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U.S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE, PENNSYLVANIA

Aviation Medical Acceleration Laboratory

NADC-MA-L6035 21 September 1960

Progress Report
Eye Protection for Nuclear Weapons Delivery Pilots, Inflight Research Studies to Obtain Quantitative Performance Data

Bureau of Naval Weapons
Problem Assignment No. J04AE23-1

U. S. NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE, PENNSYLVANIA

MA-82
7058
21 Sep 1960

From: Commanding Officer, U. S. Naval Air Development Center
To: Chief, Bureau of Naval Weapons (RAAE-13)

Subj: Report NADC-MA-L6035, "Eye Protection for Nuclear Weapons Delivery Pilots, Inflight Research Studies to Obtain Quantitative Performance Data", BuWeps Problem Assignment No. J04AE23-1; progress report concerning

Ref: (a) BuAer ltr Aer-AE-522 ser 08253 of 7 Aug 1959
(b) NASWF ltr ser 50/0319 of 29 Dec 1959 (C)
(c) CNO ltr op 704C/nb ser 893P70 of 18 Dec 1959

Encl: (1) Time in seconds that check pilots judged that subject pilots maintained safety-in-flight
(2) Analysis of variance summary table
(3) Graphical illustrations of the average length of the safety-in-flight judgements for the four variables considered independently
(4) Graphical illustrations of the interactive effects of pairs of the four variables on the average length of the safety-in-flight judgements

1. As directed by reference (a), a project was conducted jointly by the U. S. Naval Air Special Weapons Facility (NASWF), Kirtland Air Force Base and the Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center on the degree of ability of pilots to continue an operational mission when blinded for periods of time of up to 15 seconds. The equipment and procedures used by NASWF to collect the "blind flying" data are described in reference (b).

2. The present report of the project covers the statistical analysis and interpretation of the data collected by NASWF. The analysis and interpretation are based on the data collected on the three subject pilots for whom there is practically complete data. These data are presented in enclosure (1).

3. Most of the subject pilots professed in their personal statements (reference b), that they would be able to continue almost indefinitely in a straight and level flight path in the event of flash blindness. Their beliefs were supported by the data. In almost all tests in attitudes A and B, the subject pilots maintained safety-in-flight for 15 seconds,

the maximum time the check pilot allowed the pilots to fly blind. Although the subject pilots who were blinded when flying the straight and level attitudes had little difficulty maintaining safety-in-flight while flying the F9F aircraft used in these tests, the results probably would not have been as favorable if an aircraft with less inherent stability were used. Because the blinded subject pilots were not allowed to continue in control of the aircraft for longer than 15 seconds, the data obtained in the two straight and level attitudes are not valid measures of the maximum time the pilots were judged able to maintain safety-in-flight under these conditions. For this reason, these data were not included in the statistical analysis of the data for the other attitudes.

4. The mean times that the subject pilots were judged able to maintain safety-of-flight are the best estimates available of the times that pilots can maintain safety-of-flight in the event that loss of vision occurs when the aircraft is in any one of the attitudes used in these tests. These estimates are as follows:

Attitude	Mean Time in Seconds	99% Confidence Interval in Seconds
A. Straight and level at high altitude	>15.00	
B. Straight and level low altitude	>15.00	
C. 30 degree climb	11.21	9.15 - 13.27
D. 30 degree dive	6.88	5.22 - 8.54
E. Constant altitude turn at time of entry	6.96	5.11 - 8.81
F. Constant altitude turn when stabilized	5.96	4.53 - 7.39
G. 90 degree point of a slow roll	6.17	4.45 - 7.89
H. 180 degree point of a slow roll	4.79	4.18 - 5.76

It should be pointed out that the data from which these means and confidence levels were computed are biased in the negative direction because of the maximum time (15 seconds) of blind flying allowed and also because of the safety precautions which must be imposed in such test situations.

5. An analysis of variance was performed on the data in order to determine which, if any, of the variables, i.e., subject pilot, check pilot, light conditions, and attitudes, significantly influenced the results. The summary table of analysis is presented in enclosure (2). The variables which were found to be of significance are check pilots ($P \leq 0.1\%$) and attitude ($P \leq 0.1\%$). Light conditions were also a significant variable but only when taken in relation to check pilots. The interaction between check pilots and attitudes was also found to be significant ($P \leq 0.1\%$).

6. The meaning of these findings is better described graphically. Enclosure (4) shows the average times that the check pilots judged that

safety-in-flight was maintained when each of the four variables is considered by itself. Figure I A shows the average times each subject pilot was judged able to maintain safety-in-flight under all conditions of check pilots, light conditions, and attitudes. The differences among these times are not significant. These three subject pilots, although varying greatly in previous flight experience (reference b), were equally well able to maintain safety-in-flight. The average times that safety-in-flight was maintained in flights made in daylight as compared to those made in darkness are shown in Figure I B. The difference between these times is not significant. Safety-in-flight was maintained equally well whether the flight was made in the daylight or in darkness. Figure I C shows the average length of time that each check pilot judged that safety-in-flight was maintained under all conditions of subject pilot, lighting, and attitude. Check Pilot I, on the average, permitted the subject pilots to maintain control of the aircraft for longer periods of time than Check Pilot II. Figure I D shows the average length of the judged safety-in-flight interval for the six attitudes, C through H, for all subject pilots, both check pilots and both light conditions. The difference in the lengths of the intervals for the six attitudes is significant. The attitude which produced the least difficulty in maintaining safety-in-flight while the subject pilot was blinded was the 30 degree climb. The one which produced the greatest difficulty was the 180 degree point of the slow roll. The other four attitudes were of intermediate difficulty.

7. Figure II (enclosure 4) shows the average times that the check pilot judged that safety-in-flight was maintained when the interactions between pairs of variables are taken into account. Figure II A shows the average safety-in-flight times during daylight and during darkness for each subject pilot for both check pilots. The differences in these times are not significant. Figure II B shows the average safety-in-flight times for each subject pilot as judged by each check pilot for all attitudes. These variables do not interact significantly, that is, the performance of the check pilot was not a function of the subject pilot; the check pilots were not consistently biased with respect to the various subject pilots. Figure II C and II D show the interactions between attitudes and subject pilots and light conditions respectively. Neither of these interactions is significant. Figure II E shows the effects of light conditions on the check pilots' judgement for all subject pilots and attitudes. The results indicate that the two check pilots did not judge in a similar fashion when the lighting conditions were varied. From the figure it can be seen that, in addition to the fact that Check Pilot I permitted the subject pilots to maintain control of the aircraft longer than Check Pilot II, the relation between safety-in-flight judgements and the illumination conditions is different for the two check pilots. Check Pilot I permitted the subject

pilots to maintain control of the aircraft longer in darkness, whereas Check Pilot II permitted the subject pilots to maintain control longer during daylight. This interaction between light conditions and check pilots is significant. Figure IIF shows the relationship between the check pilots and attitude of the aircraft variables. The interaction between these two variables is significant. Some of the attitudes for which Check Pilot I permitted the subject pilot to maintain control of the aircraft for relatively long periods of time were among those for which Check Pilot II made relatively short safety-in-flight judgements while, on others, the reverse is the case. None of the higher order interactions (the relations among the variable taken three or four at a time) is significant.

8. It had been expected that the results of a similar study still in progress at DEVRON 5, China Lake (reference (c)) would be available at this time as a cross check on these data. Until the data from the DEVRON 5 study are available, the following interpretations, conclusions, and recommendations must be considered as only tentative. Furthermore, because of the limited amount of usable data collected in the present study, care must be exercised in its interpretation.

9. In no case did the check pilots judge that the subject pilot maintained safety-in-flight for less than three seconds and, under the most trying conditions, the average time that the check pilots judged that safety-in-flight was maintained was still 4.79 seconds. On the basis of these figures, one may conclude that a flash-blinded pilot would have a minimum of about five seconds to recover, and that a pilot equipped with flash protective devices which occlude the vision would have time to take the steps necessary to regain vision of at least his flight instruments. This estimate of five seconds is low due to the safety margin that the check pilots obviously used (no one crashed) and high due to the check pilots full knowledge of the status of the aircraft at all times.

10. The check pilots' perception time and decision time are included in the above estimate. For this reason it is recommended that steps be taken to determine whether a pilot can perceive his situation and take whatever steps are necessary to maintain safety-in-flight upon recovering his vision following loss of vision due to the "closing" of a flash blindness protective device and not merely to abort his mission. Upon the results of these tests a realistic training program for pilots can be based.

11. Mere experience as a pilot is of little value in maintaining safety-in-flight without any visual reference. In view of the training pilots receive to put their reliance in their instruments rather than the "seat of their pants", these results are to be expected. Furthermore, training in blind flying per se is not recommended but rather training in how to

regain vision should he become flash blinded or blinded by his flash blindness protective device.

12. The check pilots and subject pilots are to be commended for their excellent work in carrying out the procedure required to collect this data in a fashion that made it amenable to statistical analysis.

13. This report was prepared by Drs. J. H. Hill and G. T. Chisum, Human Engineering Branch of the Psychology Division, and was approved by Dr. James D. Hardy, Research Director, Aviation Medical Acceleration Laboratory.

F. K. SMITH
By direction

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SUBJECT PILOT		1				2				3			
CHECK PILOT		I		II		I		II		I		II	
NIGHT/DAY		N	D	N	D	N	D	N	D	N	D	N	D
ATTITUDE	A	15	10	15	15	15	15	15	15	15	15	15	15
		15	15	15	15	15	15	15	15	15	15	15	15
	B	15	15	13	8	6	12	11	3	15	15	15	10
		15	15	15	15	15	15	15	13	15	15	15	15
	C	7	5	10	10	15	11	9	6	12*	15	5	9
		15	15	6	9	15	15	12	15	15	15	12	11
	D	15	11	5	4	10	10	4	5	5	9	5	5
		9	8	4	5	9	9	6	4	5	8	5	5
	E	8	9	4	6	15	10	4	3	10	4	5	4
		6	4	5	5	6	7	8	8	15	10	6	5
	F	5	5	3	8	15	6	5	4	4	6	3	4
		5	8	4	8	5	5	5	8	8	6	6	7
	G	7*	7	5	15	4	6	7	15	5	4*	4	4
		4	4	5	6	7	6	7	8	5	4	4	5
	H	5	4	3	4	4	4	4	4	5	5	4	9
		4	7	5	5	4	5	4	5	5	8	4	4

*Estimated, data missing.

Time in seconds the check pilots judged the "blinded" subject pilots maintained safety-in-flight. In all cases the blind flying was terminated at the end of 15 seconds.

ENCLOSURE (1)

ANALYSIS OF VARIANCE

Source of Variation	df	F
Subjects	2	1.909
Check pilots	1	19.066**
Time	1	0.835
Attitude	5	19.310**
Subjects X Check Pilots	2	0.365
Subjects X Time	2	0.695
Subjects X Attitude	10	1.469
Check Pilots X Time	1	4.548*
Check Pilots X Attitude	5	5.318**
Time X Attitude	5	1.094
Subject X Check Pilot X Time	2	0.346
Subject X Check Pilot X Attitude	10	0.889
Subject X Time X Attitude	10	0.874
Check Pilot X Time X Attitude	5	0.652
Subject X Check Pilot X Time X Attitude	10	0.395

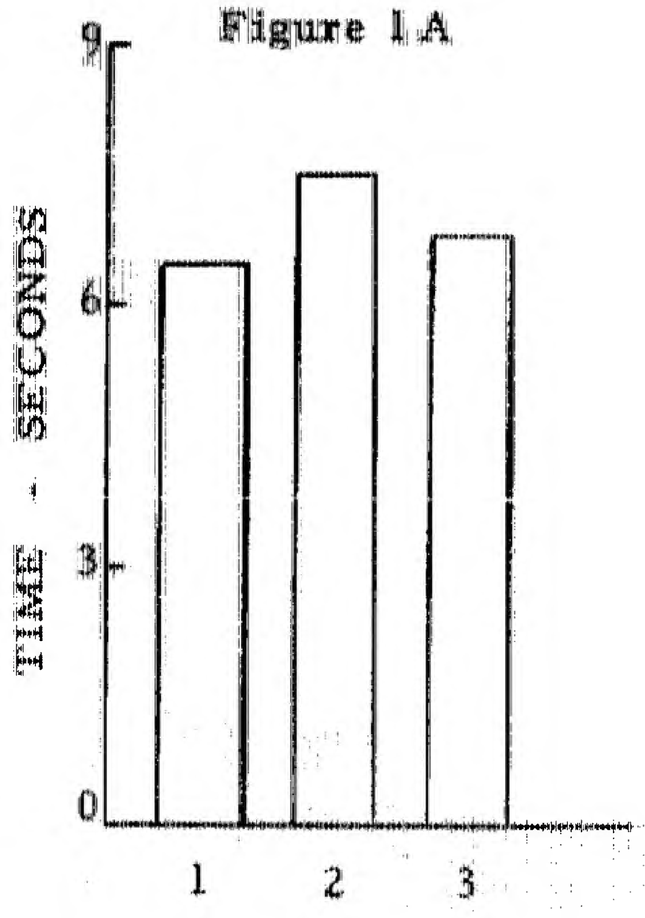
* $P < .5\%$

** $P < 0.1\%$

Summary table of analysis of variance of check pilot estimates of length of safety-in-flight period for pilots flying blind during daylight and darkness for six aircraft attitudes.

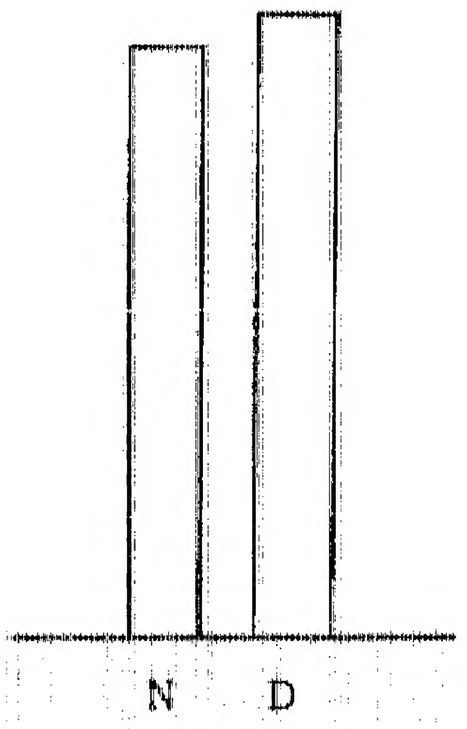
ENCLOSURE (2)

Figure 1 A



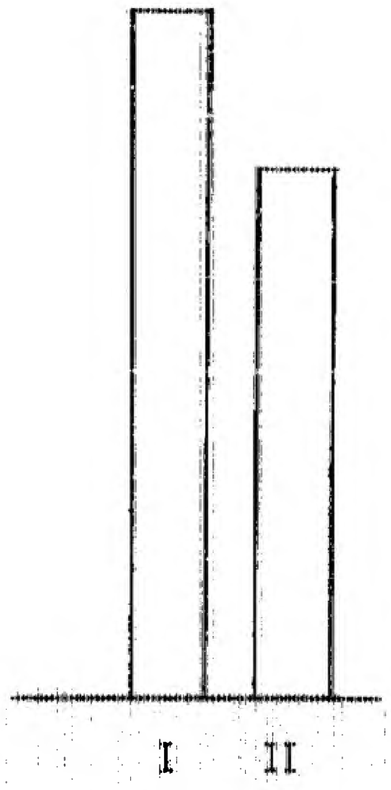
SUBJECT PILOT

Figure 1 B



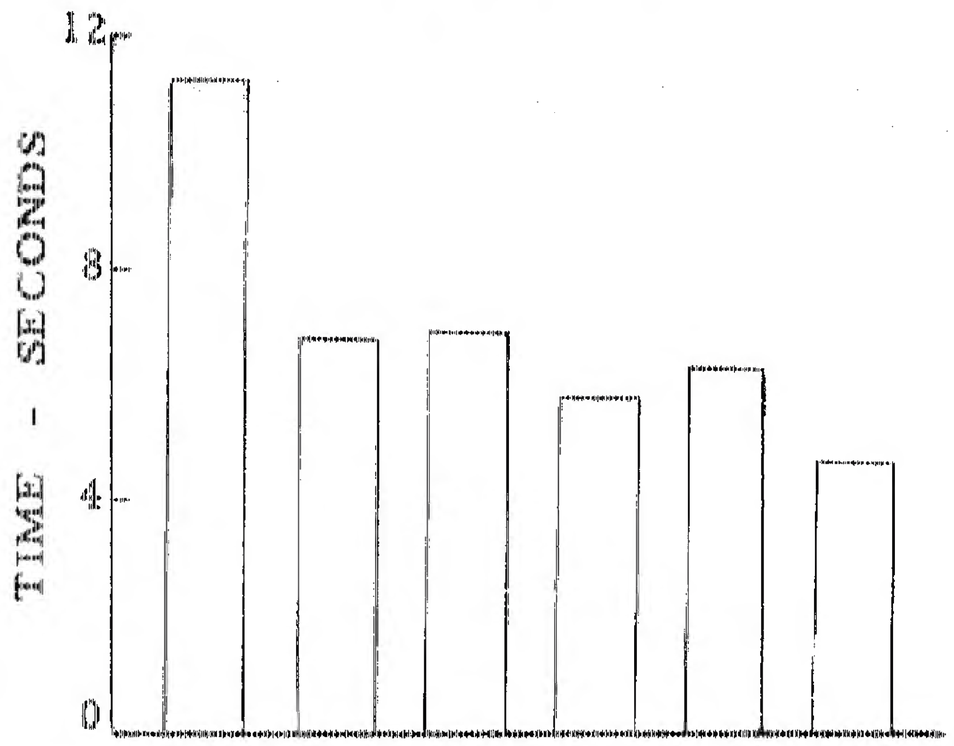
LIGHT CONDITION

Figure 1 C



CHECK PILOT

Figure 1 D



AIRCRAFT ATTITUDE

Graphical illustrations of the average length of the safety-in-flight judgements for the four variables considered independently.

ENCLOSURE (3)

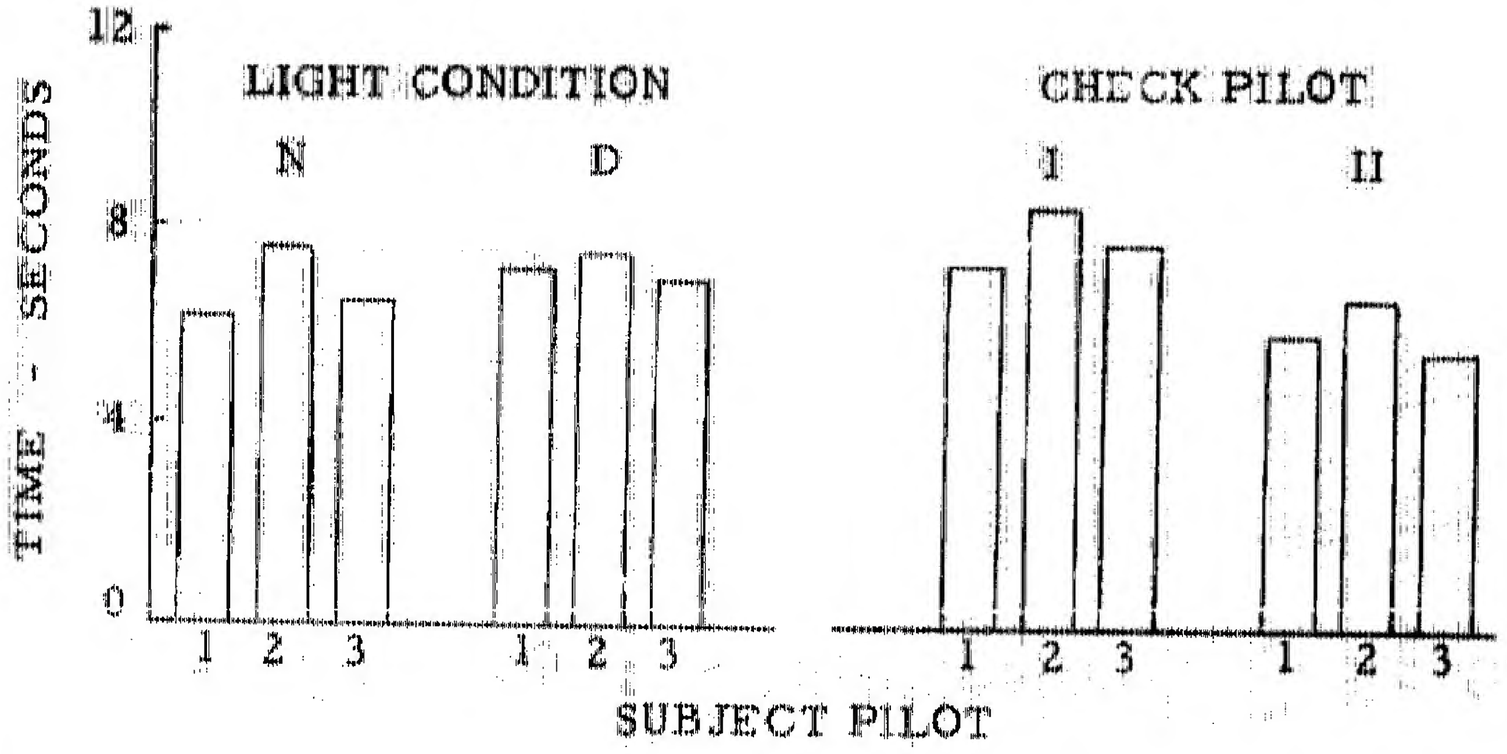


Figure II C

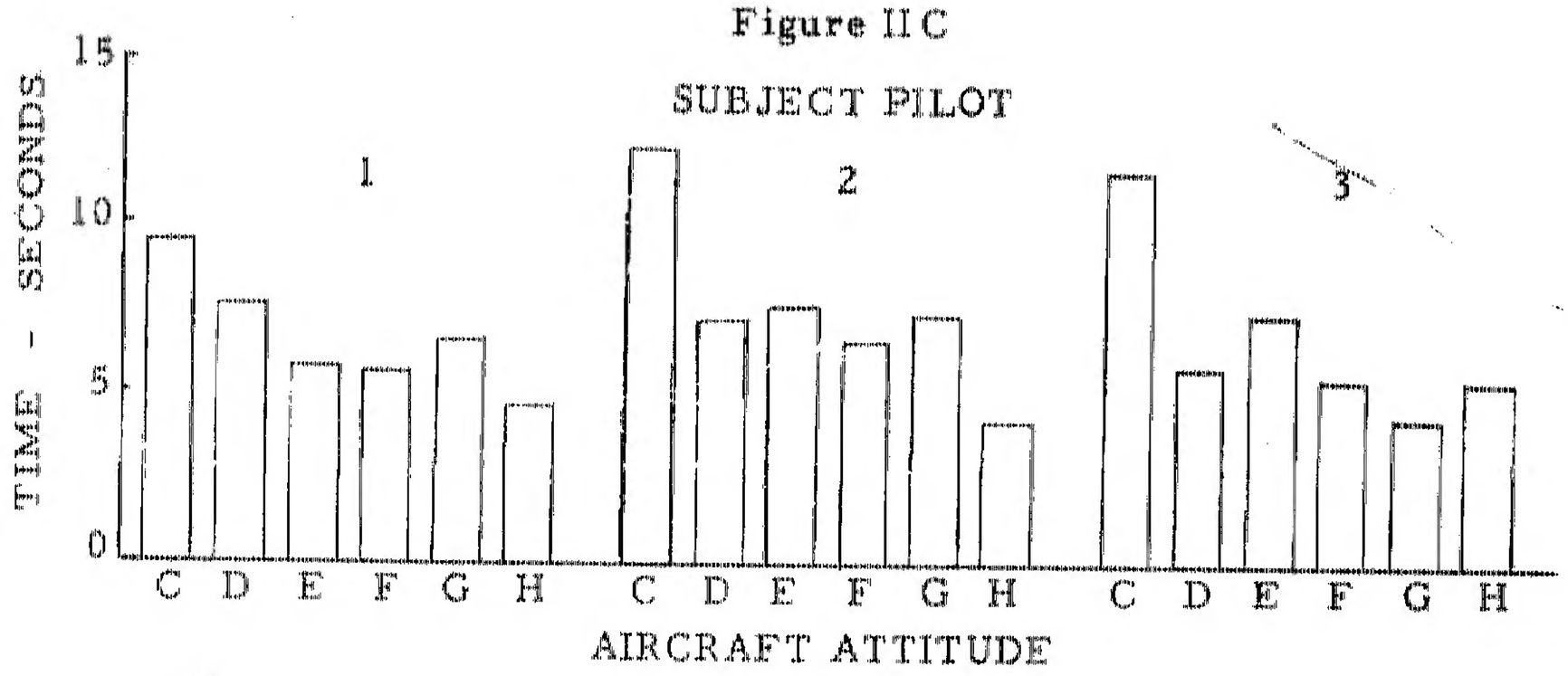
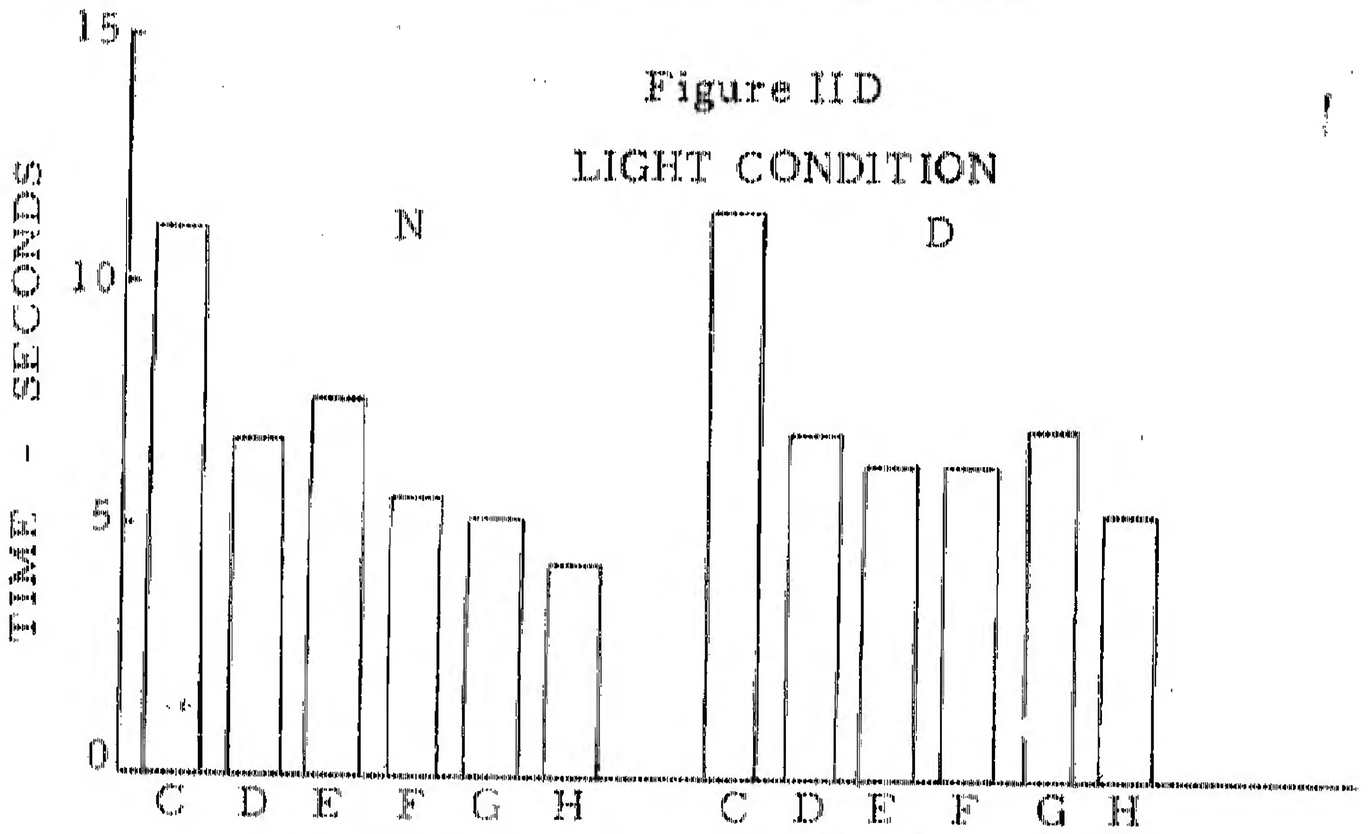


Figure II D



Graphical illustrations of the interactive effects of pairs of the four variables on the average length of the safety-in-flight judgements.

ENCLOSURE (4)

Figure II E

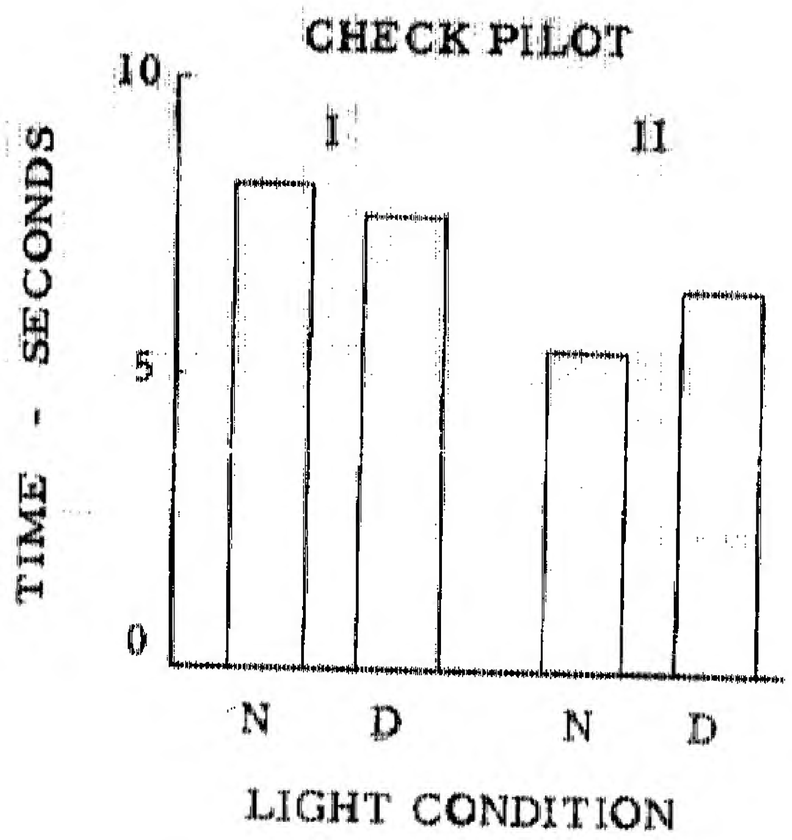
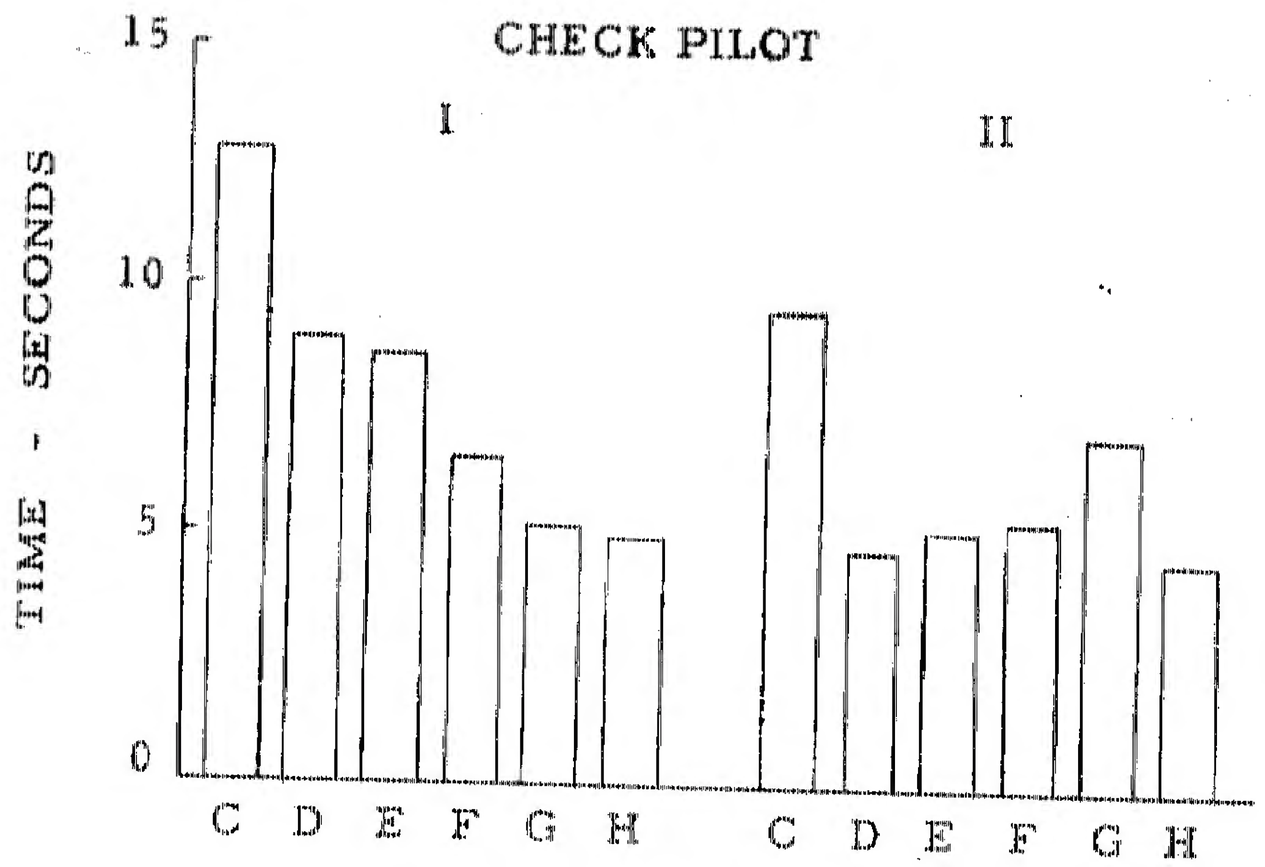


Figure II F



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