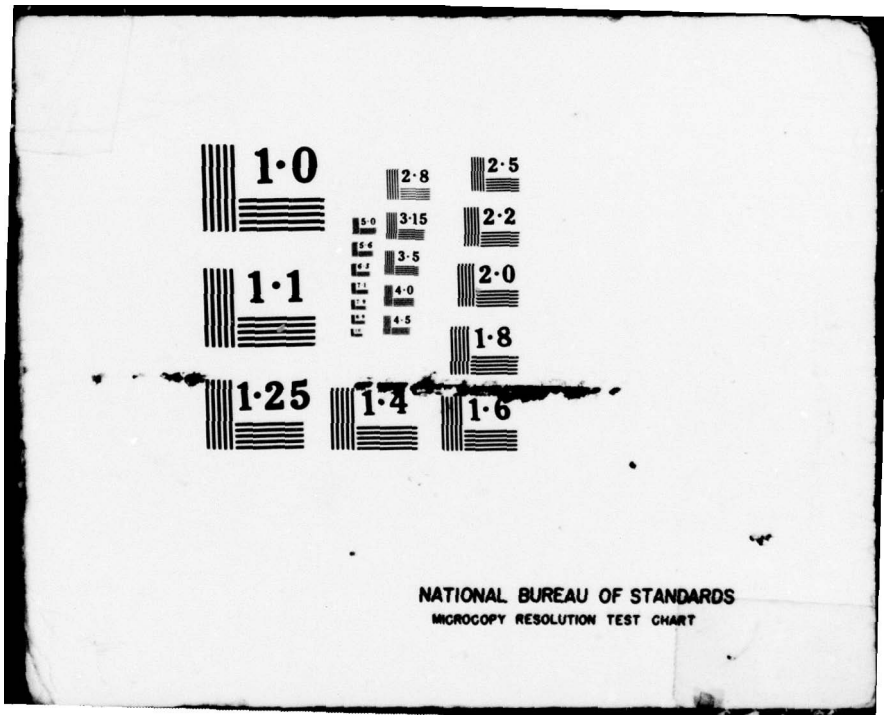
AD-A067 019 INSTITUTE FOR DEFENSE ANALYSES ARLINGTON VA SYSTEMS E--ETC F/G 19/6
REQUIREMENTS FOR REDUCED DATA FROM FIELD TEST. PROBABILITY OF H--ETC(U)
JUL 73 J R TRANSUE, G L BROWN DAHC15-73-C-0200

UNCLASSIFIED P-951 IDA/HQ-73-15080 NL

1 OF 1
ADA
067019

END
DATE
FILMED
6-79
DDC


1·0
1·1
1·25
2·8
3·15
3·5
4·0
4·5
5·0
2·5
2·2
2·0
1·8
1·4
1·6
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

UNCLASSIFIED

(1) LEVEL III

PAPER P-951

REQUIREMENTS FOR REDUCED DATA FROM FIELD TEST

PROBABILITY OF HIT BY ANTIAIRCRAFT GUNS

J. R. Transue, *Project Leader*
G. L. Brown

July 1973

This report has been prepared by the Systems Evaluation Division of the Institute for Defense Analyses in response to the Weapons Systems Evaluation Group Task Order DAHC15 73 C 0200 T-182, revised 18 September 1972.

In the work under this Task Order, the Institute has been supported by military personnel assigned by WSEG.

INSTITUTE FOR DEFENSE ANALYSES
SYSTEMS EVALUATION DIVISION

IDA Log No. HQ 73-15080
Copy 12 of 50 copies

UNCLASSIFIED

PAPER P-951

REQUIREMENTS FOR REDUCED DATA FROM FIELD TEST

PROBABILITY OF HIT BY ANTIAIRCRAFT GUNS

J. R. Transue, *Project Leader*
G. L. Brown

July 1973

This report has been prepared by the Systems Evaluation Division of the Institute for Defense Analyses in response to the Weapons Systems Evaluation Group Task Order DAHC15 73 C 0200 T-182, revised 18 September 1972.

In the work under this Task Order, the Institute has been supported by military personnel assigned by WSEG.

INSTITUTE FOR DEFENSE ANALYSES
SYSTEMS EVALUATION DIVISION
400 Army-Navy Drive, Arlington, Virginia 22202

DAHC15 73 C 0200
T-182

CONTENTS

TABLES

Part 1

INTRODUCTION

INTRODUCTION

This paper presents the requirements for reduced data from a field test of probability of hit by antiaircraft guns. The design of this field test, referred to as HITVAL, is given in WSEG Report 197.[1] The requirements for reduced data are based on planned analyses, and they are described in this paper to ensure completeness and to eliminate ambiguity in the reduced data. This paper is intended to serve as a basis for detailed planning by the Joint Test Director.

There are two basic types of data being collected during a trial: those related to the target aircraft and those related to the antiaircraft gun systems. Therefore, in addition to this introduction and a general description that follows, there are separate discussions of the aircraft position tape and the gun data tape.

This paper includes only the requirements for reduced data from the field test to be utilized for purposes of analysis related to the experimental design defined by WSEG/IDA. It does not include a discussion of data indicative of engagement success to be provided guncrews on a "quick look" basis for motivational purposes. Furthermore, it does not include a discussion of data related to the preliminary tests, or of data related to any laboratory tests of fire control computers that may be scheduled. Finally, it does not include information related to any tests that may be conducted in conjunction with the HITVAL test, such as a suggested test of a missile and a suggested test involving a flight of 16 aircraft.

In addition to this introduction and the general description that follows, this paper presents a discussion of the specific data elements that will be collected during a trial. These elements are of two basic types—those related to the target aircraft and those related to the antiaircraft gun systems—and hence will be addressed separately.

1. *Design of a Field Test for Probability of Hit by Antiaircraft Guns*, WSEG Report 197, February 1973, UNCLASSIFIED.

Part 2

GENERAL DESCRIPTION

GENERAL DESCRIPTION

A. TYPES OF DATA

There are two basic types of data to be collected during the trials–those related to aircraft position and those related to gun system functions. The reduced data will be provided by the contractor on magnetic tape, with separate tapes for the aircraft data and the gun data; these will be referred to as the Aircraft Tape and Gun Tape, respectively. The aircraft and gun data for a trial each compose two classes of information: (1) data that are constant for the entire trial and (2) data that varies with time throughout the trial. For each trial the information on the Aircraft and Gun Tapes will be arranged such that the data that are constant for the entire trial will be in a header, followed by the time varying data presented chronologically for appropriate increments of time.

B. POSITION AND DIRECTION INFORMATION

(1) Position and direction information will be presented with respect to a reference coordinate system (RCS). The RCS will have an origin in the center of the array of gun systems. The RCS will be a right-hand cartesian coordinate system with the X axis directed to the east, the Y axis to the north, and the Z axis upward. Positions of guns, radars, fire directors, and aerial targets will be presented in cartesian coordinates with respect to the RCS.

(2) Directions will be presented in spherical coordinates with the azimuth angle measured in the horizontal plane counterclockwise from the X axis (0 to 2π) and with the elevation angle measured in a vertical plane upward from the horizontal plane ($-\pi/2$ to $\pi/2$).

(3) Unless specified otherwise from a particular data item, the fundamental units for the information are to be meters for distance, radians for angles, seconds for time, degrees F for temperature, millibars for air pressure, grams/meter^3 for air density, and percent for relative humidity. Except where specified otherwise, time data will be presented to 0.001 second; angle data to 0.0001 radian; and all distances, velocities, and accelerations to 0.1 meter, 0.1 meter/second, and 0.1 meter/second^2, respectively.

C. COMPATIBILITY WITH COMPUTER

(1) WSEG/IDA intends to use the reduced data tapes on the CDC Model 6400 computer; the tapes and formats will be compatible with this machine.

(2) The maximum length of the physical record will be 5,120 binary coded decimal (BCD) characters.

(3) The logical record length in characters will be evenly divisible by 10. All data for a given time will be included on one logical record for each aircraft or for each gun.

(4) The recording density will be 556 bpi.

(5) All tapes will be even-parity BCD seven-track tapes, and all system labeling will be suppressed.

(6) Table 1 specifies the appropriate character code.

Table 1. Character Code

Alpha-Numeric Character	External BCD Code	Alpha-Numeric Character	External BCD Code
A	61	0	12
B	62	1	01
C	63	2	02
D	64	3	03
E	65	4	04
F	66	5	05
G	67	6	06
H	70	7	07
I	71	8	10
J	41	9	11
K	42	+	60
L	43	.	40
M	44	*	54
N	45	/	21
O	46	(	34
P	47	)	74
Q	50	$	53
R	51	=	13
S	22	blank (space)	20
T	23	,	33
U	24	.	73
V	25		
W	26		
X	27		
Y	30		
Z	31		

D. DATA RETRIEVAL

(1) Each gun system will have its own tape.

(2) A master numbering system for ordering the trials will be provided by WSEG/IDA.

(3) Trials from the designs of Tables 1, 2, and 3 of WSEG 197[1] should not be intermixed on the same tape.

(4) The trials will be presented in the same sequence for both the Aircraft Tape and the Gun Tape.

(5) On both Aircraft and Gun Tape, each trial will be separated by a single end of file.

1. WSEG Report 197, op. cit.

(6) The amount of data to be put on a single tape will depend on the test schedule. A file should not be split between two tapes. Two consecutive ends of files should be used to indicate the end of the data on a tape.

(7) All raw data will be available to WSEG/IDA. All raw data will be clearly labeled, cataloged, and stored to facilitate identification and retrieval. Included will be all photographic data, strip recorder data, voice recording system tapes, and manually recorded data. All original magnetic tapes of raw data requested by WSEG/IDA will be duplicated in a format that can be read on IDA's CDC 6400.

(8) WSEG/IDA requires only one copy of the reduced data tapes. The Joint Test Director should maintain a backup copy of all reduced data tapes.

(9) An index must be provided for the tapes.

E. DATA QUALITY

(1) Missing floating point data should be accounted for by substituting 9's for the missing data.

(2) A figure of merit indicating the quality of the data is normally derived during the smoothing process of the WSMR aircraft tracking data; this figure of merit, which is essentially a measure of the standard deviation of the error in the smoothed tracking data, should be provided in the reduced data. More discussion on this topic is given later in the report (data from AT 10).

(3) Dummy tapes in the prescribed format will be submitted to WSEG/IDA by 15 September 1973.

F. DATA DELIVERY

(1) Data from the first eight trials of the main field test must be in the specified format and presented within 7 days of each trial. These data are to be duplicated in the regular data package submitted to WSEG/IDA.

(2) All data from a trial will be delivered to WSEG/IDA within 3 weeks of the trial.

Part 3

DATA ELEMENTS

DATA ELEMENTS

A. AIRCRAFT TAPE

This section describes the information to be included on the Aircraft Tape. Tables 2 and 3 list the items of data to be included in the header information and the time-varying information, respectively. The tables provide the name of each item, an identifying number, the units represented by the data, the format of the data, and the number of words required for the data. The format is specified in the FORTRAN notation.

Comments related to each item in the tables are presented below in Subsections 1 and 2. They are keyed to the appropriate item by the identifying numbers in the tables. These comments relate to the source of the appropriate raw data, the processing required, and other pertinent information.

A standard format should be used for all aircraft trials. That is, the same header and time-varying data format should be used for each trial even though some spaces will be left blank because certain information is not appropriate for a given trial. Note, however, that for single-aircraft trials, space need not be left in the time-varying data for information on nonexisting aircraft that would be present in multiple-aircraft trials.

1. Header Information (Table 2)

AH1 through AH6. Each of these items will be available to the data contractor from premission planning. IDA will provide an integer code to identify each trial and an integer code to describe the experimental design factors involved in a trial. Aircraft code numbers will be the last four digits of the aircraft tail number. There can be as many as four aircraft in a trial; therefore, space has been left for four words in the header for this item. The transmission frequencies of the radar transponders on the aircraft will be listed in the same order as the corresponding aircraft code numbers. The identity of the single aircraft in each fixed-wing trial that has a laser retroreflector will be provided by the aircraft code number.

AH7 and AH8. Premission planning will provide the identity of the lead aircraft as well as the attack heading. Attack heading is defined as the azimuth of the ground track for a few seconds before simulated weapon release or, for a straight pass, the azimuth of the ground track. This data element is not applicable to helicopters performing popup maneuvers.

AH9. The ground targets used will be coded with a simple integer scheme. The identity of the target for a trial will be available from premission planning.

Table 2. Header Information for Aircraft Type

ID No.	*Item*	*Units*	*Format*
AH1	Trial identification	N/A	I5
AH2	Date	N/A	I6
AH3	Aircraft code no.	N/A	4I4
AH4	Transponder transmission frequency	MHz	4F5.0
AH5	Aircraft with retroreflector code no.	N/A	I4
AH6	Test design factors coded conditions	N/A	I6
AH7	Lead aircraft code no.	N/A	I4
AH8	Planned attack heading of lead aircraft	rad	F4.2
AH9	Ground target code no.	N/A	I1
AH10	First time in time-varying data	IRIG time (hr, min, sec)	2I2, F6.3
AH11	Simulated weapon release time	sec	4F9.3
AH12	Time of popup (unmask)	sec	F9.3
AH13	Time of remask	sec	F9.3
	Meteorological Data		
AH14	Pressure, ground level	mbar	F6.1
AH15	Air density, ground level	gm/m^3	F5.0
AH16	Wind speed	m/sec	F4.1
AH17	Wind azimuth	rad	F4.2
AH18	Visibility	m	F6.0
AH19	Ceiling	m	F6.0
AH20	Cloud cover	N/A	F3.1
AH21	Relative humidity	N/A	F4.2
AH22	Temperature, ground level	°F	F4.0
AH23	Time of meteorological data	IRIG time (hr, min)	I4
AH24	Dummy space filler*	N/A	I4

*The last word will be dimensioned so that the total number of characters in the header will be evenly divisible by 10.

AH10. This is the time AT1 in the first set of time-varying data but is presented in AH10 in hours, minutes, and seconds.

AH11. The simulated aircraft weapon release time will be obtained from a UHF tone that will be recorded on magnetic tape on the ground. Since as many as four aircraft may be present in a trial, space has been left in the header for four such times. This time is measured in seconds from the beginning of the day (midnight).

AH12 and AH13. The time of popup and remask for the appropriate helicopter trials will be available from a controller-actuated switch. Accuracy to within 1 second will be adequate.

AH14 to AH23. Meteorological data are to be provided by WSMR at intervals of 3 hours or less; the most current data will be presented. It will be necessary to convert some of the data to the units indicated in Table 2. Cloud cover will be expressed as the fraction of the sky covered by clouds.

2. Time-Varying Data (Table 3)

Data for fixed-wing aircraft should be available for the entire period when the aircraft is (are) within 10 km of the guns; for rotary-wing aircraft, such data should be available from hover before unmask until hover after remask, and throughout the straight passes and nap-of-earth passes when the aircraft is within 6 km of the guns.

On trials that involve more than one aircraft, time-varying data will be presented in the following sequence: First, present all data for one aircraft for one time, all data for another aircraft for that same time, etc., until all data for all aircraft for that time have been presented. Then present the data for the next time in the sequence just described, and continue with the data for each successive time.

AT1. The rate for presenting data will be 10 samples/second. The time origin will be the preceding midnight. See AH10.

Table 3. Time-Varying Data for Each Aircraft

ID No.	*Item*	*Units*	*Format*
AT1	Time	sec	F9.3
AT2	Cartesian coordinates of centroid of aircraft	m	3F7.1
AT3	Speed and cartesian velocity components	m/sec	4F5.1
AT4	Cartesian acceleration components	m/sec^2	3F5.1
AT5	Climb angle	rad	F6.3
AT6	Course angle	rad	F5.3
AT7	Roll, pitch, yaw of aircraft	rad	3F6.3
AT8	Track instrumentation source	N/A	I1
AT9	Smoothing technique	N/A	I1
AT10	Data quality figure of merit	m	F4.1
AT11	Dummy space filler*	N/A	I10

*The last word will be dimensioned so that the total number of characters for one time will be evenly divisible by 10. It is not needed with the data as currently shown.

AT2. The coordinates of the aircraft centroid (the aircraft reference point) will be with respect to the RCS and will be based on smoothed tracking data provided by WSMR. A laser tracker and radar trackers will provide data for fixed-wing aircraft, and a laser tracker and cinetheodolites will provide data for rotary-wing aircraft. The tracking data provided by WSMR will give the time history of position of the tracked point, usually a retroreflector or a radar transponder.

It is necessary to compensate for the fact that the location of the retroreflector or transponder is not at the centroid of the aircraft. However, in order to do this, it is necessary to know the attitude of the aircraft. For the fixed-wing aircraft, the attitude can be determined from the smoothed tracking data provided by WSMR. For rotary-wing aircraft, the attitude will be determined from instruments carried on the aircraft.

It is possible that only one transponder may be on an aircraft and that this will not be continuously in sight of the tracking radar. During the short periods of time that the transponder is not tracked, the radar may skin-track the aircraft. In addition, the radar may switch to sidelobe tracking of the aircraft. These differences in tracking point must be considered in determining distances to the centroid of the aircraft. See AT8.

AT3 through AT6. Velocity, acceleration, climb angle, and course angle data will be obtained from the smoothed tracking data provided by WSMR.

AT7. Aircraft attitude information in terms of yaw, pitch, and roll is required. Figure 1 defines these three angles. Note that yaw is measured in the opposite direction from that defined by the NASA convention; this is necessary in order to be consistent with the RCS and the attrition models. The attitude information will be obtained as described under AT2.

AT8. Since aircraft position is to be provided by laser, radar, cinetheodolite, or redundant combinations of these, it is necessary to indicate in the format the source of the reduced data presented. A code relating each tracking system to a different single digit integer will be used to describe the source in the reduced data. This same code will indicate whether radar data are based on beacon return or on skin track.

AT9. WSMR has more than one procedure for smoothing the raw tracking data. A code relating each procedure to a different single digit integer will be used to describe the source in the reduced data.

AT10. In the process of smoothing the raw position data obtained by tracking, WSMR determines a data quality figure of merit. The standard deviation of the error in the smoothed data is estimated for each point in the smoothing interval; the figure of merit is then taken to be the average value of this standard deviation determined over the points in the smoothing interval. This value, converted to meters, will be presented for each time sample in the reduced data.

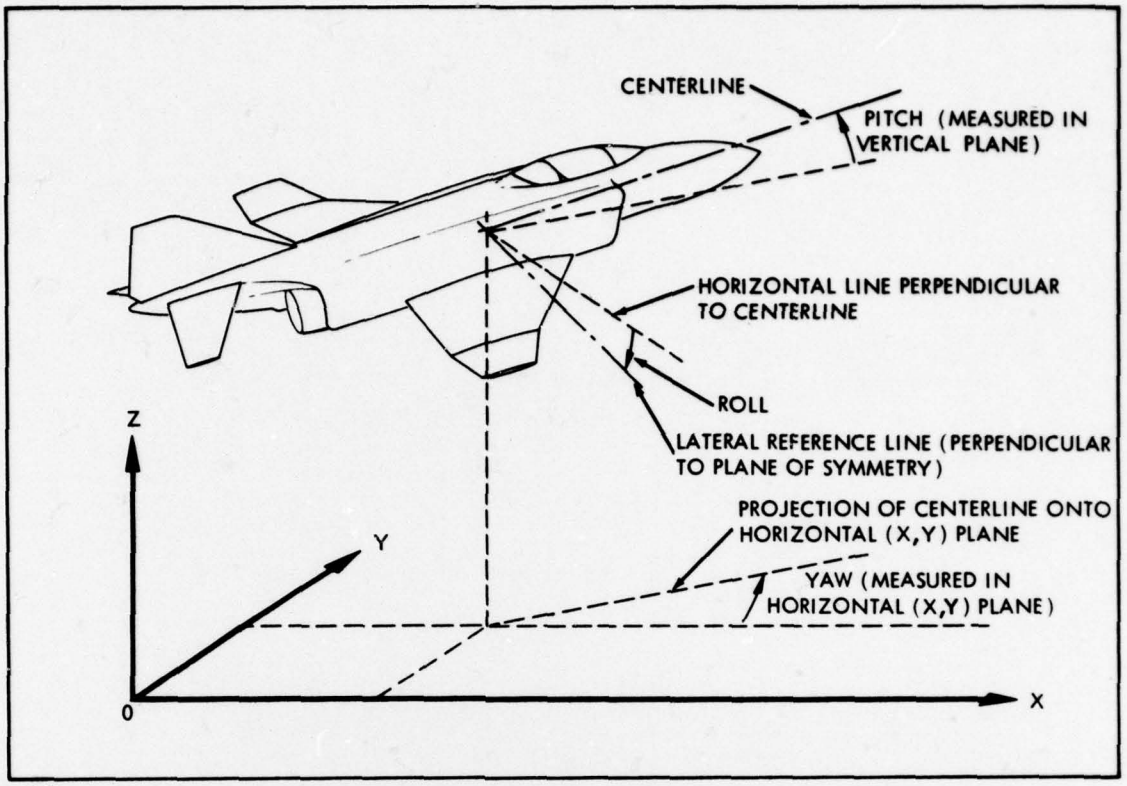


Figure 1. Description of Aircraft Yaw, Pitch, and Roll Angles

B. GUN TAPE

This section describes the data requirements for the Gun Tape. Subsection 1 and Table 4 describe the data in the Gun Tape header for each gun and each trial; Subsection 2 and Table 5 describe the time-varying data for each gun, trial, and time.

1. Header Information (Table 4)

A standardized format will be used for header information for all guns. That is, the same header format will be used for each gun even though some spaces will be left blank because certain information is not appropriate for a given gun.

GH1 and GH2. See discussion of AH1 and AH2.

GH3. Each of the four gun systems will be identified by a unique single-digit integer as follows:

1–ZU-23, twin 23mm with optical-mechanical fire control.

2–S-60, single 57mm with optical-mechanical fire control.

Table 4. Header Information for Gun Tape

ID No.	Item	Units	Format
GH1	Trial number	N/A	I5
GH2	Date	N/A	I6
GH3	Gun code number	N/A	I1
GH4	Site of gun, director, radar, solution	m	12F4.1
GH5	Aircraft code number	N/A	I4
GH6	Test design factors coded conditions	N/A	I6
GH7	Lead aircraft code number	N/A	I4
GH8	Planned attack heading of lead aircraft	rad	F4.2
GH9	Test controller code number	N/A	I2
GH10	Substitute guncrew members, code numbers	N/A	4I4
GH11	First time in time-varying data	IRIG time (hr, min, sec)	2I2, F6.3
GH12	Time of first visual detection of any aircraft	sec	F9.3
GH13	Crew member making detection, code number	N/A	I2
GH14	Range from gun at visual detection	m	F7.1
GH15	Time of first radar detection of any aircraft	sec	F9.3
GH16	Range from gun at radar detection	m	F7.1
GH17	Time of initiating radar tracking	sec	F9.3
GH18	Azimuth of gun at time GH15	rad	F5.3
GH19	Commanded initial gun azimuth	rad	F5.3
GH20	Time of possible open fire	sec	F9.3
	Fire Director Settings		
GH21	Muzzle velocity correction	m/sec	F6.1
GH22	Wind speed	m/sec	F4.1
GH23	Wind azimuth	rad	F4.2
GH24	Air density	gm/m^3	F5.0
GH25	Air temperature	$^{\circ}F$	F4.0
GH26	Air pressure	mbar	F6.1
GH27	Parallax	m	3F5.1
	Meteorological Data		
GH28	Pressure, ground level	mbar	F6.1
GH29	Air density, ground level	gm/m^3	F5.0
GH30	Wind speed	m/sec	F4.1
GH31	Wind azimuth	rad	F4.2
GH32	Visibility	m	F6.0
GH33	Ceiling	m	F6.0
GH34	Cloud cover	N/A	F3.1
GH35	Relative humidity	N/A	F4.2
GH36	Temperature, ground level	$^{\circ}F$	F4.0
GH37	Time of meteorological data	IRIG time (hr, min)	2I2
GH38	Dummy space filler*	N/A	I2
GH39	Data comments	N/A	24A10

*GH38 will be dimensioned so that the total number of characters in the header will be evenly divisible by 10.

3–S-60, single 57mm with fire director and radar.

4–5PFZ-B, twin 35mm with fire director and radar.

GH4. The site of the gun, radar, director, and solution will be presented in three cartesian coordinates with respect to the RCS; this information will be available from pretrial planning.

The site of the gun will be taken as the intersection of the axis about which the gun rotates in azimuth and the centerline of the gun barrel(s); the site of the radar will be taken as the intersection of the axis about which the radar dish rotates in azimuth and the boresight of the antenna; and the site of the director will be the centroid of the base. The solution location refers to the location of a hypothetical gun for which a fire director determines the fire solution. This hypothetical location is used because normally a fire director controls the fire of a number of guns at different locations simultaneously; hence, an "average" location of the guns is used by the director to determine the firing solution.

GH5 through GH8. See discussions of AH3, 6, 7, and 8, respectively.

GH9. For identification, test controllers will each be assigned a unique integer.

GH10. The identification of guncrew substitutions will require that each guncrew position be identified by a unique two-digit integer and each substitution for a given position should be identified by a unique two-digit integer. The identity of a single substitution can then be defined by four characters: the first two integers identify the position, and the next two integers identify the substitution for that position. Space is allotted for four substitutions. If there are more than four substitutions, the additional information must be provided in GH39. The source of information on substitutions made during a trial will be the test controller's log book.

GH11. This is the time GT1 in the first set of time-varying data but is presented in GH11 in hours, minutes, and seconds.

GH12. The time of first visual detection of any aircraft in the trial by any crew member is an event that is recorded by the test controller. Accuracy is required only to the nearest second.

GH13. The identity of the crew member making the first visual detection will be indicated by his position number. If the controller has to make this detection, a zero will be used as a means of identifying this event. The controller's log book will give this information.

GH14. The range of the detected aircraft from the gun at the time of first visual detection will be determined by comparing this time with the WSMR tracking data.

GH15. The time of detection of any aircraft in the trial by the fire control radar will be determined, possibly from an oral signal from the radar operator. Accuracy is required only to the nearest second.

GH16. GH16 is similar to GH14.

GH17. The time at which the radar is switched from search to tracking mode, or the time at which the tracking radar is locked on, as applicable, will be recorded.

GH18. The azimuth of the gun at the time of detection of any aircraft in the trial by the fire control radar can be determined by comparing the gun pointing data from the shaft angle encoders with the time of this event.

GH19. The commanded initial gun azimuth for the trial will be available from pretrial planning.

GH20. For guns 1 and 2 (optical-mechanical fire control), this time is the first time that errors in tracking and fire control inputs are all within specified limits;[1] hence, it must be determined after a trial. For the other guns (with fire directors), this time is the first time that the fire solution indicator comes on. The fire solution indicator can go off and on during a trial if the gun switches targets or temporarily loses track; therefore, the status of this indicator is also given in the time-varying data (GT9).

GH21 through GH27. These fire director settings, which will not change during a trial, will be available from the test controller's log book. It may be necessary to convert the data to the units specified in Table 4.

GH28 through GH37. See discussion of AH14 through AH23.

GH39. Trials with no valid data will be omitted from the tape. Trials for which part of the data are valid will have alphanumeric comments describing the state of validity; it may be necessary to indicate a reference that relates to written comments for more details. See GH10 and GT3.

2. Time-Varying Data (Table 5)

There will be two standard formats for time-varying data. One will be used for the two guns with optical-mechanical fire control systems, and the other will be used for the two guns with fire directors. Items GT1-GT17 and GT41 will be common to both formats. GT18-GT25 will appear only in the first format, while GT26-GT40 will appear only in the second format. In reading the gun tapes, GH3 will be used to determine which format applies.

Data will generally be presented at 0.1-second intervals and at the actual times of fire. The data format will be the same in both cases. When data are being presented for the time of fire, a flag will identify the data as such. There is no need to present data at the precise time that the firing pedal (or switch) is depressed on nonfiring trials. The fact that the pedal is depressed will be indicated by the flag just mentioned (GT2) at each 0.1 second while the pedal is depressed.

---

1. WSEG Report 197, op. cit., gives these limits: "For the ZU-23 and the S-60 using optical-mechanical fire control systems, time of possible fire is defined for this test as the first time that the angular tracking error is below 20 mrad and the four inputs to the fire control computer have all been adjusted or all fall within the following regions about their true values: speed of fixed-wing aerial targets, ±100 knots; speed of rotary-wing aerial targets, ±50 knots; target course angle, ±300 mrad; target climb or dive angle, ±300 mrad; target range, -50 to +100 percent of true range."

Table 5. Time-Varying Data for Gun Tape

ID No.	*Item*	*Units*	*Format*
GT1	Time	sec	F9.3
GT2	Round firing indication, ID of firing barrel	N/A	I1
GT3	Aircraft chosen for engagement	N/A	2I4
GT4	Track lock-on or starting time indication	N/A	I1
GT5	Target mask condition	N/A	I1
GT6	Mode of weapon operation	N/A	I1
GT7	Mode of radar	N/A	I1
GT8	Settling time chosen	N/A	I1
GT9	Fire solution indication	N/A	I1
GT10	Gun pointing angles relative to base, az. and el.	rad	2F6.4
	Tilt Information		
GT11	Tilt of gun base, as. and el.	rad	2F5.4
GT12	Smoothed mean tilt, az. and el.	rad	2F5.4
GT13	Dispersion about mean tilt, az. and el.	rad	2F5.4
	Muzzle Direction Data		
GT14	Muzzle angles relative to breech, az. and el., first barrel	rad	2F5.4
GT15	Muzzle angles relative to breech, az. and el., second barrel	rad	2F5.4
	Optical Tracking Data		
GT16	Tracking angles of sight, az. and el.	rad	2F6.4
GT17	Tracking errors, az. and el.	rad	2F7.4
	Optical-Mechanical Fire Control Input Data		
GT18	Speed estimate	m/sec	F4.0
GT19	Course angle estimate	rad	F4.2
GT20	Dive angle estimate	rad	F5.2
GT21	Range estimate	m	F5.0
GT22	Speed error	m/sec	F5.0
GT23	Course angle error	rad	F5.2
GT24	Dive angle error	rad	F5.2
GT25	Range error	m	F6.0

Table 5. (Continued)

ID No.	Item	Units	Format
	Fire Control Radar Track Data		
GT26	Azimuth	rad	F6.4
GT27	Elevation	rad	F6.4
GT28	Range	m	F5.0
GT29	Azimuth error	rad	F7.4
GT30	Elevation error	rad	F7.4
GT31	Range error	m	F6.0
	Range Input Dialed Into Director Data		
GT32	Range value dialed	m	F5.0
GT33	Range error, radar to director	m	F6.0
GT34	Range error, flight path to director	m	F6.0
	Target Velocity, Smoothed From Radar Data		
GT35	Cartesian velocity estimates	m/sec	3F4.0
GT36	Errors in velocity estimates	m/sec	3F5.0
	Range Output of Altitude Unit of Director Data		
GT37	Range estimate	m	F4.0
GT38	Range error	m	F5.0
	Commanded Gun Angles Relative to Base Data		
GT39	Commanded gun angles, az. and el.	rad	2F6.4
GT40	Error between measured and commanded angles, az. and el.	rad	2F7.4
GT41	Dummy space filler*	N/A	I8

*GT41 will be dimensioned so that the total number of characters for one time will be evenly divisible by 10.

Presented data will be synchronized with the flight path data; that is, times indicated on the Gun Tape will correspond exactly with those on the Aircraft Tape (except for the fire events on the Gun Tape). The time will be accurate to the fourth decimal place in seconds.

Data will be required at the rates specified from the time that a fixed-wing target is detected until it passes out of sight or is beyond the following ranges from the guns: 3 km for the ZU-23, 6 km for the S-60s, and 4 km for the twin-35. Data will be required at the rates specified from the time that a rotary-wing target is detected until it masks to end the trial or is more than 4 km from the guns.

GT1. Time will be presented in seconds measured from the preceding midnight.

GT2. The following integer code will be used to describe the firing state for the presented times: 0–no firing attempted; 1–single barrel weapon fired, first barrel of twin barrel weapon fired, or foot pedal depressed on nonfiring trial; 2–second barrel fired on twin barrel weapon.

GT3. The aircraft chosen for engagement will be identified in the time-varying data for trials with multiple aircraft. Two aircraft will be indicated at the same time if confusion exists as to the identity of the chosen aircraft. In this case, the aircraft chosen for engagement will be determined after the trial by comparing the aircraft position data with the fire control tracking data. For trials involving more than one aircraft, the gun system may switch targets during the trial.

GT4. The target lock-on time for the fire control radars and the start of tracking for the optical systems are events for which time is to be recorded to the nearest 0.1 second. For radar systems, this will be provided by an electrical signal indicating a switch in radar mode or type of radar used. For optical systems, start of track will be determined after the trial by studying the fire control tracking data; when the angular tracking error is less than 20 mrad, track will be considered to have started.

GT5. The tracked target mask condition with respect to the weapon system will be determined after the trial based on photographic data produced by cameras viewing through tracking sights or attached to radar dishes.

GT6. Some of these weapons have several modes in which they can operate to obtain fire control inputs. For instance, a weapon might obtain target data entirely by radar, or it might obtain target range by radar and target azimuth and elevation by optical means. Since it is possible to switch modes during an engagement, this information is in the time-varying data. The mode will be determined by sensing the position of mode switches on the gun systems.

GT7. Weapon radars may have several modes of operation such as search and track, or there may be different radars for different modes. GT7 will indicate the mode being used.

GT8. The settling time is related to the amount of time that data are collected by the fire control computer for determining a firing solution. The setting can be changed during an engagement in the S-60 with fire director; therefore, this setting will be included as time-varying data. This data element does not apply to the other gun systems.

GT9. This is the status of the fire solution indicator on the S-60 with fire director and on the 5PFZ-B. It does not apply to the two guns with optical-mechanical fire control.

GT10. These angles define the gun breech direction with respect to the chassis. Shaft angle encoders provide the raw data.

GT11 through GT13. The tilt will be measured about three orthogonal axes, and the measurements about these axes will be transformed into azimuth and elevation components of tilt. The actual time-varying azimuth and elevation tilt of the base will be presented. This will be derived by interpolating in data measured 100 times per second. In addition, for both azimuth and elevation, the smoothed mean tilt data (which is to be considered the rigid body component for analysis purposes) and the standard deviation about this mean (considered a measure of a higher frequency component) will be presented as time-varying data. The mean and standard deviation will be computed from data measured 100 times per second.

GT14 and GT15. The muzzle deflection will be presented in terms of azimuth and elevation angles relative to the gun breech direction. These angles will be measured by a photo diode matrix array camera.

GT16 and GT17. Both the actual tracking angles and the angular errors in tracking will be presented.

GT18 through GT25. The time-varying setting for the four fire control inputs can be obtained by use of resolvers. By comparing these data with data from the Aircraft Tape, the errors in these inputs can be determined. These data elements apply only to the guns with optical-mechanical fire control (guns 1 and 2).

There may be an error due to time delay between the value of range called out by the rangefinder operator and the value set into the fire control system by another operator. The range value indicated in the data is the latter one. However, the data on the former value will be available from voice recordings and will be logged separately; they need not be provided on the Gun Tape.

GT26 through GT31. Azimuth, elevation, and range data will be the values determined by the gun system's tracking radar. The errors in these quantities will be computed by comparing these data with the aircraft position from the Aircraft Tape. These data elements and the following elements through GT40 apply only to guns with radar and fire directors (guns 3 and 4).

GT32 through GT34. The modes of operation to be tested for the S-60 with the fire director (gun 3) involve range data provided by either the SON-9 radar or D49 rangefinder. The rangefinder data are entered directly into the director, but the radar data are dialed into the director by a human operator. Time-varying data will be provided on the Gun Tape for the dialed range value in order to determine the human error involved in transferring the range information from the radar to the director. A resolver or analog monitor will be used to record the value of the range dialed into the director. Comparison of this value with the radar data of GT28 will yield the range error between the radar and the director, and comparison with the

aircraft position will yield the range error between the measured aircraft range and the range input to the director. This data element applies only to gun 3.

GT35 and GT36. These data are the target velocity estimates obtained by the fire control computer by smoothing the estimated aircraft position data. The errors in these velocity estimates can be derived by comparison with the aircraft velocity components given on the Aircraft Tape.

GT37 and GT38. One particular mode of the PUAZO fire director used with the S-60 involves a target altitude estimate being set into an altitude unit. The altitude unit estimates range based on tracking angles and the estimated altitude. The error in this estimate can be derived by comparing it with the aircraft data given on the Aircraft Tape. GT37 and GT38 apply only to the S-60 with fire director (gun 3).

GT39 and GT40. The commanded gun angles are the azimuth and elevation of the direction (relative to the base or chassis) that the gun should be pointed at the time of fire as determined by the fire control computer. The data will be obtained from the output of the fire control computer. The errors between the measured and commanded gun angles will be obtained by comparing the data in GT39 with the data in GT10.