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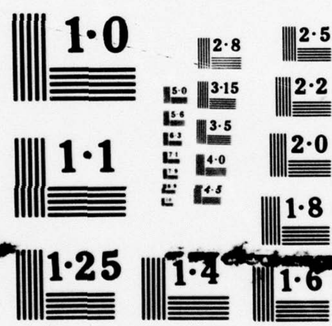

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AREA OF INTEREST/FIELD-OF-VIEW RESEARCH USING ASPT

By

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FLYING TRAINING DIVISION
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May 1978
Interim Report for Period October 1976 – December 1977

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AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

This interim report was submitted by Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

This technical report has been reviewed and is approved for publication.

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Two exploratory experiments were conducted in the Advanced Simulator for Pilot Training to examine the head-slaved area of interest (AOI) approach for reduced fields-of-view employing computer-generated imagery (CGI). The objective of Study 1 was to establish a suitable range of AOI sizes for simulated conventional gunnery range bombing performance. The results indicated an AOI size as small as 70° vertical x 90° horizontal could be usefully employed without seriously degrading bombing performance.

The objective of Study 2 was to determine the effect of AOI level of detail on air-to-surface weapon delivery performance in a tactical environment. Study 2 also addressed the question of whether AOI size affected bombing

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performance in such an environment. No effects on bombing performance of either detail level, AOI size or their interaction were observed. It was concluded from both studies that an AOI size as small as 70° x 90° is feasible for the head-slaved AOI approach. Further research on required detail level is needed.

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PREFACE

This report covers Phase I of a study conducted under project 1123, Flying Training Development, task 112303, Exploitation of Simulation in Flight Training. Mr. James F. Smith was Project Scientist, and Mr. Robert R. Woodruff was Task Scientist.

This research was conducted in support of the Simulator System Program Office's Engineering Development Project 2360, Fighter/Attack Simulator Visual System.

Engineering development necessary to the conduct of this research was completed under the supervision of Mr. Eric G. Monroe, AFHRL/FTE.

The authors wish to acknowledge the valuable contributions to this research provided by the 425th Tactical Fighter Training Squadron (TAC), Williams AFB, Arizona.

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I. INTRODUCTION

The first demonstration of a head-slaved area of interest (AOI) approach to help satisfy full field-of-view visual requirements was demonstrated during 1976, under project 2235, Air-to-Surface Visual Evaluation (Hutton, Burke, Englehard, Wilson, Rumaglia, & Schneider, 1976). The results produced two major conclusions. First, a 60° diagonal AOI was inadequate for the accomplishment of air-to-surface tasks and second, very little was known about the effects on pilot performance of using such systems. This lack of knowledge could constrain management and technical decisions for current and future simulator programs. Consequently, a program was developed between the Simulator System Program Office (SPO) of the Aeronautical Systems Division and the Flying Training Division, Air Force Human Resources Laboratory, Williams AFB, Arizona, (AFHRL/FT), to investigate the head-slaved area of interest concept. Some of the principal concerns to be investigated were:

1. What is the range of acceptable fields-of-view for conducting the air-to-surface weapons delivery task?

2. What level of detail is required within the AOI?

3. Is a head-slaved area of interest technique useful for computer generated image (CGI) systems?

Due to an urgent need for such data, it was jointly determined that the initial experiments in this program would be conducted as exploratory research; i.e., as an effort to determine trends fruitful for subsequent, more controlled study.

The Area of Interest Research to be conducted on the Advanced Simulator for Pilot Training (ASPT) at Williams AFB was structured in multiple phases to permit modifications to occur at logical points within the program. This report summarizes the findings of Phase I of this program. Phase I was subdivided into two studies. Study 1 was conducted to determine the effect of area of interest size on conventional gunnery range weapon delivery performance. The results would provide an acceptable range of area of interest sizes which could support the air-to-surface task with a minimum degradation in performance. Study 2 was conducted to determine the effect of area of interest level of detail on weapon delivery performance in a tactical environment and to provide additional information on field-of-view size under more demanding task conditions.

II. STUDY 1

Objective

Study 1 was conducted to determine the effect of AOI size on conventional gunnery range weapons delivery performance.

Method

Subjects. Four F-5 instructor pilots, assigned to the 425th Tactical Fighter Training Squadron (TAC), Williams AFB, served as subjects. Each of the subjects had completed a tour in tactical fighter aircraft and was current in weapons delivery tactics and procedures. At the time this study was conducted, two of the subjects had not established a circular error average (CEA) in the squadron for 30° dive bomb. These CEAs were established within a month and are shown in Table 1. All subjects had prior flight experience on the Gila Bend gunnery range which was selected for the simulated visual environment in this study. That is, they had performed the test bombing maneuver at that range.

Equipment. Subjects in this study wore a helmet-mounted device developed by Honeywell. The Honeywell device slaves the visual system area of interest to the subject's head position by establishing a line in space with two pairs of infrared detectors. These detectors are mounted one pair on each side of the pilot's helmet (Figure 1) and aligned parallel to the operator's line of sight. The system then calculates the position in space of the two parallel pairs of detectors.

Two Sensor Surveying Units (SSU) that are mounted to the ASPT cockpit on either side of the subject generate pairs of thin, collimated, fan-shaped infrared light beams rotating at a constant angular velocity. These infrared beams trigger signal pulses whenever the beams sweep over the helmet detectors. A beam-reference-detector inside the SSU establishes the rotational location of the beam by generating a reference (timing) pulse as the beam sweeps the detector.

Table 1. Study 1 – Subject Flight Experience

Subject	Total Time (Hrs)	F-5 Time (Hrs)	Years IN F-5	Indiv 30° Dive CEA (Ft)
R-1	1,240	154	1	117
R-2	1,754	638	2.5	101
R-3	1,830	185	1	215
R-4	2,269	121	1	138
$\bar{X}$	1,773	275	1.4	143

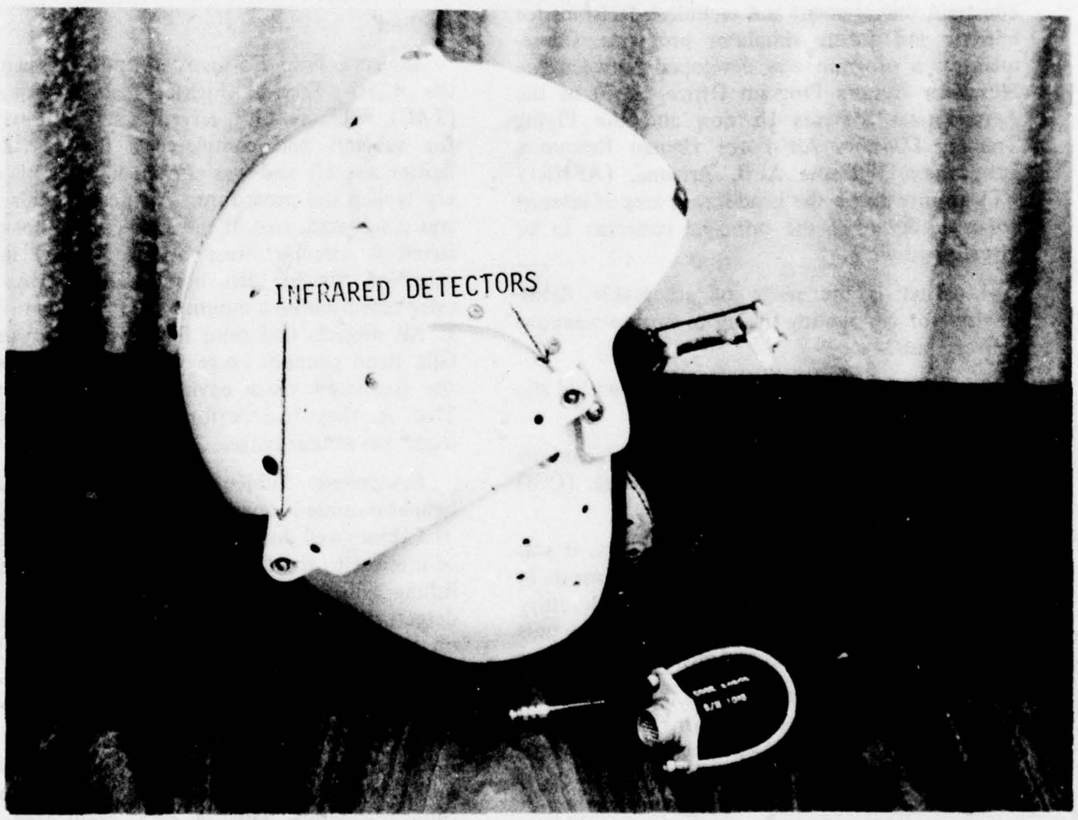

Figure 1. **Helmet with side-mounted infrared detectors.**

A Sight Control Unit (SCU) contains the digital circuitry for converting the detector pulse signals from the helmet and the SSU into digital angles, and converting the measured angles (theta angles) into azimuth and elevation drive signals suitable for controlling the location of the area of interest.

The research was conducted in the Advanced Simulator for Pilot Training (ASPT) located at AFHRL/FT. The ASPT has two fully instrumented T-37 cockpits mounted upon six-degree-of-freedom motion platforms. These synergistic motion systems have six active drive legs with approximately 5 feet of vertical travel and 4 feet of horizontal travel. Displacement capabilities include: pitch –20 degrees to +30 degrees; roll ±22 degrees; and yaw ±32 degrees. These displacements are intended to provide initial (onset) cues for all maneuvers. A 31-bellow pneumatic G-seat system in the ASPT is designed to provide more continuous motion cues than the motion platform and accomplishes this by the orderly inflation and deflation of the bellows in response to the requirements of each particular maneuver.

The visual system of the ASPT is comprised of seven 36-inch monochromatic cathode ray tubes placed around the cockpit giving the pilot +110 degrees to –40 degrees vertical cueing and ±150 degrees of horizontal cueing. The computer generated visual scene has the capability to display information for most pertinent ground references (mountains, runways, hangars, etc.) within a square area 1,250 nautical miles on each side. The configuration for this study included the conventional gunnery range visual data base developed for Project 2235 and the depressible bombing sight (A-37 Optical Sight Unit) installed for that project (Gray & Fuller, 1977).

Computer inputs provided masking of the ASPT visual display (150° vertical x 300° horizontal) down to the desired AOI sizes to be tested. The sizes selected for this study are stated in Table 2:

Table 2. **AOI Sizes**

Size No.	Vertical Visual Angle	Horizontal Visual Angle
1	38°	52°
2	70°	70°
3	70°	90°
4	70°	110°
5	70°	130°

The number and dimension of the AOIs used were established considering the major study objective and the following factors. First, the smallest area of interest was to be used in conjunction with another on-going study conducted by AFHRL. The upper limit was established by considering the approximate limits of human peripheral vision. Although a human's peripheral vision is known to include as much as ±90° viewing area in the horizontal plane, it was assumed that only viewing areas less than ±65° in the horizontal plane would significantly affect performance. As a result, area of interest sizes beginning at approximately the size demonstrated in Project 2235 up to the ±65° viewing area were chosen as the range of sizes to be studied. The AOI sizes within the extremes were chosen to permit uniform gradient in the horizontal size of the AOI. The vertical size of the AOI was established by considering the dive angle selected for this evaluation (30°), the maximum dive angle established by the tactical forces (60°), and the results of the Project 2235, Air-to-Surface Visual System Evaluation, which indicated that pilots preferred a horizon reference within the AOI to preclude a "tunnel vision" effect. To retain the horizon in the visual scene during the 30° dive bomb delivery, a ±35° vertical size was adopted.

The intent to retain the horizon within the AOI during 30° dive bomb runs was not fulfilled because of the downward vertical bias requested by the trial subjects. Three gunnery qualified pilots made bomb delivery runs with the system prior to the beginning of the study. Their unanimous choice for the vertical positioning of the AOI was a 15° negative bias. Throughout these studies, therefore, when in straight-and-level flight with the eyes on the horizon straight ahead, head and neck relaxed, the vertical center of the visual display was positioned 15° below the horizon.

The masking of the visual display was accomplished in a manner which provided a visible horizon line outside the AOI. This appeared as a line of white light across the entire ASPT visual display located in the position of the horizon during all aspects of flight. This was the only visual cue external to the AOI. This horizon, external to the AOI, was provided to assist the pilots in maintaining spatial orientation during weapon delivery.

Procedure. Each subject was presented a 25-minute ASPT Safety/Procedures video tape at the beginning of the study.

The AOI flight helmet was fitted to each subject by adjusting the thickness of removable pads mounted between the earphones and the helmet shell. Pad thickness was increased until the helmet fit comfortably but snugly. Subjects tested the fit to be sure the helmet maintained its proper position with respect to the pilot's head during rapid head movements.

Each subject received a 45-minute familiarization flight using the full field-of-view (FOV) in the ASPT with an AFHRL/FT instructor pilot in the right seat. During this period, the subjects got the feel of control and power inputs. The helmet was placed on the subject's head and boresighted to assure accurate alignment of the head-slaved AOI. Subjects were briefed on sight operation, mil settings, and 30° dive bomb pattern altitude and airspeeds. A 30° dive bomb delivery was chosen for two reasons: simulated aircraft performance characteristics and operational acceptability. The ASPT simulates the T-37 aircraft performance. To obtain the proper release conditions (including airspeed control) for dive angles in excess of 30°, the pilot must adjust throttle position and use speed brakes in an unnatural sequence. To avoid this condition and its potential effect on the results, it was decided to use 30° dive angles. In addition, 30° dive angle deliveries are considered to be more operationally acceptable and, therefore, in wider use throughout the tactical air forces. Subjects flew over the gunnery range until they were familiar with the simulated pattern features. During the remainder of the familiarization period, subjects dropped scored bombs, using 30° dive angle and full field-of-view.

During both familiarization training and the experimental sessions, with each bomb delivery, distance in feet from target center and azimuth of each hit were recorded and verbally reported immediately to the subject. In addition, while the simulator was in the freeze mode between bomb runs, a small cathode ray tube (CRT) screen in the ASPT cockpit displayed deviations from desired airspeed, altitude, and accelerometer readings which occurred at the instant of the just-completed bomb release. Subjects were unanimous in describing this information feedback as being extremely beneficial to a weapons delivery training situation. This information was available to subjects in Study 1 and Study 2.

Distance in feet of bomb hit from target constituted the principal dependent variable employed in this study. RMS vertical and horizontal head movement were also recorded. In addition, by voice recordings throughout the experimental sessions, and by interview at their completion, subjective data were elicited from each pilot, the results of which are summarized for both Studies 1 and 2 in Appendix A.

After the 45-minute orientation period with the instructor pilot (IP), the subject was given a 10-minute break. He reentered the cockpit solo and flew two 45-minute weapons delivery periods on the gunnery range pattern. Sequence of AOI size, levels 1 through 5, was randomized and changed after each bomb delivery. Subjects were permitted to make as many bombing runs as individually possible within each of the two 45-minute experimental sessions.

During each bomb run, the subject began from a reset point on the downwind leg. ASPT was programmed to reset after each bomb delivery when the simulator ascended through bomb release altitude and assumed a wings level attitude. The reset configured the simulator to downwind heading, altitude, airspeed, power and trim. The simulator remained frozen at the reset point until released by the console operator. AOI size was changed while the simulator was frozen at the reset point. Subjects rested for 10 minutes outside of the cockpit between experimental sessions.

Results and Discussion

A plot of mean circular error in bombing performance as a function of AOI size is presented in Figure 2.

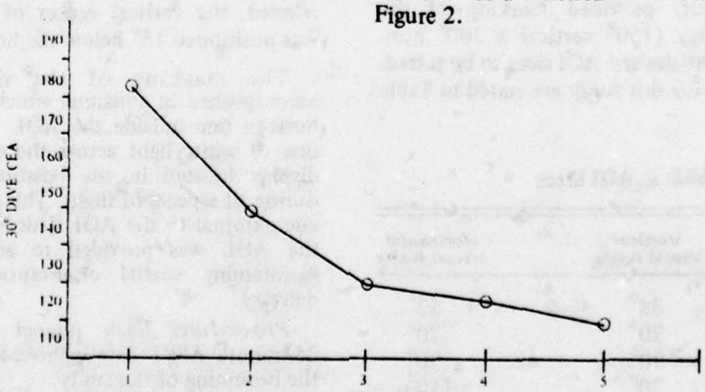

Figure 2. **Effect of AOI size on 30° dive CEA – gunnery range.**

Table 3 presents the results of a treatment by subjects repeated measures ANOVA on CEA, unweighted means (Ferguson, 1976).

An overall significant effect of AOI on performance ($F_{4/12} = 4.39$, $p < .05$) was observed, with bombing accuracy declining as AOI size decreased from level 5 (70° x 130°) through level 1 (38° x 52°). Newman-Keuls pairwise comparisons indicated performance under AOI level 1 was significantly worse ($p < .05$) than that under each of the larger AOI levels. Performance differences under AOI levels 2 through 5 were not statistically significant. Subjective reports (Appendix A) were consistent with the analysis of the performance data. Subjects reported size 2 to be the smallest acceptable visual angle for weapons delivery. Thus, while these results indicate clearly that the smallest AOI size employed (38° x 52°) significantly detracts from gunnery range performance, little effect was evident as AOI size decreased from 70° x 130° through 70° x 70°. It should be noted, however, that while bombing performance with AOI level 2 (70° x 70°) was not significantly worse than that at levels 5 through 3, an inspection of Figure 2 suggests a negative trend for performance at that level. Given the small sample size (N=4) in this experiment, therefore, it may conservatively be concluded that level 3 (70° x 90°) is the minimum acceptable AOI size for gunnery range performance. That is, in this type of task, in which relatively little difficulty in target acquisition is experienced once familiarity with the pattern features of the gunnery range is obtained, pilots are able to maintain flight parameters necessary for bombing accuracy as well with an AOI size of 70° x 90°, as with the larger AOI's. It must be emphasized that this result was obtained with experienced pilots and should not be generalized beyond that population.

RMS vertical head movement results are plotted in Figure 3. Table 4 presents the results of the ANOVA ($F = 2.76$, $p < .10$). It is clear from an

Table 3. **Study 1 – ANOVA Summary Table on CEA**

Source	SS	df	MS	F	P
Subjects	23348.42	3			
AOI	8148.79	4	2037.19	4.39	<.05
AOI X Subjects	5565.13	12	463.76		
Total	37062.33	19			

Table 4. **Study 1 – RMS Vertical Head Movement ANOVA**

Source	SS	df	MS	F	P
Subjects	213.38	3			
AOI	9.17	4	2.29	2.76	<.10
AOI X Subjects	9.95	12	.83		
Total	232.50	19			

inspection of Figure 3 that vertical amplitude in head movement was greatest at level 1. Little difference was evident in vertical amplitude between levels 2 through 5, although an increasing trend in movement amplitude is observed at level 2. This result closely parallels the findings with respect to bombing accuracy, performance degradation being most prominent at level 1, less so at the larger AOI sizes. The results are consistent with the bombing performance findings in suggesting level 3 (70° x 90°) as the minimum acceptable AOI size. Smaller AOI sizes are associated with an increased head movement effort by the pilot.

RMS horizontal head movement results are plotted in Figure 4, and the associated ANOVA is presented in Table 5. No significant differences were observed. However, the shape of the function across AOI sizes is similar to that observed with vertical movement, amplitude being largest with the smallest AOI.

Figures 5 and 6 graphically portray RMS vertical and horizontal head movement, respectively, by individual subject. A striking dichotomy is evident. Two subjects exhibited low RMS head movement values across all AOI levels. The remaining two subjects exhibited considerably higher RMS values. This result probably reflects differences in target acquisition strategy employed by the subjects. Narrative comments by the pilots indicated that the two subjects with low RMS values relied heavily on learned instrument readings for the fixed manuever pattern, an effort that reduced the visual search requirements relative to the ground target. Subjects with high RMS scores relied more significantly on repeated visual reference to ground terrain for target location.

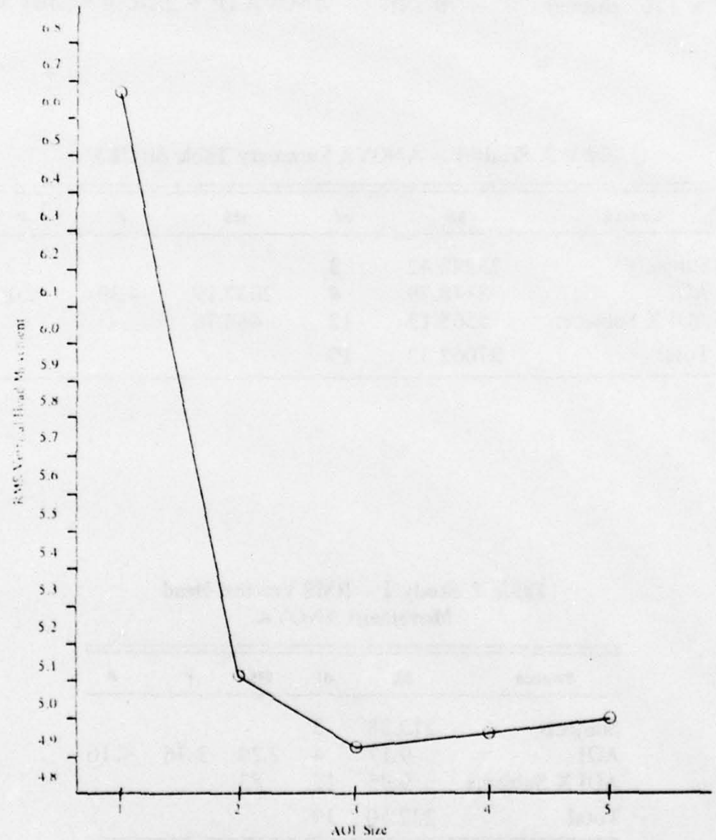

Figure 3. **Study 1 – RMS vertical head movement as a function of AOI size.**

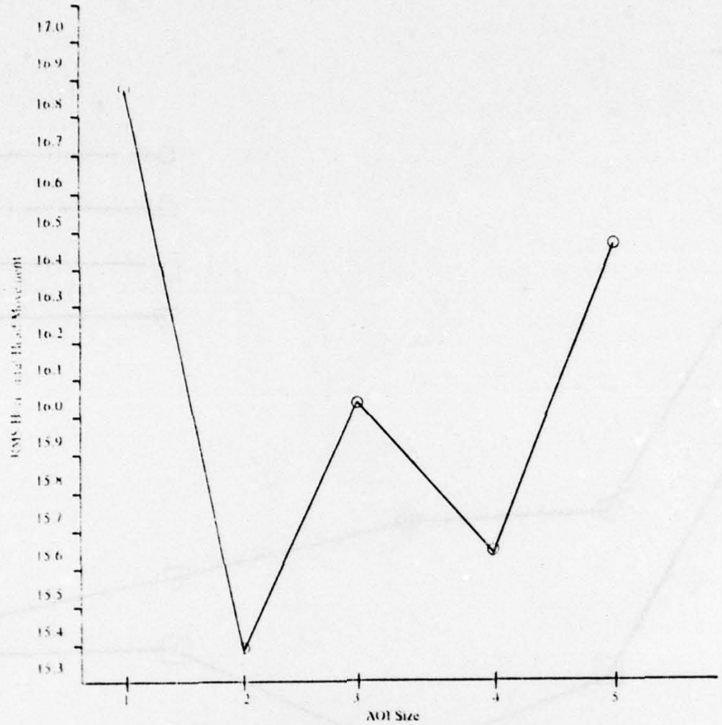

Figure 4. **Study 1 – RMS horizontal head movement as a function of AOI size.**

Table 5. **Study 1 – RMS Horizontal Head Movement ANOVA**

Source	SS	df	MS	F	P
Subjects	1701.82	3			
AOI	5.83	4	1.46	.90	NS
AOI X Subjects	19.50	12	1.63		
Total	1727.15	19			

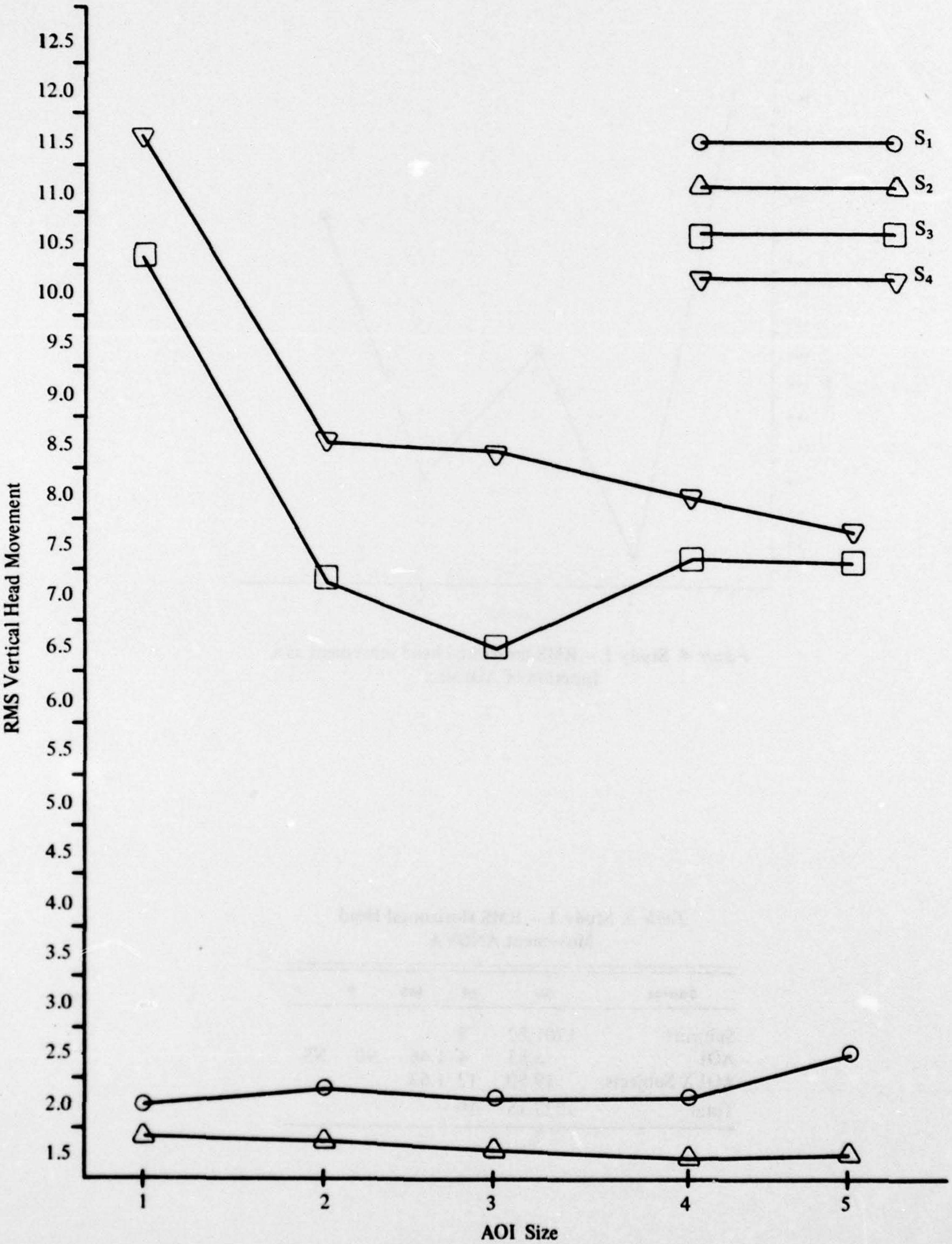

Figure 5. **Study 1 – individual subject RMS vertical head movement as a function of AOI size.**

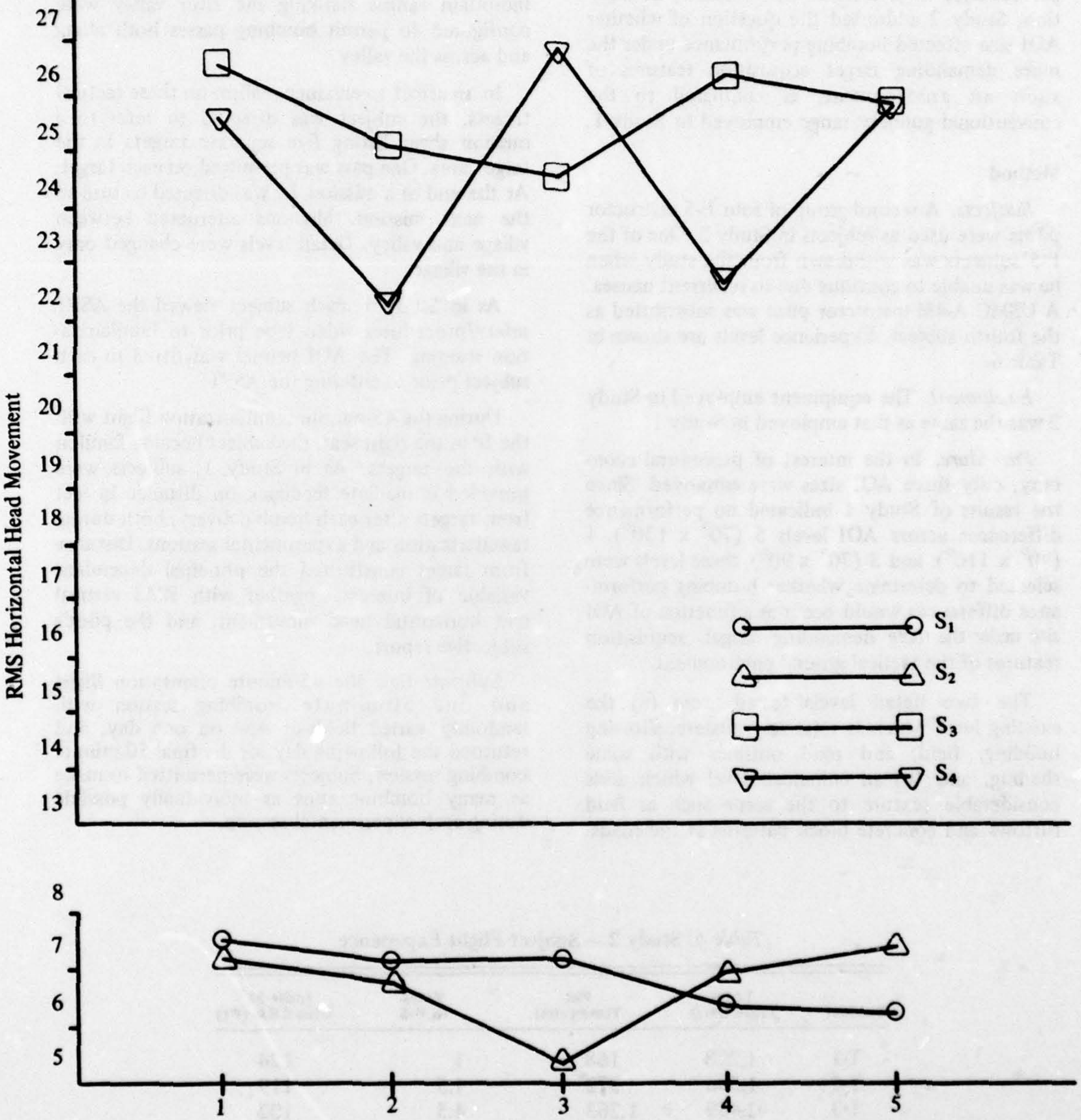

Figure 6. **Study 1 – individual subject horizontal head movement as a function of AOI size.**

III. STUDY 2

Objective

Study 2 was conducted to determine the effect of AOI level of detail on air-to-surface delivery performance in a tactical environment. In addition, Study 2 addressed the question of whether AOI size affected bombing performance under the more demanding target acquisition features of such an environment, as compared to the conventional gunnery range employed in Study 1.

Method

Subjects. A second group of four F-5 instructor pilots were used as subjects in Study 2. One of the F-5 subjects was withdrawn from the study when he was unable to continue due to recurrent nausea. A USMC A-4M instructor pilot was substituted as the fourth subject. Experience levels are shown in Table 6.

Equipment. The equipment employed in Study 2 was the same as that employed in Study 1.

Procedure. In the interest of procedural economy, only three AOI sizes were employed. Since the results of Study 1 indicated no performance differences across AOI levels 5 (70° x 130°), 4 (70° x 110°), and 3 (70° x 90°), these levels were selected to determine whether bombing performance differences would occur as a function of AOI size under the more demanding target acquisition features of the tactical ground environment.

The two detail levels tested were (a) the existing level which is relatively austere, showing building, field, and road outlines with some shading, and (b) an enhanced level which adds considerable texture to the scene such as field furrows and concrete block patterns in the roads.

Simulated target areas were (a) a village, and (b) a river valley island industrial complex. Targets in the village included a truck convoy, tanks, and an easily identifiable feature on one of the buildings. Targets on the river island consisted of buildings, tanks, gun emplacements, vehicles, and a ship. The mountain ranges flanking the river valley were configured to permit bombing passes both along and across the valley.

In an effort to enhance realism on these tactical targets, the subject was directed to refer to a mission sheet listing five separate targets in the target area. One pass was permitted on each target. At the end of a mission, he was directed to turn to the next mission. Missions alternated between village and valley. Detail levels were changed only in the village.

As in Study 1, each subject viewed the ASPT safety/procedures video tape prior to familiarization training. The AOI helmet was fitted to each subject prior to entering the ASPT.

During the 45-minute familiarization flight with the IP in the right seat, the subject became familiar with the targets. As in Study 1, subjects were provided immediate feedback on distance in feet from targets after each bomb delivery, both during familiarization and experimental sessions. Distance from target constituted the principal dependent variable of interest, together with RMS vertical and horizontal head movement, and the pilot's subjective report.

Subjects flew the 45-minute orientation flight and one 50-minute bombing session with randomly varied fields-of-view on one day, and returned the following day for the final 50-minute bombing session. Subjects were permitted to make as many bombing runs as individually possible during each experimental session.

Table 6. **Study 2 – Subject Flight Experience**

Subject	Total Time (Hrs)	F-5 Time (Hrs)	Years In F-5	Indiv 30° Dive CEA (Ft)
T-1	1,298	168	1	124
T-2	1,396	372	1.5	119
T-3	2,459	1,263	4.5	102
T-MC	1,525	1,250 (A-4M)	6 (A-4M)	70
X	1,670	763	3.25	104

The reset feature in Study 2 differed from Study 1 in that as the subject climbed to release altitude after a pass, in a wings level attitude, he was frozen at that point while the AOI size was changed. At release, he continued flight toward his next target, thus preserving the relatively more realistic properties of the weapon delivery task in Study 2.

Results and Discussion

Table 7 presents the results of the repeated measures ANOVA on bombing performance as a function of AOI and detail level.

No significant effects were noted. That is, no significant differences in tactical bombing delivery performance were observed as a function of either AOI size, detail level, or their interaction. The subjective data (Appendix A) were not consistent with the analysis results relative to detail, in that pilots reported added detail made target acquisition more difficult. The subjective opinions of AOI level, however, supported the analysis results; i.e., no significant detrement with smaller AOI.

The results of Study 2 are consistent with those from Study 1 for the AOI sizes employed. Bombing performance did not significantly deteriorate as AOI size diminished from 70° x 130° to 70° x 90°, although overall bombing error was higher across all AOI levels in Study 2 than was the case in Study 1.

While subjects reported that target acquisition was perceptually more demanding under the condition of higher detail level in the visual scene, the data failed to reveal any concomitant statistically significant detriment in bombing performance. This finding should not be generalized beyond the specific conditions of this experiment. Relative to Study 1, the multiple flight approach options permitted in Study 2 offer a greater potential for uncontrolled sources of error variance, which may have masked any effects. Further research concerning required detail level is needed.

The vertical head movement results are plotted in Figure 7 and the associated ANOVA is given in Table 8. No significant main effects were observed. However, a strong interaction effect ($F=8.69$, $P < .05$) is evident. Vertical amplitude increases under the condition of high detail as AOI size increases from level 3 to level 5. The opposite trend occurs under the condition of low detail. Thus, with high detail and a large AOI size, greater head movement occurs. With low detail and large AOI, presumably less visual search is required, as reflected in the decreased vertical amplitude of head movements for that condition.

The inverse occurs with the small AOI (level 3) although the difference between low and high detail for that condition is smaller than that observed with level 5 (70° x 130°). With the smaller AOI and high detail, less vertical head movement occurs. With low detail greater movement is evident.

The results with respect to RMS horizontal head movement are given in Figure 8 and the ANOVA in Table 9. They closely parallel the findings with respect to vertical movement. No main effects were observed. A small interaction effect, however, was evident ($F=3.58$, $P < .10$). The latter exhibited the same functional relationship to detail and AOI sizes as discussed concerning vertical head movement.

The results of Study 2 indicate that increasing visual detail level is associated with an increase in head movement amplitude as AOI size is increased. This result is consistent with what might intuitively be expected when the subject is presented with a larger, more detailed visual scene to inspect.

Under the fixed parameters of the visual task in Study 2, it will be recalled that no significant differences in bombing performance were observed as a function of either AOI size or detail level. Concomitantly, the head movement results indicate that increasing detail level under the condition of

Table 7. **Study 2 – ANOVA Summary Table on CEA**

Source	SS	df	MS	F	P
Subjects	16218.510	3			
AOI	12823.132	2	6411.566	5.113	NS
Detail	2299.280	1	2299.280	.977	NS
AOI X Detail	3408.319	2	1704.160	.648	NS
AOI X Subjects	7523.605	6	1253.934		
Detail X Subjects	7062.477	3	2354.159		
AOI X Detail X Subjects	15787.202	6	2631.200		
Total	65122.525	23			

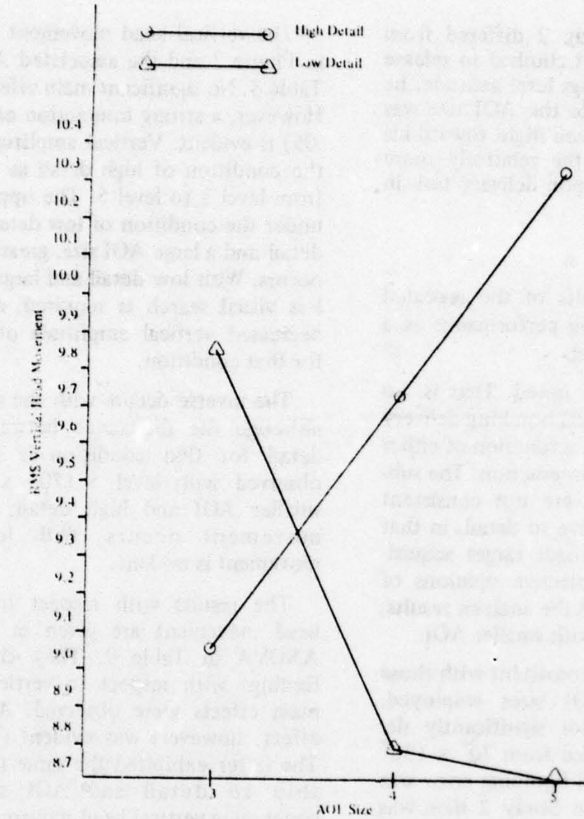

Figure 7. **Study 2 – RMS vertical head movement as a function of detail level and AOI size.**

Table 8. **Study 2 – RMS Vertical Head Movement ANOVA**

Source	SS	df	MS	F	P
Subjects	37.78	3			
AOI	.31	2	.16	.59	NS
Detail	2.11	1	2.11	3.98	NS
AOI X Detail	6.27	2	3.13	8.69	<.05
AOI X Subjects	1.65	6	.27		
Detail X Subjects	1.58	3	.53		
AOI X Detail X Subjects	2.16	6	.36		
Total	51.85	23			

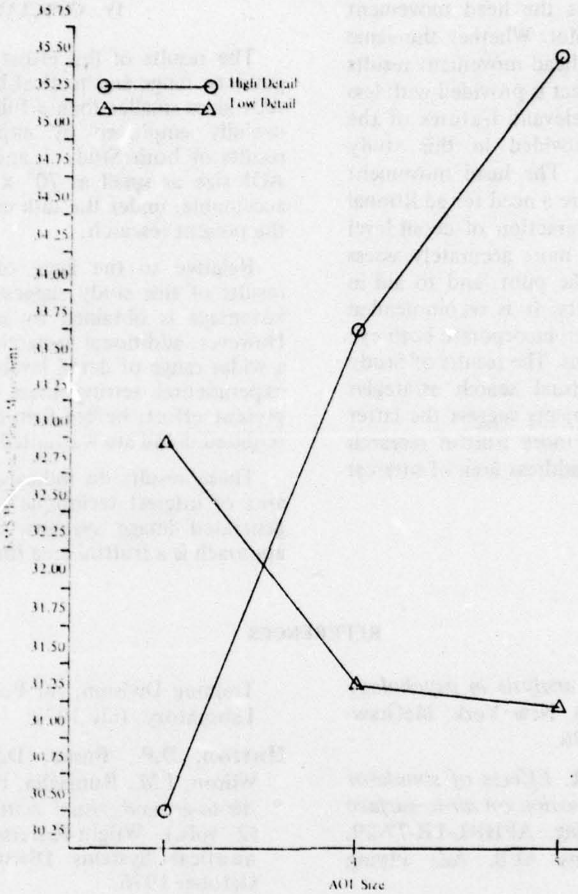

Figure 8. **Study 2 – RMS horizontal head movement as a function of detail level and AOI size.**

Table 9. **Study 2 – RMS Horizontal Head Movement ANOVA**

Source	SS	df	MS	F	P
Subjects	116.04	3			
AOI	11.13	2	5.56	1.05	NS
Detail	12.86	1	12.86	1.06	NS
AOI X Detail	49.50	2	24.75	3.58	<.10
AOI X Subjects	31.91	6	5.32		
Detail X Subjects	36.32	3	12.11		
AOI X Detail X Subjects	41.54	6	6.92		
Total	299.30	23			

smaller AOI size decreases the head movement effort exhibited by the pilot. Whether the same bombing performance and head movement results would occur when the subject is provided with less advance information on relevant features of the visual scene than was provided in this study remains to be determined. The head movement results in Study 2 underscore a need for additional research relative to the interaction of detail level and AOI size. In order to more accurately assess visual cues employed by the pilot, and to aid in the interpretation of results, it is recommended any subsequent AOI research incorporate both eye and head movement analyses. The results of Study 1 relative to differing visual search strategies employed by individual subjects suggest the latter approach would provide a more fruitful research methodology by which to address area of interest issues.

IV. CONCLUSIONS

The results of this effort suggest that for both gunnery range and tactical bombing performance, AOI sizes smaller than a full field-of-view may be usefully employed by experienced pilots. The results of both Study 1 and Study 2 indicate an AOI size as small as $70^\circ \times 90^\circ$ is the minimum acceptable, under the task conditions employed in the present research.

Relative to the issue of required detail, the results of this study suggest that no performance advantage is obtained by increasing detail level. However, additional research is needed employing a wider range of detail levels in a more controlled experimental setting than was available for the present effort, before firm conclusions relative to required detail are warranted.

These results do indicate that the head-slaved area of interest technique is useful for computer generated image systems, and suggest the AOI approach is a fruitful area for further investigation.

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APPENDIX A: PILOT INTERVIEWS AND COMMENTS

Performance

1. Do you feel that you used more instrument references with the AOI than with full visual?

   Yes. The amount of change varied considerably among subjects.

2. Was the vertical size of the FOV adequate?

   70 degree vertical size was acceptable to all subjects; 38 degree was unacceptable. Degree of unacceptability was determined by the amount of bank subjects were accustomed to using on roll-in.

3. What was the effect of the different detail levels in the town?

   All agreed added detail made target acquisition more difficult. No firm opinions as to the effect of detail in determining altitude, airspeed, and position. Range subjects all agreed detail was adequate for the task.

4. Did you have an adequate checkout with the full FOV before using the AOI?

   All agreed they gained the basic feel of the aircraft during full FOV deliveries.

5. Do you feel that you could keep track of another aircraft in the pattern with you using the AOI?

   Not with the small FOVs; probably could with the larger fields.

6. In flying your patterns, how did you compensate for the FOV restrictions?

   Subjects used various methods, but generally used more ground reference in the base and roll-in areas, flew point-to-point around the pattern, made full use of peripheral glimpses, waited until they felt the target was available before looking for it. All felt they were taking more looks toward the target.

7. Did you make use of the horizon outside the AOI?

   One subject found it very useful after he became accustomed to it. It never became realistic to most subjects, and they relied almost completely on the horizon within the FOV.

Equipment Function

1. Did the helmet fit comfortably?

   Yes.

2. Did the helmet fit snugly or did it move around on your head?

   No noticeable movement.

3. Did you notice any lag in the movement of the AOI?

   One subject noticed a very slight lag. None of the others noticed any lag.

4. Were you able to keep the pipper in sight easily?

   It was discovered in postflight interviews that two subjects had to raise themselves slightly in the seat in order to bring the pipper to bear on the target. The AOI helmet had been bore-sighted at zero mils on the pipper. It was determined that seat position should be adjusted for normal viewing at the mil setting required, then the helmet bore-sighted on a point at approximately zero mils.

5. When making large, very rapid head movements, did you notice any problem with the AOI?

   No.

6. Any problems with the AOI?

   Several subjects reported that when turning the head to the lateral limit of the visual scene, the AOI seemed to lock in position until the head returned from the extreme limit. Though a normal function of the AOI, it had a disconcerting effect on the subjects.

Training Potential

1. Do you feel that a system of this type could provide useful training in weapons delivery?

The consensus was that the device would provide useful training in a controlled gunnery range environment using the larger FOV sizes. Subjects stressed the importance of immediate information feedback on deviations from desired release parameters.

2. Do you feel that initial training in weapons delivery could be improved using this system?

Responses were generally the same as to the first question. New students could pick up bad habits in the tactical environment because of the increased difficulty in establishing the correct parameters.

3. If this simulator had F-5 characteristics, would it increase its value for training?

Yes. The most important change would be an increased roll rate. The prominent nose of the F-5, absent in ASPT, is very useful for track and position information.

Physical Effects

1. Did the device require you to make any body movements you wouldn't ordinarily make?

Only two subjects were aware of increased turning of the shoulders required with the small FOV sizes.

2. Did the device cause fatigue?

Most did not notice fatigue. Two subjects attributed some fatigue to the use of the smaller FOVs.

3. Did the device cause eyestrain?

All subjects mentioned some problems with eyestrain. Most of it was attributed to the use of a CIG scene. One subject said the scene appeared quite blurry until he became accustomed to it.

4. Did the device cause vertigo?

One subject experienced no vertigo; another only at the beginning. All others reported varying degrees of vertigo. Several mentioned vertigo induced by a peripheral awareness of AOI movement while fixating inside the cockpit.

5. Did the device cause nausea?

Two subjects experienced nausea; one of these was moderate. The other became airsick on two flights after about 30 minutes causing him to be dropped from the study.

6. Did the device require increased efforts?

No one felt he was expending extra effort due to the AOI. Several commented that it was a lot less effort than actual flight.

General Comments

1. How do you feel about using the head-slaved AOI for weapons delivery training?

The full field-of-view is much preferred over any of the AOIs. The larger the FOV size the better. Subjects did not feel that size difference in the three largest sizes had any effect on their effort or performance. A certain amount of peripheral visual information in the field-of-view is considered essential. FOV sizes smaller than 70 x 90 were described as distracting and disorienting at one time or another by all subjects.

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