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BECKETT: PILOT RELEASE-SWITCH OPERATION ACCURACY, EXPERIMENTAL RESULTS (U)

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ABSTRACT (U)

Tests were conducted to determine the accuracy with which a pilot can estimate when his position is directly over a target. The results of the tests, which are given in terms of mean errors and standard deviations, demonstrate that pilots can "pickle" over a target with sufficient accuracy to achieve REP's of 30 to 42 feet.

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BECKETT: PILOT RELEASE-SWITCH OPERATION ACCURACY, EXPERIMENTAL RESULTS

Introduction

The Beckett program is a study of the feasibility of a tactical-weapon delivery system for an aircraft in level flight at low altitude that should make possible a CEP of the order of 50 feet.* The pilot fires a velocity-compensated infrared flare on the target when passing directly over it, and then launches a weapon which is rocket-propelled back to the target, guided by the IR radiation from the flare.

One of the critical elements in this study is the determination of positional error of the aircraft over the target at flare release, i.e., whether pilots can operate their flare-release switch, or "pickle" switch, with an accuracy and reproducibility that will result in a REP of 50 feet or less. A series of tests was conducted with 19 combat-qualified pilots of the 188th Fighter Interceptor Squadron of the New Mexico Air National Guard flying F-100 aircraft. The pilots were briefed to fly over the target at an altitude of 50 feet and an indicated airspeed of 450 knots (870 ft/sec) and to press the flare-release switch, i.e., to pickle, when they estimated their position to be directly over the target. The target was a vehicle parked on a dirt road. The pilots flew along the road, which precluded any aiming advantage from peripheral visual aids. Each pilot was to make at least 10 passes at the target. Data were taken by photographing the aircraft on each pass to record its position relative to the target when the pickle switch was pressed. The pilots were given no information as to their

*Referring to delivery accuracy here in terms of CEP (Circular Error Probable) is not strictly correct, since deflection errors are expected to be small, as they are generally with low-level delivery systems. Hence, delivery accuracy here will be characterized as REP (Range Error Probable).

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accuracy until all tests were completed. No aiming device was used. Six weeks later six of the pilots with the poorest scores on the first series of passes were rebriefed, and each made 10 more passes. This report analyzes the test data and their implications for the Beckett system.

Test Results and Analysis

Figure 1 is a plot of the data from the first series of passes, 19 pilots making a total of 193 passes. The mean errors, $\bar{x}$ or $\bar{\bar{x}}$, and standard deviations, σ or $\bar{\sigma}$, were computed by routine statistical methods, i.e., $\bar{x} = \Sigma x/n$, where n is the sample size, and $\sigma = \Sigma(x - \bar{x})^2/n-1$. In this discussion, $\bar{x}$ is the mean pickle point of an individual pilot, and $\bar{\bar{x}}$ is the mean pickle point of a group of pilots. Likewise, σ is the standard deviation for an individual pilot and $\bar{\sigma}$ for a group of pilots. The outcome of the first passes resulted in a mean pickle point $\bar{\bar{x}}$ of 97 feet short with a standard deviation $\bar{\sigma}$ of 52 feet. The fact that the distribution of pickle points is decidedly bimodal was interpreted as evidence that the pilots were solving two separate problems. One group tried to solve the correct problem of determining when the aircraft was over the target, even though the target had long since disappeared from view under the aircraft nose. The second group tried to solve a skip-bombing problem. At an altitude of 50 feet the target will pass from view under the aircraft's nose at downrange distances of 150 to 235 feet, depending on seat-height adjustment. As further evidence, Table I lists the means and standard deviations for the individual pilots. For the pilots with means grouped around 50 feet short, individual σ's vary from 25 to 72 feet, and for the pilots with means grouped around 150 feet short, the individual σ's vary from 39 to 83 feet. If the data are divided into two groups based on the assumption that the two divergent means resulted from the pilots' solving two separate problems, then for the 10 pilots with the smaller errors the $\bar{\bar{x}}$ is 46 feet short with a $\bar{\sigma}$ of 49 feet, and for the nine pilots with the larger errors the $\bar{\bar{x}}$ is 154 feet short with a $\bar{\sigma}$ of 55 feet. In such a bimodal distribution neither the $\bar{\bar{x}}$ nor the $\bar{\sigma}$ has

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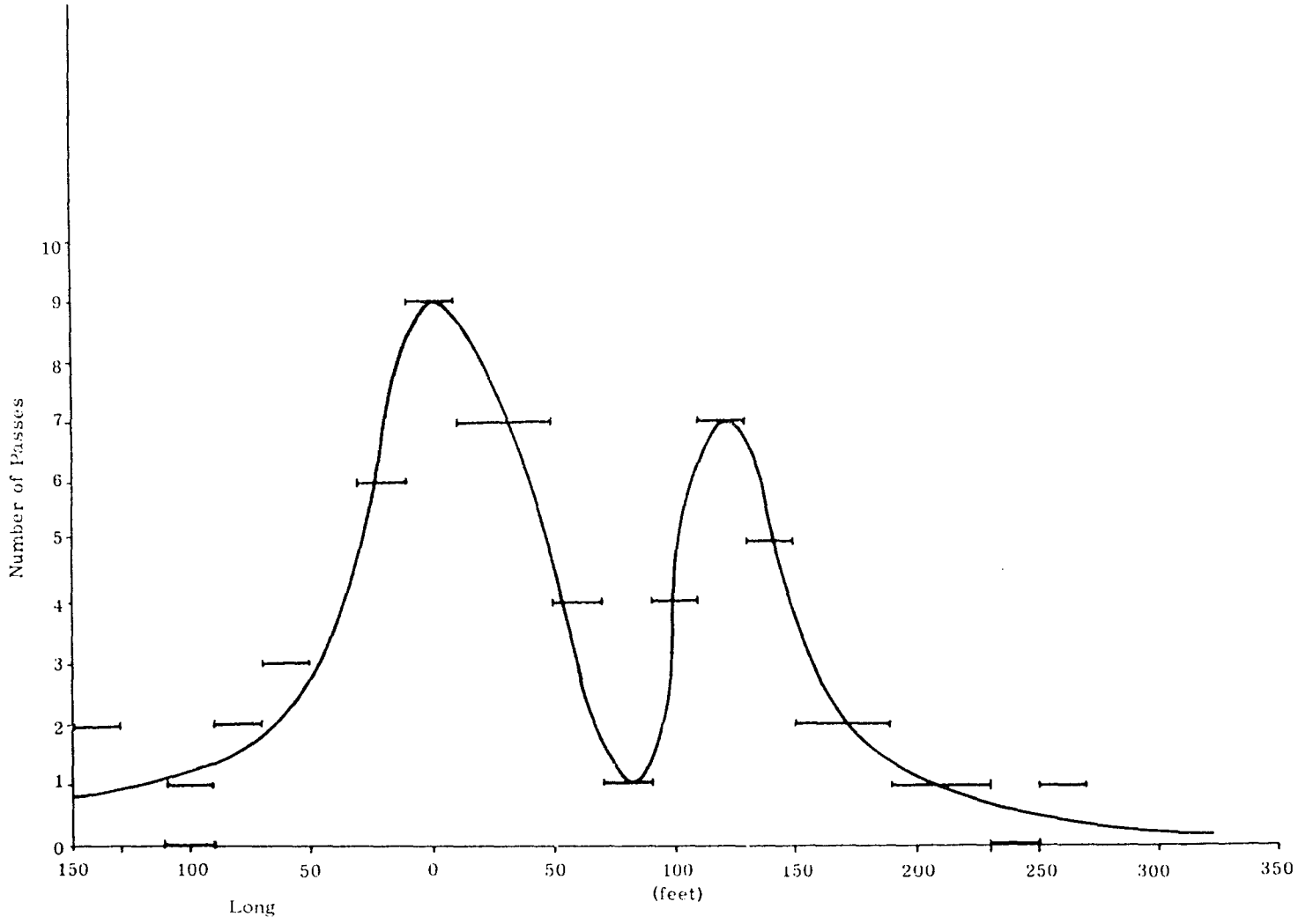

Figure 7 Distribution of Pickle Points, First Series

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meaning, i.e., the data appear to have a univariate normal distribution. Apparently the $\bar{\sigma}$'s tend to be comparable regardless of the pickling error or of the correctness of the bombing problem the pilot is trying to solve. The standard deviations may be more directly related to physiological-response time.

TABLE I

Pilot	n_1	$\bar{x}_1$	σ_1
1	11	-119.01	50.9
2	10	-167.58	42.6
3	10	-190.97	39.19
4	12	-53.71	25.45
11	11	-132.03	73.81
13	10	-182.90	68.24
14	9	-21.26	29.76
20	7	-69.37	72.09
22	10	-150.61	83.06
24	11	-64.78	70.17
30	11	-73.58	33.52
31	10	-56.38	36.62
32	11	-82.41	61.54
33	12	-131.05	55.45
40	10	-11.55	35.67
43	10	-49.46	69.97
50	8	-146.82	46.66
51	10	+25.69	56.23
52	10	-165.52	38.25
	193	$\bar{\bar{x}}_1 = -97.01$	$\bar{\sigma}_1 = 52.06$

To investigate the ability of pilots to improve their performance, the six pilots with the poorest scores in the first series of passes were shown their results, rebriefed, and the tests were repeated. The results of these second passes are shown in Figure 2 and Table II. Again the distribution of pickle points is strongly bimodal with four pilots showing marked improvement and two maintaining essentially the same magnitude of error as in their first passes. These results were interpreted as evidence that the later two pilots refused to heed the briefer and still insisted on solving the problem in their own way. This reasoning is supported further by the fact that these two pilots were two of the older and more experienced pilots in the squadron and obviously knew more about bombing and flying than did the project officer. Such a behavior pattern is not new to the author; it has been observed previously in other military contexts. If, as noted in Table II, the performances of these two, Pilots 2 and 52, are omitted, the mean shifts from 49 to 4 feet short. The improvement in the group mean from -97 feet in the first series of passes to -49 feet in the second series, or to -4 feet for pilots willing to learn, is taken as strong evidence that pilots can be trained to pickle over the target--especially when it is considered that regular Air Force units would undergo a more formal and extensive training program. A comparison of the $\bar{\bar{x}}$ and $\bar{\sigma}$ of just these six pilots from their first passes with those from their second series may result in a better estimate of the improvement possible with training. For these six pilots in the first test series, $\bar{\bar{x}}_1 = -155.4$ feet and $\bar{\sigma}_1 = 54.9$ feet, while in the second series, $\bar{\bar{x}}_2 = -49$ feet and $\bar{\sigma}_2 = 45.4$ feet. By further restricting the comparison to the four pilots who apparently did learn, the results become $\bar{\bar{x}}_1 = -149.8$ feet and $\bar{\sigma}_1 = 62.2$ feet versus $\bar{\bar{x}}_2 = -3.8$ feet and $\bar{\sigma}_2 = 44$ feet. So even if the results from all six of the retested pilots are considered, it is clear that the mean pickle point can be greatly improved by a factor of 3. If only the four pilots are considered who apparently learned, the improvement is sensational: a factor of 41.

The test data indicate that even with combat-degradation factors of 2 to 2.5, standard deviations of 110 to 150 feet would result, or stated in terms of REP, 74 to 100 feet would be achieved. Such error is smaller than the best

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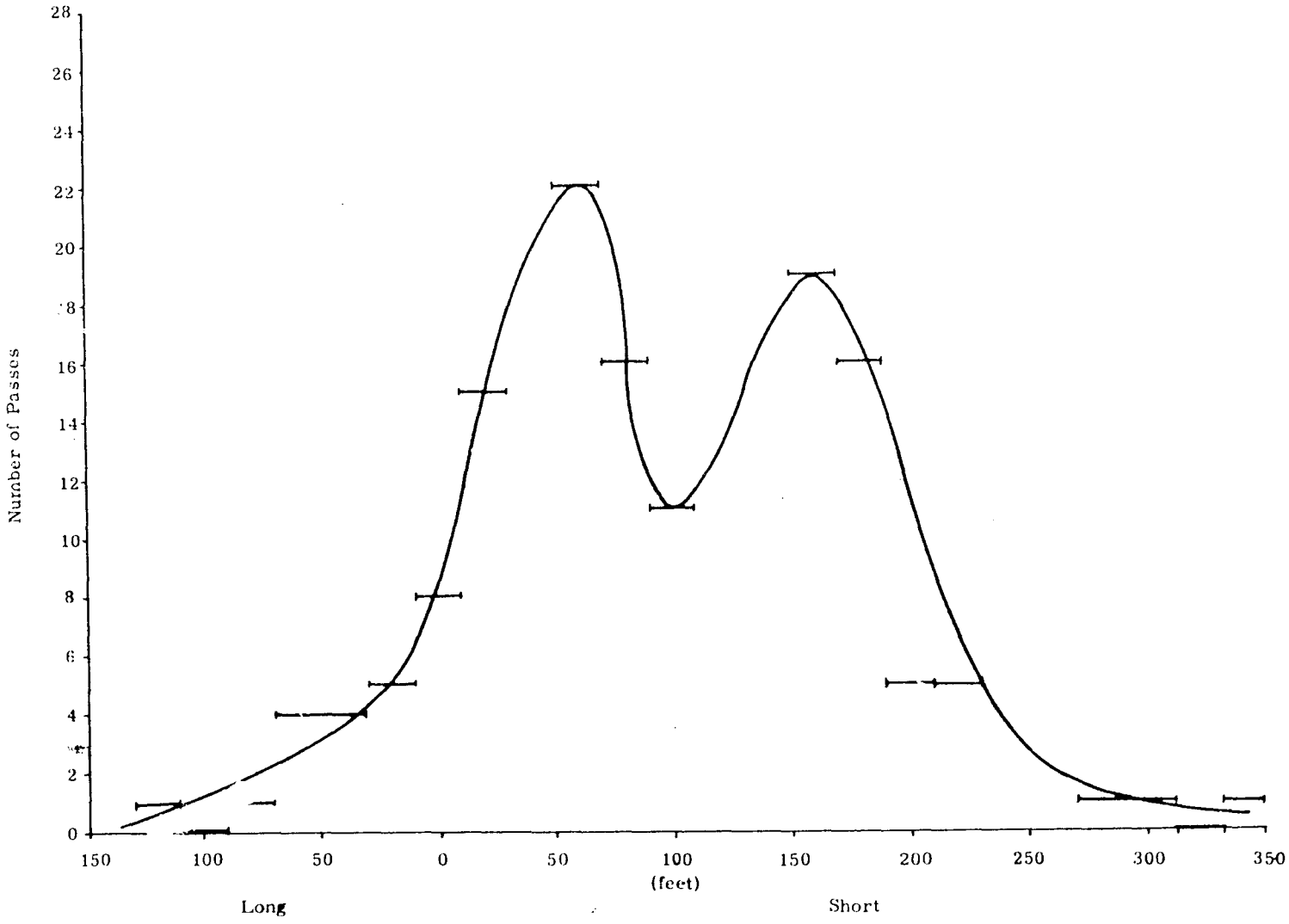

Figure 1. Distribution of Pickle Points, Second Series

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combat REP's attainable in any existing low-level bombing system by a factor of at least 2 to 3. On the other hand, it can be argued that the undegraded REP's of 44 to 62 feet in these tests can be taken as being equivalent to combat-degraded REP's since both the technique and the test site were unfamiliar to the pilots. A Navy study* concludes that an unfamiliar target area is the prime contributor to less than ideal delivery accuracies: ". . . it appears that unfamiliar target environment is the primary factor degrading the delivery accuracy in combat. Hence, accuracy data obtained under unfamiliar range conditions should approximate those obtained in combat by pilots of similar proficiency." The raw data for each pass are given in Table III.

TABLE II

Pilot	n_2	$\bar{x}_2$	σ_2
1	12	-11.89	48.62
2	12	-125.21	46.70
13	11	-11.23	18.60
22	10	+27.71	67.07
50	10	-15.90	42.29
52	11	-157.65	48.80
	66	$\bar{\bar{x}}_2 = -49.03$	$\bar{\sigma}_2 = 45.35$
If pilots 2 and 52 are omitted,		$\bar{\bar{x}}_2 = -3.77$	$\bar{\sigma}_2 = 44.14$

*Simecka, W. B., Delivery Accuracy of Air-Launched Weapons Delivered Against Ground Targets in an Unfamiliar Environment, NOTS-TP-3148, U.S. Naval Ordnance Test Station, December 1962, (C), X37350.

TABLE [illegible]

Miss Distances
(ft)

Test 1

Pilot	Miss No. 1	2	3	4	5	6	7	8	9	10	11	12	13
1	116.9	75.7	56.2	102.6	170.0	136.9	162.8	29.0	106.4	168.0	133.7		
2	193.7	-	192.3	124.5	179.4	175.0	189.0	99.2	180.9	175.5	240.5		
7	164.4	241.0	270.9	155.6	176.7	185.2	174.8	178.2	263.7	152.2			
8	52.0	112.6	-	53.2	65.1	69.2	15.3	62.2	17.3	22.4	68.0	65.0	51.3
11	7[illegible].1	11.4	217.0	223.1	229.7	9[illegible].5	158.7	43.2	158.7	138.4	143.9		
12	215.0	115.9	224.0	199.4	196.8	59.2	112.4	112.6	166.5	207.2			
14	[illegible]	21.4	+5.6	15.7	75.7	31.8	44.8	29.7	+25.5	-			
20	+4.5	25.2	+37.1	149.4	52.5	111.7	188.4	-	-	-			
22	174.0	157.1	171.4	51.7	252.7	195.4	94.0	72[illegible].2	114.6	119.3			
24	41.5	10.2	71.7	+13.4	70.0	235.2	49.4	[illegible]	63.6	65.1	93.8		
25	75.2	97.2	1[illegible].1	[illegible]	11.0	24.2	[illegible]	12[illegible]	10[illegible].1	111.0	71.8		
1	1[illegible].1	51.[illegible]	75.4	102.9	91.2	27.9	1.8	[illegible]	25.0	15.8			
2	17.[illegible]	4[illegible].2	32.6	130.8	72.0	46.2	1[illegible].8	195.5	8.3	82.9	77.4		
7	150.0	31.9	137.9	159.2	96.2	147.	274.2	112.4	104.8	134.2	55.9	93.9	
8	+7.7	4[illegible].7	60.6	[illegible]	47.1	+40.1	+11.8	[illegible]	2.7	9.1			
11	9.2	120.1	+19.9	10[illegible]	+7.4	9[illegible]	60.9	+1.3	145.8	21.6			
12	-	-	165.9	2[illegible].7	2[illegible].9	115.9	142.4	207.7	190.2	77.2			
14	46.7	12	+19.2	+[illegible]	+[illegible]	+[illegible]	+41.1	[illegible]	+[illegible]	35.7			
20	[illegible]	1[illegible]	19[illegible].7	17[illegible]	2[illegible].1	127.2	167.5	1[illegible].0	157.5	164.8			

Test 2

3	[illegible]	[illegible]	12.1	[illegible]	[illegible]	+19.7	+15.	[illegible]	9[illegible].1	5[illegible].5	[illegible].1	+1[illegible].6	
7	[illegible]	3[illegible].4	[illegible]	[illegible]	11.[illegible]	29.[illegible]	-	[illegible]	15[illegible]	155.7	121.6	98.3	123.2
8	9[illegible]	[illegible]	+[illegible]	3[illegible]	[illegible]	+1.0	+10.0	[illegible]	24.1	10[illegible]	130.3[illegible]		
22	[illegible]	[illegible]	+[illegible]	[illegible]	+[illegible]	+11[illegible]	+19.7	+[illegible]	+07.7	16.7			
9	[illegible]	[illegible]	[illegible]	[illegible]	9[illegible]	+[illegible]	+19.7	21.[illegible]	4[illegible]	68.6			
1	[illegible]	[illegible]	127.4	[illegible]	2[illegible].2	[illegible]	1[illegible]	[illegible]	[illegible]	121.7	120.1		

[illegible] [illegible]. Blanks mean the pilot did not record, all data recorded.
Pilot not [illegible] when he pickled, miss distances are estimated for a speed of 300 ft/sec.

Conclusions

1. Pilots can be taught to pickle over a target with sufficient accuracy to achieve REP's of 30 to 42 feet.

2. Both the individual and the group offset error can be reduced significantly by training and practice.

3. The range errors short of the target were consistent enough that good compensation could be achieved by including a fixed-time delay in the design of the delivery system.

4. The standard deviations do not change significantly with training, but they are smaller than comparable variations in existing low-level delivery methods.