F-15 LIMITED FIELD OF VIEW VISUAL SYSTEM TRAINING EFFECTIVENESS EVALUATION

Lt Col Maston E. O'Neal and Mr. James E. Brown
Deputy Chief of Staff Aircrew Training Devices
USAF Tactical Air Warfare Center
Eglin Air Force Base, Florida 32542

ABSTRACT

The USAF Tactical Air Warfare Center conducted a 3-month evaluation of a limited field-of-view (LFOV) visual system installed on an operational F-15 flight simulator. The evaluation was conducted at Goodyear Aerospace Corporation, Akron, Ohio. Purpose of the evaluation was to evaluate to what extent transition, air-to-air, and air-to-surface maneuvers can be trained in the simulator by use of a 60° vertical by 160° horizontal LFOV visual system. The evaluation used a total of 48 F-15, F-16, and A-10 instructor pilots. Half of the pilots were from replacement training units; the other half were from operational units. The F-16 and A-10 pilots were included in the evaluation to obtain data concerning potential application to their respective weapon system trainers. The evaluation team assessed the visual system to be capable of substantially enhancing day/night training for F-15, F-16, and A-10 aircraft in both replacement training units (RTU) and operational environments.

INTRODUCTION

Background.

The cockpit design of the F-15 is optimized for head-up operations, but the F-15 simulator presently provides only head-down visual cues. If outside visual cues were provided in the simulation, significant training effectiveness should result. To this end, Tactical Air Forces (TAF) Required Operational Capability (ROC) 307-76 established the requirement for the addition of a visual system to the F-15 operational flight trainer (OFT). The ROC was amended in September 1982 to provide for the addition of a limited field-of-view (LFOV) visual system as an intermediate step toward satisfying the training requirements. The requirement for full field-of-view (FOV) systems remains to provide the capability for full mission training in the simulator.

In December 1982, Goodyear Aerospace Corporation (GAC) and Rediffusion Simulations Incorporated (RSI) presented a proposal to the Air Force to install an LFOV visual system on an F-15 OFT at the Goodyear facility in Akron, Ohio, to demonstrate its capability. The F-15 System Program Office (SPO), Aeronautical Systems Division (ASD)/TAFA, accepted the proposal and awarded a contract to GAC and RSI to provide the system for evaluation by Headquarters (HQ) Tactical Air Command (TAC) over a 3-month period starting in January 1984.

In April 1983, HQ TAC directed United States Air Force Tactical Air Warfare Center (USAFTAWC) to conduct an F-15 feasibility demonstration. This was the first time that an LFOV visual system had been installed on an F-15 OFT, and no previous Air Force evaluations of the system have been conducted. LFOV visual systems were proposed as enhancements to OFTs used to train upgrading and operational TAF pilots in transition, air-to-air, and air-to-surface tasks. This training includes tasks that cannot be practiced adequately in the aircraft because of unacceptable risk or in existing training devices because of the absence of simulated visual cues. The purpose of this special project was to evaluate to what extent transition, air-to-air, and air-to-surface maneuvers can be trained in the OFT using a 60°-by-160° LFOV visual system. The results of this evaluation will be used to determine if a 60°-by-160° LFOV visual system should be acquired for the F-15 OFT and to evaluate the concept for potential application to A-10 and F-16 simulator systems.

Description. The visual system consisted of a four-channel CT-5A computer image generator, each channel driving one color projector. Together they projected a 60° vertical by 160° horizontal scene onto the inside surface of a 10-foot radius dome mounted over the simulator's cockpit (see figure 1).

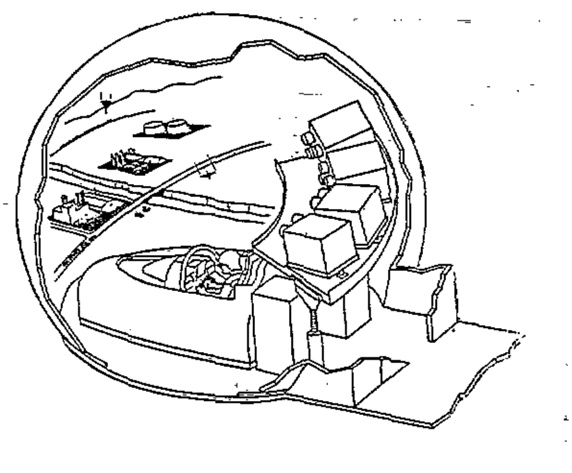

Figure 1. LFOV Visual System.

The scene changed in response to simulated maneuvers providing full-color day, dusk, and night scenes, landing light illumination effects, various weather effects, real world terrain, generic terrain, and highly detailed cultural features. It provided air fields, tactical ground targets, conventional and nuclear practice ranges, airborne threat targets, and friendly airborne targets, including a high detail, close formation lead aircraft. It provided special effects, such as enemy antiaircraft artillery (AAA) with muzzle flashes, tracers, explosion effects, surface-to-air missiles (SAMs), air-to-air missiles, air explosions, ground explosions, and secondary fire effects.

A gimbaled low power laser device was mounted inside the dome. When the target moved out of the visual system's field of view, the laser was automatically activated to project a single dot of red light at the approximate position of a selected target.

Scope.

The evaluation was conducted at the contractor's facility, to assess specific objectives. A total of 48 F-15, F-16, and A-10 instructor pilots (IPs) from TAC, Pacific Air Forces (PACAF), United States Air Forces in Europe (USAFE), and Alaskan Air Command (AAC) participated as subject matter experts to make qualitative assessments of the capability of the simulator to support the training of specific tasks. The composition of evaluation instructor pilots was: 24 F-15 IPs, 14 F-16 IPs, and 10 A-10 IPs. Half of each group of IPs from each aircraft (F-15, F-16, and A-10) were from replacement training units (RTUs), and half were from operational units. Each IP rated the training capability for his own aircraft and training environment.

F-16 and A-10 pilots were included in this evaluation to obtain data concerning training capability of the LFOV visual system for potential application to their respective weapon system trainers. Additionally, IPs for the F-16 and A-10 were considered to be the most appropriate source of air-to-surface evaluation information. Although many F-15 IPs have provided air-to-surface experience in other aircraft, air-to-surface operations are not normally practiced in the F-15. Likewise, air superiority operations are not practiced in the A-10 weapon system. The F-16 units have a multirole mission performing both air-to-surface and air superiority roles. However, weapons switchology differences between the F-16 and the F-15 would inhibit effective accomplishment of air superiority evaluation tasks by F-16 IPs. In this evaluation, F-15 IPs evaluated the system capabilities in air superiority and transition tasks. Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15, an evaluation of air-to-air tasks for F-16s was extrapolated from results for the F-15. F-16 and A-10 IPs assessed training capabilities in air-to-surface and transition tasks.

The evaluation was conducted over a 12-week period. To evaluate 111 training tasks, 336 sorties were flown. A total of 3,208 data points were collected for analysis. Each data point represented the qualitative assessment of an IP of the capability of the simulator to support the training of a particular task in his aircraft and training environment.

The number of possible event combinations resulting from 111 tasks evaluated for 3 aircraft in 2 training environments far exceeded the availability of instructor pilots and simulator time during the evaluation time window. Since every possible combination could not be evaluated, the team considered the constraints and the aircraft and mission differences in selecting representative tasks to be evaluated.

METHOD OF ACCOMPLISHMENT

Method of Test.

The visual system was evaluated to determine its capability to support initial and operational training of transition, air superiority (air-to-air), and air-to-surface tasks. The tasks are contained in TAF ROC 307-76 and are shown as appropriate under each objective. The tasks were arranged into 14 separate missions.

Prior to the start of the evaluation, team members received training on the system, practiced the evaluation tasks, and made dry runs of the evaluation procedures. F-15 IPs who had completed 1 week as an evaluator were trained in console operation through on-the-job training. They then served as console pilots for the following week.

The 48 evaluation pilots were divided into groups of 4, each group to fly their missions over a 1-week period. At the beginning of each week, the four new evaluation pilots reported to the OFT site. Evaluation pilots were briefed by the project manager on the purpose and format of the evaluation, the data collection form, the training capability rating scale (figure 2), detailed evaluation procedures, evaluation criteria, and factors to be considered in the evaluation of tasks. These pilots rated the training capabilities according to the numerical scale and provided written comments to expand upon the ratings.

Rating	Definition
5	Training capability is equal to that experienced in the aircraft. Task can be fully trained in the simulator.
4	Training capability is nearly equal to that experienced in the aircraft. Negligible differences exist between simulator and aircraft. Most of the task can be trained in the simulator.
3	Training capability is acceptable. Essential parts of the task can be taught in the simulator.
2	Little similarity between simulator and aircraft training. Only minimal training can be accomplished in the simulator. Major modifications would be required to provide adequate training capability.
1	No similarity between simulation and aircraft training. Does not meet training requirements. Provides negative training and has major deficiencies.
NR	Use an NR to identify items or questions that do not apply to you or were not tested/evaluated by you.

Figure 2. F-15 Training Capability Rating Scale.

A short cockpit and visual system familiarization briefing was given prior to the first mission of each F-15 evaluator. A more detailed briefing was given for F-16 and A-10 evaluators who had never flown the F-15. The project manager, his deputy, and the console pilots briefed and debriefed evaluators, operated the simulator console, logged task ratings and comments, and maintained a log book.

Evaluators flew tasks or series of tasks and then offered numerical ratings and verbal comments concerning the capability of the system to support training of those tasks in his particular training environment. The ratings and comments were transcribed to data collection forms and subsequently to computer data files that were used as aids to data reduction.

Method of Evaluation.

The percentage of acceptable or better ratings for each combination of task, aircraft, and training environment was compared to the criteria to arrive at assessments. The measures of effectiveness were the evaluation pilot's subjective rating and the evaluation team's assessment of the capability of the F-15 LFOV system to train pilots in an RTU and an operational training environment. The criteria were that at least 80 percent of the evaluation pilots for each aircraft from each training environment must rate each training task a 3 or better (first criterion) or the subobjective must receive an overall acceptable assessment by the evaluation team (second criterion).

In order for a combination of task, aircraft, and environment to be assessed as effectively trained, it must receive a rating of 3 or better by 80 percent of the evaluation pilots. In order for a subobjective (composed of several combinations of task, aircraft, and environment) to be assessed as effectively trained, all of those combinations must receive a rating of 3 or better. The requirement for all combinations to receive a rating of 3 or better was stipulated to preclude using an arbitrary or artificial percentage cutoff criterion. Failure of any specific combination of task, aircraft, and environment to meet the quantitative criterion (first criterion) did not necessarily constitute failure for the overall subobjective. Similarly, failure of a specific subobjective to meet the quantitative criterion (first criterion) did not necessarily constitute failure for the overall objective. An item that failed to meet the first criterion was evaluated for its impact on training. The evaluation team considered the number and complexity of trainable tasks and made a judgment of the worth of the visual system to improve training capability for a specific subobjective or objective and of its worth at the overall training effectiveness level.

RESULTS AND DISCUSSION

Objective 1. Evaluate the capability of the F-15 LFOV system to support day/night transition training.

Subobjective 1-1. Evaluate the capability of the F-15 LFOV system for day/night training of ground operations and terminal area operations (takeoff and landing).

Results and Discussion. The visual system can support day/night training of ground operations and terminal area operations for F-15, F-16, and A-10 aircraft in both RTU and operational training environments. Not all combinations of task, aircraft, and environment investigated under this subobjective received an acceptable rating by at least 80 percent of the evaluation pilots. Thus, the subobjective did not meet the first criterion. However, applying the second criterion, the evaluation team judged the training capabilities demonstrated by those tasks that were rated acceptable to be of sufficient value to warrant an overall acceptable assessment for this subobjective.

A total of 35 separate tasks (see table 1) that could not previously be effectively trained in the simulator were evaluated for F-15, F-16, and A-10 aircraft for both RTU and operational environments. This resulted in 166 combinations of task, aircraft, and training environment, 158 of which can be effectively trained in the visual system equipped simulator. Eight combinations of tasks (see table 1) did not meet the first criterion because of limitations in FOV, target resolution,* and basic simulator fidelity.

Table 1. Percentage of Acceptable Ratings For Ground Operations and Terminal Area Operations (Subobjective 1-1).

Task Number	Task	F-15		F-16		A-10	
		RTU	OPS	RTU	OPS	RTU	OPS
1	Taxi	91.7	100	100	100	100	100
2	Night taxi	100	100	100	100	100	100
3	Taxi (formation)	100	100	100	100	100	100
4	Takeoff	100	100	100	100	100	100
5	Takeoff (weather)	N/A	N/A	92.9	100	100	100
6	Night takeoff	100	100	100	100	100	100
7	Takeoff (formation)	75.0	83.3	85.7	100	100	100
8	Takeoff (formation, weather)	91.7	91.7	100	100	100	100
9	Takeoff (radar, trail, weather)	N/A	N/A	100	100	100	100
10	Night takeoff (formation)	91.7	91.7	N/A	N/A	N/A	N/A
11	Departure	100	100	N/A	N/A	N/A	N/A
12	Departure (weather)	N/A	N/A	100	100	100	100
13	Night departure	100	100	100	100	100	100
14	Departure (formation)	66.7	83.3	N/A	N/A	N/A	N/A
15	Night departure (formation)	91.7	91.7	N/A	N/A	N/A	N/A
16	Departure (formation, weather)	100	83.3	N/A	N/A	N/A	N/A
22	Takeoff emergencies	N/A	N/A	100	100	100	100
37	Landing emergencies	N/A	N/A	100	100	100	100
93	Recovery	N/A	N/A	100	100	100	100
94	Straight in	100	100	100	100	100	100
95	Touch and go landings	N/A	N/A	100	100	100	100
96	Overhead patterns	58.3	66.7	71.4	71.4	80.0	80.0
97	Go around(s)	100	91.7	100	100	100	100
98	Full stop landing	100	83.3	100	100	100	100
99	Instrument approaches	N/A	N/A	100	100	100	100
100	Precautionary landing pattern	N/A	N/A	71.4	85.7	80.0	100
101	Crosswind landing	N/A	N/A	100	100	100	100
102	Touch and go landing(s) (crosswind/slippery runway)	91.7	83.3	100	85.7	100	100
103	Barrier engagement	91.7	91.7	100	100	100	100
104	Night recovery	100	100	100	100	100	100
105	Night instrument approaches	100	100	100	100	100	100
106	Night touch and go landing(s)	91.7	91.7	100	100	100	100
107	Night missed approach	100	100	100	100	100	100
108	Night full stop landing	91.7	91.7	100	100	100	100
109	Formation landing	91.7	75.0	N/A	N/A	N/A	N/A

NOTE: 1. N/A is not appraised.
2. Tasks are numbered according to test plan.
3. OPS is operational.
4. RTU is replacement training unit.

*Several factors impact resolution. One factor is that the visual scene is composed of a finite

(Continued)

Formation takeoffs as evaluated by F-15 RTU IPs did not meet the first criterion because of simulator roll sensitivity and power response problems (see table 1). However, the same task as evaluated by F-15 operational IPs and F-16 and A-10 operational and RTU IPs did meet the criterion. To varying degrees, most F-15 pilots tended to overcorrect roll inputs resulting in a lateral pilot induced oscillation (PIO). The origin of the roll sensitivity problem was never fully determined. Possible causes include simulator control loading adjustments, roll rate algorithm errors, absence of actual roll acceleration forces as feedback cues, and delayed visual cue feedback because of slow visual scene refresh rates. Power matching was also difficult to achieve since simulator engine performance modeling did not match that of the aircraft. An engineering change proposal (ECP) to correct engine performance algorithms was on contract before this evaluation began, but was not incorporated in time for this evaluation. Both of these aircraft/simulator differences affected F-15 IPs more than they did F-16 or A-10 IPs because F-15 IPs were more familiar with the way the real aircraft responds. The F-15 IPs were forced to unlearn the feel of the aircraft and to learn the feel of the simulator. Conversely, F-16 and A-10 IPs had no preconceived notion of aircraft response; therefore, they very quickly adapted to the feel of the "new" aircraft (simulator) and found it easier to instruct the proper visual references and procedures for formation takeoffs. It should be noted that both F-15 operational and RTU IPs rated formation takeoffs under night conditions and again under weather conditions on later sorties. These latter tasks were rated acceptable by 92 percent of both groups (see tasks 8 and 10, table 1). The apparent change in ratings may be the result of gaining more familiarity with the feel of the simulator. However, it may also be the result of the IP-perceived increase in training value of the visual system when night and weather complications are added to the task.

Formation departures as rated by F-15 RTU IPs and formation landings as rated by F-15 operational IPs also did not meet the first criterion for the same reasons as in the paragraph above. Again, as IPs gained familiarity with simulator responses and as more complexities were added to the task, ratings improved (see tasks 14, 15, 16, and 109, table 1).

Overhead patterns as evaluated by F-15 and F-16 operational and RTU IPs did not meet the first criterion primarily because of FOV limitations. One of the commonly accepted visual cues a pilot uses for determining the point in space to start the base turn during overhead patterns is seeing the runway threshold at a point approximately 45° behind the wing line while flying downwind parallel to the runway. Since the visual system's FOV extends to only 10° behind the wing line, the traditional runway threshold reference was not available during the few seconds prior to the start of the base turn. This traditional reference is most important to RTU students learning to land the aircraft for the first time and for all pilots landing at unfamiliar airfields. Operational pilots landing at their home airfields develop an area awareness based as much on other references, such as nearby roads, fields, and other cultural features, as on the planned touchdown point. Such cues are available in the visual scene so most IPs considered that the short absence of the touchdown point cue did not prevent their ability to teach the essentials of the task.

Precautionary landing patterns (PLPs) as rated by F-16 RTU IPs did not meet the first criterion because of FOV limitations. A PLP requires a spiraling 360° turn to final which puts the runway and touchdown point behind the wing line during the first half of the turn. Two of the seven F-16 RTU IPs judged a continuous view of the runway critical to training the essentials of the task to RTU students. The remaining F-16 RTU IPs judged the other cues to be adequate.

As shown in table 1, 158 of the 166 combinations of tasks, aircraft, and environments in this subobjective received acceptable ratings. In addition to this very large number of combinations receiving acceptable ratings, several IPs made very favorable comments concerning the value of the system for their training environments. Tasks involving transition from outside references to instruments and vice versa, such as night and weather takeoffs, departures, approaches, and landings, and tasks involving divided attention and a degree of risk, such as emergency procedures during takeoff and landing, and radar trail departures, met the first criterion and were highly praised as valuable for training through simulation. The capability to refer to the same visual cues in the same order and for the same purpose as they are used in the aircraft allows a proper degree of attention to all tasks and speeds the overall learning process.

(Continued) number of picture elements (pixels). Pixels are the smallest elements of an image that a line scanning visual system can produce. They are roughly rectangular spots of light of a fixed size dependent upon the thickness of the projected scan line. Since an object in the scene subtends a progressively smaller arc as range to the object increases, progressively fewer pixels must be used to make up that object as it appears to get smaller with range. At some point the limited number of pixels available to make up the object begins to limit the image's detail. Additional detail is lost when the edges of objects are blended to overcome other distractions inherent in line scan systems. This loss of detail combines with other factors, such as blemishes in the projector's phosphor, focusing limitations, and projector convergence limitations, to obscure the attitude of the lead ship or target. Without attitude cues, the lead ship's range, heading alignment, and wing flash visual signals are not perceptible. All of these attitude and range cues are critical to teaching the essentials of widely spread formations.

Subobjective 1-2. Evaluate the capability of the F-15 LFOV system for day/night training of airwork tasks.

Results and Discussion. The visual system can support day/night training of airwork tasks for F-15, F-16, and A-10 aircraft in both RTU and operational environments. The visual system met the first criterion for F-15, F-16, and A-10 RTU and operational environments.

A total of seven separate tasks (see table 2) that could not previously be effectively trained in the simulator were evaluated for F-15, F-16, and A-10 aircraft for both RTU and operational environments. This resulted in 30 combinations of task, aircraft, and training environment, all of which can be effectively trained in the visual system equipped simulator.

Table 2. Percentage of Acceptable Ratings for Airwork Tasks (Subobjective 1-2).

Task Number	Task	F-15		F-16		A-10	
		RTU	OPS	RTU	OPS	RTU	OPS
17	Aileron Roll	N/A	N/A	100	100	100	100
18	Barrel Rolls	N/A	N/A	100	100	100	100
19	Slow Flight	N/A	N/A	85.7	100	100	100
20	Stalls	N/A	N/A	100	100	100	100
21	Spins	N/A	N/A	85.7	100	100	100
35	Lost Wingman (weather)	100	100	100	100	100	100
36	Rejoin (weather)	N/A	N/A	100	100	100	100

NOTE: 1. N/A is not appraised.
2. OPS is operational.
3. RTU is replacement training unit.

The tasks involving transition to or from outside visual references received very favorable comments from IPs. Lost wingman and weather rejoin tasks were very realistically presented. IPs were impressed with the capability to train such tasks without the risks inherent in the real world.

Summary of Transition Training Effectiveness. The evaluation team assessed the visual system to be capable of substantially enhancing day/night transition training for F-15, F-16, and A-10 aircraft in RTU and operational environments because of the large number of transition tasks that can be effectively trained and the value of these tasks. This assessment was based upon the results of subobjectives 1-1 and 1-2. A total of 42 separate tasks that could not previously be effectively trained in the simulator were evaluated for F-15, F-16, and A-10 aircraft for both RTU and operational environments. This resulted in 196 combinations of task, aircraft, and training environment, 188 of which can be effectively trained in the visual system equipped simulator. Overhead patterns and PLPs were not trainable for some aircraft and environments. Formation takeoffs, departures, and landings were not trainable in the F-15 simulator because of simulator roll sensitivity problems. Certain tasks involving transition from outside references to instruments and vice versa and tasks involving divided attention with risks to aircraft control, such as emergencies during takeoff and landing, radar trail departures, lost wingman situations, and weather rejoins, were highly praised by evaluation IPs.

Objective 2. Evaluate the capability of the F-15 LFOV system to support day/night training in air superiority operations.

Subobjective 2-1. Evaluate the capability of the F-15 LFOV system for day/night training of low-altitude air superiority operations (less than 5,000 feet above ground level (AGL)).

Results and Discussion. The visual system can support day/night training of low-altitude air superiority operations (less than 5,000 feet AGL) for F-15 and F-16 aircraft in both RTU and operational training environments. The visual system cannot support training of defensive air superiority tasks.** Not all combinations of task, aircraft, and training environment investigated under this subobjective received an acceptable rating by at least 80 percent of the evaluation pilots. Thus the subobjective did not meet the first criterion. However, applying the second criterion, the evaluation team judged the training capabilities demonstrated by those tasks that were rated acceptable to be of sufficient value to warrant an overall acceptable assessment for this subobjective. Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15, the evaluation team assessed that the visual system is also acceptable for F-16 RTU and operational environments.

A total of six separate tasks (see table 3) that could not previously be effectively trained in the simulator were evaluated for F-15 aircraft for both RTU and operational environments. This resulted in 12 combinations of task, aircraft, and training environment, 11 of which can be effectively trained in the visual system equipped simulator.

**Before the evaluation began, the evaluation team realized that the visual system oriented to the forward hemisphere obviously could not support training of rear hemisphere defensive basic fighter maneuvers (BFM) tasks. The full range of such maneuvers requires a continuous view of the adversary whether he is ahead of or behind the fighter. Additionally, the 1 September 1982 amendment to TAF ROC 307-76 which established the requirement for an LFOV visual system required only an offensive BFM capability and an initial front hemisphere defensive maneuver capability. As a result, the evaluation team made a conscious decision not to examine rear hemisphere BFM capabilities in either the low-altitude or high-altitude regimes. Front hemisphere defensive maneuvers were evaluated under subobjective 2-2 and were found to be not trainable with this system.

Table 3. Percentage of Acceptable Ratings. For Low-Altitude Air Superiority Operations (Subobjective 2-1).

Task Number	Task	F-15 RTU	F-15 OPS
38	Low-Altitude Intercepts	100	100
41	Tactical Intercepts	91.7	100
42	Tactical Intercepts (weather)	100	100
57	AIM 7 Employment	100	91.7
58	AIM 9 Employment	100	100
59	Gun Employment	75.0	100

NOTE: 1. OPS is operational.
2. RTU is replacement training unit.

Table 3 shows that gun employment as evaluated by F-15 RTU IPs was the only task that did not meet the first criterion. Two IPs rated it less than acceptable because of insufficient target resolution to allow accurate aspect angle determination. The lack of an aspect angle cue caused errors in nose positioning and increased time to achieve a tracking solution. One IP rated the task less than acceptable because of the roll sensitivity problem described earlier.

As shown in table 3, the remaining tasks evaluated under this subobjective met the first criterion and were rated very highly for both training environments. In addition, the IPs made very favorable comments concerning the value of the system. The IPs were very impressed with the capability to train tactical intercepts and missile employment against multiple bogies in various weather conditions. More than half of the IPs (65 percent) rated the capability to train these tasks a 4 (nearly equal to the training capability of the aircraft). The IPs considered the ability to train the tactical use of cloud decks during intercepts particularly valuable in that peacetime separation rules do not allow such training in the aircraft. They also praised the ability to train multiple missile launches against multiple front aspect targets without risk.

Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15 aircraft, the evaluation team assessed the visual system to be capable of supporting the F-16 in both the RTU and operational training environments.

Subobjective 2-2. Evaluate the capability of the F-15 LFOV system for day/night training of high-altitude air superiority operations (greater than 5,000 feet AGL).

Results and Discussion. The visual system can support day/night training of high-altitude air superiority operations (greater than 5,000 feet AGL) for F-15 and F-16 aircraft in both RTU and operational training environments. It cannot support training of defensive tasks. Not all combinations of task, aircraft, and training environment investigated under this subobjective received an acceptable rating by at least 80 percent of the evaluation pilots. Thus the subobjective did not meet the first criterion. However, applying the second criterion, the evaluation team judged the training capabilities demonstrated by the number and value of those tasks that were rated acceptable to be sufficient to warrant an overall acceptable assessment for this subobjective. Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15, the evaluation team assessed the system to be acceptable for both F-16 training environments.

A total of 17 separate tasks (see table 4) that could not previously be effectively trained in the simulator were evaluated for F-15 aircraft for both RTU and operational environments. This resulted in 34 combinations of task, aircraft, and training environment, 24 of which can be effectively trained in the LFOV visual system equipped simulator. Ten combinations of tasks did not meet the first criterion because of, in part, FOV limitations.

Table 4. Percentage of Acceptable Ratings For High-Altitude Air Superiority Operations (Subobjective 2-2).

Task Number	Task	F-15 RTU	F-15 OPS
39	Night horizontal conversions	100	100
40	Night vertical conversions	100	100
43	Low speed yo-yo	100	100
44	Acceleration maneuver	91.7	100
45	High speed yo-yo	100	83.3
46	Lag pursuit roll	83.3	50.0
47	Quarter plane maneuver	50.0	41.7
48	Barrel roll attack	83.3	75.0
49	Immelman turn	91.7	83.3
50	Lead turn (neutral BFM)	83.3	83.3
51	Low speed yo-yo (weather)	100	100
52	High speed yo-yo (weather)	83.3	91.7
53	Lag pursuit roll (weather)	75.0	83.3
54	Quarter plane (weather)	41.7	41.7
55	Barrel roll attack (weather)	83.3	75.0
56	Immelman turn (weather)	91.7	91.7
60	Defensive maneuvers	8.3	25.0

NOTE: 1. OPS is operational.
2. RTU is replacement training unit.

Lag pursuit rolls, quarter plane maneuvers, and barrel roll attacks did not meet the first criterion because of FOV limitations (see table 4). All of these are offensive BFM tasks that require rather large changes in fighter nose position in relation to the target. Depending upon pilot technique, the target at times exceeded the FOV limits of the system. When this occurred, the approximate position of the target was indicated by the laser spot, which did not provide range and closure rate information. Some pilots said that this gave them insufficient cues to properly teach the essentials of the task.

Defensive maneuvers did not meet the first criterion because of FOV and resolution limitations. Defensive maneuvers evaluated in this subobjective were limited to forward hemisphere defensive maneuvers. Target resolution problems prevented most pilots from visually acquiring the target soon enough to react to the threat. Also, the attacking aircraft or its missile quickly passed close to the edge of the available FOV where fighter defensive maneuvers even more quickly forced it out of the FOV and caused a loss of visual contact. In the fighter pilot's vernacular, "lost sight, lost fight."

As shown in table 4, night horizontal conversions and night vertical conversions met the first criterion and were rated acceptable by all IPs, over half of whom rated that training capability a 4 (nearly equal to that of the aircraft). The most impressive factors were the ability to train the techniques of transitioning to and from outside references at night and the opportunity to intercept and identify blacked out adversary aircraft without risk. Offensive BFM tasks that do not require large lead or lag angles, such as low speed yo-yos, high speed yo-yos, acceleration maneuvers, and Immelman turns, were rated satisfactory. RTU IPs commented that, though the system cannot support training of the full range of BFM capabilities, it provides an ability to teach the mechanics of offensive maneuvers early in the BFM training phase. Therefore, the system should speed the learning process on the initial BFM missions in the aircraft.

Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15, the evaluation team assessed the visual system to be capable of supporting the F-16 in both the RTU and operational training environments.

Summary of Air-to-Air Training Effectiveness. The evaluation team assessed the visual system to be capable of substantially enhancing day/night training in air superiority operations for F-15 and F-16 aircraft in RTU and operational environments because of the number and value of the tasks that can be effectively trained. This assessment was based on the results of subobjectives 2-1 and 2-2. A total of 23 separate tasks that could not previously be effectively trained in the simulator were evaluated for F-15 aircraft for both RTU and operational environments. This resulted in 46 combinations of task, aircraft, and training environment, 35 of which can be effectively trained in the visual system equipped simulator. Rear hemisphere defensive maneuvers are obviously not trainable in an LFOV system oriented to the forward hemisphere and were not evaluated. Forward hemisphere defensive maneuvers and some offensive BFM tasks involving large changes in fighter nose position were not trainable in some environments. Certain air superiority tasks, such as night vertical and horizontal conversions, tactical intercepts, and missile employment against multiple aircraft targets in various weather conditions, received very high training capability ratings. Tactical intercepts taking advantage of cloud decks were considered particularly valuable in that peacetime separation rules do not allow such training in the aircraft. RTU IPs found that the system provides an ability to teach the mechanics of offensive maneuvers early in the BFM training phase, thus speeding the learning process in the aircraft. Since the air-to-air performance, ordnance, and tasks of the F-16 are similar to those of the F-15, the evaluation team assessed that the system was also acceptable for both F-16 training environments.

Objective 3. Evaluate the capability of the F-15 LFOV system to support day/night training in air-to-surface operations.

Subobjective 3-1. Evaluate the capability of the F-15 LFOV system for day/night training of conventional/nuclear range operations.

Results and Discussion. The visual system can support day/night training of conventional/nuclear range operations for F-16 and A-10 aircraft in both RTU and operational training environments. Not all combinations of task, aircraft, and training environment investigated under this subobjective received an acceptable rating by at least 80 percent of the evaluation pilots. Thus the subobjective did not meet the first criterion. However, applying the second criterion, the evaluation team judged the training capabilities demonstrated by the number and value of those tasks that were rated acceptable to be sufficient to warrant an overall acceptable assessment for this subobjective.

A total of 21 separate tasks (see table 5) that could not previously be effectively trained in the simulator were evaluated for F-16 and A-10 aircraft for both RTU and operational environments. This resulted in 76 combinations of task, aircraft, and training environment, 68 of which can be effectively trained in the visual system equipped simulator. Eight combinations of tasks did not meet the first criterion because of FOV limitations.

Table 5. Percentage of Acceptable Ratings For Conventional/Nuclear Range Operations (Subobjective 3-1).

Task Number	Task	F-16 RTU	F-16 OPS	A-10 RTU	A-10 OPS
61	Visual laydown delivery	100	100	100	100
62	Ordnance adjustment	85.7	100	100	100
63	Visual low-angle drogue delivery	100	100	100	100
64	Visual reference point (F-16 peculiar)	100	100	N/A	N/A
66	Low angle strafe (15°)	100	85.7	100	100
67	High angle strafe (30°)	85.7	85.7	80.0	100
68	Low-angle bomb (10°)	100	85.7	100	100
69	Low angle low drag (20°)	100	85.7	80.0	100
70	Skip bomb (10°) (A-10 peculiar)	N/A	N/A	100	80.0
71	Long range strafe (A-10 peculiar)	N/A	N/A	100	80.0
72	Two target strafe (A-10 peculiar)	N/A	N/A	100	100
73	Dive bomb (30°)	100	100	80.0	40.0
74	Dive bomb (45°)	85.7	85.7	60.0	40.0
75	High-altitude dive bomb (45°)	57.1	85.7	60.0	40.0
76	VLD (weather, heavyweight)	100	100	100	100
77	VLADD (weather, heavyweight)	100	100	100	100
80	Dive bomb (30°) (weather, heavyweight)	100	85.7	80.0	40.0
81	HADB (45°) (weather, heavyweight)	85.7	100	80.0	40.0
82	Asymmetric maneuvering (weather, heavyweight)	100	100	100	80.0
90	VLD (weather)	100	100	100	100
91	Night VLD	100	100	80.0	100

NOTE: 1. N/A is not appraised.
2. OPS is operational.
3. RTU is replacement training unit.

The 45° and 30° conventional range dive bomb and HADB tasks listed in table 5 did not meet the first criterion because of FOV limitations. The evaluation of conventional range tasks included navigation around the box pattern. References necessary for positioning in the pattern and for judging the roll-in for weapon delivery vary among pilots. Some pilots refer almost exclusively to the target for their orientation.

Others use a combination of references including the target and cultural features normally seen near ranges, such as range access roads, foul lines, run-in lines, etc. Those who relied heavily on a continuous view of the target reported that insufficient cues were available to teach the techniques to establish the proper dive angle on high dive angle deliveries. On these deliveries the target left the FOV in a downward direction on the base leg just prior to roll-in. A-10 IPs were more affected by this than F-16 IPs. F-16 IPs simply dipped a wing momentarily to keep the target in view. Since the pattern airspeeds of the A-10 are considerably slower and performance is considerably less than those of the F-16, A-10 IPs tended not to dip a wing and risk energy loss. Also, very precise dive angles receive less emphasis from F-16 pilots with computer assisted delivery modes than from A-10 pilots who have only the direct delivery mode available for use. Notably, the high dive angle deliveries were rated much better by both A-10 and F-16 IPs in the tactical scenarios than on controlled ranges where box patterns were not required.

As shown in table 5, the remaining tasks including low dive angle deliveries, such as LAB, LALD, VLD, VLADD, and all strafe tasks, met the first criterion. They were rated better than the 30° and 45° high dive angle deliveries because IPs found it much easier to keep the target in view while maneuvering around the box pattern. It was also easier for IPs to judge the precise point in space for the roll-in to achieve the desired dive angle. Even on the high dive angle deliveries, IPs were very impressed with the capability to train selection of aim-off points, initial pipper placement, windage, pull-out, and routine range procedures. The IPs asserted that the ability of an RTU student to achieve a high level of familiarity with these tasks would allow much more productive training to be achieved on the first few actual range missions. Level and loft deliveries on the nuclear range were rated a 4 (nearly equal to the training capability of the aircraft) by over half the F-16 and A-10 IPs.

Subobjective 3-2. Evaluate the capability of the F-15 LFOV system for day/night training of tactical range operations.

Results and Discussion. The visual system can support day/night training of tactical range operations for F-16 and A-10 aircraft in both RTU and operational training environments. The visual system met the first criterion for F-16 and A-10 RTU and operational environments.

A total of 14 separate tasks (see table 6) that could not previously be effectively trained in the simulator were evaluated by F-16 and A-10 aircraft for both RTU and operational environments. This resulted in 52 combinations of task, aircraft, and training environment, all of which can be effectively trained in the visual system equipped simulator.

Table 6. Percentage of Acceptable Ratings For Tactical Range Operations (Subobjective 3-2).

Task Number	Task	F-16		A-10	
		RTU	OPS	RTU	OPS
53	Moving target attack	100	100	100	100
78	LAB (10°) (weather, heavyweight)	100	100	100	80.0
79	LALD (20°) (weather, heavyweight)	100	100	100	80.0
83	Pop-up attacks	100	85.7	100	100
84	Tactical dive bomb	85.7	100	100	80.0
85	Tactical LAB	100	100	100	100
86	Tactical strafe (bump-ups) (A-10 peculiar)	N/A	N/A	100	100
87	Maverick delivery	100	85.7	100	100
89	Curvilinear attack	85.7	100	100	100
110	Pop-up attack (weather)	100	100	100	100
111	Tactical dive bomb (weather)	85.7	100	100	100
112	Tactical LAB (weather)	100	100	100	100
113	Tactical strafe (weather)	N/A	N/A	100	100
114	Curvilinear attack (weather)	100	100	100	100

NOTE: 1. N/A is not appraised.
2. OPS is operational.
3. RTU is replacement training unit.

In addition to the high number of acceptable ratings for the tasks (see table 6), IPs made highly favorable comments concerning the training potential of including the various threat simulations in scenarios involving these tactical deliveries. The very realistic presentation of AAA and SAM effects during a dive bomb pass brings home to the student the reasons for pop-ups and curvilinear deliveries. The priority of survival becomes very real. Such valuable training is available only in a simulator or is achieved at considerable expense in war.

Subobjective 3-3. Evaluate the capability of the F-15 LFOV system for day/night training of low-altitude flight operations.

Results and Discussion. The visual system can support day/night training of low-altitude flight operations for F-16 and A-10 aircraft in both RTU and operational training environments. Not all combinations of task, aircraft, and training environment investigated under this subobjective received an acceptable rating by at least 80 percent of the evaluation pilots. Thus the subobjective did not meet the first criterion. However, applying the second criterion, the evaluation team judged the training capabilities demonstrated by those tasks that were rated acceptable to be of sufficient value to warrant an overall acceptable assessment for this subobjective.

A total of 11 separate tasks (see table 7) that could not previously be effectively trained in the simulator were evaluated for F-16 and A-10 aircraft for both RTU and operational environments. This resulted in 44 combinations of task, aircraft, and training environment, 28 of which can be effectively trained in the visual system equipped simulator. Sixteen combinations of tasks did not meet the first criterion because of FOV and resolution limitations.

Table 7. Percentage of Acceptable Ratings For Low-Altitude Flight Operations (Subobjective 3-3).

Task Number	Task	F-16		A-10	
		RTU	OPS	RTU	OPS
23	Night low level	100	100	100	100
24	Low level (single-ship terrain masking)	100	100	100	80.0
25	Low level (formation)	57.1	85.7	60.0	40.0
26	Low level (single-ship, weather)	100	100	100	100
27	Low level (navigation)	100	100	100	100
28	Low level (4-ship tactical, weather)	71.4	71.4	100	60.0
29	AAA avoidance	100	92.9	100	100
30	SAM avoidance	71.4	78.6	90.0	80.0
31	Threat detection (air-to-air)	100	42.9	50.0	90.0
32	Defensive maneuvers	85.7	57.1	40.0	90.0
34	Tactical formation	00.0	42.9	20.0	00.0

NOTE: 1. OPS is operational.
2. RTU is replacement training unit.

As shown in table 7, 10 of the combinations of task, aircraft, and environment associated with flying widely spaced formations, such as low-level formation, tactical formation, and 4-ship tactical formation, did not meet the first criterion. This was due to resolution and FOV problems. Insufficient resolution of the single target of interest limited the capability to train these formations. FOV limitations also affected the widely spaced formations. Tactical formations are flown in a variety of ways depending upon the threat, terrain, specific mission objectives, weather, and many other factors. Most of the formations use variations of a line abreast or slightly swept position for the wingman. During turns, wingmen must change sides approximately every 90° of turn. Vertical positioning of the wingman also varies as much as 45° high to 45° low in relation to the lead ship. These formations forced the lead ship to positions near the edge of the FOV of the visual system. Consequently, the fixed 60°-by-160° FOV system cannot continuously contain the lead ship and, therefore, cannot provide the wingman enough cues for proper responses to the leader's maneuvers.

SAM avoidance, as rated by F-16 IPs, did not meet the first criterion because of FOV and resolution limitations. Defensive maneuvers against SAMs require very early visual acquisition and relatively violent maneuvers. The pilot must maneuver to position the SAM on his beam, very near, or out of the FOV limits of the visual system. The timing of subsequent maneuvers to force the SAM into an overshoot is dependent upon how the SAM responds to the first maneuver. Since range and closure rates are not available because of resolution limitations and the SAM may no longer be in sight because of FOV limitations, the maneuver cannot be completed in the simulator. Even though all of the required visual cues for SAM avoidance were not available with the evaluation orientation of the FOV, some very important parts of the task can still be trained. The pilot can correlate radar warning receiver cues to visual launch cues and missile trajectory within the FOV. Without visual simulation, such high risk tasks will be seen in the aircraft for the first time only in the event of war. The evaluation team judged that, even though the system cannot support training of SAM avoidance maneuvers, the very simple but valuable task of visual search and acquisition of such threats can be trained.

Threat detection and training of defensive maneuvers used by air-to-surface pilots did not meet the first criterion because of FOV and resolution limitations. The limitations were identical to those found by air superiority pilots (see previous discussion of defensive maneuvers).

As shown in table 7 , basic low-level flying tasks, such as terrain masking, visual low-level navigation, night/weather low-level flying, and AAA avoidance, met the first criterion and were rated highly. Forty-one percent of the F-16 IPs and 28 percent of A-10 IPs rated these tasks a 4 (nearly equal to the training capability of the aircraft). IPs had highly favorable comments concerning the system's value for teaching the proper priorities while flying at very low levels. In the low-altitude flight regime, the threat of collision with the ground is often much higher than the enemy threat. The proper judgment of the threat and division of attention to the task at hand are critical. The visual system equipped simulator provides these lessons without risk. Also, AAA effects were very realistic and the correct avoidance maneuvers properly defeated the threat.

Summary of Air-to-Surface Training Effectiveness. The evaluation team assessed the visual system to be capable of substantially enhancing day/night training in air-to-surface operations for F-16 and A-10 aircraft in RTU and operational environments because of the number and value of the tasks that can be effectively trained. This assessment was based on the results of subobjectives 3-1, 3-2, and 3-3. A total of 46 separate tasks that could not previously be effectively trained in the simulator were evaluated for F-16 and A-10 aircraft for both RTU and operational environments. This resulted in 172 combinations of task, aircraft, and training environment, 148 of which can be effectively trained in the visual system equipped simulator. Some conventional range 30° and 45° dive bomb tasks, widely spaced tactical formations, SAM avoidance maneuvers, threat detection, and front hemisphere defensive maneuvers were not trainable in some aircraft and environments. The large number of trainable tasks includes conventional and nuclear range events, such as VLDs, LABs, LALDs, VLADDs, and all strafe events. All tactical range events including pop-up attacks, moving target attacks, curvilinear attacks, and tactical dive bomb attacks at high dive angles, such as 30° and 45° dive bomb, were trainable. Low-altitude events, such as day and night low-level flying, terrain masking, and AAA avoidance, were also trainable and of high value.

Additional Findings.

Attachment of the visual system did not limit the existing capabilities of the simulator in any way. The possibility of training some tasks not formally addressed in the evaluation plan, a preexisting problem with the g-cuing system, and

IP comments concerning the minimum requirements to train certain tasks that were less than acceptable are discussed in the following paragraphs.

Ejection Decision Training. A significant number of fatalities in aircraft mishaps result from a delayed decision to eject. The decision obviously must be made prior to entering the "no success" envelope. Currently, pilots learn the shape and size of that envelope only through charts presented in their flight manuals. The numbers from these charts do not represent all of the fully dynamic circumstances surrounding an actual ejection. A much more reliable, and certainly more graphic, way of teaching the pilot when he can expect to survive and when he cannot would be to allow him to personally explore any ejection possibility. During the evaluation, team members realized the potential of presenting the pilot's perspective in the visual scene as he ejects under any set of flight parameters he chooses. He would simply fly the simulator to those parameters and initiate ejection. At the moment of ejection the F-15 host computer would initiate a program to command the visual system's eye point to follow the trajectory and attitude changes of the pilot as he rides through the ejection sequence. The ejection system's performance would be replicated from actual system performance data that, when added to aircraft attitude and trajectory, should faithfully present what would happen in an actual ejection. The concept entails only software additions to the host simulator's computer program. To pursue the idea, technical data on ejection seat performance were acquired through ASD and examined by GAC and RSI engineers to determine the possibilities. A simple demonstration was successfully conducted for Air Force Inspection and Safety Center life sciences personnel by manually programming a very simple trajectory for the eye point after ejection. If pursued, the capability to provide such decision-to-eject training may save aircrew lives.

Tactical Mission Rehearsal. Complex tactical scenarios were not included as specific tasks to be formally evaluated. Such scenarios were demonstrated however. Combinations of tasks including low-altitude flying, navigation, tactical formation, detection and response to threats, weapon deliveries, and multiship enemy and friendly formations were demonstrated in conjunction with the formally evaluated four-ship low-level tactical formation task. IPs who flew the scenario were impressed with the potential for training complex tactical decision making in operational environments. Visual system data bases can replicate the specific terrain, cultural features, and defenses of potential adversaries in high risk areas of the world. Such data bases would provide very valuable mission rehearsal training to operational units with commitments in those areas.

G-Seat/G-Suit. The original six-degree-of-freedom motion base was not on this F-15 simulator nor is it on later models. Instead, later models have motion cuing systems composed of hydraulically and pneumatically driven bladders in the seat pan and back, a lap belt tightening and loosening system, and a g-suit inflation system. These systems are controlled by the F-15 simulator's host computer. The g-cuing computer program was written by GAC and then evaluated during formal acceptance testing procedures by several pilots who arrived at a consensus as to what they should feel while performing certain maneuvers. This evaluation was done without benefit of a visual system for visual feedback. During the evaluation of the visual system, most F-15 pilots said that the g-seat provided incorrect cues. The cues tended to distract the pilot rather than to support the visual cues. If a visual system is added to the F-15 simulator, the g-seat system should be reprogrammed to agree with visual system cues.

Additional FOV and Resolution. When tasks were rated less than acceptable, evaluators were asked to estimate the minimum additional FOV or other improvements necessary to train the task. Their comments concerning FOV limitations indicated that when a specific airborne target of interest left the FOV during maneuvering, the maneuver could not be completed. They suggested that an expansion of the fully detailed scene was not always necessary to completely train the maneuver. A visible horizon for attitude reference and a high resolution specific target image was suggested as sufficient in most cases. Their comments concerning resolution difficulties with formation lead ships and airborne adversaries at long range were similar in that only the specific target of interest requires higher resolution. In other cases where ground references, such as the runway, an air-to-surface target, or some other critical ground reference, left the FOV, they suggested that an expansion of the entire scene was not always necessary to correct the problem. In some cases a reorientation of the available FOV would suffice in lieu of expansion.

Overall Training Effectiveness.

The evaluation team assessed the visual system to be capable of substantially enhancing day/night training for F-15, F-16, and A-10 aircraft in both RTU and operational environments. This assessment was based on the combined results of objectives 1, 2, 3, and the additional findings. A total of 111 separate tasks that could not previously be effectively trained in the simulator were evaluated in 414 combinations of task, aircraft, and training environment. Of these, 371 can be effectively trained in the visual system equipped simulator. Overhead patterns, PLPs, threat detection, front and rear hemisphere defensive maneuvers, some offensive BFM tasks involving large changes in fighter nose position, some conventional range 30° and 45° dive bomb tasks, widely spaced tactical formations, and SAM avoidance maneuvers were not trainable for some aircraft and environments. Formation takeoffs, departures, and landings were not trainable in some F-15 training environments because of simulator roll sensitivity problems. The large number of newly trainable tasks includes transition tasks involving transition to and from outside references, tasks involving divided attention with risks to aircraft control, such as takeoff and landing emergencies, radar trail departures, lost wingman, and weather rejoins. This large number also includes air superiority operations tasks such as tactical intercepts, night vertical and horizontal conversions, tactical intercepts taking advantage of cloud decks, missile employment against multiple bogies in various weather conditions, and some offensive BFM tasks. Also included are: air-to-surface tasks, such as conventional and nuclear range events including VLDs, LABs, LALDs, VLADDs, and all strafe events; tactical range events, such as pop-up attacks, moving target attacks, curvilinear attacks; and high dive angle tactical dive bomb attacks, such as 30° and 45° dive bomb. These newly trainable tasks include low-altitude events, such as day and night low-level flying, terrain masking, and AAA avoidance. A potential for additional training opportunities not addressed by the evaluation plan was discovered during the evaluation in ejection decision training and tactical mission rehearsal.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions.

a) F-15, F-16, and A-10 simulator training effectiveness is substantially enhanced by the addition of an LFOV visual system.

b) F-15, F-16, and A-10 simulator day/night transition training effectiveness is substantially enhanced by the addition of an LFOV visual system.

c) F-15 and F-16 simulator day/night air superiority operations training effectiveness is substantially enhanced by the addition of an LFOV visual system.

d) F-16 and A-10 simulator day/night air-to-surface operations training effectiveness is substantially enhanced by the addition of an LFOV visual system.

Recommendations.

a) Should the TAF decide to substantially enhance the training effectiveness of F-15, F-16, and A-10 simulators in RTU and operational environments, LFOV visual systems with at least the same capability as the system evaluated should be acquired for those simulators.

b) Should the TAF decide to further enhance the transition and air-to-surface training effectiveness of simulators equipped with these devices, improvements to provide higher levels of image resolution for selected single targets of interest and improvements to allow reorientation of the available FOV to accomodate specific tasks should be considered.

c) Should the TAF decide to further enhance the air superiority training effectiveness of simulators equipped with these devices, improvements to provide presentation of a high resolution single target of interest image and a low resolution horizon reference in the area not covered by the FOV of the basic visual system should be considered.

ABOUT THE AUTHORS

LT COL MASTON E. O'NEAL III is Director of Air Superiority Simulators and F-15 Simulator Program Manager for the Deputy Chief of Staff, Aircrew Training Devices, USAF Tactical Air Warfare Center, Eglin AFB, Florida. He is responsible for managing the acquisition, modification, and testing of aircrew training devices for the Tactical Air Forces. He is a command pilot with over 3,000 flying hours in five different fighter aircraft. He served in Southeast Asia, flying 100 combat missions over North Vietnam. He also served as an exchange pilot with the Royal Air Force in Lightning fighters and three tours as an instructor pilot in F-106 and F-15 operational and replacement training units. His most recent flying tour was as an F-15 pilot and Chief of Safety at Kadena AB, Okinawa. He is a graduate of the University of Georgia with a Bachelor of Science degree in geology.

JAMES E. BROWN is an Engineering Psychologist with the USAF Tactical Air Warfare Center, Eglin AFB, Florida. He serves as technical advisor in the area of aircraft flight simulation and aircrew training. He holds a master's degree in Industrial Psychology from North Carolina State University and has over 25 years' experience in simulation. He began work for the government in 1970 as a research psychologist with the Air Force Human Resources Laboratory at Williams AFB, Arizona, where he was responsible for research in application of flight simulation to undergraduate and tactical pilot training, pilot performance measurement, and evaluation of visual systems for the Tactical Air Command at Luke AFB, Arizona. He spent 11 years in industry with Martin-Marietta Corporation and Bunker-Ramo Corporation as a program manager and principal investigator for contracts on flight control and display evaluations, ISD applications, voice warning systems, and command and control studies. Mr. Brown has written over 35 publications in the area of human factors.