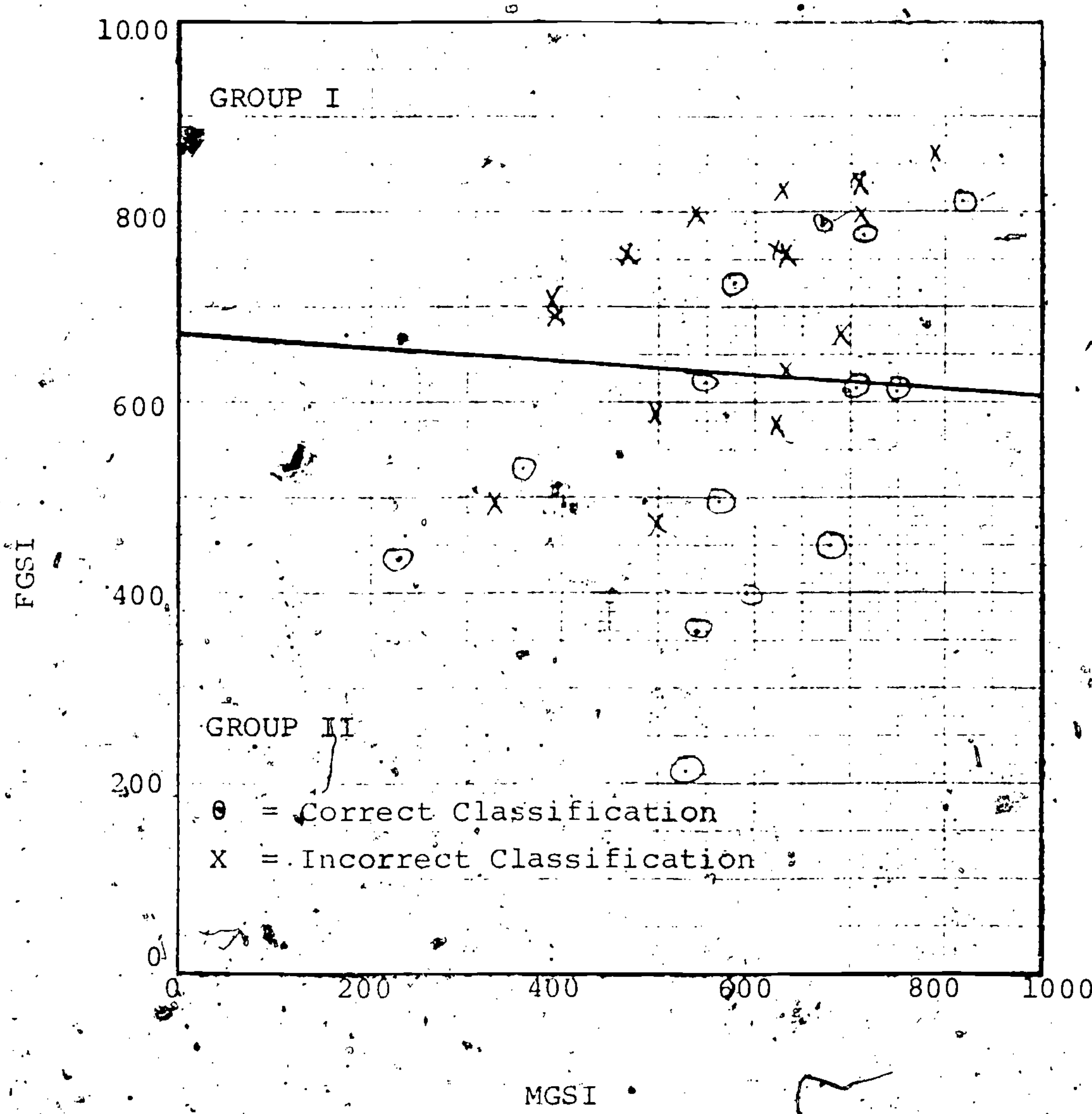

Figure 15. Classification diagram - test data (Group I = winners and runners-up; Group II = others).

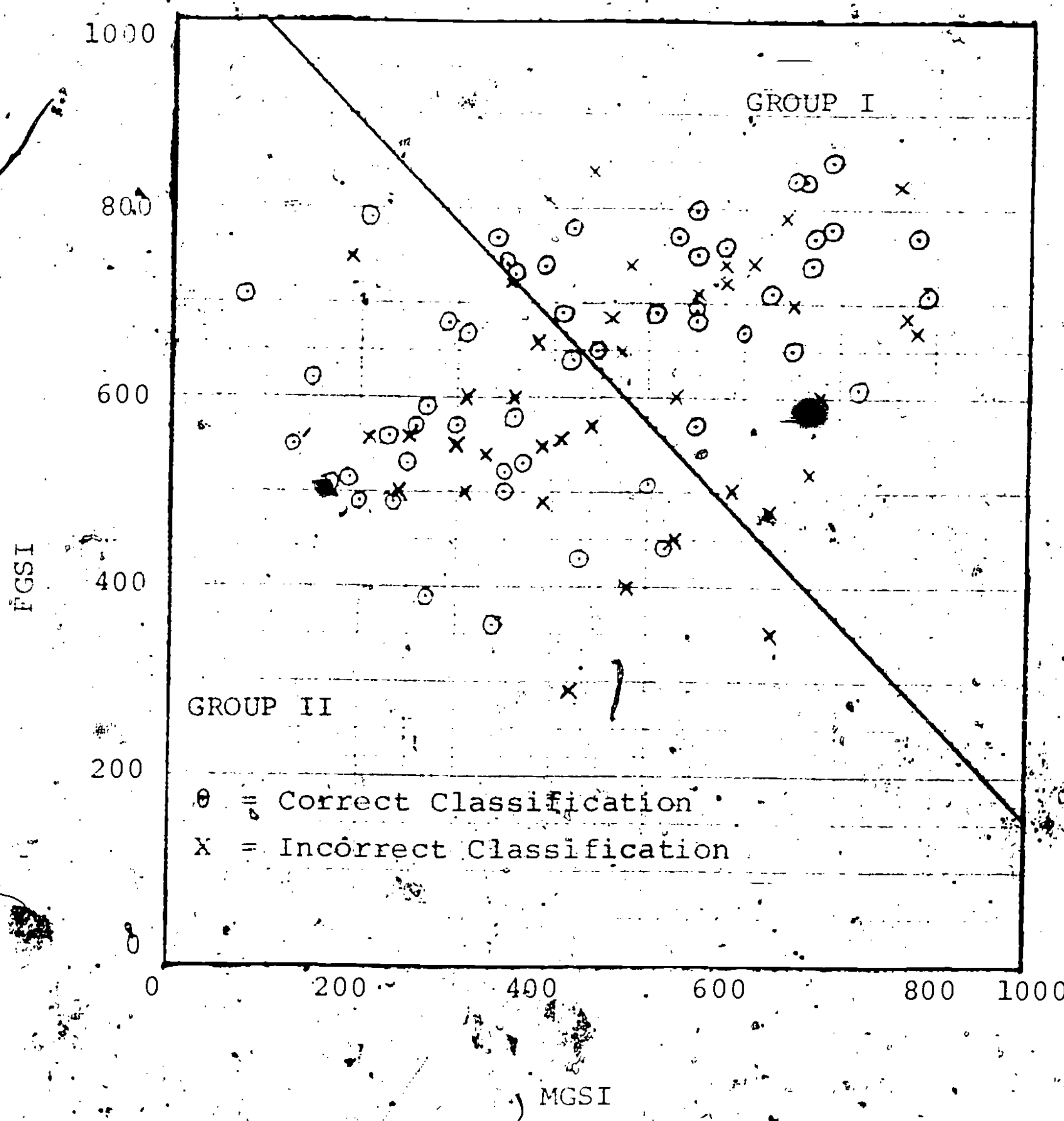

Figure 16. Classification diagram - experiment data (Group I = winners and runners-up and third eliminators; Group II = second and first eliminators).

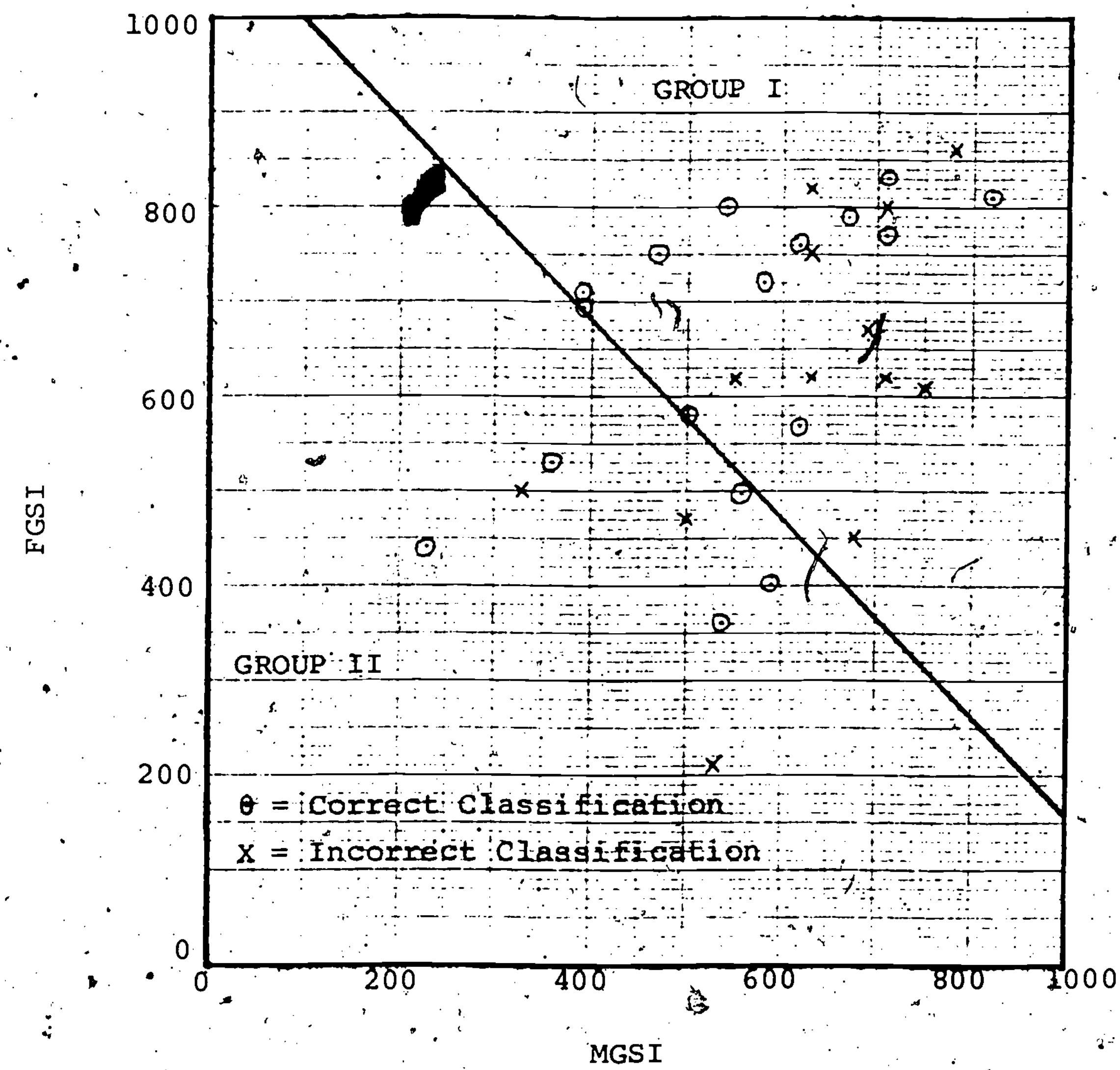

Figure 17. Classification diagram - test data (Group I = winners, runners-up, and third eliminators; Group II = second and first eliminators).

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data for the other two group definitions defined in the first analysis, i.e., Group I = winners and runners-up versus Group II = others, and Group I = winners, runners-up and third eliminators versus Group II = second and first eliminators). Similar tests of hypotheses were also conducted and accepted, i.e., no difference in prediction rates between the experimental and test data were detected.

Evaluation of Predictor Models Using Monday and Friday GSI Component Variables

The second set of comparisons were made using the predictor models developed from the second discriminant analysis. The number of predictor variables selected for the models in this analysis was usually greater than two. For this comparison, tabular displays were selected. Tables 30, 31, 32, and 33 provide the results of the test data classifications. For example, Table 30 (GP. I = Winners, GP. II = Others), shows the data (X3 and X8) and the calculated classification function scores (Class FCN I and Class FCN II) used to group the cases (actual group membership is also provided to determine correctness of the predictions). As noted previously, a case is classified into the group with the greater classification function score. For example, consider the first case (X3 = 72 and X8 = 98). The function I score is 49.4, and the function II score is 49.7. Since 49.7 is greater than 49.4, the first case is correctly predicted to belong to Group II, i.e., others or non-winners. Of the 30 predictions shown in the table, 21 or 70 percent were correct. This compares to an estimated correct prediction rate of about 61 percent for the experimental data. Testing the null hypothesis that the correct prediction rates of the experiment and test sample are equal, a test

TABLE 30- TEST OF GSI COMPONENT VARIABLE PREDICTOR MODEL
(GP. I = WINNERS, GP II = OTHERS)

CLASS	TURKEY SHOOT RANK	GP. ACTUAL MEMBERSHIP	X3	X8	CLASS FCN I	CLASS FCN II	GP. PREDICTED MEMBERSHIP	CORRECT CLASS(?)
15	7.5	2	72	98	49.4	49.7	2	Yes
	7.5	2	81	101	61.1	60.8	1	No
	4.	2	75	72	49.4	49.9	2	Yes
	2.	2	78	80	54.4	54.5	2	Yes
	1.	1	78	75	53.6	53.8	2	No
	3.	2	74	120	55.1	55.0	1	No
	5.5	2	75	72	49.4	50.0	2	Yes
	5.5	2	79	57	52.3	52.7	2	Yes
17	2.	2	63	116	40.7	41.4	2	Yes
	4.	2	66	131	46.6	46.9	2	Yes
	3.	2	72	106	50.6	50.8	2	Yes
	1.	1	68	95	44.0	44.6	2	No
	7.5	2	78	104	57.8	57.6	1	No
	5.5	2	38	100	7.0	9.7	2	Yes
	5.5	2	75	127	57.4	57.1	1	No
	7.5	2	65	80	38.0	39.1	2	Yes
18	2.	2	78	170	67.3	66.2	1	No
	7.5	2	55	161	37.2	37.8	2	Yes
	5.5	2	63	89	36.8	37.9	2	Yes
	4.	2	64	106	40.5	41.3	2	Yes
	3.	2	72	78	46.5	47.1	2	Yes
	1.	1	69	107	47.0	47.3	2	No
	5.5	2	75	101	53.6	53.7	2	Yes
19	7.5	2	64	103	40.1	40.9	2	Yes
	3.0	2	72	106	50.6	50.8	2	Yes

TABLE 30 (CONT.)

CLASS	TURKEY SHOOT RANK	GP.	ACTUAL MEMBERSHIP	X3	X8	CLASS FCN I	CLASS FCN II	GP.	PREDICTED MEMBERSHIP	CORRECT CLASS(?)
	5.5		2	42	180	23.6	24.9		2	Yes
	7.5		2	65	119	43.7	44.2		2	Yes
	2.0		2	74	91	50.9	51.2		2	Yes
	1.0		1	75	91	52.2	52.4		2	No
	5.5		2	71	93	47.4	47.9		2	Yes

No. Predictions = 30
No. Correct Predictions = 21

TABLE 31 - TEST OF CSF COMPONENT VARIABLE PREDICTOR MODEL
(GP I = WINNERS & RUNNERS-UP; GP II = OTHERS)

CLASS	TURKEY SHOOT RANK	ACTUAL GP. MEMBERSHIP	PREDICTOR VARIABLES X1	X2	X4	X5	CLASS FCN. I	CLASS FCN. II	PREDICTED GP. MEMBERSHIP	CORRECT CLASS(?)
15	7.5	2	31	31	114	27	22.09	22.06	1	No
	7.5	2	26	30	52	33	8.50	7.32	1	No
	4.0	2	29	51	70	36	21.59	21.44	1	No
	2.0	1	42	56	63	24	24.53	24.76	2	No
	1.0	1	42	49	63	12	21.45	21.41	1	Yes
	3.0	2	24	41	93	14	20.86	20.50	1	No
	5.5	2	44	19	75	42	11.62	11.08	1	No
	5.5	2	22	40	56	29	12.63	11.87	1	No
17	2.0	1	40	50	139	36	36.74	37.96	2	No
	4.0	2	33	43	116	43	28.07	28.59	2	Yes
	3.0	2	18	46	90	49	21.59	21.34	1	No
	1.0	1	36	51	87	12	26.02	26.24	2	No
	7.5	2	33	50	96	19	26.90	27.18	2	Yes
	5.5	2	26	20	[illegible]	25	25.24	25.43	2	Yes
	5.5	2	150	33	[illegible]	18	41.24	44.70	2	Yes
	7.5	2	21	24	113	30	17.16	16.62	1	No
18	2.0	1	60	19	133	41	25.96	26.84	2	No
	7.5	2	29	19	106	19	14.97	14.35	1	No
	5.5	2	33	40	109	42	25.40	25.70	2	Yes
	4.0	2	83	5	155	12	28.19	29.57	2	Yes
	3.0	2	31	47	84	10	22.82	22.71	1	No
	1.0	1	37	34	80	28	17.67	17.38	1	Yes
	5.5	2	20	42	84	16	18.80	18.22	1	No
	7.5	2	25	42	136	15	30.00	30.42	2	Yes
	3.0	2	16	38	79	31	15.50	14.68	1	No
	5.5	2	18	24	136	151	22.11	22.46	2	Yes
	7.5	2	19	20	173	10	26.88	27.02	2	Yes
	2.0	1	50	28	142	80	30.12	31.31	2	No
	1.0	1	33	50	85	26	24.77	24.91	2	No
	5.5	2	8	37	77	31	13.27	12.14	1	No

No. Predictions = 30

No. Correct Predictions = 21

[illegible] 1/2 [illegible] CLIM[illegible] FIRST [illegible]

CLASS	CURRENT SHOOT RANK	[illegible] NUMBER	[illegible]	[illegible]	[illegible]	PREDICTED SCORE	CORRECT CLASS (?)
5	7.5	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
	7.[illegible]	2	[illegible]		7	10[illegible].[illegible]	[illegible]
	[illegible]		[illegible]			10[illegible].[illegible]	Yes
	[illegible].0		[illegible]			[illegible]	Yes
	[illegible].0		7[illegible]			[illegible]	Yes
	[illegible].0		7[illegible]			[illegible]	Yes
	[illegible].5		7[illegible]			[illegible]	Yes
	5.5		7[illegible]			1[illegible].	[illegible]
	2.0		[illegible]			1[illegible]1.	[illegible]
	4.0		[illegible]			1[illegible].	[illegible]
	3.0		6[illegible]			[illegible]	[illegible]
	1.0		7[illegible]			[illegible]	[illegible]
	7.5		6			[illegible]	[illegible]
	5.5		7[illegible]			[illegible]	[illegible]
	5.5		[illegible]			[illegible]	[illegible]
	7.5		7[illegible]			[illegible]	[illegible]
3	2.0		[illegible]			10[illegible].84	[illegible]
	7.5		[illegible]			1[illegible].16[illegible]	[illegible]
	5.5		[illegible]			[illegible].1[illegible]	[illegible]s
	4.0		[illegible]			1[illegible].47[illegible]	[illegible]
	3.0		[illegible]	5		1[illegible]1.854	[illegible]
	1.0		[illegible]	4		[illegible]4.339	[illegible]
	5.5			0		[illegible]6.847	[illegible]
	7.5			4	1	112.191	[illegible]
	3.0	[illegible]		8	[illegible]1	120.020	[illegible]
	5.5	1		[illegible]	10	102.785	[illegible]
	7.5	2		[illegible]	7	75.742	[illegible]
	2.0	2		3	14	145.817	[illegible]
	1.0	1		1-2	14	145.076	[illegible]
	5.5	1		35	11[illegible]	112.264	[illegible]
		2		77	9[illegible]	98.650	[illegible]

[illegible] Predicti[illegible]

No. Correct Pre[illegible] = [illegible]

TABLE 33 - QUARTILE PLACEMENTS (GP I = WINNERS AND RUNNERS-UP; GROUP II = THIRD ELIMINATORS; GP. III = SECOND ELIMINATORS; GP. IV = FIRST ELIMINATORS)

CLASS	TURKEY SHOOT RANK	ACTUAL GP. MEMBER-SHIP	X1	X3	X5	X8	CF #1 SCORE	CF #2 SCORE	CF #3 SCORE	CF #4 SCORE	ACTUAL GP. MEMBER-SHIP	CORRECT(?)
15	7.5	4	31	72	27	98	52.600	52.616	52.250	51.821	2	No
	7.5	4	26	81	33	101	63.695	63.573	62.986	62.150	1	No
	4.0	2	29	75	36	72	53.636	54.127	52.994	52.420	2	Yes
	2.0	1	42	78	24	80	59.912	60.793	59.522	58.992	2	No
	1.0	1	42	78	12	75	59.223	60.107	58.795	57.634	2	No
	3.0	2	24	74	14	120	56.159	55.392	55.719	55.282	1	No
	5.5	3	44	75	42	72	55.863	57.072	55.568	54.718	2	No
	5.5	3	22	79	19	57	56.091	56.531	55.073	54.326	2	No
17	2.0	1	40	63	26	116	44.270	44.261	44.504	44.472	3	No
	4.0	2	33	66	43	131	48.851	48.411	48.940	49.000	4	No
	3.0	2	18	72	49	106	51.895	51.339	51.310	51.295	1	No
	1.0	1	36	68	12	95	47.707	47.852	47.563	47.182	2	No
	7.5	4	33	78	19	104	60.974	60.981	60.525	59.653	2	No
	5.5	3	26	38	25	100	8.952	8.320	9.504	11.255	4	No
	5.5	3	150	75	18	127	76.123	80.945	78.589	75.520	2	No
	7.5	4	21	65	30	80	40.533	40.367	40.050	40.236	1	No
18	2.0	1	60	78	41	170	71.810	72.001	72.405	71.242	3	No
	7.5	4	29	55	19	161	36.992	35.540	37.487	38.228	4	Yes
	5.5	3	33	63	42	89	40.797	41.073	40.711	40.861	2	No
	4.0	2	83	64	12	106	50.432	52.452	51.553	50.467	2	Yes
	3.0	2	31	72	10	78	50.322	50.577	49.837	49.266	2	Yes
	1.0	1	37	69	28	107	50.573	50.671	50.506	50.162	2	No
	5.5	3	20	75	16	101	54.972	54.393	54.293	53.850	1	No
19	7.5	4	25	64	15	103	41.923	41.406	41.696	41.822	1	No
	3.0	2	16	72	31	106	51.334	50.559	50.692	50.614	1	No
	5.5	3	18	42	151	180	22.889	21.399	23.711	26.290	4	No
	7.5	4	19	65	10	119	43.874	42.773	43.577	43.770	1	No
	2.0	1	50	74	80	91	57.948	59.346	57.962	57.312	2	No
	1.0	1	33	75	26	91	55.967	56.225	55.530	54.855	2	No
	5.5	3	8	71	31	93	47.617	96.705	46.740	46.861	1	No

statist... = 0.766 was calculated. As this is less than ... .95 = 3.84, the hypothesis cannot be rejected.

... isons of the group prediction capabilities of the remaining three discriminant prediction models were also compared to predictions made with the test data and are ... in Tables 31, 32 and 33. Tests of the hypothesis ... ity of the predictions between the experiment data and the test data were also carried out. For the prediction model where Group I = Upper ... and Group II ... lower ... the null hypothesis was not rejected. However, for the other two predictors, the null hypothesis was rejected at the 95 percent level. For the case where Group ... Winners and Runners-Up, and Group II = Others, the null hypothesis could not be rejected at the .9 percent level.

This leaves the four group predictor hypothesis rejected at the commonly acceptable levels. Examination of the sample means and standard deviations of the predictor variables used in each data set provides some evidence as ... why the null hypothesis was rejected. Tables 34 and 35 show the comparisons of sample means and standard deviations by predictor variable, data set (experiment or test) and by discriminant group. Inherent in the predictor model requirements is that group membership prediction capability requires that data for which classifications are to be made should be samples from the same distributions as those used ... determine the predictor model itself. Comparison of the means and standard deviations shows that several rather distinct differences exist between the experiment and test data parameters. An example of these distributional differences is contained in Figure 1... where X5, Average Mil Error, is compared. Note the great distributional differences between Groups II, III, and IV

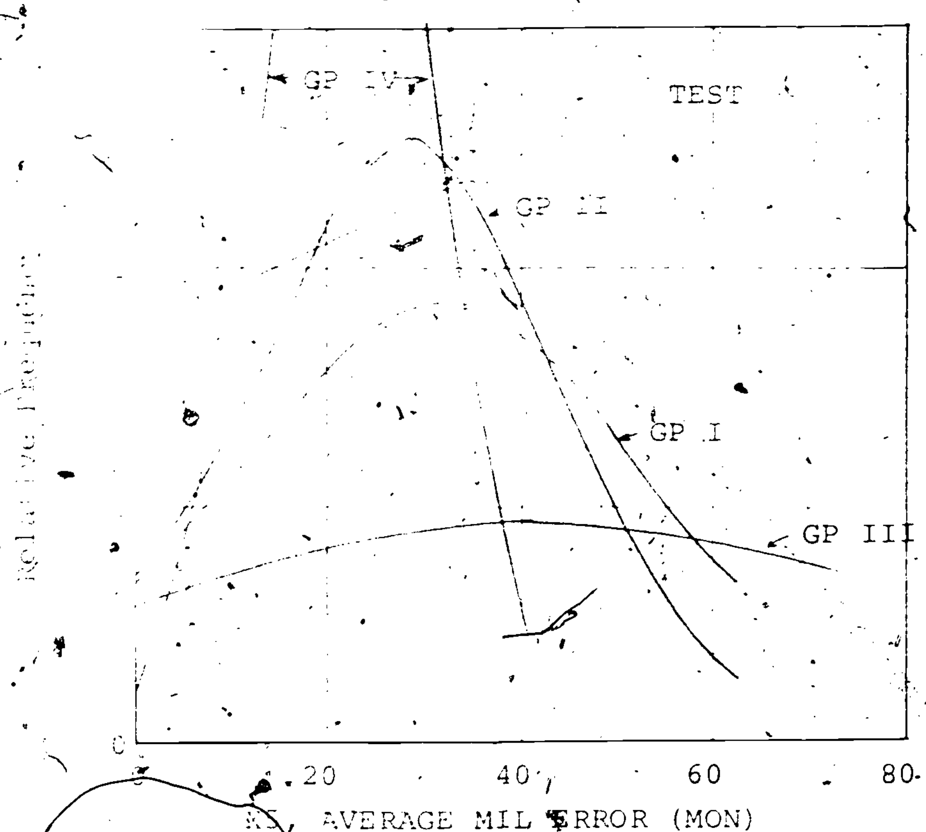
TABLE 34 - COMPARISON OF GROUP MEANS

DISCRIMINANT GROUP	DATA SET	DISCRIMINANT VARIABLES X1	X3	X5	X8
GROUP I - Winners and Runners-up	Experiment	30.4	70.6	[illegible]	124.
	Test	42.5	[illegible]	[illegible]	103.
GROUP II - Third Eliminators	Experiment	43.2	70.2	[illegible]	109.
	Test	33.4	70.7	[illegible]	103.
GROUP III - Second Eliminators	Experiment	38.5	68.4	[illegible]	134
	Test	40.1	64.8	44.3	102
GROUP IV - First Eliminators	Experiment	33.3	64.8	[illegible]	137
	Test	26.3	68.6	[illegible]	109.

TABLE 35 - COMPARISON OF GROUP STANDARD DEVIATIONS

DISCRIMINANT GROUP	DATA SET	DISCRIMINANT VARIABLES X1	X3	X5	X8
GROUP I - Winners and Runners-up	Experiment	10.4	4.84	22.3	30.8
	Test	8.72	5.61	21.8	[illegible]
GROUP II - Third Eliminators	Experiment	22.2	6.75	45.4	41.0
	Test	22.8	4.11	15.9	21.2
GROUP III - Second Eliminators	Experiment	21.1	8.29	25.7	31.2
	Test	45.7	16.0	44.2	37.6
GROUP IV - First Eliminators	Experiment	13.6	10.0	113.	31.5
	Test	5.12	9.00	8.38	25.5

by data set. While the Group-I distributions match quite well, the others change shape radically.



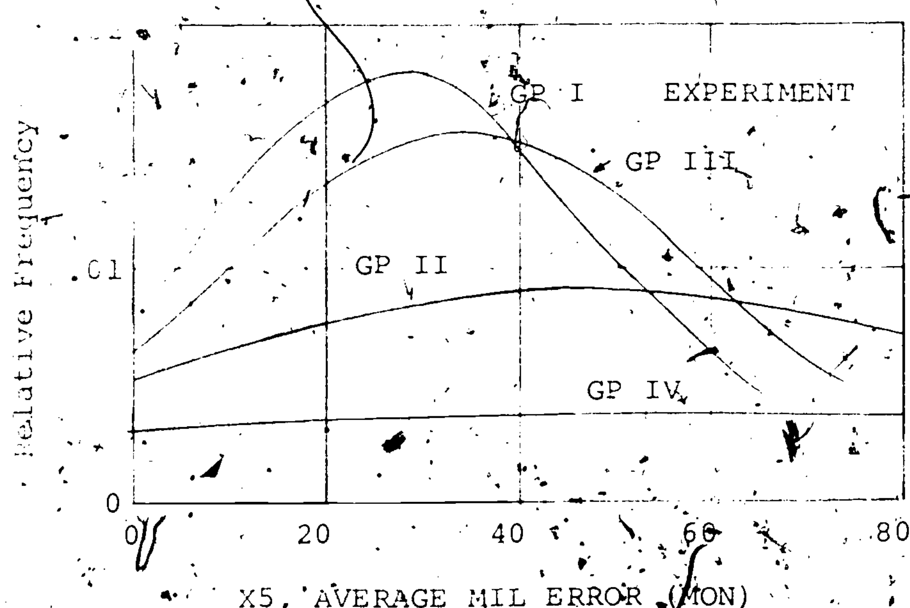


Figure 18. A Comparison Between the Distribution of Discriminant Variable X5 By Data Set.

IV. DEMOGRAPHIC DATA ANALYSIS

The data collected as a part of this study were in two primary forms: student pilot objective performance data in the simulator and student demographic data collected from background surveys and questionnaires. This section describes some of the relationships that were investigated between the student pilot's demographic/historical background data and his predicted or actual performance in the air combat simulator. The major data source for comparison was the TAC ACES I background survey, shown in Appendix B, which was adapted for use in the GSI study. The questions on this survey and their responses were utilized to form the demographic data base. The form was completed by each student in the study sample (N = 89). The questions were identified as demographic variables and tabulated into a list, which is shown in Table 35, Total Demographic Variables. This list was reduced to consider for analysis only those variables which included a positive, or other than zero response from all of the 89 subjects in the study. These are shown in Table 36, and include those factors which were used in both the correlation analysis and the stepwise selection routines.

Several methods were employed to analyze these data which were classified into two groups. Group 1 consists of that body of data which resulted from responses from all 89 subjects. Group 2 consists of that body of data which resulted from responses from differing numbers of subjects in the sample.

Group I Data

A correlation analysis was employed to estimate the functional relationship among the Group 1 data or total sample (N = 89) of subjects in the study.

TABLE 35 -- TOTAL DEMOGRAPHIC VARIABLES

	VARIABLE	RESPONDENTS N
D1	STUDENT PILOT RANK	89
D2	SQUADRON	89
D3	WING	89
D4	TOTAL PILOT FLIGHT TIME, HOURS	89
D5	TOTAL PILOT FIGHTER TIME, HOURS	89
D6	TOTAL PILOT F-4 TIME, A/C AND IP, HOURS	89
D7	TOTAL SORTIES LAST 6 MONTHS	89
D8	TYPE AIRCRAFT CURRENT	89
D9	PRIMARY DESIGNATED OPERATIONAL CAPABILITY	89
D10	TOTAL BFM/ACM SORTIES	89
D11	BFM/ACM SORTIES LAST 6 MONTHS	89
D12	BFM/ACM SORTIES LAST MONTH	89
D13	TIME SINCE LAST BFM/ACM	89
D14	TYPE A/A MISSILES FIRED	23
D15	FWIC GRADUATE	1
D16	PREVIOUS ACES ATTENDED	18
D17	LAST AGGRESSOR DACT FLIGHT	89
D18	OTHER VISUAL A/A SIMULATORS FLOWN	18
D19	TOTAL COMBAT SORTIES	19
D20	TOTAL COMBAT HOURS	19
D21	NUMBER COMBAT KILLS	1
D22	NUMBER HITS RECORDED	1
D23	NUMBER SAM ENCOUNTERS	4
D24	NUMBER HOSTILE AIRCRAFT ENGAGEMENTS	1
D25	NUMBER HITS RECEIVED	1
D27	OWN TRAINING EVALUATION	89
D28	ANY TRAINING ANOMALIES	89

TABLE 36 - GROUP 1 DEMOGRAPHIC VARIABLES

	VARIABLE	RESPONDENTS N
D1	STUDENT PILOT RANK	89
D2	SQUADRON	89
D3	WING	89
D4	TOTAL PILOT FLIGHT TIME, HOURS	89
D5	TOTAL PILOT FIGHTER TIME, HOURS	89
D6	TOTAL PILOT F-4 TIME, A/C AND IP, HOURS	89
D7	TOTAL SORTIES LAST 6 MONTHS	89
D8	TYPE AIRCRAFT CURRENT	89
D9	PRIMARY DESIGNATED OPERATIONAL CAPABILITY	89
D10	TOTAL BFM/ACM SORTIES	89
D11	BFM/ACM SORTIES LAST 6 MONTHS	89
D12	BFM/ACM SORTIES LAST MONTH	89
D13	TIME SINCE LAST BFM/ACM	89
D17	LAST AGGRESSOR DACT FLIGHT	89
D27	OWN TRAINING EVALUATION	89
D28	ANY TRAINING ANOMALIES	89

Group 1 data includes 16 demographic variables, each with a sample size of 89 data points. Each variable was examined by correlation analysis techniques to determine the extent of statistical relationships, with four simulator performance measures and one measure of predicted performance using "Expert Opinion". The results presented in Table 37 indicate no statistically significant relationships. The table shows very low correlation between each of the 16 demographic variables and with each of the performance measures shown. Correlation coefficients were also computed between the 16 variables and each of the four GSI part score components for both Monday and Friday data. Again, the resulting correlation coefficients were equally as low. Finally, analysis was performed using those classes and subjects with Wednesday data available. All of the correlation matrices developed were submitted to the Flying Training Division of the Air Force Human Resources Laboratory. Correlation coefficients were computed using the same group of 16 variables against each Wednesday part-score component and the total Wednesday GSI score. The Wednesday data involved performance scores of only 27 subjects. The results again indicated very low correlation.

Group 2 Data

An item analysis was employed to estimate the functional relationships among the responses to Group 2 data. The analysis was generalized to observations due to the limits that are imposed on statistical inference by very small sample sizes. Sample size in this group ranged from N=1 to N=22. Two of the Group 1 variables were also included in this analysis: D-17 Last Agressor DACT Flight and D-27 Own Training Evaluation.

TABLE 37 - CORRELATION ANALYSIS

	TURKEY SHOOT	FRACT. WINS	CHF.IP RANK	GSI MON	GSI FRI
D1 STUDENT RANK	-0.0584	-0.0272	-0.1061	-0.0043	0.0901
D2 SQUADRON	0.2551	-0.2454	0.0136	0.0109	0.0117
D3 WING	0.0988	-0.0881	0.1664	-0.1040	-0.0216
D4 TOT.PILOT FLIGHT TIME, HRS.	0.1835	-0.2070	0.1202	-0.1184	-0.0959
D5 TOT.FIGHTER TIME,HRS.	0.2597	-0.3093	0.0215	-0.0591	-0.0254
D6 TOT.F-4 TIME,HRS.	0.0436	-0.1252	-0.2400	0.1051	0.0074
D7 TOT.SORTIES LAST 6 MOS.	0.2684	-0.2414	-0.0361	-0.0116	0.0155
D8 TYPE ACFT	0.3218	-0.3689	0.0960	-0.0692	0.0433
D9 PRIMARY DOC	0.3168	-0.3331	0.0864	-0.1100	0.0271
D10 TOT.BFM/ ACM SORTIES	0.1352	-0.1282	0.1307	-0.0254	0.0385
D11 BFM/ACM SORTIES LAST 6 MOS.	0.1331	-0.0859	-0.0161	0.0400	0.1537
D12 BFM/ACM SORTIES LAST MONTH	0.0371	-0.0248	-0.1099	0.0800	0.1878
D13 TIME SINCE LAST BFM/ ACM	0.0089	0.0375	0.0838	-0.0712	-0.0357
D17 LAST AG-GRESSOR DACT FLT.	0.0215	-0.0338	-0.2251	0.0773	-0.0540
D27 OWN TRAIN-ING EVAL-UATION	0.0595	-0.0725	-0.0999	0.0391	0.0428
D28 ANY TRAIN-ING ANOMO-LIES	-0.1078	0.0367	-0.0641	-0.2249	-0.2097

Variable D-17, identified as the date of the subject's last dissimilar aircraft air-to-air combat training flight, was included in the investigation because of the dramatic effects of aggressor training reported by DeLeon (1977).

Variable D-27 identifies the student pilot's affective evaluation of the perceived value of the training he received. It was included for additional analysis to help identify outlier scores and to assess the effect of attitudinal values on performance.

Question/Answer Rationale

Type of Air-To-Air Missile Fired

"What A/A missiles have you fired?" (D-14)

AIM 7 ____, AIM 9 ____, AIM 4 ____, NONE ____.

Twenty-two of the 89 subjects [illegible] that they had experienced launching missiles [illegible] aircraft. The sample size (N = 22) [illegible] of the population. The surveys indicate [illegible] subjects had actually fired the AIM 4, AIM 7 [illegible] some combination of these missiles. The [illegible] this group is as follows:

	N
AIM 4	0
AIM 4, + 7	0
AIM 4, + 9	1
AIM 4, + 7, + 9	1
AIM 7	3
AIM 7, + 9	11
AIM 9	6
N_T =	22

6 DeLeon, P. The peacetime evaluation of the pilot skill factor in the air-to-air combat. Rand Report R-2070-PR. January 1977.

This group of 22 subjects were examined for their performance in the turkey shoot elimination. It was found that three of the 22 subjects were winners of turkey shoots. Also, seven subjects (30.4 percent) were found to be either winners or first runners-up, and all seven had experience firing both the AIM-7 and AIM-9 missile.

It was also found that a total of seven of the 22 subjects (30.4 percent) finished in the last two places in the turkey shoot. The CIP rankings were also compared for this group. Of the 22 subjects, two were predicted to win the turkey shoot and six were predicted to finish in last place by their IPs.

Fighter Weapon Instructor Course (FWIC)

"Are you an FWIC graduate? (D-15) Yes ___ No ___."

Of the 80 subjects in the study sample, only one of the students in the TAC ACES program had completed Fighter Weapon Instructor Course (FWIC) training. It was also found that there has been a total of 11 FWIC graduates out of the 456 subjects completing the TAC ACES training.

The subject had experienced 1700 hours of total flying time, 1500 hours of fighter aircraft time, and 1500 hours of F-4 flying time.

A comparison of turkey shoot data shows that the subject placed second in the turkey shoot contest. Both his Monday and Friday GSI performance scores were above 700 points. Analysis of the Friday GSI part scores, however, did indicate a decline of up to 30 percent from the Monday GSI part scores.

Previous ACES Attended

"Have you previously attended: TAC ACES I ____ TAC ACES II ____, NONE ____." (D-16)

This question was included to determine the extent of the subjects experience with TAC ACES programs. Specifically, it was used to determine if any relationship exists between the performance of subjects, with any or no TAC ACES experience, in the turkey shoot competition. A total of 17 (19.1 percent) of the 89 subjects in the study responded that they had previously participated in the TAC ACES I or TAC ACES II training program. One of the subjects had completed both programs. For the TAC ACES I program, 11 respondents in the sample indicated that they had completed the training. When contrasted as a group with the total sample of turkey shoot participants, it was found that the group contained one turkey shoot winner and two first runners-up (second place). It was also noted that none of the group with TAC ACES I training had finished in the last quartile; seventh and eighth place. Of the 11 subjects in this group, there were eight subjects (72.7 percent) that finished in the top four ranks of the turkey shoot contest. The mean F-4 aircraft flying hours experience for this group was 333.6 hours.

For the TAC ACES II program, seven respondents in the sample indicated that they had completed the training. Of the seven subjects, it was found that three turkey shoot winners and two first runners-up (second place) were in this relatively small group. One subject finished in the last quartile. It was also found that six subjects (85.7 percent) of this group finished in the upper three ranks of the turkey shoot competition. The mean F-4 aircraft flying hours experience for this group was 336.6 hours. Further analysis indicates that the mean Friday GSI score increased by 28.1 percent for the group with prior TAC ACES I experience. The mean Friday GSI score increased by 36.4 percent for the group with TAC ACES II experience. The mean Friday GSI score increased by 38.7 percent for the total sample.

Days Since Last DACT

"Date of last Aggressor DACT Flight: Less than 30 Days ____, Less than 180 Days ____, More Than 180 days ____, Never ____." (D-17)

All 89 subjects in this study were required to identify their most recent Dissimilar Aircraft Training (DACT) experience into three categories: less than 30 days, less than 180 days, and more than 180 days. An additional category, "Never," was provided for those subjects having no DACT experience. Of the 89 subjects, their DACT experience is distributed as follows:

less than 30 days	N = 10
less than 180 days	N = 28
more than 180 days	N = 14
Never	N = 37

The relationship of recent DACT experience and actual turkey shoot performance is contrasted in Table 38. It can be seen that 40 percent of those subjects with the most recent DACT experience (< 30 days) were also winners of the turkey shoot competition. In addition, these same subjects (N = 4) comprised one-third of the total group of 12 turkey shoot winners in the study. The table also shows that more than half of 12 winners had some DACT experience.

Six of the 10 subjects in the first category (< 30 days) were either turkey shoot winners or runners-up. This

TABLE 38 - SUBJECTS PER CATEGORY

	DAYS SINCE LAST DACT FLIGHT			
	< 30 DAYS	<180 DAYS	>180 DAYS	NEVER
WINNERS	4	2	1	5
RUNNERS-UP	2	4	2	-
THIRD ELIMINATORS	3	10	3	8
SECOND ELIMINATORS	1	8	3	10
FIRST ELIMINATORS	0	4	5	10
TOTAL	10	28	14	37

TOTAL SAMPLE N = 89

can be contrasted with the winners and first runners-up in the no experience - (Never) category. In this group, only nine subjects (24 percent) of the 37 subjects were turkey shoot winners or runners-up.

Other Visual Air-To-Air Simulators Flown

"What other visual A/A simulators have you flown?" (D-18)

The question was included to determine the extent of the subject's experience with other visual air-to-air simulators. As anticipated, the seven subjects that responded to the question concerning TAC ACES II experience (D-16) also responded here, and they were deleted from this analysis. A total of 11 respondents indicated that they had flown one familiarization flight of up to 60 minutes duration in the TAC simulator for air-to-air combat (SAAC). Of this group, eight of the subjects (72.7 percent) had a mean F-4 aircraft flight hours experience of 76.3 hours and three subjects had a mean of 468.3 hours. When this group was contrasted with the total sample of turkey shoot participants, the results were inconclusive. Only one of the group was a turkey shoot winner. None were first runners-up. It was also found that seven subjects (63.6 percent) of the group performed in the lowest two quartiles of the sample.

Combat Experience

"How many combat sorties have you flown? (D-19) sorties."
"What is your total combat flying time? (D-20) hours."
"Number of kills? (D-21)."
"Number of hits recorded. (D-22)."

"Number of SAM encounters. (D-23 "
"Number of hostile aircraft engagements. (D-24)."
"Number of hits received. (D-24 "

The questions on combat experience were developed to determine the degree of relationship between these factors and turkey shoot performance. Eight of the 12 TAC ACES I classes responded to the questions.

There were 18 respondents to this series of questions. A total of 17 respondents had indicated fighter or attack-type as their aircraft. One respondent indicated a reconnaissance-type (RC-135) and was not included here. As a group, the 17 subjects had a mean combat flying time of 316.1 hours and a mean of 137.2 combat sorties. The group had flown 12 different aircraft types in combat. This included six fighter type, three attack type and three observation type aircraft. Results indicate that there was one turkey shoot winner in this group of 17 subjects. The subject indicated 72[illegible] combat flying hours experience in observation (O-2, OV-[illegible]0) aircraft. It was found that three subjects finished as first runners-up, and four subjects of the group finished in last place. The group was also contrasted with the predicted rankings of the CIPs with similar results. The instructors ranked eight subjects in the upper half of the turkey shoot and nine subjects in the lower half (four ranks). The results indicate that for this sample, combat experience of this type is not major factor in predicting turkey shoot performance.

Own Training Evaluation

"What is the value of the overall training provided in this course to yourself? (D-27)."

This question was contained in the TAC ACES Program Evaluation and Critique (see Appendix E).

The questionnaire was developed essentially as an end-of-course critique for the TAC ACES program. It consists primarily of bipolar descriptive and acceptability scales. Narrative space is provided for observations and other comments. It was included in the study to obtain the subject's perceived value of the training they obtained. These data were to be used to assess the relationship between the subject's own training evaluation and turkey shoot performance. The results from the total sample of 89 subjects show that 87 subjects (97.8 percent) evaluated the overall training as having a positive effect, and only two of the subjects evaluated the training as having no effect on their performance. In addition, 76 of the 87 subjects evaluated the training as having a substantial positive effect on their performance. Both subjects who responded that the training had no effect on their performance finished in the lower half of the turkey shoot rankings, and one finished in last place. The results of the correlation analysis, as shown in Table 37, indicate the correlation of this variable with turkey shoot rank, fractional wins, instructor pilot rank, and GSI scores for Monday and Friday. It can be seen that the "R" values are quite low indicating a lack of relationship between this variable and the five dependent variables cited.

V. PSYCHOMETRIC AND EDUMETRIC DATA ANALYSIS

DISCUSSION

Individual and group performance data were recorded for all the 89 subjects in this study. The mean GSI performance scores for the Monday and the Friday data sessions were calculated and plotted for each of the 12 classes and are shown in Figure 19. For these data, two least squares linear trend lines were computed, using the number of classes and the class mean Monday GSI scores and the class mean Friday GSI scores. These trend lines were constructed using the data in Table 39.

Four of the 12 TAC ACES classes in this study were subjected to separate analysis. In addition to the normal TAC ACES Monday and Friday data collection sessions, GSI performance data were recorded on Wednesday of the training week. This yielded three sets of performance data for each of the four classes. Scatter diagrams, linear and quadratic curves, and frequency distributions were constructed.

For clarification, edumetrics is defined here as the measurement of an individual's gains from training experiences by the quantitative assessment and analysis of performance data, to include individual and group data. Edumetrics is shown to be concerned with measures of learning performance in contrast to psychometrics, which is concerned with the measurement of individual differences (i.e., measures of individual innate abilities and traits).

Psychometric Analysis

The results of the individual performance scores for each of the subject pilots in the four-class sample are shown by class group in Figure 20. A total of 81 data points were used to fit linear and quadratic least-square

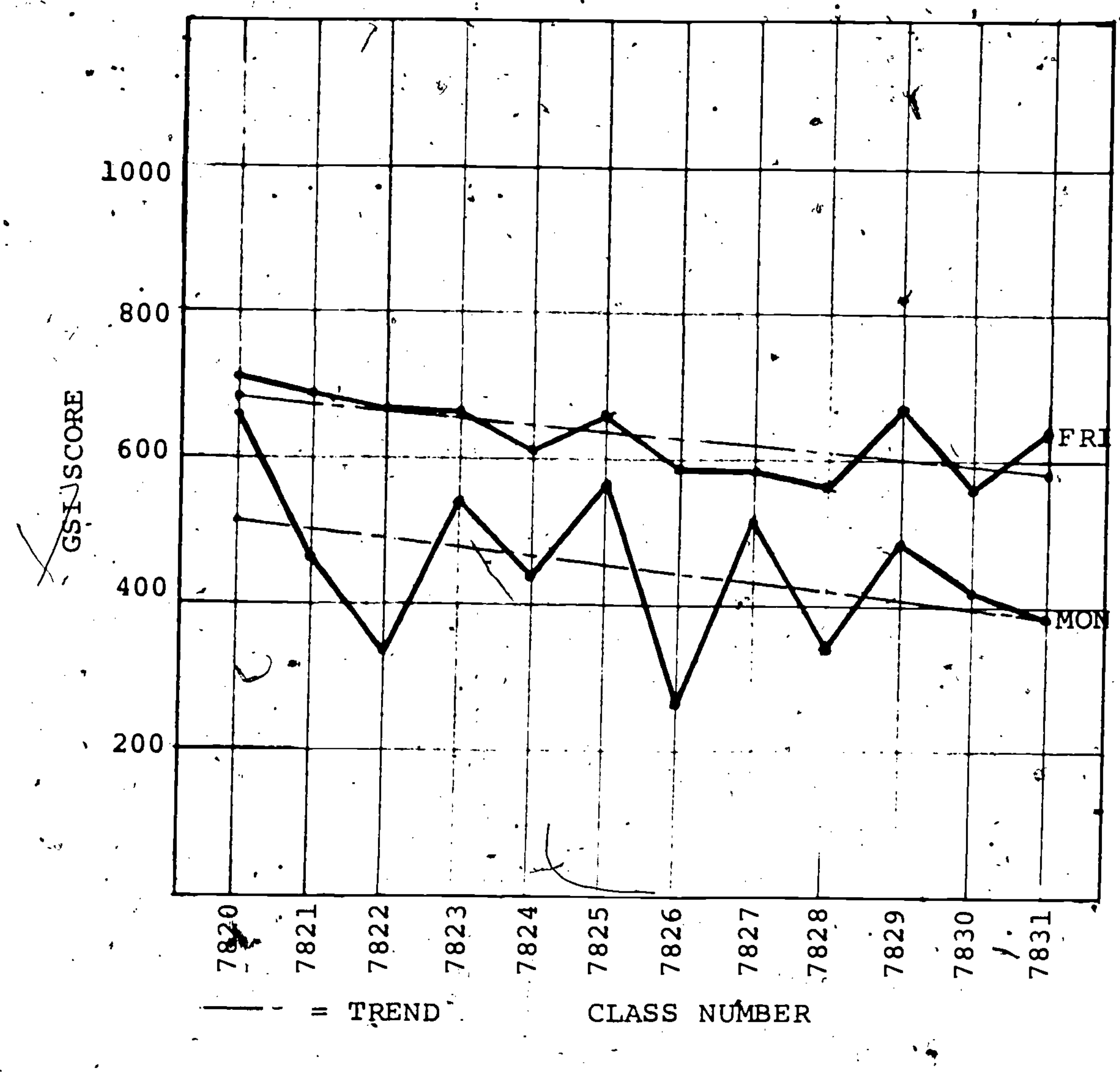
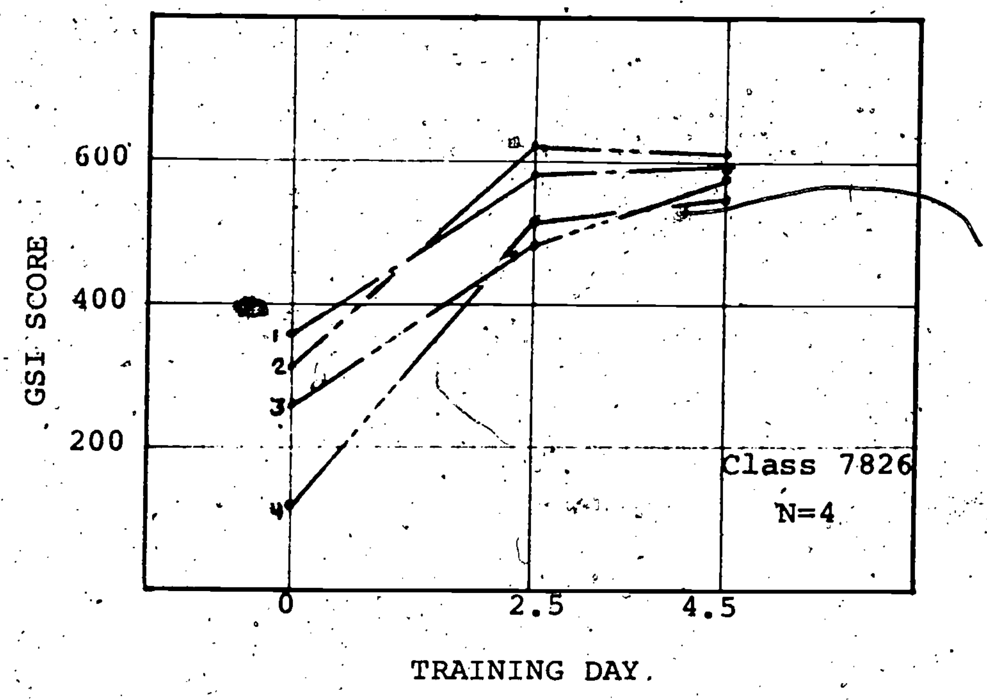


Figure 19. Class Average GSI Score.

TABLE 39 - CLASS AVERAGE GSI DATA

CLASS NO.	MONDAY GSI	FRIDAY GSI
1	660.29	701.29
2	465.25	686.00
3	327.13	669.13
4	529.38	660.88
5	433.14	604.86
6	567.75	652.13
7	265.50	583.00
8	505.88	576.00
9	341.63	558.38
10	480.13	671.00
11	420.75	554.63
12	377.43	630.29
INTERCEPT	526.574,6212	688.474,0909
SLOPE	-12.111,031,47	-9.155,437,06
X = 1	514.464	679.318
X = 12	381.242	578.609
R	-0.3929	-0.6382
STD.DEV.	111.1445	51.7235



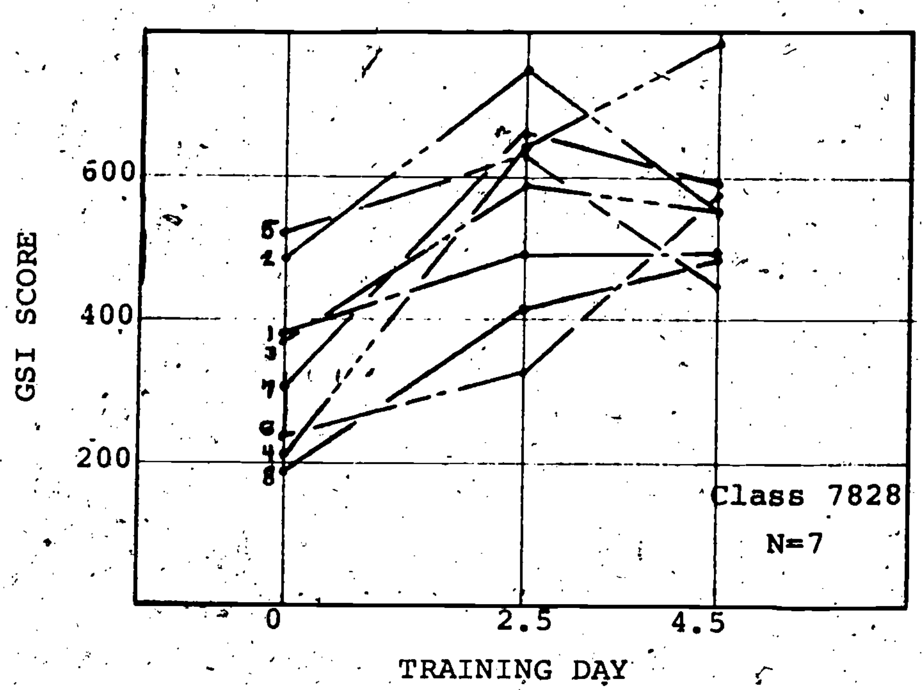
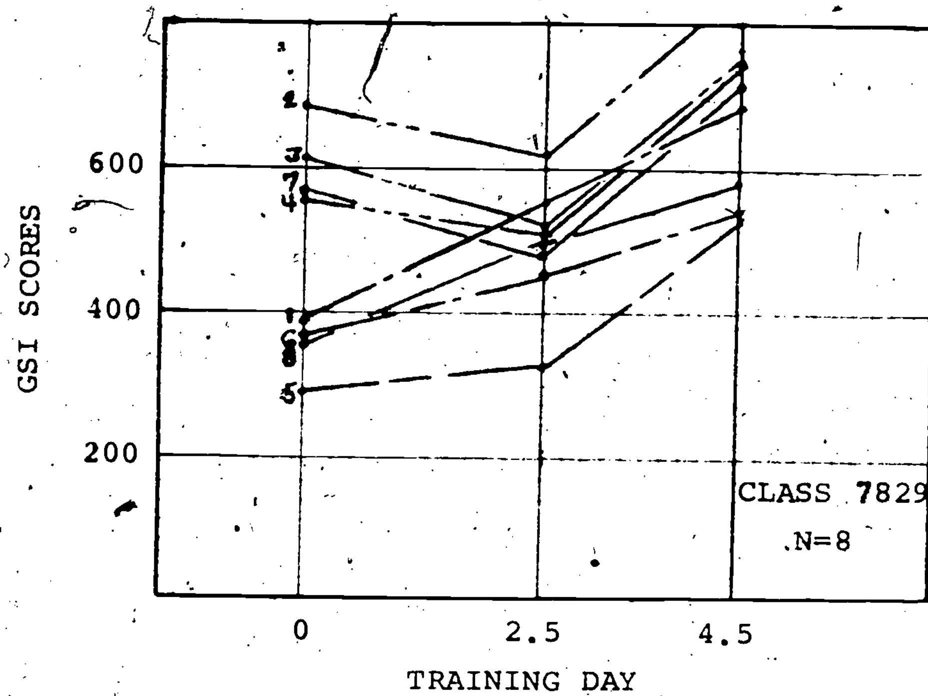


Figure 20. Individual Performance Trends.



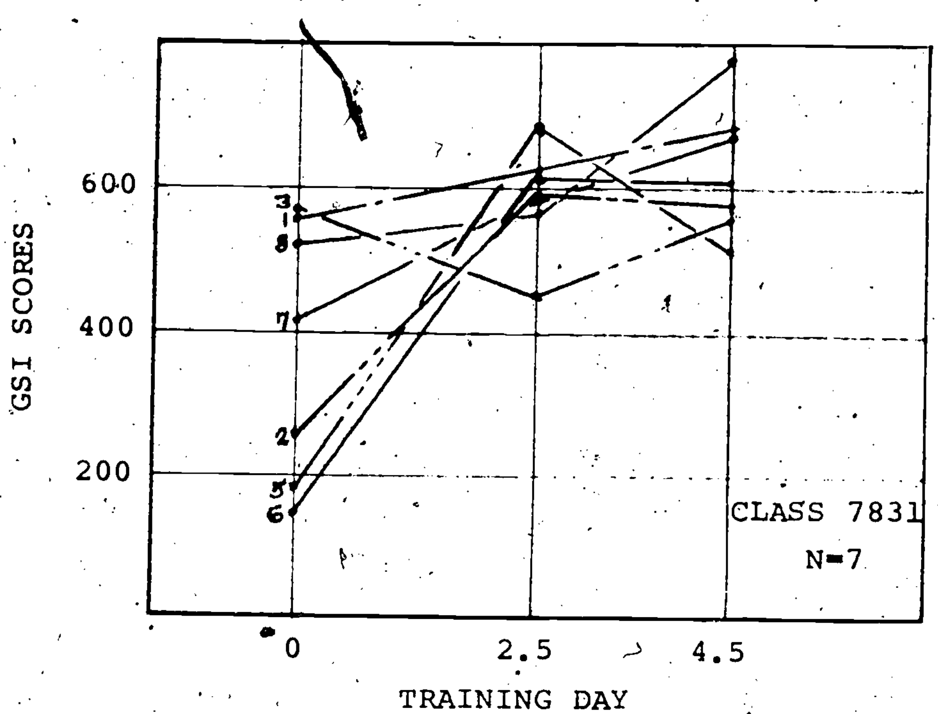


Figure 20. (Continued) Individual Performance Trends.

lines for all four classes in the sample. These are shown in Figure 21 (For clarity of presentation, the individual subject data has been grouped by class). When compared with Figure 20, it can be seen that both the linear and the quadratic equations developed approximate the centroid of the mass of data points for each pilot.

Class 7826, as shown by the data in Figure 20, consisted of four students, which is half the size of the normal TAC ACES class. These individual pilots received more intense instruction and training due to the lower student/instructor ratio and the greater amount of simulator use time available. The individual performance improvement as the length of training increases is clearly apparent in Figure 20.

Both the linear and quadratic lines fit the data well. Objective measures of these fits are shown in the edumetric analysis. The quadratic curve is preferred in describing the data because it approximates true learning rates, which tend to be non-linear as a function of time. Here it specifically shows a higher rate of learning during the early phases of training and a lower, slower rate during the final training phases.

The distribution of the GSI scores by day of training are shown characterized by normal distributions in Figure 22. It can be seen that the mean ($\overline{X}$) GSI scores improved with length of training.

Table 40 indicates that the standard deviation of the scores decreased as length of training increased. This would indicate the effects of learning. The reduced variability in the Wednesday and the Friday Standard Deviation values suggests that the subjects were using their experiences gained during the first 2-1/2 days of training and calibrating their performance responses to the expected and anticipated performance of the canned targets.

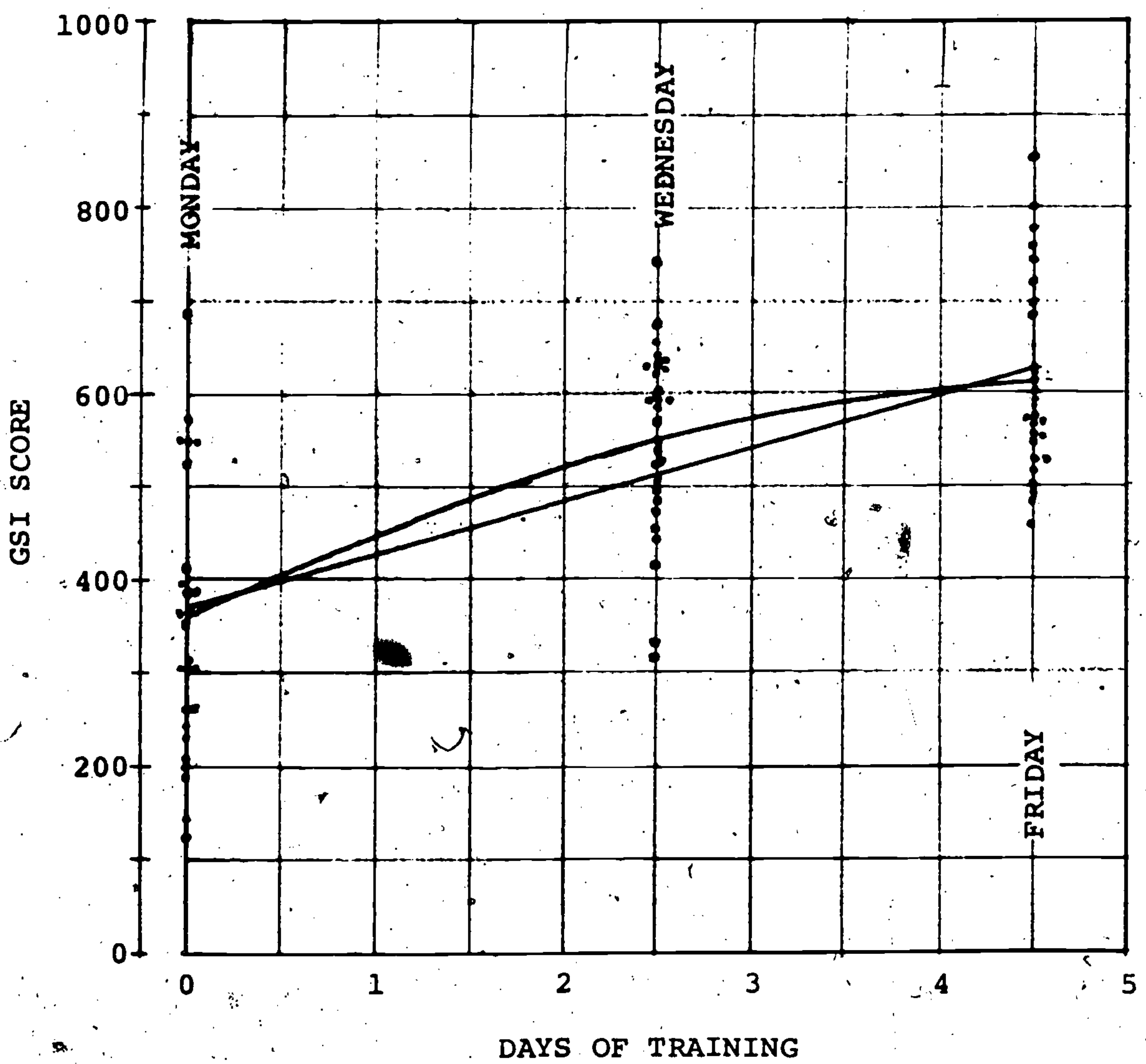


Figure 21. Scatter Plot of GSI Scores.

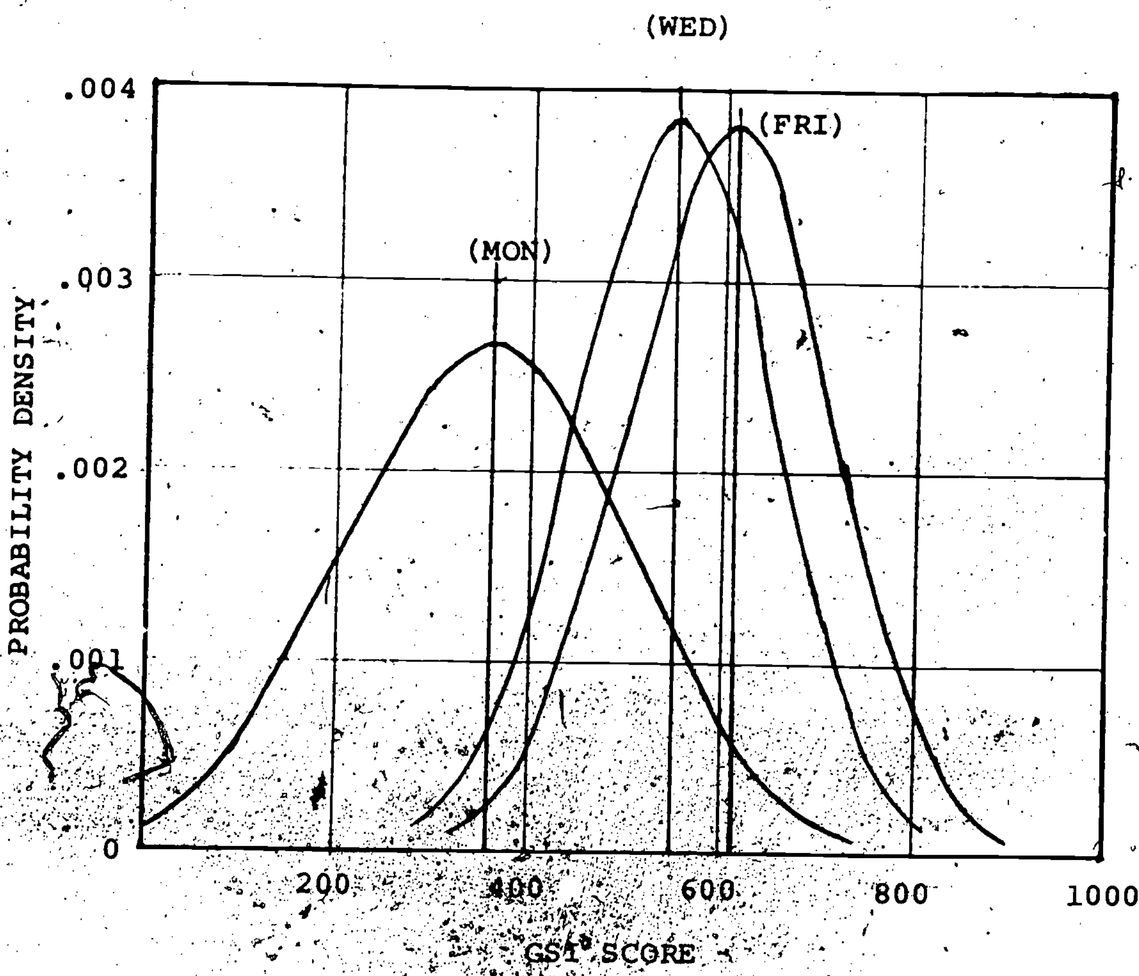


Figure 22. GSI Score Densities.

TABLE 40 - EDUMETRIC DATA BASE

CLASS NO.	PILOT NO.	Y = GSI SCORE MON (X=0)	WED (X=2.5)	FRI (X=4.5)
7826	1	359	583	595
	2	312	628	601
	3	266	471	589
	4	125	508	547
7828	1	309	494	499
	2	393	743	549
	3	304	590	552
	4	210	635	794
	5	531	638	447
	6	234	332	562
	7	304	649	570
	8	199	414	494
7829	1	393	546	487
	2	687	617	851
	3	391	522	739
	4	553	524	751
	5	247	317	531
	6	368	441	527
	7	577	469	716
	8	364	521	581
7831	1	550	631	681
	2	264	595	571
	3	553	449	566
	5	187	676	515
	6	145	631	616
	7	414	590	690
	8	529	568	773
MEAN		361.778	547.481	607.185
STD.DEV.		147.563	101.993	105.093

Figure 20 is included to show the degree of individual change in performance score for each subject in this sample over the 4.5 day training week. The data indicate the individual subjects had a mean performance score (GSI) improvement of 61.3 percent for the 27 subjects in the sample.

Edumetric Analysis

The GSI Wednesday performance data collected for four of the 12 classes in addition to the normally scheduled recordings on Monday and Friday are provided in Table 40. The method of analysis was to fit a straight line and a quadratic curve through the data. The objective was to ascertain the general trend in GSI scores as a measure of group learning rates as the classes progressed. The X-variable chosen was days of training completed. Each student was assumed to have no training, i.e., X=0, on Monday when the first GSI scores are measured. The students were assumed to have received 2.5 days of training (X = 2.5) by Wednesday and by Friday morning, 4.5 days of training (X = 4.5). The Y-variable used was GSI score.

Figure 21 shows a scatter diagram of the GSI scores versus days of training using the data provided in Table 40. The figure also shows the linear and quadratic least squares curves fit through the data. Both curves can be seen to fit well through the central regions of the data for each day. Also, each shows the general trend of GSI Score increasing with days of training. The scatter diagram also shows the wide variation in scores for each day and the general overlap which occurs from day to day. This broad variation and day to day overlap also points out the general weakness of the predictive ability of the initial GSI Score.

The linear versus the quadradic curves are contrasted in Table 41. Here the actual linear and quadratic equations

TABLE 41 — ANALYSIS OF VARIANCE OF LEARNING EFFECTS

LINEAR MODEL: GSI = 376.345 + 55.344,2 (DAY)

SOURCE OF VARIATION	SUM-OF-SQ.	DF	MEAN SQ.	F-RATIO
SS DUE TO REGRESSION	840,790.0326	1	840,790.0326	56.894,993,72
SS ABOUT REGRESSION (RESIDUAL)	1,167,456.189	79	14,777,926,45	
TOTAL SS ABOUT MEAN	2,008,246.222	80		

R^2 (Coefficient of Determination) = 0.418,668,798,3

R (Multiple Correlation Coefficient) = 0.647,046,210,4

QUADRATIC MODEL: GSI = 361.7 + 98.964(DAY)-9.873,3(DAY)^2

SOURCE OF VARIATION	SUM-OF-SQ.	DF	MEAN SQ.
SS DUE TO REGRESSION	884,476.7408	2	442,238.3704
SS ABOUT REGRESSION (RESIDUAL)	1,123,769.481	78	14,407.301,04
TOTAL SS ABOUT MEAN	2,008,246.222	80	

DAY:

MON. = 0
WED. = 2.5
FRI. = 4.5

R^2 (Coefficient of Determination) = 0.440,422,459,7

R (Multiple Correlation Coefficient) = 0.663,643,322,6 are shown along with an analysis of variance table for the linear regression and "variation breakdown" for the quadratic equation. The multiple correlation coefficients (R) are also provided as well as coefficients of determination (R^2) for both equations. The F-ratio for the linear model is included and is significant at the 99.9 percent level, ($F_{.999}(1,79) = 11.68$). This indicates that the slope of the straight line is significantly greater than zero and, thus, that GSI Score increases at an average rate of about 55 points per day of training over the 4-1/2 days of training.

The calculation of R^2 (the coefficient of determination or the multiple correlation coefficient squared) is a measure of the proportion of total variation about the mean of the GSI score explained by the regression line. Thus the straight line explains about 42 percent ($R^2 = .419$) of the variation and the quadratic equation explains about 44 percent ($R^2 = .440$) of the variation between training time and improvement in GSI.

A test was also made for "lack of fit" of the straight line to the GSI Scores. The test involves breaking the residual sum of squares into two parts, one part measuring pure error and the other measuring lack-of-fit. Repeating the residual sum of squares for the straight line in Table 41 results in the following breakdown:[7]

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE	F RATIO
Residual	79	1,167,456.189		
Lack-of-Fit	1	43,686.708	43,686,708	3.032,262
Pure Error	78	1,123,769.481	14,407.301,04	

$F_{.95}(1,78) = 3.92$

[7] Draper & Smith. Applied regression analysis. New York: John Wiley and Sons, 1966, 26-31.

Now since $3.032 < F_{.95}(1,78) = 3.92$ there is no reason to doubt the adequacy of the linear model, i.e., the lack of fit is not significant.

A further point of interest is the actual normality of the distributions of the GSI scores being analyzed by day, that is, is there any reason to doubt that a given set of scores is normally distributed? The Kolmogorov-Smirnov (K-S) test of goodness of fit was applied to GSI scores for each day.[8] The scores were found to be normally distributed at the percent significance level for each of the three sets of GSI scores.

Since it has been established that there is no reason at the 99 percent level to doubt that the GSI scores are normally distributed, it is reasonable to present Figure 23 which shows three normal densities with parameters (means and standard deviations) equal to their estimates calculated from the GSI scores for each day. This figure graphically shows the changes in GSI Score distributions which take place during the course of training. The means of the distributions increase with training time. On Monday the standard deviation of GSI scores is compared to Wednesday and Friday (S(Monday) = 147.6). By Wednesday, however, this has decreased about 31 percent over Monday (S(Wednesday)=102.0) and then by Friday there appears to be a slight increase, (S(Friday) = 105.1). To determine statistically if these differences in variance exist, Bartletts chi-square test[9] for equality of standard deviations from normal distributions was applied. It was determined that the null hypothesis of no difference between variances, ($H_0: \sigma^2(MON) = \sigma^2(WED) = \sigma^2(FRI)$), cannot be rejected at the 95 percent confidence level but can be rejected at the 90 percent confidence level.

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[8] Ostle & Mensing. Statistics in research (3rd ed.). Ames: Iowa State University Press, 1975, 489-490.

[9] Ostle and Mensing. Statistics in research (3rd ed.). Ames: Iowa State University Press, 1975, 127.

VI. CONCLUSIONS AND RECOMMENDATIONS

General

An experimental investigation has been performed that statistically validates the ability of an empirically derived performance measure, the GSI, to correctly predict student pilot performances in TAC ACES I free engagement exercises. The empirically derived GSI is shown to exhibit correct prediction capabilities of student pilot performance comparable to that of expert opinion, subjective student performance predictions by instructor pilots.

The empirically derived GSI predictor was improved using statistical methods. The four parameters of the initial (empirical) GSI, when optionally weighted, were shown to predict student pilot placement in the turkey shoot with about 75 percent accuracy. These four parameters, time in gun firing envelope, average mil error, offensive/defensive time, and time to first kill, are intuitive to the experienced combat pilot as measures of ACM skill. Each of the four, when objectively measured, can be used as teaching aids in the development of air combat skill in the student pilot.

Further improvement in the GSI was obtained by including certain available objective and subjective parameters. The optimal methods are shown to be excellent predictors of student performance (at least within the experiment data) showing probability of correct student performance prediction near 80 percent in free engagement exercises.

It is specifically recommended that the GSI algorithms and methodologies of this initial study be tested in the Simulator for Air-to-Air combat (SAAC) at Luke AFB and on the Air Combat Maneuvering Instrumentation (ACMI) Range at Nellis AFB to determine an objective measure of transfer of ACM training between the simulator and the aircraft.

Increased Sample Size

The results of the study yield GSI models that may be applied to the TAC ACES I population. The sample size used to derive these models was relatively small (12 classes) but was related to the whole by statistical inference. It is desirable to continue data collection and statistical analyses under the same control conditions as the experiment to accumulate a larger data sample.

It would be useful to collect additional TAC ACES I data for the following reasons:

1. To provide a larger sample which would provide more precise information on the distributions of the data being considered;

2. To validate the predictor models derived in this study. Careful examination of GSI data collected previous to this study was found to be poorly documented and of limited use in validating the predictor models. Care must be taken to assure that reasonable controls are placed on the data collection itself as lack of controls affect the validity of the samples themselves. By its very nature, this kind of data is very sensitive. Lack of careful sampling can result in collection of data from essentially different populations than that desired and, hence, validation becomes difficult.

Demographic Data Correlations

The master data base provides a means for further statistical analyses which can be of value in assessing training and training requirements in ACM simulators.[11]

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[11] On file at Vought Corporation, Dallas, Texas.

It is recommended that an investigation be initiated to ascertain what demographic correlations can contribute to the overall readiness training program. In order to accomplish this objective, it is necessary to continue to a) collect these data, b) supplement these data with other data which may be of value, and c) analyze the data to obtain correlation with simulator performance measures and, ultimately, d) assess performance on the ACMI range exercises.

Apply GSI to Other ACM Simulator Training

The parameters comprising the GSI, if measured in a similar manner and under similar conditions, are applicable to other ACM simulator training. The interrelationship of these parameters, i.e., weighting and interaction, is believed to be specific for a particular simulator and training syllabus. It is recommended that the GSI, as derived for TAC ACES I, be introduced as a prospective measure of student pilot performance in an ACM simulator such as the SAAC and adjustments made in the parametric contributors to develop a statistically derived GSI specific to that facility and training syllabus.

The GSI Application to ACMI Range

The promise of the GSI as a screening tool to aid in the selection of fighter talent is premature, but given a larger data sample and successful application of the GSI to range operational exercises such as the ACMI range at Nellis, the GSI could become that powerful tool.

Potential Utility of the GSI

The GSI was shown to be a measure of student pilot performance in the TAC ACES I Program. GSI scores indicate the relative performance of students in the simulator and careful scrutiny of the GSI contributory parameters can evaluate the strong and weak points of a given student relative to his overall performance measure. These "part scores" are associated with basic flying maneuvers, tracking, weapon switchology, etc. from which judgements may be made by the instructor pilot where to concentrate his training efforts.

The GSI may also be utilized to obtain a measure of student pilot learning trends during the simulator training period. The skills of pilots in air combat can vary greatly depending upon individual background experience and innate ability. The individual learning abilities also vary. The GSI may be used as an indicator of a pilot's current proficiency in air combat, as well as an indicator of improvements in air combat skills in the simulator.

The GSI can be used to establish an optimal training period for the norm student by statistical investigation of initial student skill and skill growth over training periods varying in duration. A cursory survey of the 12 class sample in this experiment indicates that an optimal training period in the simulator can be established for the TAC ACES I population by further statistical analyses of student entry skills and student learning trends.

Contributing parameters that comprise the Air Combat Simulator GSI have rudimentary commonalities with many other flight simulator training devices. It is probable that other flight simulators, i.e., Weapons System Trainers (WST), Operational Flight Trainers (OFT), Instrument

Flight Trainers (IFT), etc., can utilize the same or similar methodologies as presented in the report to achieve comparable simulator performance measures.

Utility of Data Taken During Turkey Shoot

The turkey shoot data were examined to investigate the utility of the data collected during turkey shoot competition. The performance measures and the data formats were essentially identical to those used in the GSI data. A basic difference is that performance data were recorded separately and simultaneously for each pair of combatants. No GSI scores were computed from this data set.

The performance results were examined for a class selected at random.

The data indicated that pilots who finished in the upper half of the turkey shoot had, as a group, lower mean minimum altitude values than pilots who finished in the lower half of the turkey shoot. The data show that a sufficient body of pilot performance data has been collected to warrant a detailed statistical analysis. A cursory examination of the data indicates that trends of a relationship appears to exist between turkey shoot rank and factors such as maximum g, minimum altitude, and offensive time. The free engagement data may be of value since they approximate engagements on an air combat maneuvering range. The data may also be useful in determining links between GSI performance predictors and those predictors to be determined for the ACMI range(s).

Limitations of the GSI System

The GSI as presented in this report is specific to TAC ACES I training. However, its application to other air combat simulator training where the environmental training features are similar, i.e., training hardware, software, and training syllabuses are of a similar character, may be expected to yield good measures of air combat skill (in the simulator).

The GSI scoring system is derived for air combat one-versus-one engagements at the inception of offensive/defensive maneuvers. In its present form, the GSI is not applicable where initial sighting of adversary or two-versus-one, or one-versus-two, is instrumental in the training scenario.

The GSI is an objective indicator of air combat skill in the simulator but should not be construed as an absolute measure. It is not proposed as a substitute for subjective opinion. When the two measures, GSI, and the subjective opinion of the instructor pilot are used in conjunction, they produce a maximal evaluator of air combat simulator skill.

GSI Application to Other ACM Facilities

The degree of fidelity of simulation, training syllabus and the extent of training are factors governing transfer of training for a given task. In general, ACM simulator facilities differ widely in the synergistic fidelity of air combat.

Lack of absolute fidelity in a simulator requires the student pilot to suppress many preconditioned responses and acquire associated responses to representative external stimuli. The ability of the student to transcend to this representative environment directly affects his performance in a particular simulator.

The differences in fidelity of simulation between simulators of like kind and the difficulty of association transfer experienced by the student will determine the applicability of the GSI to other ACM simulators as a measure of ACM skill and as a predictor of free engagement one-versus-one contest results.

Some examples of known ACM simulator fidelity differences which can influence GSI application are motion/no-motion, g-suit/g-seat, ground rush visual cue, and the extent of computer modeling of aircraft flight characteristics (aerodynamic fidelity, control response fidelity, instrument and weapon systems fidelity). The effect of the differences can be positive, negative, or neutral, on the contributory parameters of the GSI.

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APPENDIX A

ANALYTICAL METHODOLOGY

APPENDIX A - ANALYTICAL METHODOLOGY

The analytical methodology used in the study began with preparation of elementary statistical displays of the GSI and the four component variables used to calculate the GSI score. These displays consisted of histograms and scatter diagrams. Variance-covariance matrices and correlation matrices were also generated to analyze relationships between the variables.

Regression analysis was used extensively in an attempt to define suitable functional predictive relationships between the various candidate predictor variables and turkey shoot outcomes.

Two Y-variables (dependent variables) were considered in the regression analysis. They were turkey shoot rank, i.e., 1,2,3,4 ..., and fractional wins. "Fractional wins" is defined as the ratio of total wins to total engagements in the turkey shoot for a given participant.

Both variable selection and ridge regression were used in addition to all-variable regressions to explore the utility of direct predictive relationships. Various non-linear relationships (in the candidate predictor variables) were explored, but none provided relationships as good as a simple GSI ranking predictor. There are several possible reasons why this was so: Exploration of the X'X matrices indicated that in all cases minimum eigenvalues were very close to zero. This is indicative of the existence of multicolinearities in the predictive variable sets. This condition indicates that basic assumptions generally used in the application of least squares are being violated and also that it is likely the parameter estimates will vary substantially from sample to sample. Another difficulty was shown to exist from the analyses of variance performed. This was the significant variation detected between classes.

The regression models were obviously affected by this and the fact that no constraints were (or could be) applied to rank predictions. For example, only one winner is allowed per class, but several might be predicted.

In general, models explored using ridge regression showed a degeneration in predictive capability as the bias factor was increased. While, in general, the parameters did stabilize, as might be expected, the predictive rates declined and remained unacceptable.

The all-variable, variable selection, and ridge regression programs used in this study had been developed by Vought previous to the beginning of this study.

As it became apparent that the regression programs were not providing useful indicators of predictive ability, it was decided to explore three sources of variation in the GSI scores and the GSI component variables. Using basic analysis of variance methodology, the sources of variation included in the three-way analysis were "between" days, "between" classes, and "between" turkey shoot ranks. In general, significant differences tended to appear between days and between classes.

At the beginning of the study, a master data base was designed and then implemented. This brought data from the source data tapes into a common file where it could be conveniently studied, manipulated, and reduced to forms suitable for use with the statistical programs.

The next and final statistical program exercised against the data was the Discriminant Analysis program provided in the SPSS package available on Vought's System 370. Discriminant analysis can be used to classify data sets into predefined groups. In the case of this analysis, the groups were defined as combinations of turkey shoot ranks. As explained in the main body of the text, this part of the analysis was performed for four different group definitions with four different data sets. The program was always operated in the variable selection mode using the Lambda variable selection option. Data sets, prior to input, were sorted by turkey shoot rank with all winners at the top of the list, runners-up following, and so on. Program control parameters were then used to define the number of groups and the number of members of each group. As noted above, four groupings were defined for four different data sets. Thus, in all, 16 discriminant analyses were performed. These, in general, provided the best predictors of turkey shoot outcomes developed in the study. The results are documented in the main body of the report.

Several other commonly used statistical techniques were also employed. Among these were the calculation of confidence intervals on the proportions of correct classifications of cases by the discriminant program using data from the 12-class sample. This procedure made use of the normal approximation to the binomial distribution which is often used where sample size is adequate. Certain tests of hypotheses were also used during the comparison of the discriminant results calculated from the 12-class sample and with the four classes of data used to test various predictors. This was used to test equality of prediction rates of the discriminant predictors on the 12-class experiment data with the four class test data.

Certain other tests were employed to test for normality of data and applicability of a straight line to the learning rate data used in the edumetric analysis. Footnotes are used in the main text to identify references applicable to the statistical methods employed.

APPENDIX B

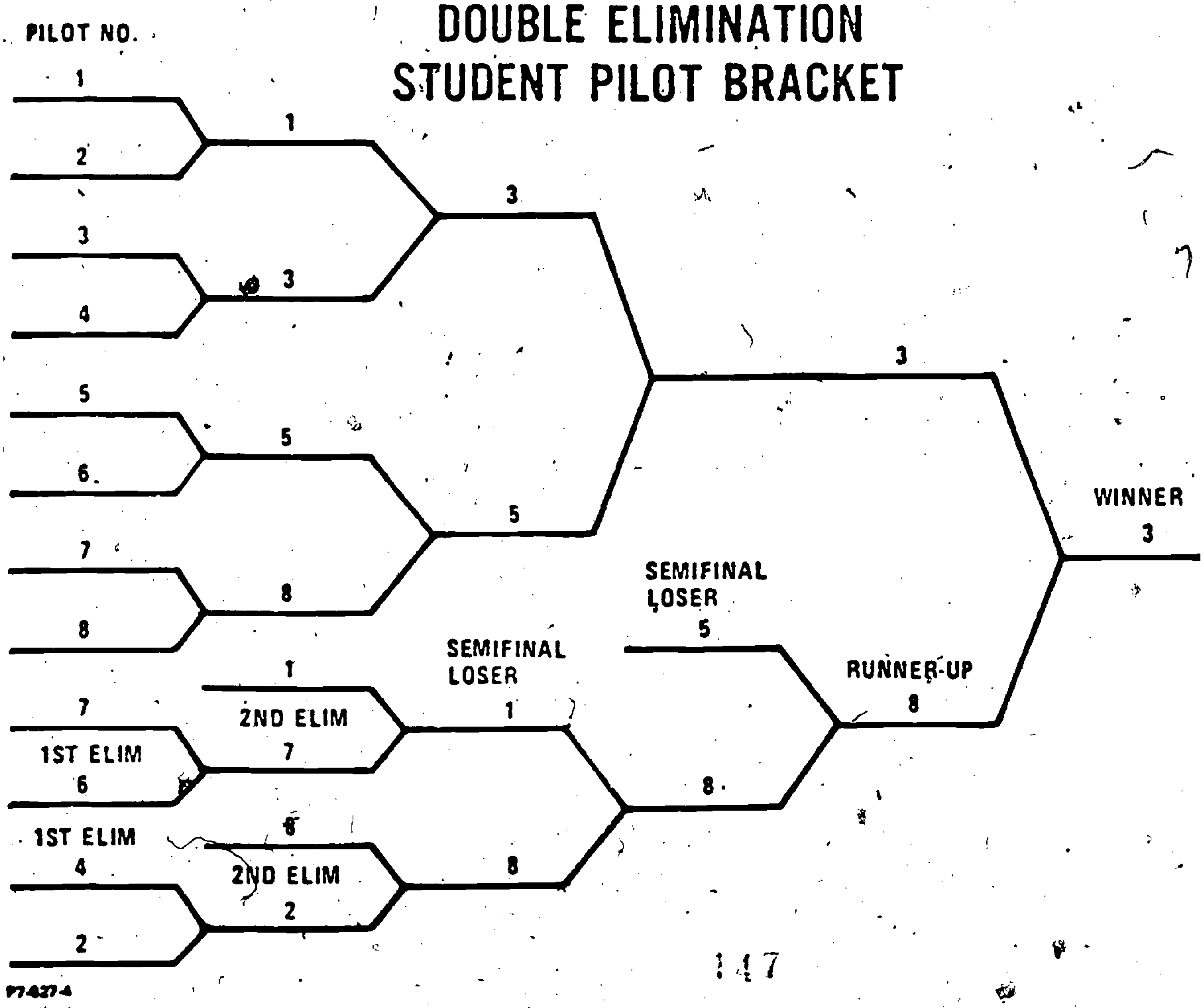
FORMS UTILIZED IN THE
GOOD STICK INDEX VALIDATION STUDY

TAC ACES BACKGROUND SURVEY

1. FULL NAME ________________ RANK (D-1) 2. DATE ________
3. CLASS & PILOT # ________________ 4. ACES I [ ], ACES II [ ]
5. MIL ADD. SQDN (D-2) WING (D-3) BASE (D-0) ZIP (D-0)
6. TOTAL FLYING TIME (D-4) 7. TOTAL FIGHTER TIME (D-5)
8. TOT. F-4 TIME (A/C & IP) (D-6) 9. SORTIES (LAST 6 MOS) (D-7)
10. CURRENT IN: F-4C [ ], F-4D [ ], F-4E [ ], (OTHER) (D-8) [ ]
11. PRIMARY DOC: A/A [ ], A/G [ ], RTU IP [ ], (OTHER) (D-9) [ ]
12. RECENT BFM/ACM EXPERIENCE: SORTIES-TOTAL (D-10), LAST 6 MOS (D-11), LAST MO. (D-12)
13. TIME SINCE LAST BFM/ACM: 0-2 WKS [ ], 3-4 WKS [ ], 5-12 WKS [ ], 13-25 WKS [ ], 26-52 WKS [ ] (D-13)
14. WHAT A/A MISSILES HAVE YOU FIRED? AIM-7 [ ], AIM-9 [ ], AIM-4 [ ], NONE [ ] (D-14)
15. ARE YOU AN FWIC GRADUATE? YES [ ], NO [ ] (D-15)
16. HAVE YOU PREVIOUSLY ATTENDED: TAC ACES I [ ], TAC ACES II [ ], NO [ ] (D-16)
17. DATE OF LAST AGGRESSOR DACT FLIGHT: LESS THAN 30 DAYS [ ], LESS THAN 180 DAYS [ ], MORE THAN 180 DAYS [ ], NEVER [ ] (D-17)
18. WHAT OTHER VISUAL A/A SIMULATORS HAVE YOU FLOWN? (D-18)
____
19. COMBAT EXPERIENCE: YES [ ], NO [ ]. IF YOU HAVE HAD COMBAT EXPERIENCE, WHAT IS YOUR TOTAL COMBAT FLYING TIME? (D-20) HOURS. HOW MANY COMBAT SORTIES HAVE YOU FLOWN? (D-19) SORTIES. WHAT TYPE OF AIRCRAFT HAVE YOU FLOWN IN COMBAT? (D-0) NO. OF AIRCRAFT ENGAGEMENTS (D-24). NO. OF HITS RECORDED (D-22). NUMBER OF HITS RECEIVED (D-25). NUMBER OF KILLS (D-21). NUMBER OF SAM ENCOUNTERS (D-23).
20. DATE OF BIRTH (D-0).

*D-0 - NOT INCLUDED IN ANALYSIS

TURKEY SHOOT FORMAT
DOUBLE ELIMINATION
STUDENT PILOT BRACKET



INSTRUCTOR OPINION FORM

In your opinion, how will each of the students in class ________ perform in the Turkey Shoot Competition? Please rank-order the students on a scale of from 1 to 8. Use the rank of 1 to identify the student who you feel will win the Turkey Shoot, the rank of 2 to identify the first runner-up, and so on until the rank of 8 to identify the student who you feel will place last. Please rank all the students.

____	____________	____	____________
____	____________	____	____________
____	____________	____	____________
____	____________	____	____________

____

INSTRUCTOR PILOT DATE

NOTE: Please complete this form before the student Turkey Shoot Competition each Friday. The form will be collected from you by Mr. R.A. Jorge sen.

TAC ACES DATA COLLECTION VERIFICATION

CLASS ________ DATE ________

1. THE CURRENT TAC ACES TRAINING SYLLABUS WAS APPLIED, AND ADHERED TO, CONSISTENTLY DURING THE DATA RECORDING PERIOD(S) FOR THIS CLASS.

____________________	____________
INSTRUCTOR PILOT	DATE

2. THERE WERE NO APPARENT MECHANICAL OR ELECTRICAL PERTURBATIONS IN THE AIR COMBAT SIMULATOR DURING THE DATA RECORDING PERIOD(S) FOR THIS CLASS. (EXCEPTIONS AS NOTED ON REVERSE SIDE OF THIS FORM)

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INSTRUCTOR PILOT	DATE
____________________	____________
SIMULATION	DATE

3. THERE WERE NO SIGMA 7 COMPUTER MALFUNCTIONS OR ANOMALIES PRESENT DURING THE DATA RECORDING PERIOD(S) FOR THE CLASS WHICH WOULD AFFECT THE DATA BEING COLLECTED. (EXCEPTIONS AS NOTED ON REVERSE SIDE OF THIS FORM)

NOTE: COMPLETED FORM WILL BE COLLECTED BY MR. R. A. JORGENSEN.

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REAL TIME COMPUTING	DATE

TAC ACES PROGRAM EVALUATION AND CRITIQUE

NAME/RANK ______________________ CLASS # ______ PILOT # ______ DATE ________

TAC ACES PROGRAM: I ( ), II ( )

NOTE: This evaluation will be conducted in three parts.

In part I you are asked to give your ratings of the utility of this training concept. In short, would regular exposure to visual air-to-air simulation be beneficial? Does it possess the potential to increase your combat capability?

In part II you are asked to assess and rate the relative benefit of the simulator itself including instructional features. What improvements must it have? Where is it good enough?

Part III consists of unstructured questions relating to simulator training capabilities and limitations, course value, instruction, and the TAC ACES program in total.

PART I:

Use the following scales to rate each question and add appropriate comments when necessary:

Rating	General Meaning
5	Substantial positive training
4	Slight positive training
3	No effect
2	Possible negative training
1	Definite negative training

A. What is the value of the overall training provided in this course to:

	5	4	3	2	1	COMMENT
Experienced pilots						
Inexperienced pilots						
Yourself						
A/A DOC pilots						
A/G DOC pilots						
RTU IPs						

B. How did this training affect your knowledge or proficiency in the following tasks?

Use rating scale on page 1.

	5	4	3	2	1	COMMENT
Engagement Geometry						
Includes visual slant range, aspect determination, closure rate control, etc.						
AIM-7 Employment						
Includes status monitoring, launch envelope, launch constraints, etc.						
AIM-9 Employment						
See above						
Gun Envelope and LCOSS						

PART II

The simulator's chief purpose is to aid the instructor in teaching various air-to-air tasks. As such it should be like the aircraft in many respects but not necessarily in every detail. In addition it should be designed to ease the workload on the instructor while still providing effective control over the engagement.

A. Compare the simulator to the aircraft in the following areas using the rating scale provided:

5 - Much better than aircraft
4 - Slightly better
3 - About the same
2 - Slightly worse
1 - Much worse

	5	4	3	2	1	COMMENT
Acceleration Performance						
Deceleration Performance						
Roll Performance						
Pitch Performance						
Yaw Performance						
Turn Rate						
AOA Indications (buffet, tone, noise)						
Longitudinal Stick Feel						
Lateral Stick Feel						
Rudder Feel						
AIM-7 Performance						
AIM-9 Performance						
Gun Performance						
Gunsight Performance						
IR Tone Operation						

B. Do you feel cockpit motion is necessary for an A/A simulator? Yes ( ) No ( )
Comment:

PART III

A. What A/A tasks and/or BFM maneuvers CAN be trained in the simulator?

B. What do you consider to be the best training features of this simulator?

C. What A/A tasks and/or BFM maneuvers CANNOT be trained in the simulator?

D. What do you consider to be the most significant limitations of this simulator?

E. Has the training provided during this week improved your overall operational fighter skills? Yes ( ) No ( )

Comment:

F. Should the course be offered on a recurring basis? Yes ( ) No ( )

Comment:

G. Comment on the quality and quantity of instruction.

H. What features/capabilities would you like to see added to this simulator?

I. List any comments/recommendations you have regarding the TAC ACES program. (i.e., syllabus/administrative/scheduling/quarters/transportation/etc...)

APPENDIX C

TAC ACES I TRAINING SYLLABUS
AND
TURKEY SHOOT COMPETITION RULES

TAC ACES I
SYLLABUS

DAY 1

Sortie #1 - Simulator Familiarization (:30) (F-4/F-4)

Objective: To become familiar with simulator visual display, switchology, aural and dynamic cues, flight controls, and performance characteristics.

Pilot will perform following tasks:

a. Acceleration maneuvers
b. Rolling maneuvers
c. Turning maneuvers
d. High and low altitude flight
e. High and low speed stalls

Sortie #2 - Weapons Familiarization (:30) (F-4/F-4)

Objective: To become familiar with AIM-7E, AIM-9J, and 20mm employment.

Pilot will perform/demonstrate following tasks:

a. AIM-7 and AIM-9 employment against a controlled target
b. Gun tracking exercises against a controlled target
c. Understanding of weapons switchology
d. Recognition of aspect angle, range, and closure velocity
e. Max performance maneuvering

Sortie #3 - Performance Measurement Data (:30) (F-4/Computer Flown Target)

Objective: To collect a baseline performance measurement on each pilot as he flys against a prerecorded profile.

The performance measurement will consist of the following exercises:

a. 2 x Stabilized (Cine) tracking exercises
b. 3 x Head-On maneuvering exercises

DAY 2

Sortie #4 - Gun/Tracking (1:00) (F-4/F-4)

Objective: To fully understand operation and employment of gun and LCOSS.

Each pilot will accomplish:

a. Stabilized tracking exercises
b. High angle gun employment
c. Tracking a maneuvering target

Sortie #5 - Basic Fighter Maneuvers - Offensive (1:00) (F-4/F-4)

Objective: To understand and be able to perform basic fighter maneuvers from a canned set-up.

Each pilot will perform the following:

a. High and low Yo-Yo
b. Quarter plane maneuver
c. Lag roll
d. Acceleration and separation maneuvers

DAY 3

Sortie #6 - Basic Fighter Maneuvers - Defensive (1:00) (F-4/F-4)

Objective: To understand energy management and basic defensive maneuvers.

Each pilot will understand and practice:

a. Overshoots
b. Extensions
c. Reversals
d. Jink-outs

Sortie #7 - Air Combat Maneuvering - Similar (1:00) (F-4/F-4)

Objective: To increase proficiency in entire maneuvering envelope.

Each pilot will demonstrate understanding of:

a. Use of the vertical
b. Lead turn
c. High AOA maneuvering
d. Combat separations

DAY 4

Sortie #8 - Threat Orientation (1:00) (F-4/Threat)

Objective: To develop an appreciation for the performance characteristics of a typical threat aircraft.

Each pilot will observe the following threat characteristics:

a. Flight control responses
b. Turning capability
c. Performance envelope (altitude, airspeed, etc.)

Sortie #9 - Air Combat Maneuvering - Dissimilar (1:00) (F-4/Threat)

Objective: To increase proficiency in maneuvering against dissimilar aircraft.

Each pilot will fly each aircraft in fluid engagements against each other. Lessons learned will be discussed during debriefing.

DAY 5

Sortie #10 - Review of Sorties 1-9 (:45) (F-4/F-4)

Objective: Briefly review all previous sorties for areas of confusion/misunderstanding.

Each pilot will demonstrate knowledge of basic concepts of air-to-air combat maneuvering.

Sortie #11 - Performance Measurement Data (:15) (F-4/ Computer Flown Target)

Objective: To collect an end of course performance measurement as the pilot flys against a pre-recorded profile.

The performance measurement will consist of the following:

a. 2 x Stabilized (Cine) tracking exercises
b. 3 x Head-On maneuvering exercises

Sortie #12 - Turkey Shoot (F-4/F-4)

Objective: To allow pilots to demonstrate their air-to-air ability in a class fly-off.

Each pilot will be eliminated after losing to two other pilots in a double elimination tournament. Rules of engagement will be briefed prior to start of fly-off.

--On all 1.0 hour sorties, pilots will switch cockpits after first 30 minutes.

-- Sorties should be recorded for debriefing.

TURKEY SHOOT RULES

Double Elimination

1. Initial pairings will be made by drawing names from a hat.

2. Both aircraft will be F-4E's at 15,000 feet and 425 kts, head on at 18,000 slant range.

3. Paired participants will flip a coin for choice of cockpit.

4. There will be a 3 minute time limit for each engagement. After 3 minutes, both aircraft will be reset to the initial set-up.

5. Aircraft over-G (10 G's), hitting the ground, and spins that bomb the computer are automatic kills.

6. Head on gun kills are not authorized. An aspect angle greater than 135 degrees for the shooter at time of kill is considered a head on gun kill.

7. Radar lock-on can only be accomplished by pilot activated auto-acq after the second engagement. Radar missiles will not be used until the third engagement.

8. Switchology trickology is unauthorized.

9. Entry fee will be decided by the class (normally $1/pilot).

10. These may be agreed to or changed by the entire class.

11. Lie, cheat, and steal, but keep your six clear and may the better man win!!

12. Head-on kills on the initial pass are not authorized at any time.

LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

A/A	- Air-to-Air
A/C	- Aircraft
ACES	- Air Combat Engagement Simulator
ACM	- Air Combat Maneuvering
ACMI	- Air Combat Maneuvering Instrumentation Range
AFHRL	- Air Forces Human Resources Laboratory
AVG	- Average
BFM	- Basic flying maneuvers
CIP	- Chief Instructor Pilot
CIPP	- Chief Instructor Pilot predictions of turkey shoot ranking
CF	- Classification Function
CTK, CINETK	- Cinetrack exercise in tracking maneuvers
D, DEM.	- Demographic data
DISCRIM	- Discriminant analysis program used
DF	- Degrees of freedom.
Elim.	- Eliminated(ors) from Turkey Shoot
ENV	- Envelope
EXP.	- Expanded (list of variables)
F	- Friday scoring data
FCN	- Function
F - ratio	- Variance between groups divided by variance within groups
F test	- Test of significance used in analysis of variance
FTO	- Flight Training Operations
FWIC	- Fighter Weapons Instructor Course
G, g	- Acceleration relative to that of gravity
>	- Greather than
GP	- Group
GSI	- Good Stick Index

LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS (Cont.)

H	- Hit
H_1	- Hypothesis where $P_E \neq P_T$
H-MIS	- Heat missile
H_O	- Hypothesis where $P_E = P_T$
HON, HD-ON	- Head-on exercise
INT., Int.	- Internal
IP	- Instructor Pilot
LBS	- Pounds (fuel)
[illegible]	- Less than
[illegible]	- Monday scoring data
MIL ERR	- Average pointing error in Mils
N	- Sample size
O/D	- Ratio of offensive time (target in front hemisphere of subject aircraft) to defensive time
OTOPS	- Opaque Target Optical Projector System
PANG	- Pointing Angle Advantage (Time in envelope)
P_E	- Proportion of correct classifications using data within the experiment
Pred.	- Prediction(s) -or(s)
P_T	- Proportion of correct classifications using test data from outside the experiment
R	- Correlation coefficient
R^2	- Coefficient of determination
R-MIS	- Radar missile
R.U.	- Runner(s)-Up of Turkey Shoot
S	- Standard deviation
SAAC	- Simulator for Air-to-Air Combat
SAM	- Surface-to-Air Missiles
SR	- Slant range

LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS (Cont.)

SS	- Sums of squares
TAC	- Tactical Air Command
TAC ACES I	- Simulator training program at Vought
II	- at Luke Air Force Base
TAS	- Training and simulation
TFWC	- Tactical Fighter Weapons Center
T.S., TS	- Turkey Shoot
TTFK	- Time from start of engagement to first kill
VAR	- Variable
σ^2	- Variance
W	- Wednesday scoring data
Win.	- Winner(s) of Turkey Shoot
$\bar{X}$	- Sample mean
X^2	- Chi-Square test statistic
X_i	- Variable quantities
Y	- Dependent variable quantity

☆U.S. GOVERNMENT PRINTING OFFICE: 1979- 671-056/60