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THE NUMERICAL ANALYSIS OF AIR COMBAT ENGAGEMENTS DOMINATED BY M--ETC(U)

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Technical Memorandum

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THE NUMERICAL ANALYSIS OF
AIR COMBAT ENGAGEMENTS
DOMINATED BY MANEUVERING PERFORMANCE

by

Mr. W. R. Simpson
Strike Aircraft Test Directorate

and

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Arlington, Virginia 22209

20 June 1977

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PREFACE

Recent emphasis on Air Combat Maneuvering (ACM), including the congressionally directed AIMVAL/ACEVAL trials, has created interest in developing methods of analysis to assess aircraft capabilities, pilot proficiency, force requirements, etc. Several methods are in use by industry, but many emphasize specific aircraft characteristics and are therefore limited in their application. This report describes an ACM analysis method developed by Mr. W. S. Stewart (Naval Weapons Center), Dr. R. A. Oberle (Center for Naval Analyses), and Mr. W. R. Simpson (NAVAIRTESTCEN). Several aspects of these analysis methods are being explored jointly by the Navy Fighter Weapons School, the Naval Weapons Center, the Center for Naval Analyses, and NAVAIRTESTCEN. These analysis techniques have been implemented at NAVAIRTESTCEN, the Naval Weapons Center, the Air Combat Maneuvering Range, and the Center for Naval Analyses. The NAVAIRTESTCEN participation was funded by the Joint Technical Coordinating Group/Munitions Effectiveness chaired by the Army Materiel Systems Analysis Agency, Aberdeen, Maryland. Assistance in the application of these techniques to specific problems of air combat is available through:

- a. NAVAIRTESTCEN (SA43)
- b. NAVWPNCEN (Code 4072)
- c. Naval Air Combat Maneuvering Range (CNA Rep to COMFITAEW-WINGPAC)
- d. Center for Naval Analyses

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J. H. Foxgrover
 J. H. FOXGROVER, RADM, USN
 Commander, Naval Air Test Center

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INTRODUCTION

BACKGROUND

1. The development of adequate analysis techniques in the area of Air Combat Maneuvering (ACM) is vital to the definition of the mission effectiveness of fighter aircraft, performance devices installed on fighter aircraft, and aircraft weapon systems. For the most part, however, the development of ACM testing and analysis procedures has lagged other evaluation areas such as air-to-ground or aircraft performance and flying qualities testing. Beginning in late 1971, the Commander, Operational Test and Evaluation Force initiated development of stochastic ACM analysis techniques. This effort resulted in the finite state maneuver conversion model (reference 1) and its application to the ACM evaluation of a thrust vectored attack aircraft as part of CNO Project P/V-2 (reference 2). An additional application of the maneuver conversion model to an in-flight ACM evaluation was made at NAVAIRTESTCEN for the F-11A thrust vector control system (reference 3). Following these applications, the finite state maneuver conversion model was extended by the introduction of a continuous time/continuous state performance index (reference 4). The performance index scales the offensive value of the interaircraft dynamics via the product of angle, range, and energy penalty functions. Numerical analysis of the stochastic process resulting from the application of these two evaluation techniques to sample ACM engagements has been an ongoing effort at NAVAIRTESTCEN, NAVWPNCEN, COMFITAEW-WINGPAC and CNA. The goal of the exploitation has been the development of tactically meaningful readiness measures through further mathematical development of the ACM models for application in aircraft test and evaluation and pilot training.

PURPOSE

2. This memorandum is intended as a supplement to references 1 and 4 to discuss the implementation of ACM analysis methods at several facilities, to present further developments, and to illustrate the use of the analytical methods via application to an example data set selected from a family of flight tests conducted on the Air Combat Maneuvering Range (ACMR). The data base and the numerical techniques described are also being used to guide further investigations into stochastic models useful for evaluating air combat maneuvering engagements.

1) R. A. Oberle, Air Combat Maneuver Conversion Model, Center for Naval Analyses Report No. CRC274, of Nov 1974.

2) Final Report, CNO Project P/V-2 (Battle Cry) (Task XII), Commander, Operational Test and Evaluation Force, Conduct an Operational Appraisal of the AV-8A Aircraft, of 24 Apr 1974 (Secret Report).

3) W. R. Simpson and M. T. Pilletere, Navy Evaluation of F-11A Inflight Thrust Control System, NAVAIRTESTCEN Report SA-C3R-76, Confidential Supplement to NAVAIRTESTCEN Report SA-75R-75, of 26 Jan 1976.

4) W. R. Simpson, Development of a Time-Variant Figure-of-Merit for Use in Analysis of Air Combat Maneuvering Engagements, NAVAIRTESTCEN Technical Memorandum TM-76-1SA, of 16 Jul 1976.

METHOD OF TESTS

3. Test methods for ACM evaluation are detailed in reference 4. This memorandum addresses the form of numerical techniques applied to quantitative ACM data.

ANALYSIS PARAMETERS

4. The primary ACM parameters to be used in this memorandum are given in table I. A complete listing of general technical terms is presented at the end of this report.

Table I

ACM Parameters

Parameter	Definition
-----------	------------

Airplane Parameters

Angle of Attack (AOA)	Angle between the free stream flow and the airplane reference line
Normal Acceleration (N_z)	The load factor taken perpendicular to the flight path
Altitude (ALT)	Geometric altitude above ground level
Indicated Airspeed (IAS)	Airspeed measured by AIS uncorrected for position error
Specific Energy (E_g)	Sum of the weight specific kinetic and potential energies
Target Mach Number (MT)	Mach number of the target airplane

Interairplane Parameters

Range (R)	Line of sight distance between the c.g. of two airplanes
Closing Velocity (VC)	Time rate of change of range
Antenna Train Angle (ATA)	The angle between the aircraft reference line forward of the c.g. and any sight line
Angle Off Tail (AOT)	The angle between the aircraft reference line aft of the c.g. and any sight line

Table I (Cont'd)

Parameter	Definition
Analysis Parameters	
Performance Index	A time variant figure-of-merit based on angular, range and energy penalty functions (detailed in reference 4)
Conversion Coefficient	An ACM state adaptation of the performance index (detailed in this memorandum)
ACM State	Maneuver conversion model state (detailed in reference 1)

ANALYSIS METHODS

5. The primary analysis methods employed in this report are the maneuver conversion model (detailed in reference 1) and the performance index model (reference 4). The maneuver conversion model characterizes an ACM engagement as a realization of a semi-Markov process with state conversion probabilities and time in state distributions. The performance index model is a continuous state continuous time stochastic process. A secondary analysis method, the conversion coefficient, combines the continuously varying measurement of the performance index and the state definitions of the maneuver conversion model to yield a third continuous time process. This third model, although suffering from discontinuities at state boundaries, is also being investigated for applicability to ACM evaluation. These models are used in combination because of their complimentary nature and the fact that the same conclusions follow from the three methodologies. Even though the maneuver conversion model includes a no-history Markov assumption and the performance index and conversion coefficient models assume a continuous time dependence, no conflict between results has yet been observed, nor is any expected. It is anticipated that for field application the analysts can select any of the methodologies for planning and evaluating a group of ACM flight tests. The methodology will primarily be chosen on the basis of off-line computational capability as well as the mathematical sophistication of the intended data usage.

ANALYSIS PROGRAMS

GENERAL

6. An analysis capability has been developed to define pertinent information and identify significant conclusions for air combat maneuvering engagements up to four fighter aircraft versus four target aircraft. Computer programs are available which calculate analysis data for specific aircraft pairs, fighter or bogie section analysis data for two-on-one engagements, and a stochastic analysis program for two-on-one engagements which is extendable to many versus many. The primary modes of analysis in these programs are the characterization of the semi-Markov parameters of the maneuver conversion model and a one dimensional evaluation of the stochastic process during the performance index model, together with stochastic data for the conversion coefficient and an expression of the expected paths for a statistical sample. The resulting numerical techniques are being used by the authors to support further theoretical development. For example, in reference 4, a feedback sequence leading to the development of a predictor model is discussed. Achievement of this predictor model requires a theoretical characterization of the underlying probability space for which the performance index and conversion coefficient are natural realizations. Identification of this underlying probabilistic structure is the goal of the ongoing investigations.

PAIRED ANALYSIS

7. The first step in the analysis is the computation of analysis parameters for fighter-to-adversary pairs in the engagement. The NAVAIRTESTCEN implementation of the paired analysis computer program is given in appendix A. Input is taken as the aircraft and interaircraft data of table I. These data are directly available from tests conducted at the ACMR in Yuma, Arizona, but can also be computed from use of radar data and onboard tape. Required inputs to the program are given in table II. These inputs are assumed to be at 1 second intervals from initialization. The beginning of the engagement can be taken analytically (such as at first visual contact) or mathematically (such as a fixed interaircraft range). Because of the inconsistency of results initialized at first visual contact, the latter is recommended.

Table II
Input Required for Paired Analysis Program

Input	Definition	Notes
TITLE	A 50-character identifier of the engagement	
ES1	Fighter aircraft specific energy	(1)
ES2	Target aircraft specific energy	
AOT	Fighter-to-target angle off tail	
ATA	Fighter-to-target antenna train angle	
R	Fighter-to-target interaircraft range	
RMAX1	Fighter offensive maximum range	(2)
RMAX2	Fighter defensive maximum range	
ROPT1	Fighter optimum missile launch range	
ROPT2	Target optimum missile launch range	
RO1	Target zero penalty range	
RO2	Fighter zero penalty range	
RG1	Fighter range at which guns tactics begin to dominate fight	
RG2	Target range at which guns tactics begin to dominate fight	
EDEV1	Fighter energy relevance term	
EDEV2	Target energy relevance term	
FG1	Fighter interenvelope gun penalty	
FG2	Target interenvelope gun penalty	
ATAOF	Antenna train angle for offensive state	(3)
AOTOF	Angle off tail for offensive state	
ATAWEP	Antenna train angle for weapons envelope	
AOTWEP	Angle off tail for weapons envelope	
R1WEP	Weapons envelope minimum range	
R2WEP	Weapons envelope maximum range	
RNUT	Range beyond which the fight is considered neutral for the maneuver conversion model	
NFILES	The number of data files to be input	
IPRINT	Print Option 1 for terminal output 5 for printer output	
IGRAF	Graph Option 1 for terminal output 5 for printer output	

NOTES: (1) As a function of time
(2) Defined in reference 4
(3) Defined in reference 1

8. The program computes and graphs the paired analysis data. An example data run is given in appendix B. Data output is defined in table III, and output data are placed on disk file for further use.

Table III
Output From Paired Analysis Program

Output	Definition	Notes
TIME	Assumed 1 second interval beginning at 1	
RANGE	Interaircraft range from table II	(1)
AOT	Angle off tail from table II	
ATA	Antenna Train Angle from table II	
NRG #1	Fighter aircraft ES1 from table II	
NRG #2	Target aircraft ES2 from table II	
DIR ANG	Normalized Directional Angle	(2)
NRG FN	Energy function for performance index calculation	
RNG FN	Range function for performance index calculation	
PERF INDEX	Performance Index	
STATE	ACM State	(3)

NOTES: (1) Output only on printer (print option 5). Not included in appendix B output.

(2) Defined in reference 4.

(3) Defined in reference 1.

SECTION ANALYSIS

9. The section coefficient data are computed by a second program as given in appendix C. The program was written for two versus one engagements and requires two output files generated by the previous program. These output files are for the two fighter-to-target pairs. The program computes the section performance index, section coordination, coordination consistency, the conversion coefficient, and the ACM state by the two-on-one state definitions of reference 1.

Section Performance Indices

10. The section performance indices are computed by the magnitude sum method (the vector sum method of reference 4). Section coordination and coordination consistency are computed as per reference 4.

Conversion Coefficient

11. The conversion coefficient was introduced to compensate for difficulties arising in the tactical interpretation of the section performance index. Specifically, as more aircraft are introduced, the section performance index becomes less responsive to tactical extremes because of mathematical "washout." That is, alternate signs in the performance index cancel to yield a numerically neutral fight which is often not representative of the tactical situation. For example, a precise interpretation of the "daisy chain" shown in figure 1 cannot be realized mathematically. The individual fighter-to-target performance indices cancel mathematically, yet tactically the fighter section is advantaged.

FIGHTER

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FIGHTER

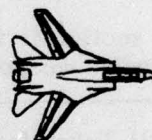
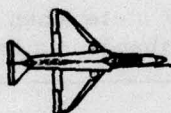
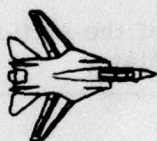


Figure 1
Air Combat "Daisy Chain" for Two-On-One Engagements

12. The situation as shown in figure 1 favors the fighter section if none of the aircraft are in a weapons envelope because of two very important reasons:

- a. The forward fighter has a friendly observer looking over his rear quarter (the rear fighter).
- b. In an attempt to close to the weapons envelope, the target aircraft in the middle will be flying a flight path which is in a large part determined by the first aircraft whose maneuvers can be made known to the rear aircraft. The situation will last only a short time with a smart pilot in the center aircraft and will quickly lead to "bogie switching," (a term applied to the situation) where the target (center) aircraft switches his offensive press to the other fighter.

13. The extension of the maneuver conversion model given in table IV covers this point adequately. (Rule 2 applies to the "daisy chain" of figure 1.)

Table IV⁽¹⁾

Rules for State Evaluation of a Two-On-One Engagement

1. The section is OFFENSIVE WEAPON when at least one member is in offensive weapon state and the other is higher than a fatal defensive state.
2. The section is OFFENSIVE when at least one member has an offensive position and the other is higher than a fatal defensive state.
3. The section is NEUTRAL when both members are in neutral state.
4. The section is DEFENSIVE when at least one member is in defensive state and the other is either neutral or defensive.
5. The section is FATAL DEFENSIVE when at least one member is in fatal defensive state and the other has less than offensive weapon state.
6. The section is in a TRADE OFF state when one member of the section is in offensive weapon state and the other is in a fatal defensive state.

NOTE: (1) Taken from reference 1.

14. The conversion coefficient introduced in this memorandum is an attempt to modify the performance index to cover the "daisy chain" situation and increase responsiveness. It is computed along the lines of table IV as follows:

- a. The conversion coefficient is equal to the section performance index when both of the paired performance indices are less than 30 in absolute value (corresponding to conditions 3 and 4 of table IV).
- b. The conversion coefficient is equal to the section performance index when both paired performance indices have the same sign (corresponding in part to conditions, 2, 3, and 4 of table IV).
- c. The conversion coefficient is equal to the section performance index when the paired performance indices are both greater than 75 in absolute value and opposite in sign (corresponding to condition 6 of table IV). These are flagged as a trade-off situation.

- d. The conversion coefficient is not equal to the section performance index when the paired performance indices are opposite in sign and one is greater than 30 but less than 75. In this case, the conversion coefficient is computed as follows:

$$\text{CONCO} = \text{PI}_1^2 \left(1 - \frac{|\text{PI}_2|}{75} \right) \quad (1)$$

where PI_1 is the positive value of the paired performance indices. This weights the positive (offensive factor) but degrades to a neutral value as a defensive fatal situation evolves (corresponding to condition 2 of table IV).

- e. The conversion coefficient is not equal to the section performance index when the paired performance indices are opposite in sign with one greater than 75 in absolute value and both greater than 30 in absolute value. In this case, it is computed as follows:

$$\text{CONCO} = \text{PI}_1^2 \left(1 - \frac{|\text{PI}_2|}{400} \right) \left(\frac{|\text{PI}_1|}{\text{PI}_1} \right) \quad (2)$$

where PI_1 is the paired performance index greater than 75 in absolute value and PI_2 is the other paired performance index. This weights the offensive weapons and defensive fatal states (corresponding to conditions 1 and 5 of table IV).

15. The conversion coefficient combines the best features of the maneuver conversion model with the performance index model but suffers in discontinuities due to equation changes at specified points. Care must be taken in further extensions of the conversion coefficient to include not only the case of the "daisy chain" (figure 2 shows a two versus two "daisy chain") but also other potential situations which cannot readily be described functionally such as the "floating diamond" in figure 3.

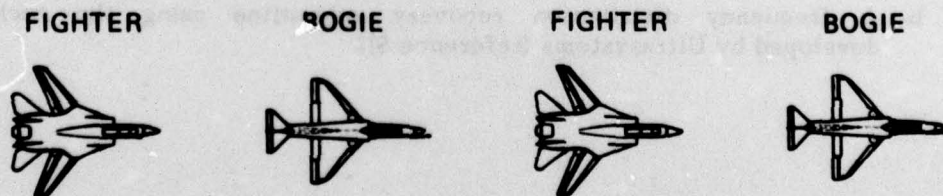


Figure 2
Air Combat "Daisy Chain" for Two-On-Two Engagements

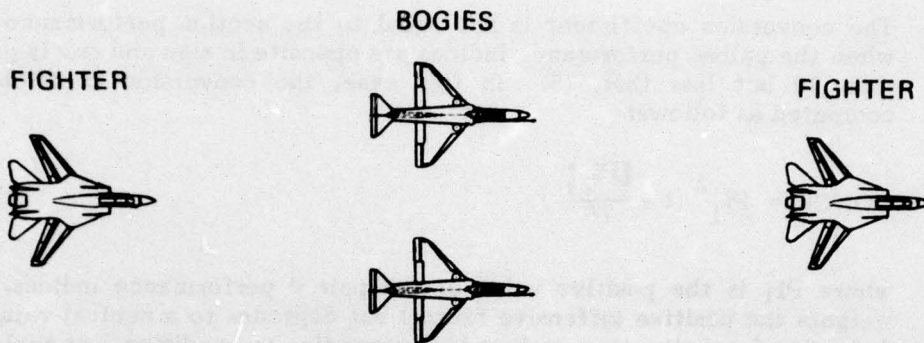


Figure 3
Air Combat "Floating Diamond" for Two-On-Two Engagements

Maneuver Conversion Model

16. The computation of the two-on-one ACM state is taken directly from table IV as obtained from reference 1.

Output of Section Analysis Program

17. An example output of the section analysis program is given in appendix D. The data are self-explanatory. These data are additionally output onto disk for use in the stochastic analysis program.

STOCHASTIC ANALYSIS

18. The stochastic analysis program takes the output data from both previous programs for a large sample of data. Because of the number of data points and calculations required, the program requires segmentation to fit most computers (the program given in appendix E takes in excess of 250K storage). Pertinent features of the program are:

- a. A file of data management options which allows the user to selectively compute and output data as documented in appendix E.
- b. A frequency distribution recovery subroutine using the techniques developed by Ultrasystems (reference 5).

5) Dr. R. Curry and Dr. R. Egbert, Investigation of Distribution Recovery Techniques, Operations Research and Economic Analysis Development Department, Ultrasystems, Incorporated, Newport Beach, California, 11 Feb 1974.

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- c. A moment generating routine calculating the classical moments of distributed functions with a given frequency distribution (reference 6).
 - d. An integration routine for integration of equally spaced functions using a combination of Simpson's rule and Newton's three-eighths rule (reference 7).
 - e. A general plot routine for use of the line printer in plotting developed at the NAVAIRTESTCEN.
19. The purposes of the stochastic analysis program are to:
- a. Compute the frequency distributions of the continuous variables in time for section data and paired data.
 - b. Compute the first 4 moments of these frequency distributions.
 - c. Compute the maneuver conversion/conversion probability matrix for aircraft sections and pairs.
 - d. Compute the time in state frequency distributions for the maneuver conversion model.
 - e. Compute the first 4 moments of these frequency distributions.

Stochastic Analysis Program Output

20. Full output of the stochastic analysis program is too voluminous to present here. Selected output for the test run and significant analysis information is, however, included for documentation. The test run, while representing actual engagement data, is for purposes of illustrating analysis methodology only. Separate reports are being written covering test data analysis and conclusions.

Continuous Variable Frequency Distributions and Moment Data

21. Frequency data output at 5 second intervals and for selected values of the performance index are shown in table V for a sample data set. The conclusions to be drawn from the data set are a function of the frequency value assumed to be significant. For example, the attainment of an optimal position (either best or worst) will come much less frequently than the neutral position. In table V, if a significance level of .001 is used, it can be seen that an optimal position will be attainable for the fighter section 20-30 seconds into the fight (a performance index of +100). This value does not occur until 80-90 seconds for the target (a performance index value of -100). This would indicate an early advantage to the fighter section and a recommended action to press and exploit the early advantage.

6) H. G. Kendall, The Advanced Theory of Statistics, Vol. I. Hafner Publishing Company, New York, 1958.

7) System 360 Scientific Subroutine Package (360A-CM-03X) Version II Programmers Manual, International Business Machines Report H20-0205-2, White Plains, N.Y., 1967.

Table V
Performance Index Distribution for Two-On-One Example Data Set

Time (sec)	Frequency of Occurrence of Specific Performance Indices										
	-100	-98	-80	-78	0	2	80	82	98	100	
1	0.00000	0.00000	0.00000	0.00000	0.03268	0.03643	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00001	0.00001	0.01432	0.01553	0.00004	0.00002	0.00000	0.00000	0.00000
11	0.00010	0.00012	0.00044	0.00050	0.00944	0.00976	0.00157	0.00135	0.00025	0.00025	0.00025
16	0.00025	0.00029	0.00092	0.00103	0.00793	0.00814	0.00273	0.00246	0.00092	0.00080	0.00080
21	0.00061	0.00068	0.00149	0.00160	0.00805	0.00819	0.00303	0.00280	0.00132	0.00119	0.00119
26	0.00058	0.00064	0.00135	0.00146	0.00806	0.00822	0.00323	0.00299	0.00148	0.00134	0.00134
31	0.00016	0.00019	0.00076	0.00087	0.00949	0.00953	0.00232	0.00212	0.00090	0.00080	0.00080
36	0.00032	0.00036	0.00100	0.00111	0.00955	0.00963	0.00228	0.00209	0.00093	0.00082	0.00082
41	0.00010	0.00012	0.00040	0.00044	0.01115	0.01133	0.00177	0.00155	0.00043	0.00035	0.00035
46	0.00011	0.00013	0.00047	0.00053	0.01055	0.01073	0.00173	0.00153	0.00047	0.00039	0.00039
51	0.00000	0.00000	0.00011	0.00015	0.01245	0.01263	0.00019	0.00014	0.00001	0.00001	0.00001
56	0.00000	0.00000	0.00010	0.00014	0.01238	0.01237	0.00028	0.00021	0.00002	0.00001	0.00001
61	0.00003	0.00004	0.00030	0.00036	0.01229	0.01228	0.00078	0.00066	0.00013	0.00010	0.00010
66	0.00009	0.00011	0.00060	0.00070	0.01064	0.01068	0.00132	0.00116	0.00034	0.00029	0.00029
71	0.00043	0.00049	0.00129	0.00142	0.00858	0.00867	0.00262	0.00241	0.00109	0.00097	0.00097
76	0.00054	0.00061	0.00155	0.00169	0.00809	0.00814	0.00287	0.00266	0.00132	0.00120	0.00120
81	0.00057	0.00065	0.00178	0.00195	0.00799	0.00808	0.00220	0.00199	0.00080	0.00070	0.00070
86	0.00150	0.00161	0.00287	0.00302	0.00696	0.00697	0.00328	0.00311	0.00187	0.00173	0.00173
91	0.00173	0.00185	0.00308	0.00323	0.00734	0.00734	0.00282	0.00268	0.00169	0.00159	0.00159
96	0.00093	0.00104	0.00254	0.00276	0.00850	0.00839	0.00158	0.00147	0.00074	0.00068	0.00068
101	0.00125	0.00138	0.00300	0.00323	0.00805	0.00794	0.00166	0.00154	0.00078	0.00071	0.00071
106	0.00057	0.00066	0.00215	0.00240	0.00835	0.00820	0.00126	0.00113	0.00041	0.00035	0.00035
111	0.00067	0.00077	0.00212	0.00232	0.00791	0.00793	0.00173	0.00155	0.00054	0.00047	0.00047
116	0.00124	0.00137	0.00288	0.00309	0.00770	0.00765	0.00200	0.00185	0.00089	0.00081	0.00081
121	0.00057	0.00067	0.00243	0.00272	0.00820	0.00809	0.00081	0.00071	0.00022	0.00018	0.00018
126	0.00089	0.00100	0.00255	0.00278	0.00810	0.00803	0.00153	0.00139	0.00056	0.00049	0.00049
131	0.00100	0.00112	0.00253	0.00273	0.00788	0.00785	0.00206	0.00190	0.00089	0.00080	0.00080
136	0.00103	0.00114	0.00247	0.00265	0.00798	0.00796	0.00224	0.00209	0.00105	0.00096	0.00096
141	0.00086	0.00096	0.00229	0.00249	0.00806	0.00799	0.00229	0.00214	0.00115	0.00106	0.00106
146	0.00130	0.00142	0.00285	0.00305	0.00768	0.00762	0.00236	0.00222	0.00124	0.00114	0.00114
151	0.00066	0.00076	0.00216	0.00239	0.00845	0.00827	0.00189	0.00177	0.00093	0.00085	0.00085
156	0.00121	0.00134	0.00292	0.00314	0.00810	0.00796	0.00172	0.00162	0.00121	0.00114	0.00114
161	0.00129	0.00142	0.00306	0.00328	0.00804	0.00790	0.00172	0.00162	0.00088	0.00080	0.00080
166	0.00185	0.00201	0.00374	0.00396	0.00699	0.00686	0.00237	0.00226	0.00145	0.00136	0.00136
171	0.00276	0.00291	0.00442	0.00459	0.00674	0.00665	0.00243	0.00234	0.00169	0.00162	0.00162
176	0.00256	0.00273	0.00448	0.00469	0.00698	0.00685	0.00192	0.00184	0.00130	0.00124	0.00124
181	0.00343	0.00357	0.00487	0.00502	0.00660	0.00651	0.00233	0.00225	0.00167	0.00161	0.00161
186	0.00089	0.00102	0.00284	0.00313	0.00839	0.00812	0.00073	0.00065	0.00022	0.00019	0.00019

22. For the fringe of a weapons envelope (as shown in table V) at a value of +80 for the fighter or -80 for the target, a significance level of .003 may be chosen due to the higher incidence of occurrence. These values again occur at 20-30 seconds for the fighter section (+80 performance index) and much later, 80-90 seconds for the target (-80 performance index) with the same conclusions. Further, the data indicate a loss of this advantage in the later stages of the fight due to the higher frequency of occurrence of performance indices in the negative range after 90 seconds, suggesting it may be desirable for the fighters to stay engaged for only short periods (say up to 60 seconds). The defensive disengagement for the fighter section between 60 and 90 seconds is the tactical defense to the tide of battle shifting to the bogie. The neutral values (values of performance index near 0) are included for reference.

23. Table VI shows the statistical summary data for the data of table V. The variation of the mean as a function of time points again to an early advantage to the fighter section and loss of that advantage at around 90 seconds into the fight. The variance shows that events in the latter half of the engagement are more random in nature (larger relative values of variance). That is, events are less in control of either the fighter section or the target section, but not a significant difference. The value of the mean is indicative of the relative worth of the two sections and the engagements show to be predominantly neutral with a slight advantage to the fighter section initially and a slight advantage to the target section later in time. The overall conclusion is that the sections are fairly equally matched. The third and fourth moments were computed for later analysis and model building.

24. Figure 4 shows the output of the frequency of occurrence plot as a function of performance index for the start of the set of engagements. Figure 4(a) shows a tightly distributed data set in the region of -16 to +20 indicating a neutral start condition. One or more engagements are seen to start with the fighter section at a disadvantage as shown in the secondary peak between -30 and -16, and these engagements should probably be deleted from the engagement set for the neutral start analysis.

Table VI

Summary Statistics for Section Performance Index Distribution

Time (sec)	Number of Points	Mean Performance Index	Variance of Performance Index	Third Moment of Performance Index About Mean	Fourth Moment of Performance Index About Mean
1	33	6.34	114.37	-636.67	56159.57
6	33	12.80	462.40	-4176.03	757210.59
11	33	14.57	1151.75	-12832.23	3800686.85
16	33	13.90	1570.17	-19020.63	6318563.84
21	33	10.42	1811.55	-17839.51	8065442.44
26	33	12.29	1782.15	-19620.96	7975665.77
31	33	8.27	1491.78	-1178.67	5558583.45
36	33	8.14	1527.16	-5578.23	6023055.01
41	33	13.02	1120.23	-4447.80	3593418.53
46	33	11.47	1198.91	-5504.27	3974260.30
51	32	5.99	807.96	-4006.78	1734312.40
56	32	3.55	847.04	380.94	1840745.63
61	32	4.27	1000.48	1595.19	2757920.97
66	32	4.97	1249.15	-201.43	4090099.35
71	30	8.30	1702.58	-9678.55	7107357.44
76	30	7.00	1850.01	-7680.61	8024471.00
81	30	4.25	1800.18	-9594.28	7555697.28
86	30	2.31	2300.12	-5018.21	11336444.27
91	29	-0.77	2242.77	1069.86	11057383.18
96	28	-7.02	1766.26	12959.65	7677819.65
101	27	-8.54	1871.21	15561.02	8432997.65
106	27	-8.12	1624.86	14356.95	6497451.97
111	27	-0.96	1797.02	-1663.24	7357124.42
116	27	-4.89	1983.82	8765.20	8980127.66
121	27	-11.43	1540.44	12607.21	5774302.76
126	25	-6.31	1789.32	9495.46	7541745.63
131	24	-2.79	1934.10	5310.66	8574531.13
136	24	-1.51	1957.46	3766.21	8824056.90
141	21	-1.93	1927.95	9173.04	8660194.07
146	19	-3.53	2064.53	9781.27	9692787.76
151	19	-6.13	1768.54	19825.28	7818620.14
156	18	-7.86	1930.58	21118.76	9156490.34
161	18	-9.46	1879.12	19982.05	8677585.29
166	16	-9.20	2209.73	27797.15	11175677.66
171	14	-10.19	2369.51	27960.52	12478168.37
176	14	-13.59	2179.04	31991.96	11230738.18
181	12	-11.99	2422.24	30528.05	12983093.75
186	10	-16.13	1456.25	18236.56	5761935.46

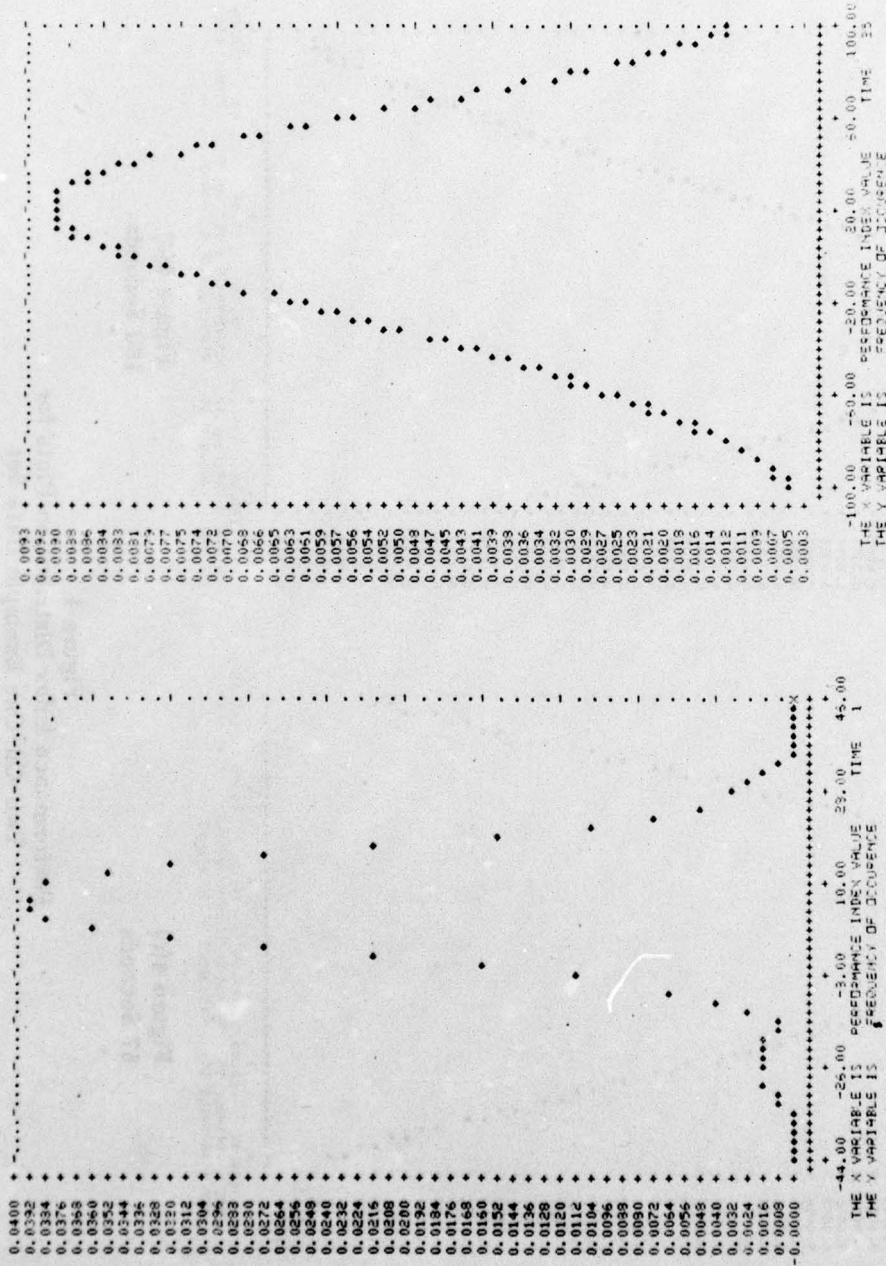


Figure 4(a)
Start of Engagement

Figure 4(b)
25 Seconds

Figure 4

Performance Index Distribution Plots for
Two-On-One Example Data Set

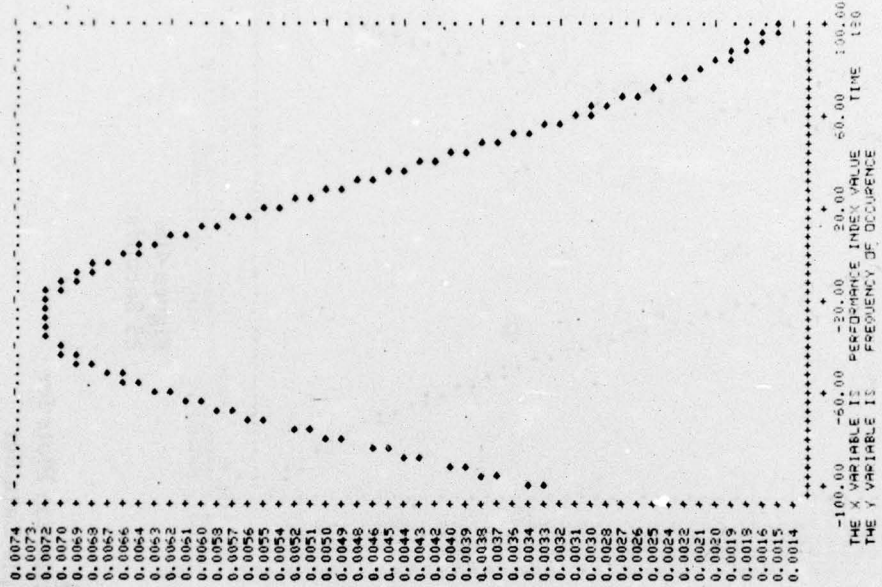


Figure 4(c)
87 Seconds

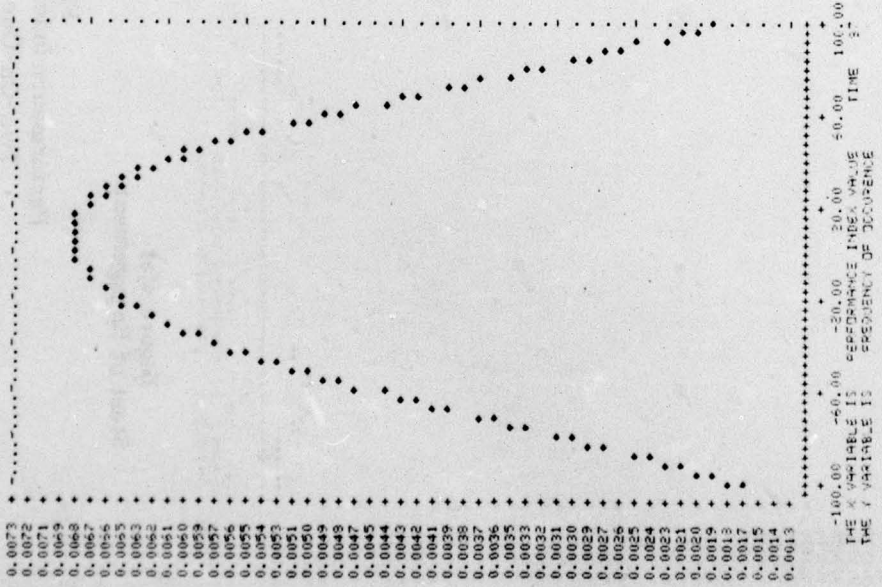


Figure 4(d)
180 Seconds

Figure 4
Performance Index Distribution Plots for
Two-On-One Example Data Set

25. Figure 4(b) shows the output of the frequency of occurrence plot as a function of performance index for a time 25 seconds into the engagements. As discussed in paragraphs 21 and 22, it can be seen that for a significance level of 0.003, the distribution of performance indices lies between -54 and +82 which contains the fringe weapon envelope case for the fighter section (+80), but not the target (-80), indicating a decided advantage for the fighter section in this time frame. Thus, the neutral starts have shifted to a fighter section advantage during the initial engagement period.

26. Figures 4(c) and 4(d) show the reversal of this trend later in the engagement. In figure 4(c), the frequency distribution at 87 seconds into the engagements shows that both the fighter section and the target section have weapon opportunities available. Figure 4(d), taken for 180 seconds into the engagements, shows a very skewed distribution which includes weapon opportunities for the target aircraft but none for the fighter section. This reflects the breakdown of the fighter section integrity as engagement time accumulates and the resulting dominance by the bogie. At this point, the fighters are essentially uncoordinated and the more maneuverable bogie is selectively engaging the most vulnerable fighter of the section.

27. Engagement dominance can be taken from the cumulative probability of occurrence of performance indices at various times during the engagements as shown in figure 5 for the times corresponding to figure 4. Mathematically, the fighter section will dominate if a positive value of performance index has a cumulative probability of greater than 50%. Practically, however, the split should be greater than 51/49 or more like 70/30. As shown in the figures, and taking the split in the value of cumulative probability at zero performance index, no tendency to dominate is present in either the fighter section or the target aircraft over the entire engagement time. There is, however, a mathematical tendency for the fighter section to dominate early in the fight and to lose this advantage to the target aircraft later in the fight. This is consistent with the trend isolated by the time history of expected values discussed in paragraph 23. While no combatant controlled the entire engagement, the initial engagement dominance by the fighter section is a decided advantage since the fighter section will incur the majority of early shot opportunities.

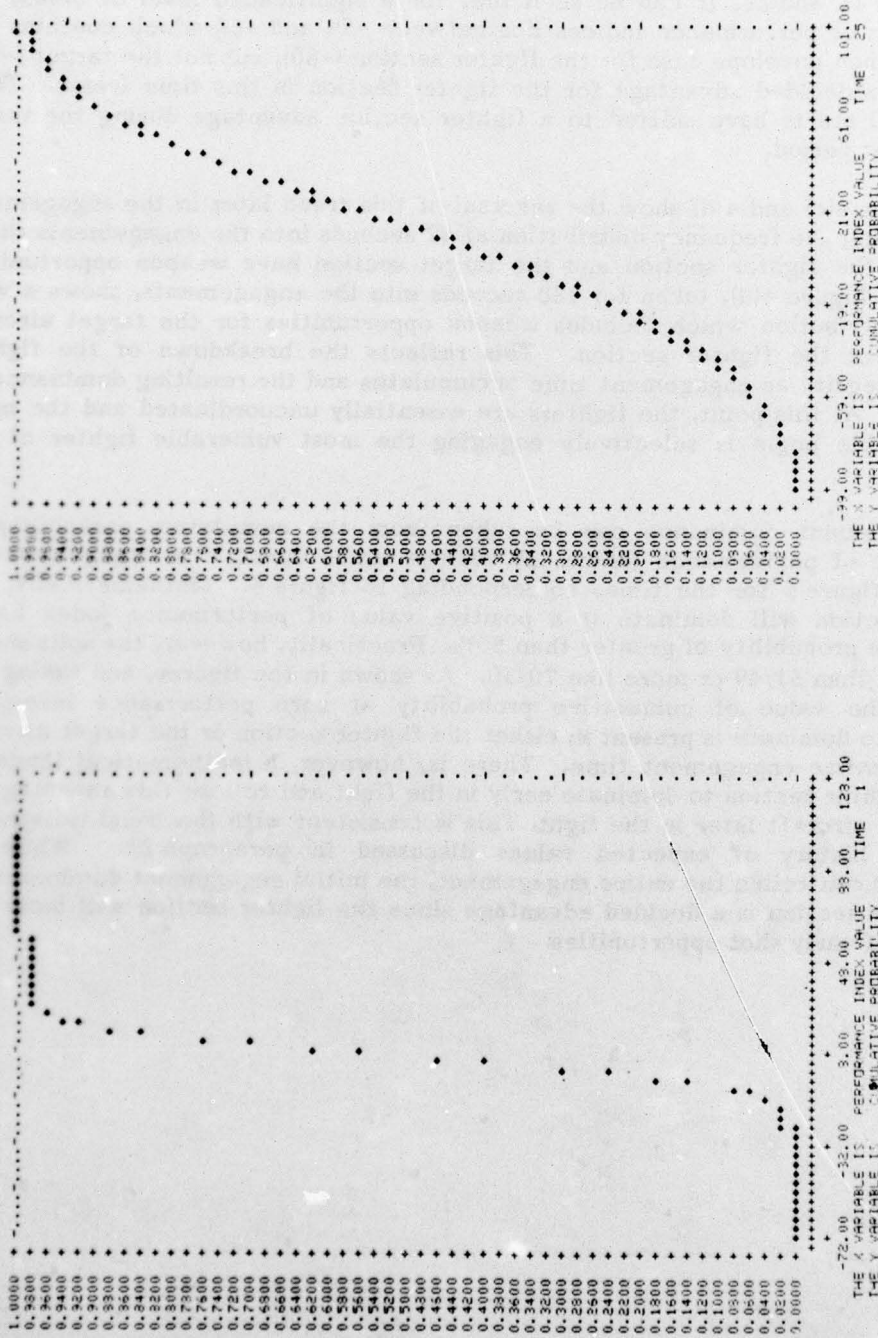


Figure 5(b)
25 Seconds

Figure 5(a)
Start of Engagement

Figure 5
Cumulative Probability Plots for Performance Indices
of Two-On-One Example Data Set

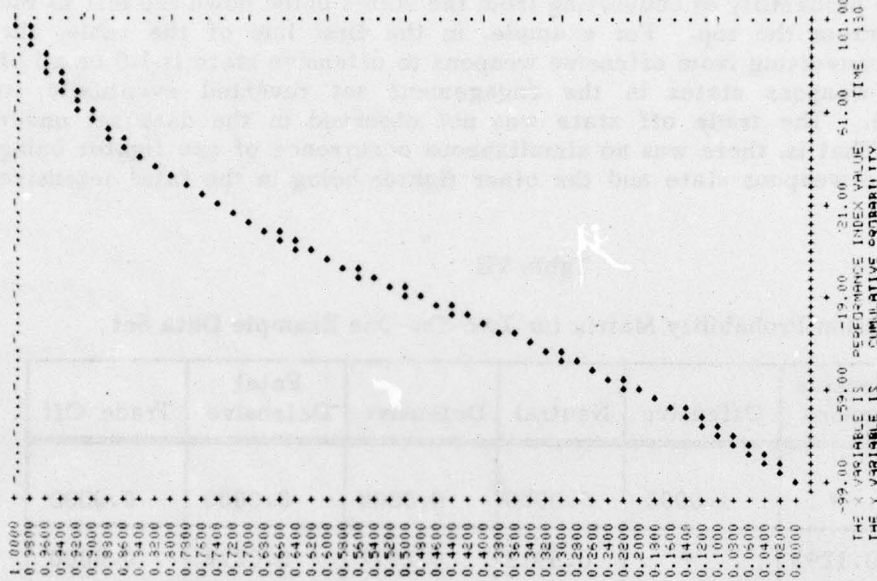


Figure 5(c)
87 Seconds

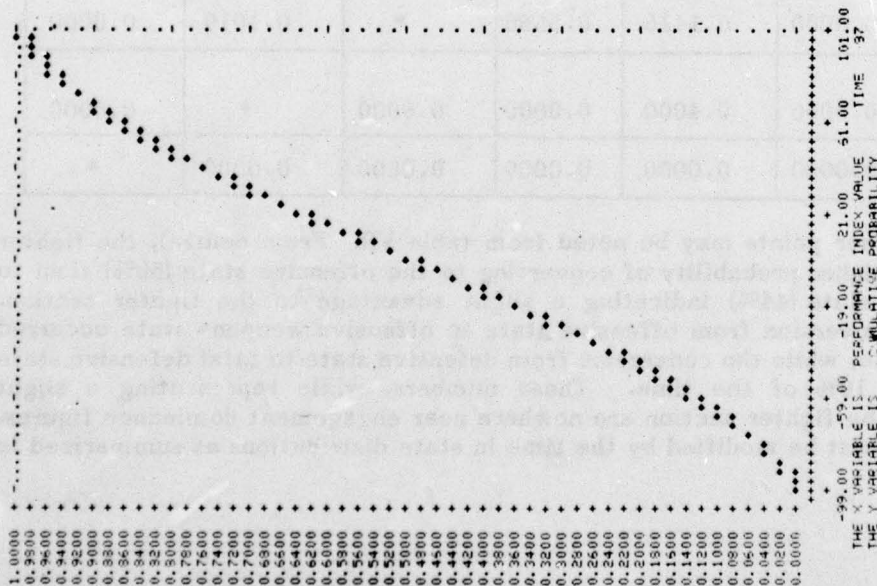


Figure 5(d)
180 Seconds

Figure 5
Cumulative Probability Plots for Performance Indices
of Two-On-One Example Data Set

Maneuver Conversion/Conversion Probability Matrix

28. Table VII shows the program output of the conversion probability matrix for the sample data set as computed by the methods described in reference 1. The table shows the probability of converting from the states listed down the left to the states listed across the top. For example, in the first line of the table, the probability of converting from offensive weapons to offensive state is 1.0 or all of the offensive weapons states in the engagement set reverted eventually to offensive state. The trade off state was not observed in the data set under investigation. That is, there was no simultaneous occurrence of one fighter being in the offensive weapons state and the other fighter being in the fatal defensive state.

Table VII

Conversion Probability Matrix for Two-On-One Example Data Set

Section State	Offensive Weapons	Offensive	Neutral	Defensive	Fatal Defensive	Trade Off
Offensive Weapons	*	1.0000	0.0000	0.0000	0.0000	0.0000
Offensive	0.1293	*	0.5918	0.2517	0.0272	0.0000
Neutral	0.0000	0.5583	*	0.4417	0.0000	0.0000
Defensive	0.0000	0.3426	0.5556	*	0.1019	0.0000
Fatal Defensive	0.0000	0.4000	0.0000	0.6000	*	0.0000
Trade Off	0.0000	0.0000	0.0000	0.0000	0.0000	*

29. Several other points may be noted from table VII. From neutral, the fighter section had a higher probability of converting to the offensive state (56%) than to the defensive state (44%) indicating a slight advantage to the fighter section. Further, the conversion from offensive state to offensive weapons state occurred 13% of the time, while the conversion from defensive state to fatal defensive state occurred only 10% of the time. These numbers, while representing a slight advantage to the fighter section are nowhere near engagement dominance figures. Further, they must be modified by the time in state distributions as summarized in table VIII.

Table VIII
Time in State Summary for Two-On-One Example Data Set

Section State	Number of Points	Mean Time in State (sec)	Variance of Mean Time in State (sec ²)	Third Moment about Mean Time in State (sec ³)	Fourth Moment about Mean Time in State (sec ⁴)
Offensive Weapons	18	2.93	4.39	9.74	68.59
Offensive	142	14.52	141.52	2329.60	96707.36
Neutral	153	18.13	206.64	3876.30	197143.09
Defensive	97	15.30	136.32	1862.18	77235.03
Fatal Defensive	16	2.56	5.08	14.96	96.76
Trade Off	0	0.00	0.00	0.00	0.00

30. As shown in table VIII, the mean time spent in the offensive state is somewhat less than the mean time spent in the defensive state for roughly the same variance (same degree of consistency), thus offsetting the partial advantage to the fighter section. The nonparametric frequency function fits for time in offensive, neutral, and defensive states displayed the log normal characteristic referred to in reference 2. Figure 6(a) shows the time in state distribution for the offensive state.

31. Time in state distributions for the offensive weapons and defensive fatal states are multimodal and means do not compare directly. Figure 6(b), the time in state distribution of the offensive weapons state for the fighter section, is characterized as a bimodal distribution which approximates the log normal form. Figure 6(c), the time in state distribution of the fatal defensive state for the fighter section, is characterized by a trimodal distribution which approximates the log normal form. The primary difference in the two states is probably characterized by the pilot tactics employed in two-on-one engagements. The first peak in figure 6(b) probably represents a transient or "flash through" computation in the neighborhood of one second, while the second peak (at 8.5 to 9 seconds) represents the tracking solution. The fatal defensive state (figure 6(c)) shows both these peaks, together with an intermediate peak which is probably due to 'bogie switching' as discussed in paragraph 12. The target aircraft, being threatened, in some instances would not complete the tracking solution, but hold the state for some finite time (around 5 seconds), fire a missile, and then switch. No such pressures to switch states are incumbent upon the fighter section in a two-on-one engagement. This intermediate short duration peak could be termed the 'survival sting' peak. This logic would lead to the supposition that a trimodal distribution for offensive weapons and defensive fatal states would be present in all engagements with multiple bogies and multiple fighters. The above observations are based upon a small data base and must be verified by further data samples.

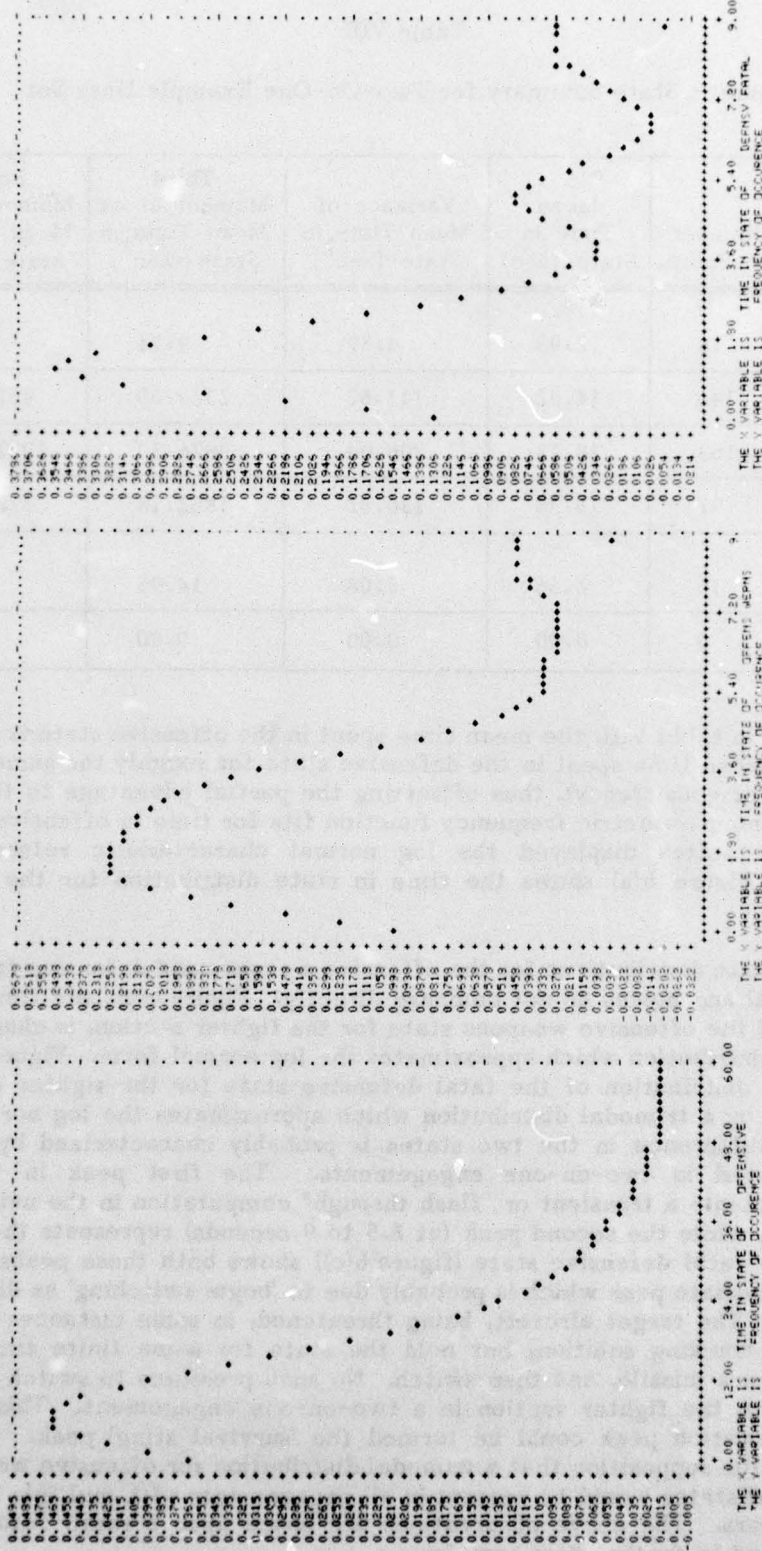


Figure 6(a)
Offensive State

Figure 6(b)
Offensive Weapons State

Figure 6(c)
Fatal Defensive State

Figure 6
Time in State Distributions for Two-On-One Example Data Set

32. The above discussion exhausts the conclusions that can be drawn directly from the estimated values of the maneuver conversion parameters. Further analysis, for example, the complete characterization of the underlying probability space and the estimation of the expected trade off ratio (the ratio of the probability of a win to the probability of a loss), requires the methodology described in reference 8. Since the techniques are adequately described in reference 8, they will not be repeated here.

33. At this point in the analysis, the semi-Markov process of the maneuver conversion model is defined, and when integrated with the weapon employment parameters, the full range of ACM measures of effectiveness including exchange ratios, survivability and dominance indices, etc., can be computed. These terms are treated in detail in references 1 and 8. The stochastic process of the performance index is only partially defined and is still in the developmental phase.

MODEL VALIDATION

34. The question of model validity may be addressed at two levels. The first level is consistency of conclusions drawn from the differing analytic techniques. The above discussions demonstrate this consistency for the data set under consideration. The authors believe that the two models are equally right or equally wrong. Thus, validation is reduced to determining if either model characterizes ACM correctly. An indication of this validity has already been obtained by noting the consistency of the common conclusion set with the intuitive evaluation of the participating aircrews. A formal mathematical validation may be obtained by comparing the tactical measures (listed in reference 1) as estimated from the computer solution of the semi-Markov process and as estimated directly from the data sample. Although this has not been done for this data sample, a valid comparison has been described in reference 8.

8) R. A. Oberle and W. R. Nunn, Evaluation of Air Combat Maneuvering Engagements, CNA Study No. 77-3, (to be published).

CURRENT RESEARCH

35. The above discussion summarizes some of the early research into the evaluation of test range ACM engagements. Work is continuing toward the development of a completely mathematical characterization of such engagements. Specifically, the investigations are directed toward a complete characterization of the underlying probability structure for which the performance index and conversion coefficient are natural realizations. The numerical techniques discussed above not only provide tactically significant data interpretation techniques but also serve as the initial technical tools to support the ongoing research. Further numerical techniques which are expected to be useful for data interpretation include a full nonparametric covariance and increment analysis along with selected distribution fitting analyses. The current research emphasis centers around a characterization of the performance index as a solution of a stochastic differential equation. It is expected that such a characterization will identify a few stochastic parameters that will serve to replace the mass of numerical calculations currently necessary as well as identify the theoretical connection between the maneuver conversion and the performance index models.

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3. W. R. Simpson and M. T. Pilletere, Navy Evaluation of F-11A Inflight Thrust Control System, NAVAIRTESTCEN Report SA-C3R-76, Confidential Supplement to NAVAIRTESTCEN Report SA-75R-75, of 26 Jan 1976.
4. W. R. Simpson, Development of a Time-Variant Figure-of-Merit for Use in Analysis of Air Combat Maneuvering Engagements, NAVAIRTESTCEN Technical Memorandum TM-76-1SA, of 16 Jul 1976.
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7. Systems 360 Scientific Subroutine Package (360A-CM-03X) Version II Programmers Manual, International Business Machines Report H20-0205-2, White Plains, N.Y., 1967.
8. R. A. Oberle and W. R. Nunn, Evaluation of Air Combat Maneuvering Engagements, CNA Study No. 77-3, (to be published).

PAIRED ANALYSIS PROGRAM

L PFINDX

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100 BERRMES
200 FILE 5=RANDY,UNIT=PRINTER BACKUP DISK
300 FILE 4=REF,UNIT=DISK
400 FILE 2=ACM,UNIT=DISK
500 FILE 3=CONST,UNIT=DISK
600 FILE 1=TRMNL,UNIT=REMOTE
700 INTEGER X
800 REAL K
900 DIMENSION TITLE(50)
910 DIMENSION ISTAT(500)
1000 DIMENSION STATE(500)
1100 DIMENSION BE(500),AA(500)
1200 DATA BLANK,DOT,STAR,XXX/" ",",",","♦","X"/
1300 DATA PLUS/"+" /
1400 DATA OFWEP,OFF,DEF,NUT,DEFAT/"W","D","D","N","F"/
1410 C-
1420 C- DATA FOR ACM STATE CALCULATION W=OFFENSIVE WEAPON STATE
1430 C-                                     D=OFFENSIVE STATE
1440 C-                                     N=NEUTRAL STATE
1450 C-                                     D=DEFENSIVE STATE
1460 C-                                     F=DEFENSIVE FATAL STATE
1470 C-
1480 C-
1500 DIMENSION R(500),K(500),FRNG(500),DA(500),PI(500)
1600 DIMENSION ES1(500)
1700 DIMENSION ES2(500)
1800 DIMENSION AOT(500)
1900 DIMENSION ATA(500)
1950 IFIL=1
1960 PRINT 433
1970 433 FORMAT(5X,"HOW MANY FILES AM I LOOKING AT")
1980 READ(1,/) NFILES
2000 KOUNT=1
2100 READ(3,/) RMAX1,RMAX2,ROPT1,ROPT2,R01,R02,RG1,RG2,EDEV1,EDEV2,
2110 C-
2115 -F51,F52,ATAOF,AOTOF,R1WEP,R2WEP,RNUT,ATAWEP,AOTWEP
2120 C- SEE TEXT FOR EXPLANATION OF THESE NUMBERS
2130 C-
2200 PRINT 434
2200 434 FORMAT(5X,"WHERE DO YOU WANT DATA OUT, 1=HERE, 5=PRINTER",
2300 -"OTHERS=NONE")
2310 READ(1,/) IPRINT
2320 PRINT 435
2330 435 FORMAT(5X,"WHERE DO YOU WANT A GRAPH, 1=HERE, 5=PRINTER",
2400 -"OTHERS=NONE")
2500 READ(1,/) IGRAF
2510 86 CONTINUE
2512 KOUNT=1
2515 READ(2,/) N,(R(I),I=1,N),(ES1(I),I=1,N),(ES2(I),I=1,N),
2520 -(AOT(I),I=1,N),(ATA(I),I=1,N)
2530 READ(2,111) (TITLE(I),I=1,50)
2540 111 FORMAT(50A1)
2550 191 CONTINUE
2560 WRITE(1,111) (TITLE(I),I=1,50)
2600 IF(IPRINT.EQ.1.OR.IPRINT.EQ.5) GO TO 937
2700 GO TO 100

```

TM 77-2 SA

```

3900 987 CONTINUE
3900 WRITE (IPRINT,1003) (TITLE(I),I=1,50)
4000 1003 FORMAT(1H1,10X,50A1)
4100 WRITE (IPRINT,444) RMAX1,RMAX2,ROPT1,ROPT2,R01,R02,RG1,RG2,
4110 -EDEV1,EDEV2,FG1,FG2,ATAOF,ROTOF,ATAWEP,ROTWEP,R2WEP,R1WEP,RNUT
4200 444 FORMAT(10X,"INPUT CONSTANTS FOR THIS RUN",/
4300 -10X," FIGHTER OFFENSIVE MAX RANGE",F10.1," TARGET =",F10.1,/
4500 -10X," FIGHTER OPT MISSILE RANGE ",F10.1," TARGET =",F10.1,/
4600 -10X," FIGHTER MINIMUM RANGE (GUN) ",F10.1," TARGET =",F10.1,/
4700 -10X," FIGHTER GUN ENVELOPE RMAX ",F10.1," TARGET =",F10.1,/
4800 -10X," FIGHTER ENERGY RELEVENCE ",F10.4," TARGET =",F10.4,/
4900 -10X," FIGHTER INTER-ENVELOPE PENAL",F10.4," TARGET =",F10.4,/
4910 -10X,"OFFENSIVE ATA=",F10.1," ROT=",F10.1,/
4920 -10X,"OFF WEP ATA=",F10.1," ROT=",F10.1,/
4925 -10X,"OFF WEP RMAX=",F10.1,"RMIN=",F10.1,/
4930 -10X,"FIGHT NUETRAL BEYOND",F10.1," RANGE")
5000 IF (IPRINT.EQ.1) WRITE (1,30)
5010 IF (IPRINT.EQ.5) WRITE (5,301)
5020 301 FORMAT (5X,"TIME RANGE ROT ATA NR6#1 NR6#2 DIR ANG",
5030 -" NR6 FN RNS FN PERF INDEX STATE")
5100 30 FORMAT (5X,"TIME DIR ANG NR6 FN RNS FN",4X,
5200 -"PERF INDEX", " STATE")
5210 C-
5220 C- COMPUTE ACM STATE
5230 C-
5300 100 DO 10 I=1,N
5400 STATE(I)=NUT
5500 IF (ATA(I).LE.ATAOF.AND.ROT(I).LE.ROTOF) STATE(I)=OFF
5600 IF (ATA(I).LE.ATAWEP.AND.ROT(I).LE.ROTWEP.AND.R(I).GE.R1WEP.AND.
5700 -R(I).LE.R2WEP) STATE(I)=OFWEP
5800 IF (ATA(I).GE.(180.-ROTOF).AND.ROT(I).GE.(180.-ATAOF)) STATE(I)=DEF
5900 IF (ATA(I).GE.(180.-ROTWEP).AND.ROT(I).GE.(180.-ATAWEP).AND.
6000 -R(I).GE.R1WEP.AND.R(I).LE.R2WEP) STATE(I)=DEFAT
6050 IF (R(I).GT.RNUT) STATE(I)=NUT
6050 C-
6070 C- COMPUTE NORMALIZED DIRECTIONAL ANGLE
6080 C-
6100 DA(I)=100.*((180.- (ROT(I)+ATA(I)))/180.)
6200 IF (DA(I)+0) 15,25,25
6210 C-
6220 C- BRANCH ON DIRECTIONAL ANGLE PLUS FOR OFFENSIVE FIGHTER
6230 C- MINUS FOR DEFENSIVE FIGHTER
6240 C-
6300 15 CONTINUE
6400 RMAX=RMAX2
6410 ROPT=ROPT2
6420 R0=R02
6430 RG=RG2
6440 EDEV=EDEV2
6450 FG=FG2
6500 GO TO 45
6500 25 RMAX=RMAX1
6510 ROPT=ROPT1
6520 R0=R01
6530 RG=RG1
6540 EDEV=EDEV1
6550 FG=FG1
6700 45 IF (RG.EQ.ROPT.OR.RG.EQ.R0.OR.FG.EQ.0.) GO TO 35

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TM 77-2 SA

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6710 C-
6720 C- BEGIN COMPUTATION OF PERFORMANCE INDEX
6730 C-
6800 FSTR=FG/((RG/RMAX)♦((RG-ROPT)/RMAX♦(RG-R0)/RMAX)♦♦2)
6900 GO TO 55
7000 35 FSTR=0.
7100 55 A=R(I)
7200 B=(A-ROPT)/RMAX
7300 C=(A-R0)/RMAX
7400 D=EXP(-3.♦((A-RG)/ROPT)♦♦2)
7500 E=FSTR♦A/RMAX♦(B♦C♦D)♦♦2
7600 FRNG(I)=E+1./ (1.+500.♦EXP(-12.♦B))
7700 ES1=ES1(I)-ES2(I)
7800 ES2=(ES1(I)+ES2(I))/2.
7900 DES=ES1/ES2
8000 GEE=(2.♦R(I)-RMAX-ROPT)/(RMAX-ROPT)
8100 EFF=EDEV♦EXP(-4.♦GEE♦♦2)
8200 ECH=1./ (1.+EDEV♦EXP(-6.91♦R(I)/R0))
8300 K(I)=1.+(ECH+EFF-1.)♦DES
8400 IF (DA(I)+0) 17, 18, 18
8500 17 K(I)=1./K(I)
8600 18 CONTINUE
8700 PI(I)=DA(I)♦K(I)♦(1.-FRNG(I))
8800 IF (IPRINT.EQ.1.OR.IPRINT.EQ.5) GO TO 986
8900 GO TO 10
9000 986 CONTINUE
9200 IF (KOUNT.EQ.45) WRITE (IPRINT,1003) (TITLE(KK),KK=1,50)
9300 IF (KOUNT.EQ.45.AND.IPRINT.EQ.5) WRITE (5,301)
9310 IF (KOUNT.EQ.45.AND.IPRINT.EQ.1) WRITE (1,30)
9400 IF (KOUNT.EQ.45) KOUNT=0
9500 KOUNT=KOUNT+1
9550 IF (IPRINT.EQ.5) WRITE (5,278) I,R(I),AOT(I),ATA(I),ES1(I),ES2(I),
9560 -DA(I),K(I),FRNG(I),PI(I),STATE(I)
9570 278 FORMAT (6X,I3,2X,I5,2(2X,I3),2(2X,I5),2X,F6.2,2X,F7.4,
9580 -F7.4,2X,F10.2,5X,A1)
9600 IF (IPRINT.EQ.1) WRITE (1,20) I,DA(I),K(I),FRNG(I),PI(I),STATE(I)
9700 20 FORMAT (5X,I4,6X,F7.2,3X,F6.4,4X,F6.4,4X,F10.2,5X,A1)
9800 10 CONTINUE
9900 KOUNT=1
10000 IF (IGRAF.EQ.1.OR.IGRAF.EQ.5) GO TO 985
10100 GO TO 88
10200 985 CONTINUE
10210 C-
10220 C- BEGIN COMPUTATION FOR GRAPHICAL OUTPUT
10230 C-
10300 MT=1
10400 DO 44 I=1,N
10500 44 AA(I)=PI(I)
10600 WRITE (IGRAF,2222)
10700 2222 FORMAT (1H1)
10800 WRITE (IGRAF,1003) (TITLE(I),I=1,50)
10900 WRITE (IGRAF,1114)
11000 1114 FORMAT (25X,"♦ PERFORMANCE INDEX",/
11100 -.1X,"T",23X,"+ DIRECTIONAL ANGLE")
11200 WRITE (IGRAF,90)
11300 90 FORMAT (1X,"I",1X,"S",/1X,"M",1X,"E",3X,
11400 --"-100",2X,"-90",2X,"-60",3X,"-40",2X,"-20",
11500 -3X,"0",3X,"+20",2X,"+40",2X,"+60",2X,"+80",2X,"+100")

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11600 DO 66 J=10,60
11700 BE(J)=DOT
11800 66 CONTINUE
11900 DO 666 J=10,60,5
12000 BE(J)=PLUS
12100 666 CONTINUE
12200 WRITE(IGRAF,77) (BE(J),J=10,60)
12300 77 FORMAT(1X,"E",1X,"C",5X,51A1)
12400 DO 89 I=1,N
12500 DO 99 J=10,60
12600 BE(J)=BLANK
12700 99 CONTINUE
12800 BE(35)=DOT
12900 BE(60)=STATE(I)
13000 BE(10)=STATE(I)
13100 IF(DA(I).GT.99.9.OR.DA(I).LT.-99.9) GO TO 4123
13200 IK=.25*DA(I)+35.5
13300 BE(IK)=PLUS
13400 GO TO 4133
13500 4123 BE(35)=XXX
13600 4133 CONTINUE
13700 IF(AA(I).GT.99.9.OR.AA(I).LT.-99.9) GO TO 9876
13800 J=.25*AA(I)+35.5
13900 BE(J)=STAR
14000 GO TO 7654
14100 9876 BE(35)=XXX
14200 7654 CONTINUE
14400 IF(KOUNT.EQ.45) WRITE(IGRAF,1003) (TITLE(KK),KK=1,50)
14500 IF(KOUNT.EQ.45) WRITE(IGRAF,1114)
14600 IF(KOUNT.EQ.45) WRITE(IGRAF,90)
14700 IF(KOUNT.EQ.45) KOUNT=0
14800 KOUNT=KOUNT+1
14900 WRITE(IGRAF,11) MT,(BE(J),J=10,60)
15000 11 FORMAT(14,5X,51A1)
15100 MT=MT+1
15200 89 CONTINUE
15210 PRINT 411,IFIL
15220 411 FORMAT(5X,"ANOTHER FILE DONE ",I4)
15230 WRITE(4,786) N
15240 786 FORMAT(2X,I4)
15250 WRITE(4,785) (TITLE(JK),JK=1,50)
15260 785 FORMAT(2X,50A1)
15270 DO 42 I=1,N
15280 IF(ABS(PI(I)).GT.99.9) PI(I)=0.
15290 42 CONTINUE
15300 WRITE(4,789) (PI(I),I=1,N)
15400 789 FORMAT(50(2X,9(F6.2,""),F6.2/))
15410 DO 1141 J=1,N
15420 IF(STATE(J).EQ.OFWEP) ISTAT(J)=1
15430 IF(STATE(J).EQ.OFF) ISTAT(J)=2
15440 IF(STATE(J).EQ.NUT) ISTAT(J)=3
15450 IF(STATE(J).EQ.DEF) ISTAT(J)=4
15460 IF(STATE(J).EQ.DEFAT) ISTAT(J)=5
15470 1141 CONTINUE
15500 WRITE(4,790) (ISTAT(I),I=1,N)
15600 790 FORMAT(50(2X,9(I1,""),I1/))

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TM 77-2 SA

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15625 IFIL=IFIL+1
15650 IF(IFIL.LE.NFILES) GO TO 86
15700 PRINT 8111
15900 8111 FORMAT(//////////5X,"REQUIRED FILE KEEPING TO SAVE DATA\
      \ \ IS-"/
15900 -"LOAD YOUR DATA FILE"/"ADD REF"/"SAVE"/"REMOVE REF,ACM"/
16000 -"MAKE ACM AND REF"/"SAVE"////////"TH-TH-THATS ALL FOLKS")
16100 8765 CALL EXIT
16200 END
```

END QUIKLIST 4.2 SEC.

TM 77-2 SA

PAIRED ANALYSIS PROGRAM OUTPUT
FOR EXAMPLE DATA SET

TM 77-2 SA

R PFINDX_
RUNNING

HOW MANY FILES AM I LOOKING AT
?1_
WHERE DO YOU WANT DATA OUT, 1=HERE, 5=PRINTEROTHERS=NONE
?1_
WHERE DO YOU WANT A GRAPH, 1=HERE, 5=PRINTEROTHERS=NONE
?1_

AIM553Y A/C1 F4 TO A/C3 A4 ONE-ON-ONE
 1 AIM553Y A/C1 F4 TO A/C3 A4 ONE-ON-ONE

INPUT CONSTANTS FOR THIS RUN

FIGHTER OFFENSIVE MAX RANGE 24000.0 TARGET = 30000.0
 FIGHTER OPT MISSILE RANGE 6000.0 TARGET = 7500.0
 FIGHTER MINIMUM RANGE (GUN) 500.0 TARGET = 300.0
 FIGHTER GUN ENVELOPE RMAX 3000.0 TARGET = 3500.0
 FIGHTER ENERGY RELEVENCE 0.5000 TARGET = 0.7500
 FIGHTER INTER-ENVELOPE PENAL 0.0250 TARGET = 0.0500
 OFFENSIVE ATA= 60.0 AOT= 90.0
 OFF WEP ATA= 5.0 AOT= 40.0
 OFF WEP RMAX= 9000.0 RMIN= 3000.0
 FIGHT NEUTRAL BEYOND 18000.0 RANGE

TIME	DIR ANG	NRG FN	RNG FN	PERF	INDEX	STATE
1	20.00	1.0360	0.0500		19.63	N
2	23.33	0.9333	0.0277		21.17	N
3	26.11	0.9572	0.0169		24.57	N
4	28.89	0.9942	0.0113		28.39	O
5	31.67	0.9946	0.0036		31.22	O
6	34.44	0.9946	0.0075		34.00	O
7	36.11	0.9938	0.0075		35.62	O
8	38.89	0.9943	0.0064		38.42	N
9	40.56	0.9889	0.0101		39.70	N
10	40.56	0.9846	0.0127		39.43	N
11	41.67	0.9811	0.0159		40.23	N
12	41.67	0.9785	0.0196		39.97	N
13	40.56	0.9792	0.0237		38.77	O
14	41.67	0.9798	0.0272		39.71	O
15	41.67	0.9825	0.0297		39.72	O
16	42.22	0.9839	0.0307		40.27	O
17	43.33	0.9879	0.0298		41.54	O
18	43.89	0.9904	0.0271		42.29	O
19	43.89	0.9948	0.0231		42.65	O
20	45.00	0.9989	0.0187		44.11	O
21	44.44	0.9999	0.0143		43.80	O
22	42.78	1.0016	0.0105		42.39	O
23	42.78	1.0018	0.0075		42.53	O
24	37.78	1.0016	0.0053		37.64	N
25	34.44	1.0012	0.0037		34.36	N
26	29.44	1.0008	0.0027		29.39	N
27	26.67	1.0006	0.0020		26.63	N
28	24.44	1.0005	0.0018		24.41	N
29	25.00	1.0004	0.0023		24.95	O
30	22.78	1.0004	0.0027		22.73	O
31	20.56	1.0005	0.0023		20.52	N
32	18.33	1.0008	0.0018		18.31	N
33	21.11	1.0012	0.0019		21.10	N
34	20.00	1.0018	0.0024		19.99	N
35	15.00	1.0035	0.0031		15.01	N
36	20.00	1.0053	0.0040		20.02	N
37	15.56	1.0077	0.0053		15.59	N
38	15.00	1.0126	0.0070		15.03	N
39	12.78	1.0177	0.0091		12.89	N
40	11.11	1.0245	0.0115		11.25	N
41	9.44	1.0328	0.0143		9.62	N
42	6.67	1.0400	0.0171		6.82	N
43	8.89	1.0472	0.0197		9.12	N
44	9.44	1.0503	0.0220		9.70	N

1

TIME	DIR ANG	NRG FN	RNG FN	PERF INDEX	STATE
45	7.22	1.0556	0.0237	7.44	N
46	5.00	1.0578	0.0244	5.16	N
47	4.44	1.0602	0.0242	4.60	N
48	2.78	1.0587	0.0231	2.87	N
49	0.00	1.0573	0.0214	0.00	N
50	-1.67	0.9765	0.0065	-1.62	N
51	-7.22	0.9779	0.0060	-7.02	N
52	-12.22	0.9787	0.0054	-11.90	N
53	-18.89	0.9797	0.0049	-18.41	N
54	-24.44	0.9796	0.0046	-23.34	D
55	-29.89	0.9792	0.0044	-28.16	D
56	-35.00	0.9779	0.0044	-34.03	D
57	-40.56	0.9753	0.0046	-39.37	D
58	-47.22	0.9712	0.0050	-45.63	D
59	-52.22	0.9656	0.0057	-50.14	D
60	-57.78	0.9590	0.0066	-55.05	D
61	-57.22	0.9499	0.0078	-53.93	D
62	-61.11	0.9384	0.0093	-56.81	D
63	-64.44	0.9236	0.0113	-58.85	D
64	-67.22	0.9073	0.0139	-60.15	D
65	-72.22	0.8877	0.0169	-63.03	D
66	-73.89	0.8549	0.0238	-61.66	D
67	-75.56	0.8365	0.0289	-61.38	D
68	-75.00	0.8173	0.0346	-59.17	D
69	-75.00	0.8045	0.0412	-57.85	D
70	-73.89	0.7892	0.0431	-55.51	D
71	-72.22	0.7788	0.0549	-53.16	D
72	-70.00	0.7697	0.0620	-50.53	D
73	-68.33	0.7574	0.0690	-48.18	D
74	-66.67	0.7510	0.0755	-46.29	D
75	-65.00	0.7432	0.0813	-44.38	D
76	-62.22	0.7411	0.0863	-42.13	D
77	-61.11	0.7499	0.0901	-41.70	D
78	-58.89	0.7583	0.0931	-40.49	D
79	-57.22	0.7677	0.0953	-39.74	D
80	-55.56	0.7745	0.0965	-38.87	D
81	-54.44	0.7752	0.0965	-38.13	D
82	-54.44	0.7733	0.0958	-38.07	D
83	-53.33	0.7725	0.0943	-37.31	D
84	-51.67	0.7747	0.0922	-36.34	D
85	-49.44	0.7761	0.0888	-34.96	D
86	-45.00	0.7839	0.0939	-32.32	D
87	-40.00	0.7907	0.0790	-29.13	D
88	-34.44	0.7979	0.0744	-25.44	D
89	-31.67	0.8052	0.0782	-23.71	N

TIME	DIR ANG	NRG FN	RNG FN	PERF INDEX	STATE
90	-28.33	0.8061	0.0672	-21.31	D
91	-23.33	0.8109	0.0652	-17.69	N
92	-18.33	0.8179	0.0633	-14.05	N
93	-15.56	0.8200	0.0626	-11.96	N
94	-10.56	0.8236	0.0625	-8.15	N
95	-7.78	0.8260	0.0632	-6.02	N
96	-4.44	0.8258	0.0649	-3.43	N
97	-1.67	0.8271	0.0678	-1.28	N
98	-0.56	0.8272	0.0716	-0.43	N

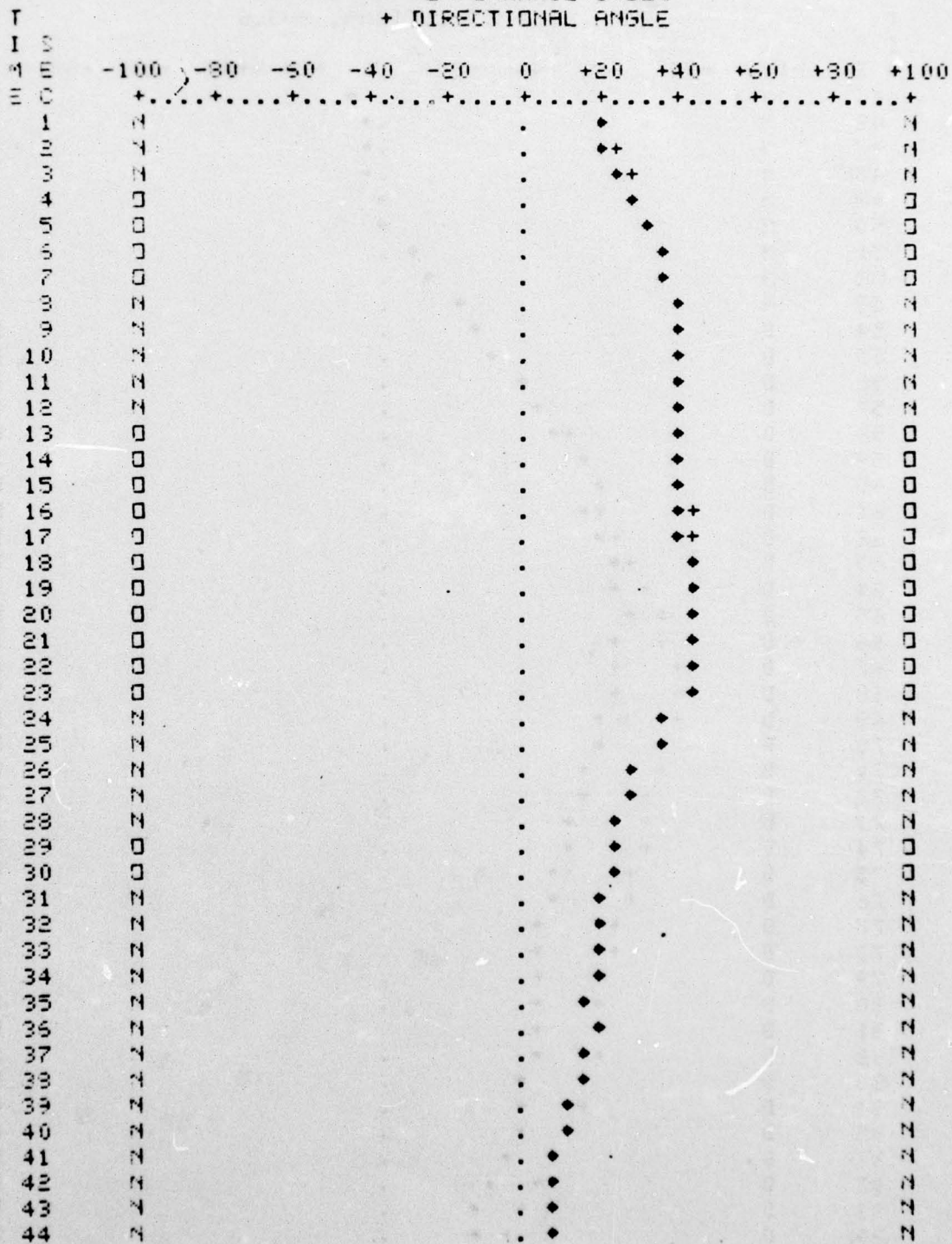
TM 77-2 SA

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AIM553Y A/C1 F4 TO A/C3 A4 ONE-ON-ONE

◆ PERFORMANCE INDEX

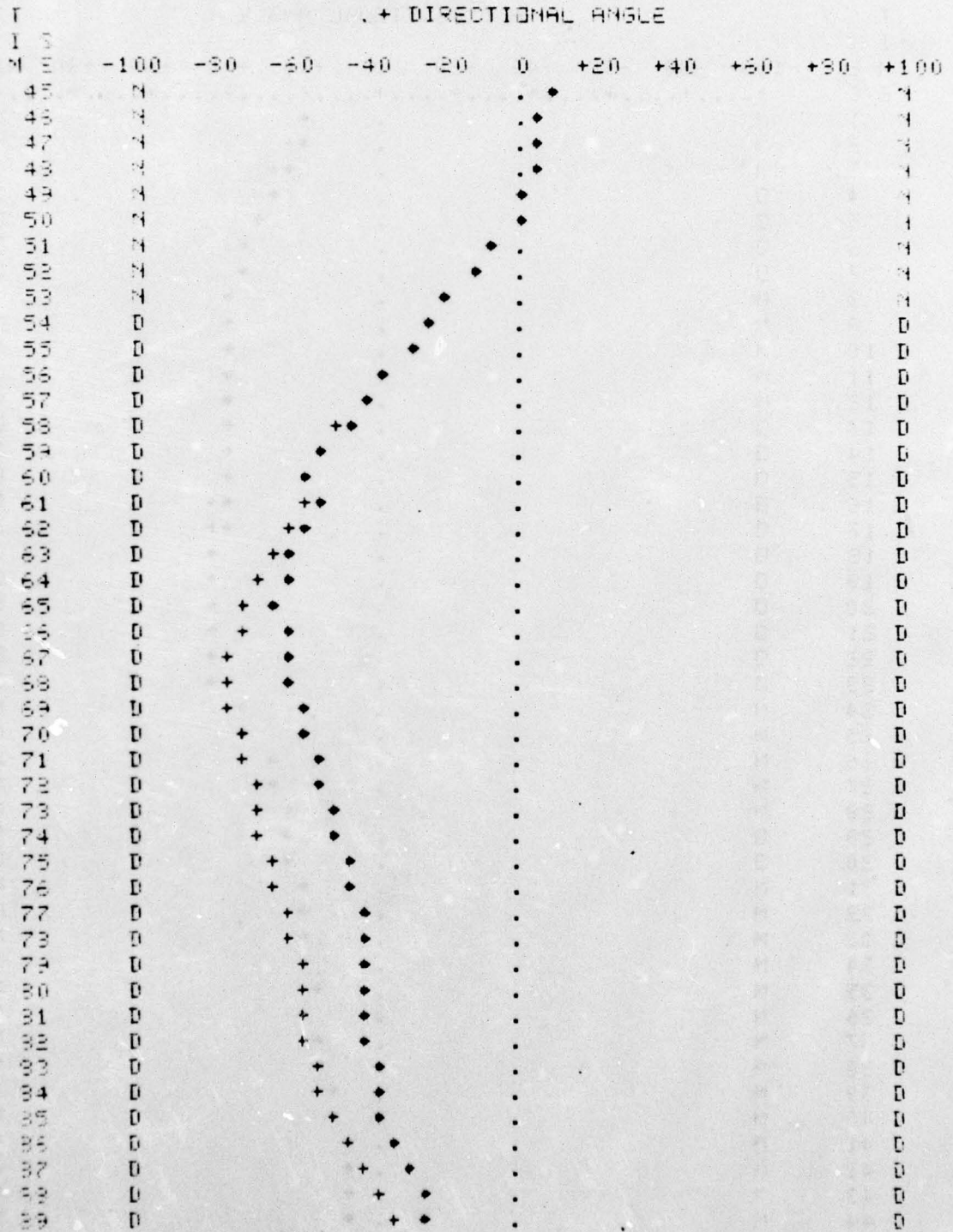
+ DIRECTIONAL ANGLE



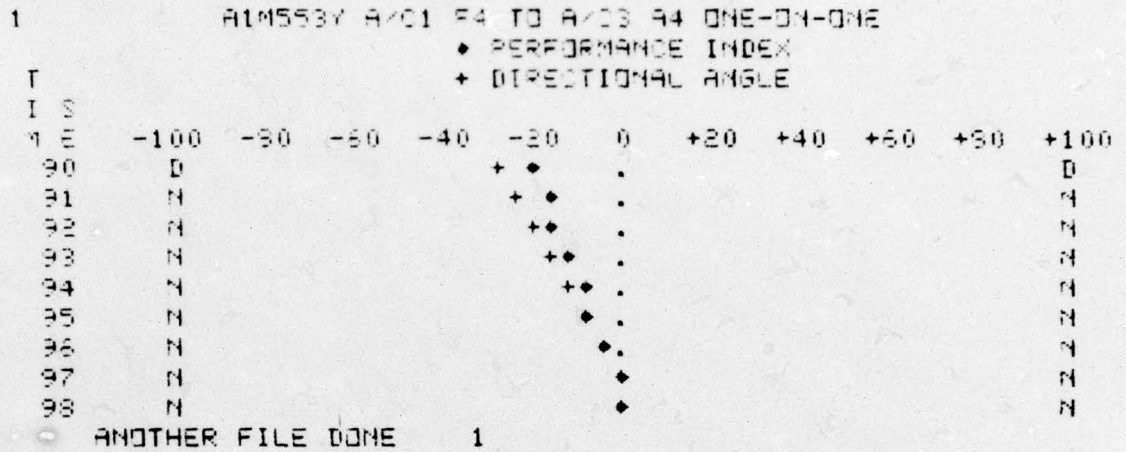
1 AIM553V A/C1 F4 TO A/C3 A4 ONE-ON-ONE

◆ PERFORMANCE INDEX

+ DIRECTIONAL ANGLE



TM 77-2 SA



REQUIRED FILE KEEPING TO SAVE DATA IS-
LOAD YOUR DATA FILE
ADD REF
SAVE
REMOVE REF, ACM
MAKE ACM AND REF
SAVE

TH-TH-THATS ALL FOLKS

END PFINDX 14.9 SEC.

SECTION ANALYSIS PROGRAM

L SECT12

FILE:SECT12 -08/16/76 10:01 AM.

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100  FERRMES
200  FILE  1=TRMNL,UNIT=REMOTE
300  FILE  2=ACM,UNIT=DISK
400  FILE  3=BCM,UNIT=DISK
500  FILE  4=REF,UNIT=DISK
600  FILE  5=RANDY,UNIT=PRINTER BACKUP DISK
810  C-
815  C- REFERENCES ***** REFERENCES ***** REFERENCES
620  C-  1--- NATO RPT SA-CBR-76 OF 26 JAN 1976
630  C-  2--- NATO RPT TM-76-13A OF 16 JUL 1976
640  C-  3--- CENTER FOR NAVAL ANALYSES RPT CRC 274 OF NOV 1974
650  C-
700  DIMENSION R1(500),R2(500),ES11(500),ES12(500),ES21(500),
800  -ES22(500),ADT1(500),ADT2(500),ATA1(500),ATA2(500),
900  -TITLE1(50),TITLE2(50),PI1(500),PI2(500),ISTAT1(500),
1000 -ISTAT2(500),PIS(500),PHI(500),STATE(500)
1100 DIMENSION AA(500),BE(500)
1200 DIMENSION CONCO(500)
1300 DIMENSION ISTAT(500)
1400 DATA BLANK, DOT, STAR, XXX, PLUS/" ", ". ", "♦", "X", "+"/
1500 DATA DOLL/"$"/
1600 DATA OFWEP, OFF, DEF, NUT, DEFAT, TRADE/"W", "O", "D", "N", "F", "T"/
1601 C-
1602 C- MANEUVER CONVERSION DATA  W=OFFENSIVE WEAPONS
1603 C-                               O=OFFENSIVE
1604 C-                               N=NEUTRAL
1605 C-                               D=DEFENSIVE
1606 C-                               F=FATAL DEFENSIVE
1607 C-                               T=TRADEOFF
1608 C-
1610 PRINT 433
1620 433 FORMAT(5X,"HOW MANY FILES AM I LOOKING AT ")
1630 READ(1,/) NFILES
1640 IFIL=1
1700 PRINT 434
1800 434 FORMAT(5X,"WHERE DO YOU WANT DATA OUT, 1=HERE, 5=PRINTER",
1900 -"OTHERS=NONE")
2000 READ(1,/) IPRINT
2100 PRINT 435
2200 435 FORMAT(5X,"WHERE DO YOU WANT A GRAPH, 1=HERE, 5=PRINTER",
2300 -"OTHERS=NONE")
2400 READ(1,/) IGRAF
2450 WRITE(1,775)
2455 86 CONTINUE
2460 775 FORMAT(2X,"GO TO SLEEP, I WILL CALL WHEN I AM READY")
2465 C-
2470 C- BEGIN INPUT FROM PERFORMANCE INDEX PROGRAM
2480 C- PAIR 1 DATA IS LOCATED IN DISK FILE ACM
2485 C- PAIR 2 DATA IS LOCATED IN DISK FILE BCM
2490 C-
2500 READ(2,/) N1
2700 READ(2,123) (TITLE1(I),I=1,50)
2800 123 FORMAT(50A1)

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2900 READ(2,/) (PI1(I),I=1,N1)
3000 READ(2,/) (ISTAT1(I),I=1,N1)
3100 READ(3,/) N2
3300 READ(3,123) (TITLE2(I),I=1,50)
3400 READ(3,/) (PI2(I),I=1,N2)
3500 READ(3,/) (ISTAT2(I),I=1,N2)
3600 N=N1
3700 IF(N2.LT.N1) N=N2
3800 PHIT=0.
3910 C-
3920 C- BEGIN COMPUTATION OF SECTION PERFORMANCE INDEX BY
3930 C- MAGNITUDE SUM METHOD OF REFERENCE 2
3940 C-
3950 DO 10 I=1,N
4000 PI1SQ=PI1(I)**2
4100 PI2SQ=PI2(I)**2
4200 RAD=ABS(PI1SQ+PI2SQ)
4300 IF(ABS(RAD).LT.0.1) PIS(I)=0.
4400 IF(ABS(RAD).LT.0.1) GO TO 3
4500 SIGN=(PI1SQ+PI2SQ)/RAD
4600 PIS(I)=SIGN*SQRT(RAD/2.)
4601 3 CONTINUE
4602 C-
4603 C- BEGIN COMPUTATION OF CONVERSION COEFFICIENT AS OUTLINED
4604 C- IN THE TEXT
4605 C-
4700 IF(ABS(PI1(I)).GT.100.) CONCO(I)=0.
4800 IF(ABS(PI2(I)).GT.100.) CONCO(I)=0.
4900 IF(ABS(PI1(I)).GT.100..OR.ABS(PI2(I)).GT.100.) GO TO 9
5000 IF((PI1(I).GT.30..AND.PI2(I).LT.30.)..OR.(PI2(I).GT.30..AND.
5100 -PI1(I).LT.30.)) GO TO 5
5200 CONCO(I)=PIS(I)
5300 GO TO 9
5400 5 IF(ABS(PI1(I)).LT.75..AND.ABS(PI2(I)).LT.75.) GO TO 6
5401 IF(ABS(PI1(I)).LT.0.1) PI1(I)=0.1
5402 IF(ABS(PI2(I)).LT.0.1) PI2(I)=0.1
5500 IF(ABS(PI1(I)).GT.ABS(PI2(I))) CONCO(I)=SQRT(PI1(I)**2*
5600 -(1.-ABS(PI2(I)/400.)))*PI1(I)/ABS(PI1(I))
5700 IF(ABS(PI2(I)).GT.ABS(PI1(I))) CONCO(I)=SQRT(PI2(I)**2*
5800 -(1.-ABS(PI1(I)/400.)))*PI2(I)/ABS(PI2(I))
5900 IF(ABS(PI1(I)).GT.75..AND.ABS(PI2(I)).GT.75.) CONCO(I)=PIS(I)
6000 GO TO 9
6100 6 IF(PI1(I).GT.PI2(I))
6200 -CONCO(I)=SQRT(PI1(I)**2*(1.-ABS(PI2(I))/75.))
6300 IF(PI2(I).GT.PI1(I))
6400 -CONCO(I)=SQRT(PI2(I)**2*(1.-ABS(PI1(I))/75.))
6500 9 XK1=ABS(PI1(I)-PIS(I))
6600 XK2=ABS(PI2(I)-PIS(I))
6700 DEN=XK2
6800 XNUM=XK1
6900 IF(XK1.GT.XK2) DEN=XK1
7000 IF(XK1.GT.XK2) XNUM=XK2
7050 IF(DEN.LT.0.1) PHI(I)=0.
7050 IF(DEN.LT.0.1) GO TO 10
7100 PHI(I)=XNUM/DEN
7200 10 PHIT=PHIT+PHI(I)
7300 PHIT=PHIT/N

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```

7310 C-
7320 C- COMPUTE ACM STATE FOR TWO ON ONE PER REFERENCE 3
7330 C-
7400 DO 20 I=1,N
7500 STATE(I)=DEF
7600 IF(ISTAT1(I).EQ.1.AND.ISTAT2(I).NE.5) STATE(I)=DFWEP
7700 IF(ISTAT2(I).EQ.1.AND.ISTAT1(I).NE.5) STATE(I)=DFWEP
7800 IF(ISTAT1(I).EQ.1.AND.ISTAT2(I).EQ.5) STATE(I)=TRADE
7900 IF(ISTAT2(I).EQ.1.AND.ISTAT1(I).EQ.5) STATE(I)=TRADE
8000 IF(ISTAT2(I).EQ.2.OR.ISTAT1(I).EQ.2) STATE(I)=OFF
8100 IF(ISTAT1(I).EQ.3.AND.ISTAT2(I).EQ.3) STATE(I)=NUT
8200 IF(ISTAT1(I).EQ.5.AND.ISTAT2(I).NE.1) STATE(I)=DEFAT
8300 IF(ISTAT2(I).EQ.5.AND.ISTAT1(I).NE.1) STATE(I)=DEFAT
8400 20 CONTINUE
8500 SUM=0.
8600 DO 30 J=1,N
8700 30 SUM=SUM+PHI(J)♦♦2
8800 COORD=1.-SORT(SUM/N)
8810 C-
8820 C- BEGIN PRINT OF OUTPUT
8830 C-
8900 IF(IPRINT.NE.1.AND.IPRINT.NE.5) GO TO 40
9000 WRITE(IPRINT,1003) (TITLE1(I),I=1,50), (TITLE2(I),I=1,50)
9100 1003 FORMAT(1H1,10X,50A1/11X,50A1)
9200 WRITE(IPRINT,301)
9300 301 FORMAT(5X,"TIME      PERF      PERF      PERF      CONVERSION  <<<
      <<< STATE"/
9400 -      5X,"      INDEX      INDEX      INDEX      COEFFICIENT <<<
      <<< (SECTION)"/
9500 -      5X,"      PAIR1      PAIR2      SECTN")
9600 KOUNT=1
9610 C-
9620 C- BEGIN GRAPHICAL COMPUTATIONS FOR OUTPUT GRAPH
9630 C-
9700 DO 40 J=1,N
9800 IF(KOUNT.EQ.45) WRITE(IPRINT,1003) (TITLE1(I),I=1,50),
9900 -(TITLE2(I),I=1,50)
10000 IF(KOUNT.EQ.45) WRITE(IPRINT,301)
10100 IF(KOUNT.EQ.45) KOUNT=0
10200 KOUNT=KOUNT+1
10300 WRITE(IPRINT,278) J,PI1(J),PI2(J),PIS(J),CONCO(J),STATE(J)
10400 278 FORMAT(5X,I3.4(3X,F6.2),9X,A1)
10500 40 CONTINUE
10600 IF(IPRINT.EQ.1.OR.IPRINT.EQ.5) WRITE(IPRINT,909) PHIT,COORD
10700 909 FORMAT(10X,"SECT COORD = ",F6.4,5X,"CONSISTENCY = ",F6.4)
10800 MT=1
10900 DO 44 I=1,N
11000 44 AA(I)=PIS(I)
11100 IF(IGRAF.NE.1.AND.IGRAF.NE.5) GO TO 50
11200 KOUNT=1
11300 WRITE(IGRAF,1003) (TITLE1(KK),KK=1,50), (TITLE2(KK),KK=1,50)
11400 WRITE(IGRAF,1114)
11500 1114 FORMAT(25X,"♦ SECTION INDEX + FOR TRADE-OFF",/,25X,
11600 -"§ CONVERSION COEFFICIENT ",/,1X,"I")
11700 WRITE(IGRAF,90)
11800 90 FORMAT(1X,"I",1X,"S",/1X,"M",1X,"E",3X,
11900 -"-100",2X,"-80",2X,"-60",2X,"-40",2X,"-20",

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TM 77-2 SA

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12000 -3X,"0",3X,"+20",2X,"+40",2X,"+60",2X,"+80",2X,"+100")
12100 DO 66 J=10,60
12200 BE(J)=DOT
12300 66 CONTINUE
12400 DO 66 J=10,60,5
12500 BE(J)=PLUS
12600 666 CONTINUE
12700 WRITE(IGRAF,77) (BE(J),J=10,60)
12800 77 FORMAT(1X,"E",1X,"C",5X,51A1)
12900 DO 99 I=1,N
13000 DO 99 J=10,60
13100 BE(J)=BLANK
13200 99 CONTINUE
13300 BE(35)=DOT
13400 BE(60)=STATE(I)
13500 BE(10)=STATE(I)
13600 IF (CONCO(I).GT.99.9.OR.CONCO(I).LT.-99.9) GO TO 4123
13700 K=.25*CONCO(I)+35.5
13800 BE(K)=DOLL
13900 GO TO 4133
14000 4123 BE(35)=XXX
14100 4133 CONTINUE
14200 IF (AR(I).GT.99.9.OR.AR(I).LT.-99.9) GO TO 9876
14300 J=.25*AR(I)+35.5
14400 BE(J)=STAR
14500 IF ((PI1(I).GT.75..AND.PI2(I).LT.-75.)OR.(PI1(I).LT.-75..
14600 -AND.PI2(I).GT.75.)) BE(J)=PLUS
14700 GO TO 7654
14800 9876 BE(35)=XXX
14900 7654 CONTINUE
15000 IF (KOUNT.EQ.45) WRITE(IGRAF,1003) (TITLE1(KK),KK=1,50),
15100 -(TITLE2(KK),KK=1,50)
15200 IF (KOUNT.EQ.45) WRITE(IGRAF,1114)
15300 IF (KOUNT.EQ.45) WRITE(IGRAF,90)
15400 IF (KOUNT.EQ.45) KOUNT=0
15500 KOUNT=KOUNT+1
15600 WRITE(IGRAF,11) MT, (BE(J),J=10,60)
15700 11 FORMAT(14,5X,51A1)
15800 MT=MT+1
15900 99 CONTINUE
16000 50 CONTINUE
16010 WRITE(1,776)
16020 776 FORMAT(2X,"WAKE UP, I HAVE DONE ANOTHER FILE")
16030 WRITE(1,123) (TITLE1(I),I=1,50)
16031 C-
16032 C- CREATE AN OUTPUT FILE ON DISK (REF) FOR FURTHER ANALYSIS
16033 C-
16050 WRITE(4,777) N
16060 777 FORMAT(2X,14)
16100 WRITE(4,789) (PI3(I),I=1,N)
16125 WRITE(4,787) (TITLE1(I),I=1,50), (TITLE2(I),I=1,50)
16150 787 FORMAT(2X,50A1,/,2X,50A1)
16200 789 FORMAT(50(2X,9(F6.2,""),F6.2/))
16300 DO 1141 J=1,N
16400 IF (STATE(J).EQ.OFWEP) ISTAT(J)=1
16500 IF (STATE(J).EQ.OFF) ISTAT(J)=2

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16600 IF (STATE(J).EQ.NUT) ISTAT(J)=3
16700 IF (STATE(J).EQ.DEF) ISTAT(J)=4
16800 IF (STATE(J).EQ.DEFAT) ISTAT(J)=5
16900 IF (STATE(J).EQ.TRADE) ISTAT(J)=6
17000 1141 CONTINUE
17100 WRITE (4,790) (ISTAT(I),I=1,N)
17200 790 FORMAT (50(2X,9(I1,""),I1/))
17300 WRITE (4,789) (CONCO(I),I=1,N)
17350 IFIL=IFIL+1
17360 IF (IFIL.LE.NFILES) GO TO 86
17400 8765 CALL EXIT
17500 END
```

END QUIKLST 3.1 SEC.

SECTION ANALYSIS PROGRAM OUTPUT
FOR EXAMPLE DATA SET

SECTION ANALYSIS PROGRAM OUTPUT
FOR EXAMPLE DATA SET

7 2

TM 77-2 SA

R SECT12_
RUNNING

HOW MANY FILES AM I LOOKING AT

?1_

WHERE DO YOU WANT DATA OUT, 1=HERE, 5=PRINTER OTHERS=NONE

?1_

WHERE DO YOU WANT A GRAPH, 1=HERE, 5=PRINTER OTHERS=NONE

?1_

GO TO SLEEP. I WILL CALL WHEN I AM READY

ENDING ANALYSIS PROGRAM OUTPUT

FOR EXAMPLE DATA SET

TM 77-2 SA

1

ADM564Y 1 TO 3 2 ON 1 TEST 5/40, 3-9K, 60/90, 13KM
 BCM564 2 ON 1, 2 TO 3 TEST 5/40, 3-9K, 60/90, 13KMAX

TIME	PERF INDEX PAIR1	PERF INDEX PAIR2	PERF INDEX SECT4	CONVERSION COEFFICIENT	STATE (SECTION)
1	-10.42	-2.53	-7.59	-7.59	N
2	-14.57	-3.56	-10.61	-10.61	N
3	-17.59	-4.27	-12.30	-12.30	N
4	-19.94	-5.30	-14.59	-14.59	N
5	-21.58	-6.20	-15.83	-15.83	N
6	-22.56	-7.43	-16.30	-16.30	N
7	-22.44	-7.61	-16.76	-16.76	N
8	-22.60	-8.43	-17.06	-17.06	N
9	-22.16	-8.71	-16.84	-16.84	N
10	-22.14	-8.81	-16.35	-16.35	N
11	-21.63	-9.34	-16.43	-16.43	N
12	-20.31	-9.51	-16.13	-16.13	N
13	-19.16	-9.21	-14.74	-14.74	N
14	-17.52	-6.07	-13.11	-13.11	N
15	-16.62	-4.71	-12.21	-12.21	N
16	-14.44	-3.49	-10.50	-10.50	N
17	-13.40	-2.09	-9.59	-9.59	N
18	-11.35	-0.54	-8.39	-8.39	N
19	-10.50	1.12	-7.33	-7.33	N
20	-9.32	3.34	-6.15	-6.15	N
21	-7.52	6.62	-2.52	-2.52	N
22	-6.89	9.11	3.02	3.02	N
23	-5.77	19.10	12.13	12.13	N
24	-4.30	22.07	15.32	15.32	N
25	-1.71	23.42	20.06	20.06	N
26	0.00	30.27	21.40	30.27	N
27	1.96	31.33	22.20	30.92	N
28	3.34	26.11	19.61	19.61	N
29	4.46	19.49	14.14	14.14	N
30	5.77	15.03	11.42	11.42	N
31	5.94	15.70	11.37	11.37	N
32	6.46	16.87	12.77	12.77	N
33	7.77	12.41	10.35	10.35	N
34	9.31	3.43	3.90	3.90	N
35	10.67	5.03	3.36	3.36	N
36	12.06	0.00	3.53	3.53	N
37	13.10	-6.01	3.23	3.23	N
38	14.35	-14.26	1.13	1.13	N
39	15.35	-19.25	-7.72	-7.72	N
40	19.71	-22.05	-3.25	-3.25	N
41	21.31	-27.62	-12.42	-12.42	N
42	24.32	-34.30	-17.03	-17.03	D
43	22.24	-38.72	-19.27	-19.27	D
44	22.72	-45.22	-22.13	20.60	D

TIME	ACMS64Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,18KM		BCMS64 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,18KMAX		STATE (SECTION)
	PERF INDEX PAIR1	PERF INDEX PAIR2	PERF INDEX SECTN	CONVERSION COEFFICIENT	
45	36.95	-51.77	-25.64	20.56	D
46	41.69	-57.70	-28.21	20.02	D
47	46.27	-63.68	-30.94	17.98	D
48	50.15	-69.74	-34.27	13.28	D
49	53.19	-74.23	-36.61	5.39	D
50	56.42	-79.85	-39.96	-74.00	F
51	61.57	-82.20	-38.51	-75.61	F
52	65.16	-82.88	-36.22	-75.33	F
53	70.45	-84.62	-33.15	-76.91	F
54	74.67	-85.21	-29.03	-76.35	F
55	79.10	-86.31	-25.93	-25.93	D
56	79.97	-87.94	-25.37	-25.37	D
57	79.37	-86.21	-23.30	-23.30	D
58	85.73	-80.62	20.62	20.62	D
59	86.90	-76.11	29.66	29.66	D
60	84.26	-71.60	31.41	76.35	D
61	82.32	-65.41	35.34	75.29	D
62	80.86	-59.66	39.35	74.70	D
63	78.21	-51.32	41.73	73.02	D
64	75.86	-40.72	45.26	71.90	D
65	72.02	-28.03	46.91	56.99	D
66	68.04	-19.76	46.04	58.39	D
67	62.60	-10.02	43.69	58.27	D
68	59.06	2.35	41.79	59.13	D
69	51.70	9.44	37.16	48.34	D
70	44.79	22.33	35.39	37.53	D
71	37.79	29.36	33.94	29.48	D
72	32.66	34.41	33.55	33.55	N
73	26.70	35.50	31.41	28.49	N
74	23.63	34.61	29.63	23.64	N
75	23.84	28.99	26.54	26.54	N
76	22.81	26.13	24.55	24.55	N
77	21.74	22.91	22.28	22.28	N
78	20.69	21.32	21.26	21.26	N
79	20.23	24.07	22.23	22.23	N
80	20.61	22.91	21.79	21.79	N
81	20.93	21.53	21.23	21.23	N
82	21.59	20.57	21.09	21.09	N
83	22.69	18.70	20.79	20.79	D
84	22.61	16.37	19.95	19.95	N
85	24.16	15.03	20.14	20.14	N
86	25.72	12.95	20.36	20.36	N
87	26.18	11.03	20.10	20.10	N
88	27.79	9.74	20.32	20.32	N
89	31.40	8.29	22.96	29.61	N

1 ACM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,18KM
 BCM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,18KMAX

TIME	PERF INDEX PAIR1	PERF INDEX PAIR2	PERF INDEX SECTN	CONVERSION COEFFICIENT	STATE (SECTION)
90	39.46	7.20	28.36	37.52	N
91	43.77	7.12	31.36	41.64	D
92	60.34	6.89	42.94	57.50	D
93	67.66	7.10	48.11	64.38	D
94	38.78	6.82	37.84	36.97	N
95	16.03	6.31	12.13	12.13	N
96	7.73	6.23	7.02	7.02	N
97	-0.55	5.70	4.01	4.01	N
98	-9.40	5.44	-5.42	-5.42	N
99	-21.05	5.09	-14.44	-14.44	N
100	-37.72	5.34	-26.40	-26.40	D
101	-53.27	5.56	-37.46	-37.46	D
102	-62.11	5.41	-43.75	-43.75	D
103	-64.73	5.48	-45.61	-45.61	D
104	-59.93	5.12	-42.22	-42.22	D
105	-55.49	5.13	-39.07	-39.07	N
106	-50.77	5.01	-35.72	-35.72	N
107	-48.95	4.54	-34.46	-34.46	N
108	-48.49	4.01	-34.17	-34.17	N
109	-45.40	3.40	-32.01	-32.01	N
110	-40.93	3.03	-28.86	-28.86	N
111	-38.62	2.63	-27.24	-27.24	N
112	-36.84	2.42	-25.99	-25.99	N
113	-35.56	2.31	-25.09	-25.09	N
114	-33.13	2.20	-23.37	-23.37	N
115	-33.36	2.28	-23.53	-23.53	N
116	-34.02	2.32	-24.00	-24.00	N
117	-34.56	2.34	-24.38	-24.38	N
118	-34.32	2.63	-24.20	-24.20	N
119	-29.77	2.97	-20.95	-20.95	N
120	-27.63	3.60	-19.37	-19.37	N
121	-25.92	4.71	-18.02	-18.02	N
122	-24.16	6.61	-16.43	-16.43	N
123	-22.40	8.72	-14.59	-14.59	N
124	-23.40	10.63	-14.74	-14.74	N
125	-23.42	13.14	-13.71	-13.71	N
126	-22.19	15.52	-11.21	-11.21	N
127	-20.39	15.03	-9.74	-9.74	N
128	-18.76	12.49	-9.90	-9.90	N
129	-18.42	10.13	-10.88	-10.88	N
130	-15.76	5.07	-11.30	-11.30	N
131	-14.47	2.47	-10.09	-10.09	N
132	-11.52	0.60	-8.13	-8.13	N
133	-8.92	4.05	-5.62	-5.62	N
134	-7.35	5.68	-3.93	-3.93	N

TM 77-2 SA

1 BOM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,19KM
 BOM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,19KMAX

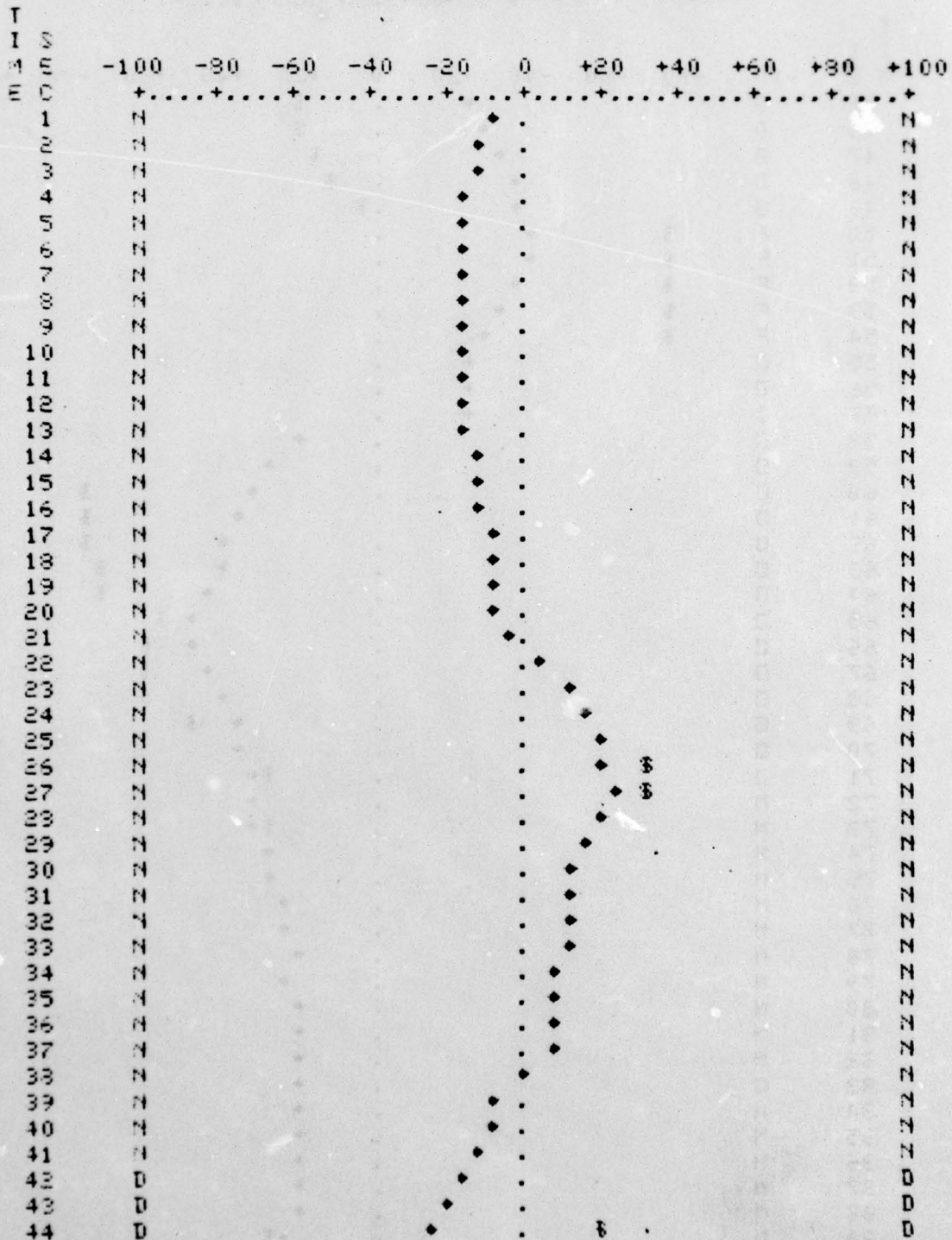
TIME	PERF INDEX PAIR1	PERF INDEX PAIR2	PERF INDEX SECTA	CONVERSION COEFFICIENT	STATE (SECTION)
135	-7.18	11.22	6.10	6.10	N
136	-5.00	16.18	10.83	10.83	N
137	-0.73	24.43	17.30	17.30	N
138	1.35	29.93	21.22	21.22	0
139	6.25	29.37	21.23	21.23	0
140	11.75	33.83	25.32	31.07	N
141	18.22	41.11	31.80	35.77	N
142	20.73	43.39	34.00	36.91	N
143	22.70	47.35	37.13	39.54	0
144	23.39	49.65	38.81	41.19	0
145	23.20	51.98	40.25	43.20	0
146	22.75	55.43	42.37	46.27	0
147	22.61	59.96	45.31	50.11	0
148	21.70	63.36	47.36	53.41	0
149	23.63	66.77	50.08	55.26	0
150	27.20	71.79	54.28	57.31	0
151	30.76	76.76	58.47	58.47	0
152	34.94	77.83	60.33	60.33	0
153	39.81	73.34	61.76	61.76	0
154	41.24	79.37	63.25	63.25	0
155	46.17	77.04	63.51	63.51	0
156	51.64	71.92	62.61	62.61	0
157	55.15	69.06	62.49	62.49	0
158	58.44	65.11	61.36	61.36	0
159	57.99	62.28	60.17	60.17	0
160	55.67	60.03	57.89	57.89	0
161	53.54	57.10	55.35	55.35	0
162	52.47	53.09	52.73	52.73	0
163	50.26	48.95	49.61	49.61	0
164	46.60	43.61	47.62	47.62	0

SECT CORR = 0.5645 CONSISTENCY = 0.4010

TM 77-2 SA

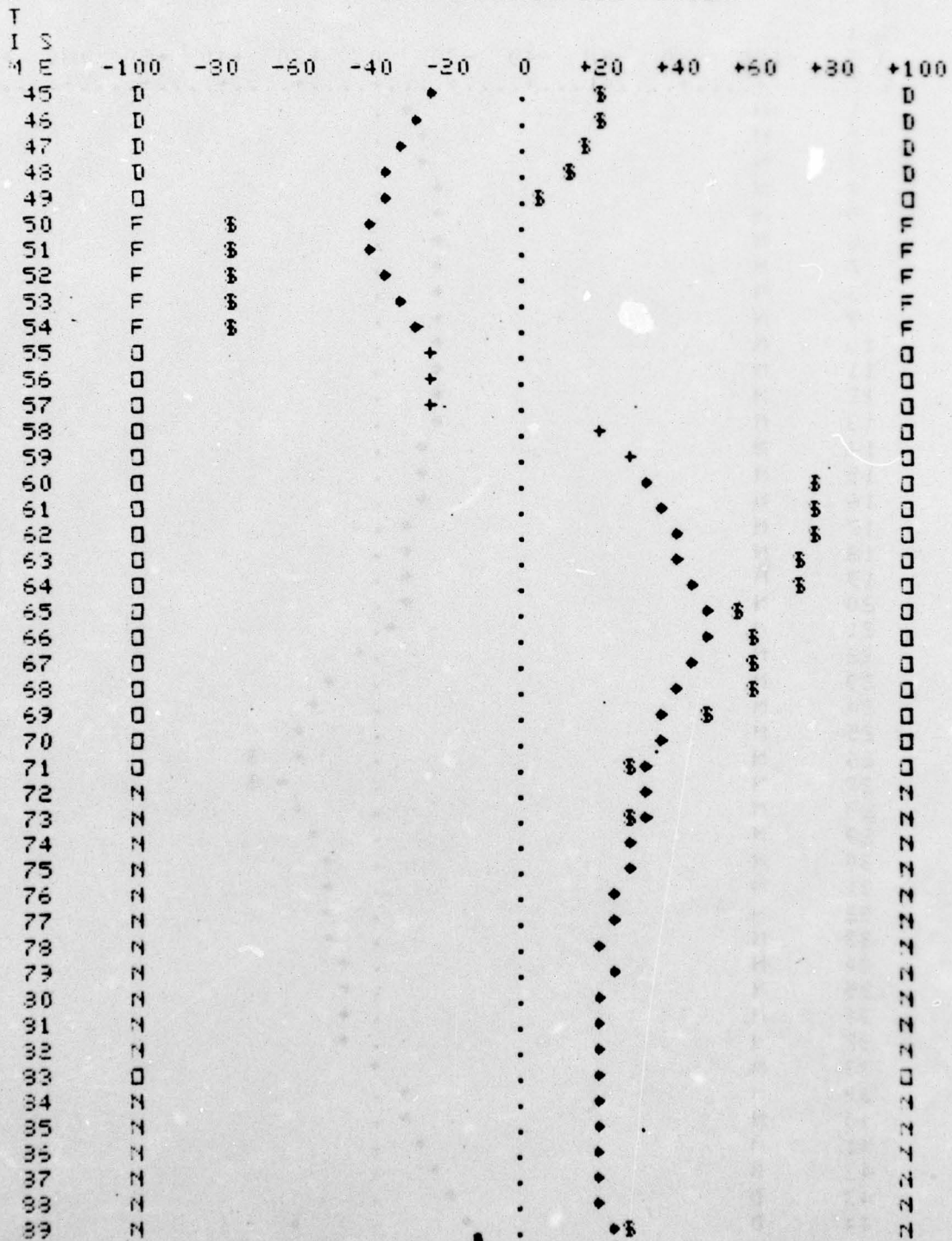
1

ACM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,18KM
 BCM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,18KMAX
 ◆ SECTION INDEX + FOR TRADE-OFF
 § CONVERSION COEFFICIENT



1

RCM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,18KM
 BCM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,18KMAX
 ◆ SECTION INDEX + FOR TRADE-OFF
 § CONVERSION COEFFICIENT

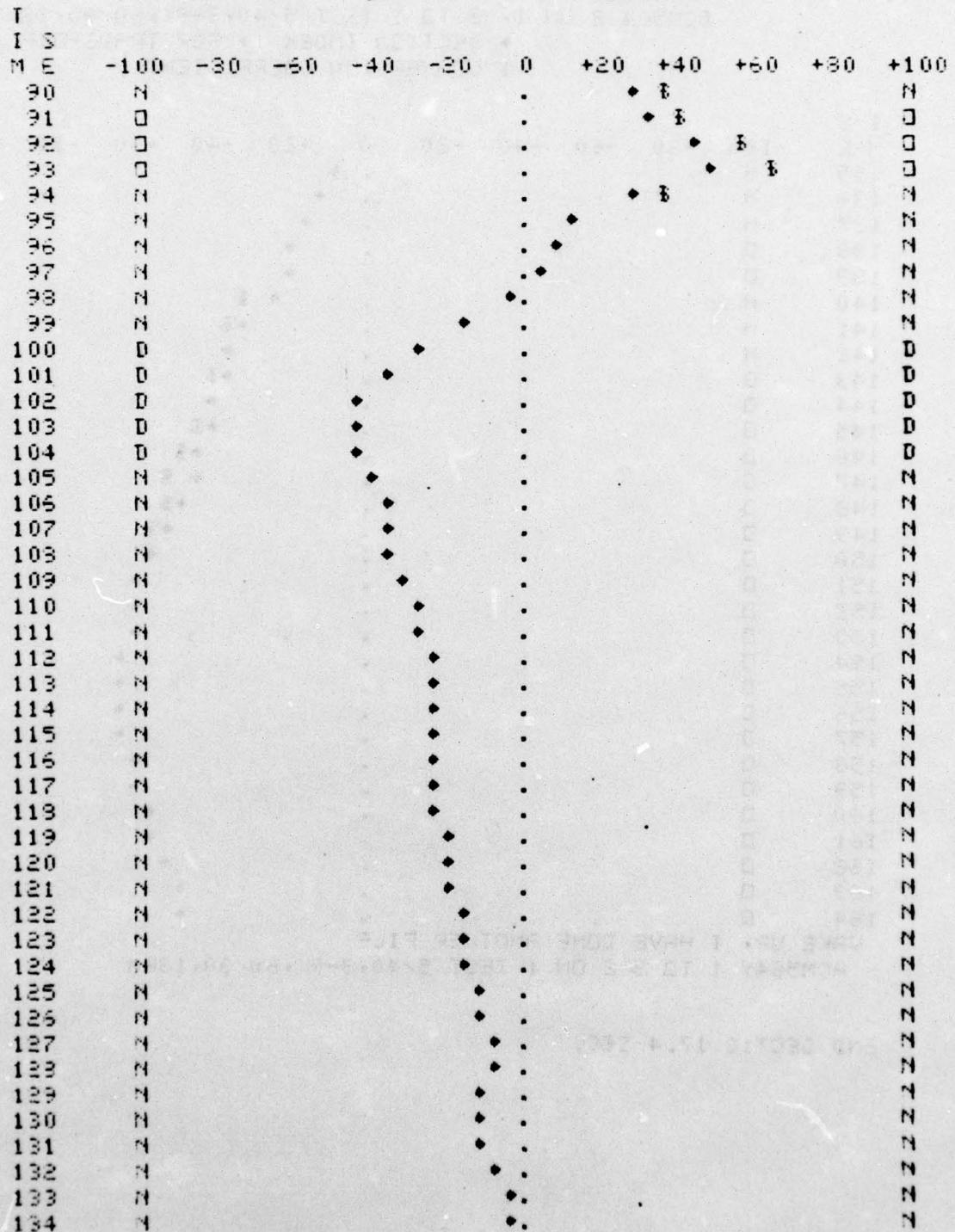


TM 77-2 SA

AS-47-87

1

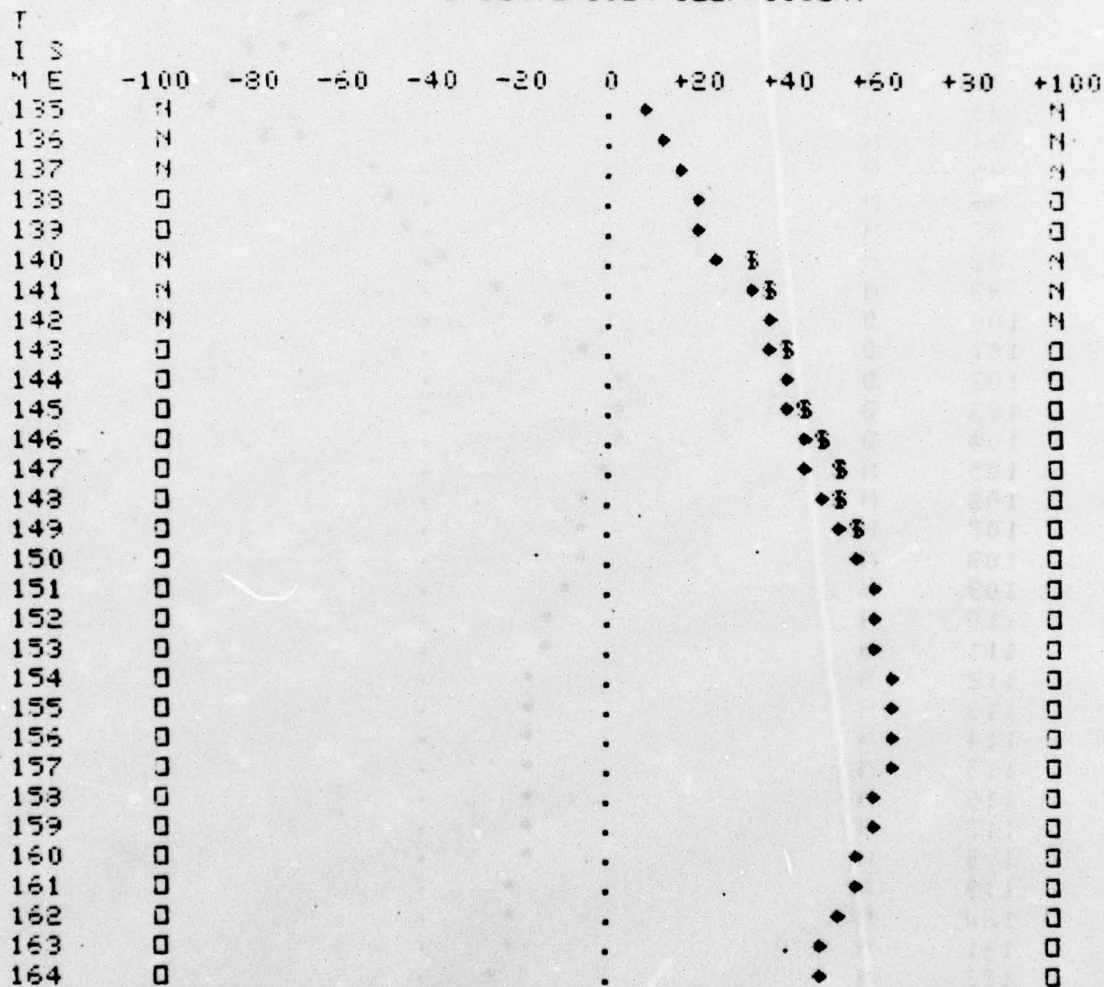
ACM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,13KM
 BCM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,13KMAX
 ♦ SECTION INDEX + FOR TRADE-OFF
 § CONVERSION COEFFICIENT



TM 77-2 SA

1

ACM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,13KM
BCM564 2 ON 1, 2 TO 3 TEST 5/40,3-9K,60/90,13KMAX
♦ SECTION INDEX + FOR TRADE-OFF
§ CONVERSION COEFFICIENT



WAKE UP, I HAVE DONE ANOTHER FILE

ACM564Y 1 TO 3 2 ON 1 TEST 5/40,3-9K,60/90,13KM

END SECT12 17.4 SEC.

STOCHASTIC ANALYSIS PROGRAM

FILE:STACM6 -08/23/76 10:33 AM.

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100 $ERRMES
200 FILE 1=TRMNL,UNIT=REMOTE
300 FILE 2=ACM,UNIT=DISK
400 FILE 3=BCM,UNIT=DISK
500 FILE 4=REF,UNIT=DISK
600 FILE 5=RANDY,UNIT=PRINTER BACKUP DISK
700 FILE 6=CCM,UNIT=DISK
800 FILE 7=OPT,UNIT=DISK
900 INTEGER GRAFOP
1000 DATA PLUS/"+"
1100 DATA BLANK/" "
1200 DATA DQT/"."
1300 DATA STAR/"*"
1400 DATA DOLL/"$"
1500 DATA AT/"#"
1600 DIMENSION TPCALE(5,51)
1700 DIMENSION N(40),PIS(40,300),SECTIT(40,140),ISTATS(40,300),
1800 -CONCD(40,300),NPAIR(80),PARTIT(80,70),PIPAIR(80,300),
1900 -ISTATP(80,300),A(300),B(300),KPIS(300),FPIS(250,120),
2000 -FREQ(300),CUMPIS(250,120),CUMP(300),PISMN(300),PISDEV(300),
2100 -PISM3(300),PISM4(300),ANS(4),FCC(250,120),CUMPCC(250,120)
2200 DIMENSION CCMN(300),CCDEV(300),CCM3(300),CCM4(300),KIPAIR(300),
2300 -FPIP(250,120),CUMPIP(250,120),PIPMN(300),PIPDEV(300),PIPM3(300),
2400 -PIPM4(300),NCS(6,6),CPS(6,6),TC(6),MXX(300),NAME1(40),NAME2(40)
2500 DIMENSION IFL(6),ITIS(6,300),TSCALE(6,51),TFREQ(6,51),TCUMP(6,51),
2600 -TMEAN(6),TDEV(6),TMOM3(6),TMOM4(6),CPP(5,5),NCP(5,5),ITIP(5,300),
2700 -TPFREQ(5,51),TPCUMP(5,51),TPMEAN(5),TPDEV(5),TPMOM3(5),TPMOM4(5)
2800 DIMENSION NAME3(40),NAME4(40)
2900 DIMENSION NAMES(40)
2910 DIMENSION IFM(6)
3000 C- READ IN REQUIRED CONSTANTS FOR DATA MANAGEMENT
3100 C-
3200 READ(7,/) NFILES,IPRINT,IGRAF,ICALC,DELTA,ICOMP
3300 GRAFOP=IGRAF/ABS(IGRAF)
3400 IGRAF=ABS(IGRAF)
3500 NKC=IGRAF/ICOMP
3600 NKC=IGRAF/ICOMP+0.999
3700 IF(NCK.NE.NKC) IGRAF=ICOMP
3800 101 FORMAT(40A1)
3900 READ(7,101) (NAME1(I),I=1,40)
4000 READ(7,101) (NAME2(I),I=1,40)
4100 READ(7,101) (NAME3(I),I=1,40)
4200 READ(7,101) (NAME4(I),I=1,40)
4300 READ(7,101) (NAME5(I),I=1,40)
4400 C-
4500 C-
4600 C- NFILES IS THE NUMBER OF DATA FILES TO BE REDUCED
4700 C-
4800 C-
4900 C- IPRINT IS OUTPUT OPTION, 1 FOR TERMINAL 5 FOR PRINTER
5000 C-
5100 C-
5200 C- IGRAF IS PLOTTING TIME INTERVAL + FOR FREQUENCY DATA - FOR FEO &
5300 C- CUMULATIVE PROBABILITY
5400 C-

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5500 C-
5600 C- ICALC IS CALCULATION OPTION 1 FOR CONVERSION COEFF & SECTION PI
5700 C- 2 FOR PAIRED PI IN ADDITION
5800 C- 3 FOR MANEUVER CONVERSION OF SECTION
5900 C- IN ADDITION TO 1&2
6000 C- 4 FOR ALL ABOVE PLUS IND
6100 C- PAIRED MAN CONV
6200 C- 5 FOR SECTION DATA ONLY (ALL COMPUTATIONS)
6210 C- DELTA IS GRID SIZE FOR CONTINUOUS COMPUTATIONS IN RANGE OF \\
\\ +/-100
6215 C-
6300 C- ICOMP IS THE FREQUENCY OF DATA COMPUTATION IN INTEGER SECONDS
6400 C- NAME1 IS THE TITLE FOR FREQUENCY DATA GRAPH
6500 C- NAME2 IS THE TITLE FOR PERFORMANCE INDEX GRAPH
6600 C- NAME3 IS THE TITLE FOR CUMULATIVE PROBABILITY GRAPH
6700 C- NAME4 IS THE TITLE FOR CONVERSION COEFFICIENT GRAPHS
6800 C- NAME5 IS THE TITLE FOR TIME IN STATE GRAPHS
6900 C- N IS NUMBER OF PTS IN SECTION FILES--IT HAS NFILES VALUES
7000 C- NPAIR IS THE NUMBER OF POINTS IN PAIRED FILES IT HAS
7100 C- 2.*NFILES VALUES
7200 C- FOR A 2 V 1 ENGAGEMENT
7300 C- PIS ARE THE SECTION PERFORMANCE INDICES IT HAS N(I) VALUES
7400 C- PER DATA FILE
7500 C- ISTATS ARE THE MANEUVER CONVERSION STATES--N(I) VALUES PER FILE
7600 C- 1=OFF WEAPONS
7700 C- 2=OFFENSIVE
7800 C- 3=NEUTRAL
7900 C- 4=DEFENSIVE
8000 C- 5=DEF FATAL
8100 C- 6=UTRADEOFF
8200 C- CONCO ARE THE CONVERSION COEFFICIENTS N(I) VALUES PER FILE
8300 C- PIPAIR ARE THE PAIRED PERF INDEX VALUES NPAIR(I) VALES PER PAIR
8400 C- PER FILE
8500 C- ISTATP ARE THE PAIRED STATE DATA SAME AS ISTATS BUT NO 6
8600 C- SECTIT A TITLE FOR SECTION,PARTIT-A TITLE FOR PAIRS
8700 DO 200 I=1,NFILES
8800 READ(2,/) N(I)
8900 JK=N(I)/10
9000 KJ=JK*10
9100 READ(2,/) (PIS(I,J),J=1,N(I))
9200 IF(KJ.EQ.N(I)) READ(2,300) BLANK
9300 READ(2,300) (SECTIT(I,J),J=1,70)
9400 READ(2,300) (SECTIT(I,J),J=71,140)
9500 READ(2,/) (ISTATS(I,J),J=1,N(I))
9600 READ(2,/) (CONCO(I,J),J=1,N(I))
9700 200 CONTINUE
9800 WRITE(1,310)
9900 310 FORMAT("I JUST READ ALL THE SECTION DATA")
10000 IF(ICALC.EQ.1.OR.ICALC.EQ.5) GO TO 500
10100 DO 400 I=1,NFILES
10200 READ(3,/) NPAIR(I)
10300 READ(3,300) (PARTIT(I,J),J=1,70)
10400 READ(3,/) (PIPAIR(I,J),J=1,NPAIR(I))
10500 READ(3,/) (ISTATP(I,J),J=1,NPAIR(I))
10600 400 CONTINUE
10700 WRITE(1,320)
10800 320 FORMAT("I JUST READ PAIR A DATA")
10900 DO 500 I=1,NFILES
11000 K=I+NFILES

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11100 READ(6, /) NPAIR(K)
11200 READ(6, 300) (PARTIT(K, J), J=1, 70)
11300 READ(6, /) (PIPAIR(K, J), J=1, NPAIR(K))
11400 READ(6, /) (ISTATP(K, J), J=1, NPAIR(K))
11500 500 CONTINUE
11600 WRITE(1, 330)
11700 330 FORMAT("I JUST READ PAIR B DATA")
11800 300 FORMAT(70A1)
11900 WRITE(1, 332)
12000 332 FORMAT("DATA ARE IN")
12100 WRITE(IPRINT, 410)
12200 410 FORMAT(1H1, 2X, "THE FOLLOWING DATA IS USED IN THIS RUN")
12300 WRITE(IPRINT, 300) ((SECTIT(I, J), J=1, 140), I=1, NFILES)
12400 NBIG=0
12500 NPBIG=0
12600 DO 501 I=1, NFILES
12700 IF(N(I).GT.NBIG) NBIG=N(I)
12800 IF(NPAIR(I).GT.NPBIG) NPBIG=NPAIR(I)
12900 501 CONTINUE
13000 NPTS=200./DELTA+1
13100 C-
13200 C-
13300 C- SECTION INDEX FREQUENCY DISTRIBUTIONS IN TIME
13400 C-
13500 C-
13600 DO 600 I=1, NBIG, ICOMP
13700 KSET=I
13800 K=0
13900 DO 550 J=1, NFILES
14000 IF(N(J).LT.I) GO TO 550
14100 K=K+1
14200 A(K)=PIS(J, I)
14300 KPIS(I)=K
14400 B(K)=CONCO(J, I)
14500 550 CONTINUE
14600 IF(K.LT.10) GO TO 610
14700 CALL FREDIS(-100., 100., DELTA, A, K, FREQ, CUMP, ANS)
14800 DO 570 J=1, NPTS
14900 FPIS(I, J)=FREQ(J)
15000 570 CUMPIS(I, J)=CUMP(J)
15100 PISMN(I)=ANS(1)
15200 PISDEV(I)=ANS(2)
15300 PISM3(I)=ANS(3)
15400 PISM4(I)=ANS(4)
15500 CALL FREDIS(-100., 100., DELTA, B, K, FREQ, CUMP, ANS)
15600 DO 580 J=1, NPTS
15700 FOC(I, J)=FREQ(J)
15800 580 CUMPOC(I, J)=CUMP(J)
15900 COMN(I)=ANS(1)
16000 CODEV(I)=ANS(2)
16100 COM3(I)=ANS(3)
16200 COM4(I)=ANS(4)
16300 600 CONTINUE
16400 GO TO 620
16500 610 KSET=I-ICOMP
16600 620 CONTINUE
16700 WRITE(1, 333) KSET
16800 333 FORMAT("I JUST FINISHED SECTION FREQ DATA FOR", I3, " PTS")
16900 IF(ICALC.EQ.1.OR.ICALC.EQ.5) GO TO 920

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17000 C-
17100 C-
17200 C- CALCULATE PAIRED INFORMATION FREQUENCY DATA
17300 C-
17400 C-
17500 DO 300 I=1,NPBIG,ICOMP
17600 KPARLS=I
17700 K=0
17800 KQ=NFILES*2
17900 DO 650 J=1,KQ
18000 IF(NPAIR(J).LT.I) GO TO 650
18100 K=K+1
18200 A(K)=PIPAIR(J,I)
18300 KIPAIR(I)=K
18400 650 CONTINUE
18500 IF(K.LT.10) GO TO 310
18600 CALL FREDIS(-100.,100.,DELTA,A,K,FREQ,CUMP,ANS)
18700 DO 770 J=1,NPTS
18800 FPIP(I,J)=FREQ(J)
18900 770 CUMPIP(I,J)=CUMP(J)
19000 PIPMN(I)=ANS(1)
19100 PIPDEV(I)=ANS(2)
19200 PIPM3(I)=ANS(3)
19300 PIPM4(I)=ANS(4)
19400 300 CONTINUE
19500 GO TO 320
19600 310 KPARLS=I-ICOMP
19700 320 CONTINUE
19800 WRITE(1,334) KPARLS
19900 334 FORMAT("I JUST FINISHED PAIRED FREQ DATA FOR",I3," PTS")
20000 C-
20100 C-
20200 C- CALCULATE SECTION MANEUVER CONVERSION DATA
20300 C-
20400 C-
20500 IF(ICALC.LT.3) GO TO 1201
20600 DO 950 I=1,6
20700 DO 950 J=1,6
20800 CPS(I,J)=0.
20900 950 NCS(I,J)=0.
21000 DO 900 I=1,NFILES
21100 NN=N(I)-1
21200 DO 900 J=1,NN
21300 IF(ISTATS(I,J).LE.0.OR.ISTATS(I,J+1).LE.0) GO TO 900
21400 IF(ISTATS(I,J).EQ.ISTATS(I,J+1)) GO TO 900
21500 IDEX=ISTATS(I,J)
21600 JDEX=ISTATS(I,J+1)
21700 NCS(IDEX,JDEX)=NCS(IDEX,JDEX)+1
21800 900 CONTINUE
21900 DO 1000 I=1,6
22000 TC(I)=0.
22100 DO 1000 J=1,6
22200 1000 TC(I)=NCS(I,J)+TC(I)

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22300 DO 1200 I=1,6
22400 DO 1200 J=1,6
22500 IF (I.EQ.J) GO TO 1200
22600 IF (TC(I).LT.0.5) CPS(I,J)=0.
22700 IF (TC(I).LT.0.5) GO TO 1200
22800 CPS(I,J)=NCS(I,J)/TC(I)
22900 1200 CONTINUE
23000 1201 CONTINUE
23100 WRITE(1,335)
23200 335 FORMAT("I JUST FINISHED SECTION MANEUVER CONV DATA")
23300 C-
23400 C-
23500 C- CALCULATE TIME IN STATE DISTRIBUTION
23600 C-
23700 C-
23800 IF (ICALC.LT.3) GO TO 2702
23900 DO 1600 I=1,6
24000 IFL(I)=1
24100 DO 1600 J=1,300
24200 1600 ITIS(I,J)=0.
24300 DO 1900 I=1,NFILES
24400 NN=N(I)-1
24500 DO 1300 J=1,NN
24600 M=ISTATS(I,J)
24700 L=IFL(M)
24800 IF (ISTATS(I,J).EQ.ISTATS(I,J+1)) GO TO 1750
24900 IFL(M)=IFL(M)+1
25000 1750 ITIS(M,L)=ITIS(M,L)+1
25100 IF (J.EQ.NN.AND.ISTATS(I,J).EQ.ISTATS(I,J+1)) ITIS(M,L)=0.
25200 IF (ITIS(M,L).EQ.0) IFL(M)=IFL(M)-1
25300 1300 CONTINUE
25400 TMAX=0.
25500 DO 2000 I=1,6
25600 NN=IFL(I)
25610 TMAX=0.
25700 DO 1950 J=1,NN
25800 A(J)=ITIS(I,J)
25900 1950 IF (ITIS(I,J).GT.TMAX) TMAX=ITIS(I,J)
26000 IF (TMAX.LT.0.5) GO TO 2050
26100 DEL=TMAX/50.
26200 DO 1900 K=1,51
26300 1900 TSCALE(I,K)=(K-1)*DEL
26310 IF (NN.LT.3) GO TO 2050
26400 CALL FREDIS(0.,TMAX,DEL,A,NN,FREQ,CUMP,ANS)
26500 DO 1950 K=1,51
26600 TFREQ(I,K)=FREQ(K)
26700 1950 TCUMP(I,K)=CUMP(K)
26800 TMEAN(I)=ANS(1)
26900 TDEV(I)=ANS(2)
27000 TMOM3(I)=ANS(3)
27100 TMOM4(I)=ANS(4)
27200 GO TO 2000

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27300 2050 CONTINUE
27400 DO 2050 K=1,51
27500 TSCALE(I,K)=0.
27600 TFREQ(I,K)=0.
27700 2050 TCUMP(I,K)=0.
27800 TMEAN(I)=0.
27900 TDEV(I)=0.
28000 TMQM3(I)=0.
28100 TMQM4(I)=0.
28200 2000 CONTINUE
28300 WRITE(1,2001)
28400 2001 FORMAT("I JUST FINISHED SECTION TIME IN STATE")
28500 C-
28600 C-
28700 C- CALCULATE PAIRED MANEUVER CONVERSION DATA
28800 C-
28900 C-
29000 IF(ICALC.NE.4) GO TO 2702
29100 DO 2100 I=1,5
29200 DO 2100 J=1,5
29300 CPP(I,J)=0.
29400 2100 NCP(I,J)=0
29500 NX=2.*NFILES
29600 DO 2200 I=1,NX
29700 NN=NPAIR(I)-1
29800 DO 2200 J=1,NN
29900 IF(ISTATP(I,J).LE.0.OR.ISTATP(I,J+1).LE.0) GO TO 2200
30000 IF(ISTATP(I,J).EQ.ISTATP(I,J+1)) GO TO 2200
30100 IDEX=ISTATP(I,J)
30200 JDEX=ISTATP(I,J+1)
30300 NCP(IDEX,JDEX)=NCP(IDEX,JDEX)+1
30400 2200 CONTINUE
30500 DO 2300 I=1,5
30600 TC(I)=0.
30700 DO 2300 J=1,5
30800 2300 TC(I)=TC(I)+NCP(I,J)
30900 DO 2400 I=1,5
31000 DO 2400 J=1,5
31100 IF(I.EQ.J) GO TO 2400
31200 IF(TC(I).LT.0.5) CPP(I,J)=0.
31300 IF(TC(I).LT.0.5) GO TO 2400
31400 CPP(I,J)=NCP(I,J)/TC(I)
31500 2400 CONTINUE
31600 WRITE(1,2401)
31700 2401 FORMAT("I JUST FINISHED PAIRED MAN CONV")
31800 C- C-
31900 C-
32000 C- CALCULATE TIME IN STATE FOR PAIRS
32100 C-
32200 C-
32300 DO 2500 I=1,5
32400 IFM(I)=1
32500 DO 2500 J=1,300
32600 2500 ITIP(I,J)=0
32700 DO 2600 I=1,NX
32800 NN=NPAIR(I)-1

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32900 DO 2600 J=1,NN
33000 M=ISTATP(I,J)
33100 L=IFM(M)
33200 IF (ISTATP(I,J).EQ.ISTATP(I,J+1)) GO TO 2550
33300 IFM(M)=IFM(M)+1
33400 2550 ITIP(M,L)=ITIP(M,L)+1
33500 IF (J.EQ.NN.AND.ISTATP(I,J).EQ.ISTATP(I,J+1)) ITIP(M,L)=0
33600 IF (ITIP(M,L).EQ.0) IFM(M)=IFM(M)-1
33700 2600 CONTINUE
33800 TMAX=0.
33900 DO 2700 I=1,5
34000 NN=IFM(I)
34100 TMAX=0.
34200 DO 2610 J=1,NN
34300 A(J)=ITIP(I,J)
34400 2610 IF (ITIP(I,J).GT.TMAX) TMAX=ITIP(I,J)
34500 IF (TMAX.LT.0.5) GO TO 2655
34600 DEL=TMAX/50.
34700 DO 2620 K=1,51
34800 2620 TPCALC(I,K)=(K-1)*DEL
34810 IF (NN.LT.3) GO TO 2655
34900 CALL FREDIS(0.,TMAX,DEL,A,NN,FREQ,CUMP,ANS)
35000 DO 2650 K=1,51
35100 TPFREQ(I,K)=FREQ(K)
35200 2650 TPCUMP(I,K)=CUMP(K)
35300 TPMEAN(I)=ANS(1)
35400 TPDEV(I)=ANS(2)
35500 TPMOM3(I)=ANS(3)
35600 TPMOM4(I)=ANS(4)
35700 GO TO 2700
35800 2655 CONTINUE
35900 DO 2656 K=1,51
36000 TPFREQ(I,K)=0.
36100 TPCUMP(I,K)=0.
36200 2656 TPCALC(I,K)=0.
36300 TPMEAN(I)=0.
36400 TPDEV(I)=0.
36500 TPMOM3(I)=0.
36600 TPMOM4(I)=0.
36700 2700 CONTINUE
36800 2702 CONTINUE
36900 WRITE(1,2701)
37000 2701 FORMAT("I JUST FINISHED PAIRED TIME IN STATE-OUTPUT BEGINS")
37010 C-
37020 C- BEGIN OUTPUT OF THE COMPUTED DATA
37030 C-
37040 C- THE COMPUTED DISTRIBUTION OF THE SECTION PERF INDICES
37050 C-

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37100 DO 7950 J=1,NPTS
37200 7950 MXX(J)=-100.+(J-1)*DELTA
37300 WRITE (IPRINT,8000)
37400 8000 FORMAT (1H1,2X,"PERFORMANCE INDICES DISTRIBUTION")
37500 NMXP= NPTS/10
37600 NMXP=NMXP*10
37700 DO 9000 KQ=1,NMXP,10
37800 KQ9=KQ+9
37900 WRITE (IPRINT,8001) (MXX(I),I=KQ,KQ9)
38000 8001 FORMAT (2X,"TIME FREQ(",I4,") FREQ(",I4,") FREQ(",
38100 -I4,") FREQ(",I4,") FREQ(",I4,") FREQ(",I4,") FREQ(",
38200 -I4,") FREQ(",I4,") FREQ(",I4,") FREQ(",I4,")")
38300 DO 9000 J=1,KSET,ICOMP
38400 WRITE (IPRINT,8950) J, (FPIS(J,K),K=KQ,KQ9)
38500 8950 FORMAT (2X,I4,F12.5,9F12.5)
38600 9000 CONTINUE
38700 NR=NMXP+1
38800 WRITE (IPRINT,8001) (MXX(I),I=NR,NPTS)
38900 DO 9001 J=1,KSET,ICOMP
39000 WRITE (IPRINT,8950) J, (FPIS(J,K),K=NR,NPTS)
39100 9001 CONTINUE
39200 WRITE (IPRINT,8975)
39300 8975 FORMAT (1H1,2X,"SUMMARY STATISTICS FOR PERF INDICES DIST")
39400 WRITE (IPRINT,9002)
39500 9002 FORMAT (2X,"TIME NPTS MEAN VARIANCE 3RDMOM",
39600 -" 4THMOM")
39700 DO 9004 I=1,KSET,ICOMP
39800 WRITE (IPRINT,9003) I,KPIS(I),PISMN(I),PISDEV(I),PISM3(I),PISM4(I)
39900 9004 CONTINUE
40000 9003 FORMAT (2X,I4,I7,F7.2,F10.2,F12.2,F14.2)
40100 DO 10000 J=1,KSET,IGRAF
40200 WRITE (4,9200) J
40300 9200 FORMAT ("TIME ",I4)
40400 BACKSPACE 4
40500 READ (4,9205) (NAME2(I),I=31,40)
40600 9205 FORMAT (10A1)
40700 DO 9500 K=1,NPTS
40800 B(K)=CUMPIS(J,K)
40900 9500 A(K)=FPIS(J,K)
41000 CALL PLOT (MXX,A,NPTS,IPRINT,NAME2,NAME1)
41100 IF (GRAFOP.EQ.-1) CALL PLOT (MXX,B,NPTS,IPRINT,NAME2,NAME3)
41200 10000 CONTINUE
41300 WRITE (1,2999)
41400 2999 FORMAT (" PISECT IS OUT")
41410 C-
41420 C- THE COMPUTED DISTRIBUTION OF THE CONVERSION COEFFICIENTS
41430 C-
41500 WRITE (IPRINT,3000)
41600 3000 FORMAT (1H1,2X,"CONVERSION COEFFICIENT DISTRIBUTION")
41700 DO 3100 KQ=1,NMXP,10
41800 KQ9=KQ+9
41900 WRITE (IPRINT,8001) (MXX(I),I=KQ,KQ9)

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42000 DO 3100 J=1,KSET,ICOMP
42100 WRITE (IPRINT,8950) J, (FCC(J,K),K=K0,K09)
42200 3100 CONTINUE
42300 WRITE (IPRINT,8001) (MXX(I),I=NR,NPTS)
42400 DO 3101 J=1,KSET,ICOMP
42500 WRITE (IPRINT,8950) J, (FCC(J,K),K=NR,NPTS)
42600 3101 CONTINUE
42700 WRITE (IPRINT,3120)
42800 3120 FORMAT (1H1,2X,"SUMMARY STATISTICS FOR CONVERSION COEFF")
42900 WRITE (IPRINT,9002)
43000 DO 3102 I=1,KSET,ICOMP
43100 WRITE (IPRINT,9003) I,KPIS(I),CCMN(I),CCDEV(I),CCM3(I),CCM4(I)
43200 3102 CONTINUE
43300 DO 3200 J=1,KSET,IGRAF
43400 WRITE (4,9200) J
43500 BACKSPACE 4
43600 READ (4,9205) (NAME4(I),I=31,40)
43700 DO 3150 K=1,NPTS
43800 B(K)=CUMPCO(J,K)
43900 3150 A(K)=FCC(J,K)
44000 CALL PLOT(MXX,A,NPTS,IPRINT,NAME4,NAME1)
44100 IF (GRAFOPT.EQ.-1) CALL PLOT(MXX,B,NPTS,IPRINT,NAME4,NAME3)
44200 3200 CONTINUE
44300 WRITE (1,9201)
44400 3201 FORMAT ("CONV COEFF IS OUT")
44500 IF (ICALC.NE.1.AND.ICALC.NE.4) GO TO 3603
44510 C-
44520 C- THE COMPUTED DISTRIBUTION OF THE PAIRED PERFORMANCE INDICES
44530 C-
44600 WRITE (IPRINT,3300)
44700 3300 FORMAT (1H1,2X,"PAIRED PERFORMANCE INDICES DISTRIBUTION")
44800 DO 3400 K0=1,NMXPT,10
44900 K09=K0+9
45000 WRITE (IPRINT,8001) (MXX(I),I=K0,K09)
45100 DO 3400 J=1,KPARLS,ICOMP
45200 WRITE (IPRINT,8950) J, (FPIP(J,K),K=K0,K09)
45300 3400 CONTINUE
45400 WRITE (IPRINT,8001) (MXX(I),I=NR,NPTS)
45500 DO 3401 J=1,KPARLS,ICOMP
45600 WRITE (IPRINT,8950) J, (FPIP(J,K),K=NR,NPTS)
45700 3401 CONTINUE
45800 WRITE (IPRINT,9002)
45900 DO 3402 I=1,KPARLS,ICOMP
46000 WRITE (IPRINT,9003) I,KIPAIR(I),PIPMN(I),PIPDEV(I),PIPM3(I),
46100 -PIPM4(I)
46200 3402 CONTINUE
46300 DO 3600 J=1,KPARLS,IGRAF
46400 WRITE (4,9200) J
46500 BACKSPACE 4
46600 READ (4,9205) (NAME2(I),I=31,40)
46700 DO 3550 K=1,NPTS
46800 B(K)=CUMPIP(J,K)
46900 3550 A(K)=FPIP(J,K)

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47000 CALL PLOT(MXX,A,NPTS,IPRINT,NAME2,NAME1)
47100 IF(GRAFOP.EQ.-1) CALL PLOT(MXX,B,NPTS,IPRINT,NAME2,NAME3)
47200 3600 CONTINUE
47300 3603 CONTINUE
47400 WRITE(1,3601)
47500 3601 FORMAT("PI PAIR IS OUT")
47600 IF(ICALC.LT.3) GO TO 3633
47700 WRITE(IPRINT,3604)
47800 3604 FORMAT(1H1,2X,"SECTION MANEUVER CONVERSION/CONVERSION",
47900 -" PROBABILITY MATRIX")
48000 WRITE(IPRINT,3603)
48100 3603 FORMAT(15X,"OFF WEP    OFFENSIVE NEUTRAL    DEFENSIVE ",
48200 -"DEF FAT    TRADEOFF")
48300 WRITE(IPRINT,3610) (CPS(1,J),J=2,6)
48400 3610 FORMAT(2X,"OFF WEP          *",5X,5F10.4)
48500 WRITE(IPRINT,3612) CPS(2,1), (CPS(2,J),J=3,6)
48600 3612 FORMAT(2X,"OFFENSIVE ",F10.4,4X,"*",5X,4F10.4)
48700 WRITE(IPRINT,3614) (CPS(3,J),J=1,2), (CPS(3,J),J=4,6)
48800 3614 FORMAT(2X,"NEUTRAL . ",2F10.4,4X,"*",5X,3F10.4)
48900 WRITE(IPRINT,3616) (CPS(4,J),J=1,3), (CPS(4,J),J=5,6)
49000 3616 FORMAT(2X,"DEFENSIVE ",3F10.4,4X,"*",5X,2F10.4)
49100 WRITE(IPRINT,3618) (CPS(5,J),J=1,4), (CPS(5,6))
49200 3618 FORMAT(2X,"DEF FAT    ",4F10.4,4X,"*",5X,F10.4)
49300 WRITE(IPRINT,3620) (CPS(6,J),J=1,5)
49400 3620 FORMAT(2X,"TRADEOFF    ",5F10.4,4X,"*")
49500 WRITE(IPRINT,3622)
49600 3622 FORMAT(1H1,2X,"SECTION TIME IN STATE DISTRIBUTION")
49700 WRITE(IPRINT,3624)
49800 3624 FORMAT(8X,"TIME FREQ(OFFWEP) TIME FREQ(OFFNSV)"
49900 -" TIME FREQ(NEUTRL) TIME FREQ(DEFNSV) TIME FREQ(DEFFAT)",
50000 -" TIME FREQ(TRADE ) ")
50100 DO 3650 J=1,51
50200 WRITE(IPRINT,3626) ((TSCALE(I,J),TFREQ(I,J)),I=1,6)
50300 3626 FORMAT(2X,6(F10.2,F10.4))
50400 3650 CONTINUE
50500 WRITE(IPRINT,3628)
50600 3628 FORMAT(1H1,4X,"SUMMARY STATISTICS FOR SECTION MANEUVER\
  \ CONVERSION")
50700 WRITE(IPRINT,3630)
50800 3630 FORMAT(2X,"STATE      MEAN      VARIANCE"
50810 -," 3RDMOM      4THMOM      NPTS")
50900 WRITE(4,3655)
51000 3655 FORMAT("OFF WEP"/"OFFENSIVE"/"NEUTRAL"/"DEFENSIVE"/"DEF\
  \ FAT"/
51100 -"TRADE OFF")
51200 DO 3654 J=1,6
51300 3654 BACKSPACE 4
51400 DO 3660 J=1,6
51500 READ(4,3657) ANNA,KING
51600 3657 FORMAT(2A5)
51700 WRITE(IPRINT,3662) ANNA,KING,TMEAN(J),TDEV(J),TMOM3(J),TMOM4(J)
51710 -,IFL(J)
51800 3662 FORMAT(2X,2A5,4F10.2,I7)
51900 3660 CONTINUE
52000 DO 3665 J=1,6
52100 3665 BACKSPACE 4

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52200 DO 3680 I=1,6
52300 DO 3670 J=1,51
52400 A(J)=TFREQ(I,J)
52500 3670 B(J)=TSCALE(I,J)
52600 READ(4,3656) (NAME5(K),K=31,40)
52700 3656 FORMAT(10A1)
52800 CALL PLOT(B,A,51,IPRINT,NAME5,NAME1)
52900 IF(GRAFOP.NE.-1) GO TO 3680
53000 DO 3675 J=1,51
53100 3675 A(J)=TCUMP(I,J)
53200 CALL PLOT(B,A,51,IPRINT,NAME5,NAME3)
53300 3680 CONTINUE
53400 3683 CONTINUE
53500 WRITE(1,3681)
53600 3681 FORMAT("SECT MN CNV IS OUT")
53700 IF(ICALC.NE.4) GO TO 3800
53800 WRITE(IPRINT,3682)
53900 3682 FORMAT(1H1,2X,"PAIRED MANEUVER CONVERSION PROBABILITY",
54000 -" MATRIX")
54100 WRITE(IPRINT,3608)
54200 WRITE(IPRINT,3610) (CPP(1,J),J=2,5)
54300 WRITE(IPRINT,3612) CPP(2,1), (CPP(2,J),J=3,5)
54400 WRITE(IPRINT,3614) (CPP(3,J),J=1,2), (CPP(3,J),J=4,5)
54500 WRITE(IPRINT,3616) (CPP(4,J),J=1,3), (CPP(4,J),J=5,5)
54600 WRITE(IPRINT,3618) (CPP(5,J),J=1,4)
54700 WRITE(IPRINT,3684)
54800 3684 FORMAT(1H1,2X"PAIRED TIME IN STATE DISTRIBUTIONS")
54900 WRITE(IPRINT,3624)
55000 DO 3686 J=1,51
55100 WRITE(IPRINT,3626) ((TPCALE(I,J),TPFREQ(I,J)),I=1,5)
55200 3686 CONTINUE
55210 WRITE(IPRINT,3687)
55300 WRITE(IPRINT,3630)
55400 WRITE(4,3655)
55500 DO 3689 J=1,6
55600 3689 BACKSPACE 4
55800 3687 FORMAT(1H1,2X,"SUMMARY STATISTICS FOR PAIRED TIME IN STATE")
56000 DO 3690 J=1,5
56100 READ(4,3657) ANNA,KING
56200 WRITE(IPRINT,3662) ANNA,KING,TPMEAN(J),TPDEV(J),TPMOM3(J)
56300 -,TPMOM4(J),IPM(J)
56400 3690 CONTINUE
56500 DO 3691 J=1,5
56600 3691 BACKSPACE 4

```

```

56700 DO 3698 I=1,5
56800 DO 3692 J=1,51
56900 A(I)=TPFREQ(I,J)
57000 3692 B(J)=TPCALC(I,J)
57100 READ(4,3656) (NAME5(K),K=31,40)
57200 CALL PLOT(B,A,51,IPRINT,NAME5,NAME1)
57300 IF (GRAFOF.NE.-1) GO TO 3698
57400 DO 3694 J=1,51
57500 3694 A(J)=TPCUMP(I,J)
57600 CALL PLOT(B,A,51,IPRINT,NAME5,NAME3)
57700 3698 CONTINUE
57800 3800 CONTINUE
57900 WRITE(1,3699)
58000 3699 FORMAT("ALL DATA ARE OUT")
58100 C-
58200 C- START OUTPUT OF EXPECTED PATHS
58300 C-
58310 DO 4005 I=1,101
58320 A(I)=BLANK
58330 4005 B(I)=BLANK
58400 DO 4000 J=1,101,10
58500 B(J)=PLUS
58600 A(J)=DOT
58700 4000 CONTINUE
58800 WRITE(IPRINT,4001)
58900 4001 FORMAT(1H1,2X,"EXPECTED PATHS FOR CONTINUOUS DATA"///
59000 -10X," + PERFORMANCE INDEX SECTION"/
59100 -10X," + PERFORMANCE INDEX PAIRS"/
59200 -10X," $ CONVERSION COEFFICIENT SECTION"/
59300 -//3X,"-100      -80      -60      -40      -20
59310 -"0      +20      +40      +60      +80      +100")
59400 WRITE(IPRINT,4002) (B(J),J=1,101),(A(J),J=1,101)
59500 4002 FORMAT(2X,"TIME",4X,101A1/2X,"SECS",4X,101A1)
59600 DO 4100 J=1,101
59700 4100 B(J)=PLUS
59800 WRITE(IPRINT,4101) (B(J),J=1,101)
59900 4101 FORMAT(10X,101A1)
59910 IF (ICALC.EQ.1.OR.ICALC.EQ.5) KPARLS=KSET
60000 DO 5000 J=1,KPARLS,ICOMP
60100 DO 4003 I=1,101
60200 4003 A(I)=BLANK
60300 A(51)=DOT
60400 A(1)=PLUS
60500 A(101)=PLUS
60600 IF (J.GT.KSET) GO TO 4004
60700 K=0.50*CCMN(J)+50.5
60800 IF (K.GE.1.AND.K.LE.101) A(K)=DOLL
60900 L=0.50*PISMN(J)+50.5
61000 IF (L.GE.1.AND.L.LE.101) A(L)=STAR
61100 4004 M=0.50*PIPMN(J)+50.5
61200 IF (M.GE.1.AND.M.LE.101) A(M)=PLUS
61300 WRITE(IPRINT,4006) J,(A(KK),KK=1,101)
61400 4006 FORMAT(3X,I4,3X,101A1)
61500 5000 CONTINUE
61600 CALL EXIT
61700 END

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61800 SUBROUTINE FREDIS (ALPHA, BETA, DELTA, X, NDATA, FREQ, CUMP, ANS)
61810 C-
61820 C- THIS SUBROUTINE USES FREQUENCY DISTRIBUTION
61830 C- RECOVERY TECHNIQUE---◆◆◆ PER ULTRASYSTEMS RPT
61840 C-
61850 C- IT CALLS AN INTEGRATION SUBROUTINE (QSF) AND A MOMENT◆◆
        ◆◆ CALCULATION
61860 C- SUBROUTINE (MOMEN)
61870 C-
61880 C- THE DISTRIBUTION FUNCTION OF THE X STRING VECTOR IS COMPUTED
61891 C- AND PLACED IN FREQ AFTER IT IS NORMALIZED
61892 C-
61893 C- X HAS NDATA VALUES WITH A MAXIMUM OF BETA (RANGE VALUE)
61894 C- A MINIMUM OF ALPHA (RANGE VALUE) TO BE COMPUTED OVER
61895 C- A GRID VALUE OF DELTA
61896 C-
61897 C- THE PROGRAM ALSO RETURNS THE NORMALIZED CUMULATIVE PROBABILITY
61898 C- OF OCCURENCE (CUMP) AND THE FIRST FOUR MOMENTS (ANS)
61899 C-
61900 DIMENSION◆◆
        ◆◆ UBO(5), ANS(4), X(500), FREQ(500), CUMP(500), Y(500), XI(500),
62000 -FHAT(500), U(500)
62100 DIMENSION NX(500), RF(500)
62200 UBO(1)=ALPHA
62300 UBO(2)=BETA
62400 UBO(3)=DELTA
62500 SUM1=0.
62600 SUM2=0.
62700 NPTS=(BETA-ALPHA)/DELTA+1
62800 SUMAIJ=0.
62900 NINT=(BETA-ALPHA)/DELTA
63000 DO 10 I=1,NDATA
63100 DO 10 J=1,NDATA
63200 10 SUMAIJ=(X(I)-X(J))◆◆2+SUMAIJ
63300 XMU=0.
63400 XMU=SUMAIJ
63500 XMU=XMU/(NDATA◆(NDATA-1))
63600 IF (ABS(XMU).LT.1.E-08) RHO=0.
63700 IF (ABS(XMU).LT.1.E-08) GO TO 22
63800 IF (XMU.GT.1.) DELTA1=0.010
63900 IF (XMU.GT.1.) RHO=(DELTA1◆ALOG(NDATA)+ALOG(XMU))/XMU
64000 IF (XMU.LE.1.) DELTA1=0.250
64100 IF (XMU.LE.1.) RHO=DELTA1◆ALOG(NDATA)/XMU
64200 22 CONTINUE
64300 BINV=0.
64400 DO 30 I=1,NDATA
64500 DO 30 J=1,NDATA
64600 ECH=EXP(-1.◆RHO◆(X(I)-X(J))◆◆2)
64700 FUNC=(X(I)-X(J))◆◆2◆ECH
64800 30 BINV=BINV+FUNC
64900 IF (ABS(BINV).LT.1.E-08) B=0.
65000 IF (ABS(BINV).LT.1.E-08) GO TO 32
65100 BINV=BINV/(NDATA◆(NDATA-1))
65200 B=1./BINV
65300 32 CONTINUE

```

```
65400 DO 40 I=1,NPTS
65500 40 Y(I)= ALPHA+(I-1)*DELTA
65600 DO 50 I=1,NPTS
65700 FHAT(I)=0.
65800 DO 50 J=1,NDATA
65900 STEP1=Y(I)-X(J)
66000 STEP2=EXP(-1*(B*STEP1)**2/2.)
66100 50 FHAT(I)=FHAT(I)+B/NDATA*STEP2
66200 CALL QSF(DELTA,FHAT,XI,NPTS)
66300 DO 500 J=1,NPTS
66400 IF(ABS(XI(NPTS))>.5T.1.E-08) GO TO 490
66500 FREQ(J)=0.
66600 CUMP(J)=0.
66700 GO TO 500
66800 490 FREQ(J)=FHAT(J)/XI(NPTS)
66900 CUMP(J)=XI(J)/XI(NPTS)
67000 500 CONTINUE
67100 CALL MOMEN(FREQ,UBD,NPTS,ANS)
67200 RETURN
67300 END
```

```
67400 SUBROUTINE OSF(H,Y,Z,NDIM)
67410 C- THIS IS A GENERAL INTEGRATION ROUTINE FOR EQUALLY SPACED
67420 C- FUNCTIONS (Y)
67430 C-
67440 C- THE SPACING OF Y IS H--- THE NUMBER OF POINTS IS NDIM
67450 C- THE INTEGRAL OF Y IS Z
67460 C-
67470 C- THE SUBROUTINE USES A COMBINATION OF SIMPSONS RULE
67480 C- AND NEWTONS THREE-EIGHTHS RULE
67490 C-
67500 DIMENSION Y(1),Z(1)
67600 HT=H*1./3.
67700 1 SUM1=Y(2)+Y(2)
67800 SUM1=SUM1+SUM1
67900 SUM1=HT*(Y(1)+SUM1+Y(3))
68000 AUX1=Y(4)+Y(4)
68100 AUX1=AUX1+AUX1
68200 AUX1=SUM1+HT*(Y(3)+AUX1+Y(5))
68300 AUX2=HT*(Y(1)+3.875*(Y(2)+Y(5))+2.625*(Y(3)+Y(4))+Y(6))
68400 SUM2=Y(5)+Y(5)
68500 SUM2=SUM2+SUM2
68600 SUM2=AUX2-HT*(Y(4)+SUM2+Y(6))
68700 Z(1)=0.
68800 AUX=Y(3)+Y(3)
68900 AUX=AUX+AUX
69000 Z(2)=SUM2-HT*(Y(2)+AUX+Y(4))
69100 Z(3)=SUM1
69200 Z(4)=SUM2
69300 IF (NDIM-6) 5,5,2
69400 2 DO 4 I=7,NDIM,2
69500 SUM1=AUX1
69600 SUM2=AUX2
69700 AUX1=Y(I-1)+Y(I-1)
69800 AUX1=AUX1+AUX1
69900 AUX1=SUM1+HT*(Y(I-1)+AUX1+Y(I))
70000 Z(I-2)=SUM1
70100 IF (I-NDIM) 3,6,6
70200 3 AUX2=Y(I)+Y(I)
70300 AUX2=AUX2+AUX2
70400 AUX2=SUM2+HT*(Y(I-1)+AUX2+Y(I+1))
70500 4 Z(I-1)=SUM2
70600 5 Z(NDIM-1)=AUX1
70700 Z(NDIM)=AUX2
70800 RETURN
70900 6 Z(NDIM-1)=SUM2
71000 Z(NDIM)=AUX1
71100 RETURN
71200 END
```

```

71300 SUBROUTINE MOMEN(F,UBO,NPTS,ANS)
71310 C-
71320 C- THIS ROUTINE CALCULATES THE CLASSICAL MOMENTS OF A GIVEN
71330 C- FREQUENCY FUNCTION (F) HAVING A MAX (UBO(2)) A MIN (UBO(1))
71340 C- AND A GRID SIZE(UBO(3)) THE MOMENTS ARE PLACED IN ANS
71350 C-
71360 C- THE FIRST MOMENT (MEAN IS ABOUT THE ORIGIN
71370 C- ALL SUBSEQUENT MOMENTS ARE ABOUT THE MEAN
71380 C-
71400 DIMENSION F(1),ANS(1),XM(500),Y(500)
71500 DIMENSION UBO(3)
71600 DO 10 I=1,4
71700 10 ANS(I)=0.
71800 DO 20 I=1,NPTS
71900 Y(I)=UBO(1)+(I-1)*UBO(3)
72000 20 XM(I)=Y(I)*F(I)
72100 CALL QSF(UBO(3),XM,XM,NPTS)
72200 ANS(1)=XM(NPTS)
72300 DO 30 I=1,NPTS
72400 30 XM(I)=F(I)*(Y(I)-ANS(1))*2
72500 CALL QSF(UBO(3),XM,XM,NPTS)
72600 ANS(2)=XM(NPTS)
72700 DO 40 I=1,NPTS
72800 40 XM(I)=F(I)*(Y(I)-ANS(1))*3
72900 CALL QSF(UBO(3),XM,XM,NPTS)
73000 ANS(3)=XM(NPTS)
73100 DO 50 I=1,NPTS
73200 50 XM(I)=F(I)*(Y(I)-ANS(1))*4
73300 CALL QSF(UBO(3),XM,XM,NPTS)
73400 ANS(4)=XM(NPTS)
73500 RETURN
73600 END

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77800 XAVG=(XBIG+XSMALL)/2.
77900 YAVG=(YBIG+YSMALL)/2.
78000 XMIN=XAVG-XDEL/2.
78100 XMAX=XAVG+XDEL/2.
78200 YMIN=YAVG-YDEL/2.
78300 YMAX=YAVG+YDEL/2.
78400 XINC=(XMAX-XMIN)/50.
78500 YINC=(YMAX-YMIN)/50.
78600 DO 20 I=1,NDATA
78700 IF (X(I).GT.XMAX) GO TO 12
78800 IF (X(I).LT.XMIN) GO TO 13
78900 IF (Y(I).GT.YMAX) GO TO 16
79000 IF (Y(I).LT.YMIN) GO TO 17
79100 K=(X(I)-XMIN)*(1./XINC)+1.
79200 L=(Y(I)-YMIN)*(1./YINC)+1.
79300 PLOTS(L,K)=STAR
79400 GO TO 20
79500 12 K=51
79600 IF (Y(I).LT.YMIN) L=1
79700 IF (Y(I).GT.YMAX) L=51
79800 IF (Y(I).LT.YMIN.OR.Y(I).GT.YMAX) GO TO 19
79900 L=(Y(I)-YMIN)*(1./YINC)+1.
80000 GO TO 19
80100 13 K=1
80200 IF (Y(I).LT.YMIN) L=1
80300 IF (Y(I).GT.YMAX) L=51
80400 IF (Y(I).LT.YMIN.OR.Y(I).GT.YMAX) GO TO 19
80500 L=(Y(I)-YMIN)*(1./YINC)+1.
80600 GO TO 19
80700 16 L=51
80800 K=(X(I)-XMIN)*(1./XINC)+1.
80900 GO TO 19
81000 17 L=1
81100 K=(X(I)-XMIN)*(1./XINC)+1.
81200 19 PLOTS(L,K)=XXX
81300 20 CONTINUE
81400 DO 22 I=1,51
81500 Z1(I)=XMIN+(I-1)*XINC
81600 Z2(I)=YMIN+(I-1)*YINC
81700 22 CONTINUE
81800 WRITE (IPRINT,25)
81900 25 FORMAT(1H1,/)
82000 DO 30 K=1,51
82100 I=52-K
82200 WRITE (IPRINT,26) Z2(I),(PLOTS(I,J),J=1,51)
82300 26 FORMAT(2X,F10.4," + ",51A1)
82400 30 CONTINUE

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```
82500 WRITE (IPRINT,40)
82600 40 FORMAT (15X,"+++++
      \\++++")
82700 WRITE (IPRINT,50)
82800 50 FORMAT (16X,"+
      \\ +")
82900 WRITE (IPRINT,45) Z1 (1),Z1 (11),Z1 (21),Z1 (31),Z1 (41),Z1 (51)
83000 45 FORMAT (9X,6F10.2)
83100 WRITE (IPRINT,46) (NAMEX (I),I=1,40), (NAMEY (I),I=1,40)
83200 46 FORMAT (10X,"THE X VARIABLE IS ",40A1/
83300 -      10X,"THE Y VARIABLE IS ",40A1)
83400 RETURN
83500 END
```

END QUIKLIST 14.0 SEC.

TERMINOLOGY

- ACM - Acronym for Air Combat Maneuvering
- ACM State - A descriptor of the ACM situation as offensive, defensive, etc.
- AIS - Airborne Instrumentation Subsystem
- Bimodal - Having two characteristic peaks.
- Bogie - A term applied to the opposition aircraft in an engagement.
- Bogie Switching - A maneuver wherein the opposition aircraft switches his offensive press to avoid being "predictable".
- Conversion Coefficient - An analysis term computed by combining the performance index and maneuver conversion computations.
- Conversion Probability - The probability of converting from one ACM state to another.
- Coordination Consistency - The difference between unity and the standard deviation of the section coordination term.
- Defensive - A mathematical state where the subject aircraft or section is being threatened.
- Distributions - A mathematical term applied to the probable range of events and how test data covers that range.
- Dominance - A term applied when one aircraft or section is in decisive control of the engagement.
- Expected Path - The locus of expected values of a variable.
- Fatal Defensive - A mathematical state where the subject aircraft or section is in a weapons opportunity of an opponent.
- "Flash Through" - A mathematical term indicating a transient situation (extreme short duration).
- Frequency Distribution - A distribution of the frequency of occurrence of a variable as a function of the variable.
- Magnitude Sum - A method of combining paired data to yield section data.
- Markov - A mathematical term referring to a time independence occurrence of events.

Multimodal	- Having several characteristic peaks.
Maneuver Conversion Model	- An ACM analysis model made up of ACM states.
Neutral	- A mathematical state where the subject aircraft has neither an advantage nor disadvantage.
Offensive	- A mathematical state where the subject aircraft is threatening an opponent.
Offensive Weapons	- A mathematical state where the subject aircraft has a weapons opportunity on an opponent aircraft.
Paired Data	- A term applied to data generated for a specific fighter-to-target pair.
Paired Coefficient	- An analysis parameter generated for a specific fighter-to-target pair.
Performance Index	- A time variant figure-of-merit which scales the offensive value of a fighter-to-target pair or aircraft section via the product of angle, range, and energy penalty functions.
Section Data	- A term applied to data generated for a fighter or target section.
Section Coefficient	- An analysis parameter for a fighter or target section.
Section Coordination	- An analysis parameter which accounts for the relative contribution of each aircraft in the section.
Semi-Markov	- A Markov process modified to include a time dependence only within a given state.
Significance Level	- A mathematical term representing a minimum acceptable tactical advantage or maximum acceptable disadvantage.
State	- See ACM State.
Stochastic	- A mathematical term applied to a time dependent occurrence of events that are statistical in nature.
"Survival Sting"	- A term applied to a shortened tracking solution due to the tactical press of an opponent.
Target Aircraft	- An opponent aircraft; a bogie.

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- Trade Off** - An ACM state where, in a section, the offensive weapons and defensive fatal states exist simultaneously.
- Trade Off Ratio** - The ratio of opponent aircraft shot down to friendly aircraft lost.
- Trimodal** - Having three characteristic peaks.
- Vector Sum** - A method of combining paired information.

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