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AN INITIAL INVESTIGATION OF THOSE ACMR PARAMETERS RELATED TO INITIAL AIR-TO-AIR VISUAL ACQUISITION

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Introduction

The purpose of this pilot study was to isolate those parameters routinely recorded at the Display and Debriefing Subsystem (DDS) of the Air Combat Maneuvering Range (ACMR) which exhibited a significant relationship with air-to-air visual acquisition performance. Two criteria of visual acquisition performance were investigated (acquisition rate - expressed as a percentage of total opportunities and range at which the acquisition occurred).

This study was designed as an initial attempt to determine those parameters which were the most likely candidates to control in future studies aimed at exploring individual differences in air-to-air visual acquisition performance. Only those parameters which could reasonably be under experimental control without interfering with the ACMR training objectives were investigated in this study.

Method

Thirty magnetic tape records of "2 on 1" (two fighters vs one adversary) ACM engagements on the ACMR were selected randomly from the pool of available tapes stored in the DDS. From these 30 tapes, 53 ACM engagements were sufficiently free from degradation to qualify for further analysis. These magnetic tapes contained all data routinely displayed on the three DDS display scopes (Status Display, Alpha-Numerics Display and the Graphics Display). Table I

Table I

List of ACMR Parameters

ACMR Parameter	Levels
Fighter Type	F-14 and F-4
Target Type	A-4 and F-5
Time of Engagement	0900-1100, 1100-1300, and 1300-1500
Hassle Number	1 - 3
Bogey Position	Bogey High and Bogey Low
Fighter Heading	0-90, 90-180, 180-270, and 270-360
Altitude Separation	Absolute value in feet
Angle Off the Tail	Absolute value in degrees
Antenna Train Angle	Absolute value in degrees
Closing Velocity	Actual value in kts/hr
Vectoring Type	GIP, Radar Contact, and Radar Lock
Range	Actual value in feet
Acquisition Rate	Percentage of Opportunities

lists the parameters investigated. The data tapes selected were replayed in the DDS. At the occurrence of the initial visual acquisition (noted by the verbal report "Tally Ho") all information on the three displays was copied via a high speed printer located in the DDS. In those engagements where there was no initial acquisition made on the first pass, the tape was backed up to the mean acquisition range and the data collected at that point.

Results

Table II illustrates the acquisition rate and frequency for each of the dichotomous variables investigated. Table III listed the correlation between each parameter investigated and acquisition rate for the total sample of 53 engagements. Table IV shows the multiple regression analysis using acquisition rate as the criterion. Four parameters (fighter type, time of engagement, Bogey high and absolute separation in altitude) were significant contributors to the acquisition.

The extremely large contribution to the criterion variance made by altitude separation precipitated a more detailed investigation into the factors responsible for the relationship. This relationship is emphasized in Table V which shows the acquisition rate for three intervals of altitude separation between the lead fighter and the target. The most apparent reason for variation in altitude separation is the method of vectoring the aircraft to the initial intercept. Three types of vectoring were found in this study. Ground Instructor Pilot (GIP), Radar Intercept Officer (RIO) and Radar Lock on Target whereupon pilot flew diamond. Unfortunately this information was discernible from only 40 intercepts. Table VI demonstrates the average altitude separation found for each type of vectoring. It is rather obvious that method of vectoring the aircraft is largely responsible for the variability in altitude separation and may well be a latent variable explaining other relationships between ACMR parameters and acquisition rate. In order to

Table II

Acquisition Rate (N=53)

Variable		f	Acquisition Rate (%)
Fighter Type	F-14	23	78.2
	F-4	30	60.0
Target Type	A-4	35	74.3
	F-5	18	55.6
Time of Engagement	0900-1100	19	63.2
	1100-1300	16	87.5
	1300-1500	18	55.6
Fighter Heading	0-90	7	71.4
	90-180	31	67.7
	180-270	6	83.3
	270-360	7	42.9
Bogey Position	High	37	76.9
	Low	16	45.8

Table III

Correlation Coefficients between ACMR Parameters and Acquisition Rate

Variable	Correlation Coefficient
Hassle #	-.0632
F - 14	.1939
F - 4	-.1939
A - 4	.1900
F - 5	-.1900
Time 1	.0763
2	.2758*
3	-.1900
Bogey High	.2900*
Bogey Low	-.2900
Heading (0-90)	.0293
(90-180)	-.0046
(180-270)	.1179
(270-360)	-.2095
Altitude Separation	-.7034**

*p<.05

**p<.01

Table IV

Multiple Regression Analysis For Total Sample (N=53)

Using Acquisition Rate as Criterion

Source	df	SS	MS	F	P
Hassle #	1	.0040	.0040	<1	
Fighter Type	1	.0399	.0399	4.73	.05
Target Type	1	.0146	.0146	1.73	
Time	2	.0713	.0357	4.23	.05
Bogey High	1	.0625	.0625	7.40	.01
Fighter Heading	3	.0610	.0204	2.42	
Altitude Separation	1	.3925	.3925	46.49	.001
Error	42	.3546	.0084		
TOTAL	52	1.00			

$R = .8034$

$R^2 = .6454$

Table V

Relationship Between Altitude Separation

and Acquisition Rate

Altitude Separation	Acquisitions	Misses	Percentage
0 - 2499	29	1	96.67
2500 - 4999	6	7	46.15
5000 +	1	9	10.0
TOTAL	36	17	67.93

Table VI

Relationship Between Altitude Separation

and Type of Vectoring

Vectoring Type	Frequency	Mean Altitude Separation	Acquisition Rate
GIP	18	4315.67	38.89
Radar Contact	10	1195.00	90.00
Radar Lock	12	1232.75	100.00
TOTAL	40	2610.63	70.0

check for this possibility a multiple regression analysis of ACMR parameters against acquisition rate was computed for the 40 intercepts having valid vectoring information. In this analysis vectoring type was extracted first followed by the remaining ACMR parameters. Table VII lists the results of this analysis. As can be seen when type of vectoring is partialed out, only altitude difference remains significant. These results suggest that the significance of fighter type, time of day, and Bogey high shown in Table IV was an artifact of differential vectoring under these parameters.

The mean range of acquisition for each of the dichotomous ACMR parameters is shown on Table VIII for the 35 first pass acquisitions. The first order correlation coefficients of all recorded ACMR parameters with range at acquisition are presented in Table IX. The multiple regression analysis of these parameters on range at acquisition is presented in Table X. From this analysis three parameters are found to make a significant contribution to the acquisition rate variance. These parameters are the time of day at which the acquisition occurred, the heading of the fighter (expressed as four dummy variates) and the antenna train angle (the angle made by the logitudinal axis of the fighter and the line of sight between fighter and target).

Discussion

If we consider acquisiton rate we see that altitude related factors account for 45.5 percent of the criterion variance (39.25% for altitude separation plus 6.25% for Bogey position-high vs low). We have seen that the method used to vector the fighter to the intercept explained a large portion of this altitude related variance, however from Table VII we can see that even with method of vectoring already partialed out, altitude separation still uniquely explains 20.06% of the acquisition rate variance.

Table VII

Multiple Regression Analysis For Cases Where Vectoring Information Available (N=40) Acquisition Rate as Criterion

Source	df	SS	MS	F	P
Type Vectoring	2	.3836	.1918	15.6	.001
Hassle Number	1	.0002	.0002	<1	
Fighter Type	1	.0012	.0012	<1	
Target Type	1	.0103	.0103	<1	
FXT	1	.0156	.0156	1.27	
Time	2	.0261	.0130	1.06	
Bogey High	1	.0314	.0314	2.55	
Fighter Heading	3	.0115	.0038	<1	
Altitude Difference	1	.2006	.2006	16.32	.001
Error	26	.3196	.0123		
TOTAL	39	1.00			

$R = .8106$

$R^2 = .6571$

Table VIII

Mean Range at Acquisition

Variable		Frequency	Mean Range (feet)
Fighter Type	F-14	18	16481.0
	F-4	17	13707.8
Target Type	A-4	26	15963.7
	F-5	9	12737.1
Time of Day	0900-1100	11	17352.7
	1100-1300	14	11957.9
	1300-1500	10	17140.1
Fighter Heading	0-90	5	11426.0
	90-180	20	16109.3
	180-270	5	19257.4
	270-360	3	7917.3
Bogey Position	High	28	15154.6
	Low	7	15051.8

$\overline{X}$ = 15134.03

Table IX

Correlation Coefficients Between ACMR Parameters and Range at Initial Visual Acquisition

ACMR Parameter	Correlation Coefficient
Hassle Number	.0601
F-14	.1821
F-4	-.1821
A-4	.1853
F-5	-.1853
Time 1 (0900-1100)	.1973
Time 2 (1100-1300)	-.3407*
Time 3 (1300-1500)	.1667
Bogey High	.0054
Fighter Heading 1	-.1984
Fighter Heading 2	.1479
Fighter Heading 3	.2212
Fighter Heading 4	-.2903*
Altitude Separation	.0042
Closing Velocity	.0474
Antena Train Angle	-.1926

*p<.05

Table X

Multiple Regression Analysis for Range at Initial Visual Acquisition (N=35)

Source	df	SS	MS	F	P
Hassle #	1	.00361	.00361	<1	
Fighter Type	1	.03241	.03241	1.79	
Target Type	1	.01136	.01136	<1	
Time	2	.12226	.06113	3.37	.05
Bogey Position	1	.00738	.00738	<1	
Fighter Heading	3	.22824	.07608	4.19	.05
Altitude Separation	1	.0001	.0001	<1	
Closing Velocity	1	.04838	.04838	2.66	
Antena Train Angle	3	.18320	.06107	3.36	.05
Error	20	.36308	.01815		
TOTAL	34	1.00			

$R = .79807$

$R^2 = .6369$

When considering range at acquisition as our criterion it is apparent that the significant parameters (time of day, heading of fighter, and antenna train angle) are all factors of where in relation to the ACMR the pilot must look to see the target. It is very probable that sun angle and peculiarities of the range background explain at least a portion of this factor. Anecdotal comments by fighter pilots who have flown the range confirm this point.

It is apparent that if a future study of individual differences in initial air-to-air visual acquisition is to be accomplished in a training environment on the ACMR, the following ACMR parameters must be kept within fairly tight bounds:

(1) Altitude separation - within 2500 feet.

(2) Time of day - all engagements within the same two hour time segment.

(3) Fighter heading - $\pm$ 10 degrees.

(4) Antenna Train Angle - $\pm$ 10 degrees (coupled with #3 this restricts the target heading).

The preceding restrictions will reduce the uncertainty of target position and thereby the scan pattern, however it is felt that this is a desirable feature in the initial stages of isolating critical pilot factors. As these factors become better understood, the level of uncertainty about target position can be increased and its impact on scan pattern investigated.