AIR-TO-SURFACE FULL MISSION SIMULATION
BY THE ASUPT SYSTEM

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ABSTRACT

Air-to-surface weapons delivery is one realm of visual flight simulation which has been rather neglected until recent investigations were made by the USAF to determine the state-of-the-art in this area. As part of this investigation (Project 2235, Air-to-Ground Visual Evaluation),the Advanced Simulator for Undergraduate Pilot Training (ASUPT) system was expanded to include the additional capabilities required to perform air-to-surface weapons delivery. Evaluations of the various systems under consideration have shown the ASUPT computer image generation approach to air-to-surface visual simulation to be the most viable. This paper summarizes the engineering modifications made to the ASUPT system for Project 2235 and presents the operational capabilities of the new system configuration.

INTRODUCTION

Project 2235 arose from an urgent requirement to determine the state-of-the-art in visual air-to-surface (A/S) mission simulation. Specifically, the project supports the establishment of Required Operational Capabilities (ROC's) for the proposed A-10 and F-16 Mission Simulators. Air Staff RDQ and the Aeronautical Systems Division/Simulator Systems Program Office (ASD/SIMSPO/SD24F) of Air Force Systems Command (AFSC) felt that a study to assess visual simulation capabilities was necessary to reduce the performance and cost risks of procuring aircrew simulators which require A/S capabilities. A consortium of the Air Staff, ASD/SIMSPO and AFSC arrived at a decision, dictated to a large extent by available funds and time, to make the assessment by evaluating three systems currently in the field. These systems are the Advanced Simulator for Undergraduate Pilot Training (ASUPT) System located at Air Force Human Resources Laboratory, Flying Training Division (AFHRL/FT), Williams AFB, Arizona; the Large Amplitude Multi-Mode Aerospace Research Simulator (LAMARS) located at the Flight Dynamics Laboratory (FDL), Wright Patterson AFB, OH; and the Simulator for Air-to-Air Combat (SAAC) F-4E No. 18 combined systems located at Luke AFB, AZ. Each of these systems utilized a different approach to visual simulation: ASUPT features a Computer Image Generation (CIG), wide-angle,field-of-view (FOV) cathode ray tube (CRT) display; LAMARS, an area-of-interest (AOI) dome projection of a model board; and the SAAC, wide-angle,FOV CRT display with a camera1 model AOI of the F-4E terrain model board.

AFHRL/FT became actively involved in Project 2235 on 8 July 1975 at the Test and Support Planning Meeting held at Wright Patterson AFB. A project plan was developed at this meeting to serve as a basis for all agreements among project participants and outlining the specific A/S task objectives to be evaluated. Shortly thereafter, AFHRL/FTE developed an Engineering Development Plan to define the scope of ASUPT's ability to respond to Project 2235's objectives, to establish functional task areas requiring engineering development, and to project a schedule for the ASUPT engineering development.

It was confirmed that ASUPT could provide the capability to perform all of the A/S mission requirements established in the overall Project 2235 Test and Evaluation Plan;

however, additional development was required in both hardware and software areas.

The purpose of this paper is to describe the expansion of the ASUPT system features to include A/S mission simulation and to report the operational results thereof.

General System Description. The ASUPT system consists of two T-37B simulator cockpits. Each cockpit with G-seat is mounted on a six-degree-of-freedom synergistic motion base surrounded by seven cathode ray tubes (CRT's) with special infinity optics providing a wide-angle,field-of-view (FOV) visual display. The visual scene is produced by means of a computer image generation (CIG) technique which provides a perspective two-dimensional image of an environmental model defined in three dimensional vector space and stored in computer memory. Unique characteristics of this visual system are:
1. Wide-angle,field-of-view
2. Unrestricted viewpoint position and attitude
3. Unlimited number of environmental data bases which can be modified, amended and constructed with reasonable effort and little expense
4. Large gaming area (1250nm X 1250nm)
5. Provision for an independent moving model which may take the form of lead/FAC aircraft, moving ground target, SAM, etc.

Operational A/S Requirements Provided by the Original System Configuration. The ASUPT system, designed to accommodate research in undergraduate pilot training, easily facilitates those Project 2235 scenarios encompassing UPT missions. Tasks such as takeoffs, departures, approaches, landings, aerobatics and formation flight during day, dusk, night and varying ceiling and visibility conditions are readily accomplished.

The observance and monitoring of pilot performance and aircraft maneuvers is also provided. At the various instructor-operator stations, one may survey the situation by means of duplicate instruments, closed circuit TV, CRT monitors, and graphics displays. (See Fig. 1 AIOS)

Operational A/S Requirements Necessitating Additional Development. In addition to the requirements imposed by A/S scenarios with tasks common to those in UPT, are the ones more directly related to weapons delivery. These requirements necessitated the acquisition, modification and development of both hardware and software. First, an entirely new visual data base was designed and developed to provide an appropriate environment for air-to-surface weapons delivery. A CA503
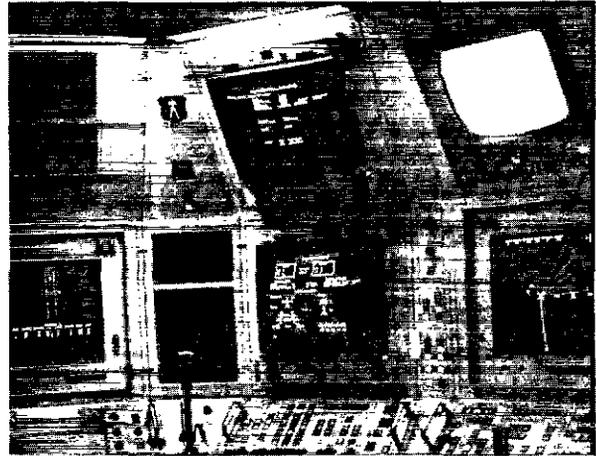

Figure 1. Advanced Instructor/Operator Station

optical gunsight for an A-37 aircraft was procured, modified, and installed in one of the two cockpits. The stick triggers were wired, activated and integrated with the simulator computer. Algorithms were developed to provide paths for the ordnance, surface-to-air missile (SAM), and moving ground target. Significant software was developed to provide visual display of ordnance ground impacts and the two graphics displays were reprogrammed to provide for delivery scoring. Also, missions utilizing the FAC/lead aircraft required a moving model visible at ranges far in excess of those for formation flight, again necessitating software program modifications. To handle the extra software in an efficient manner, 8K of computer core memory and a 24 million byte moving-head disk drive were purchased and installed.

Operational Capabilities. The environmental gaming area is a square area 36 nautical miles on a side and consists of random surface texture, an airfield, a gunnery range, and two tactical complexes. (See Fig. 2)

The airfield (see Figs. 3 and 4) is composed of a 12,000 foot fully-marked and lighted runway with numerous three-dimensional features to provide the necessary velocity and altitude cues.

The conventional gunnery range is in a baseball diamond pattern as shown in Fig. 5 and consists of two bomb circles, two skip bomb targets, and two strafe targets. Buildings scattered throughout the area, range towers, and as shown in Fig. 6, trucks in the bomb circles provide the three-dimensional cues.
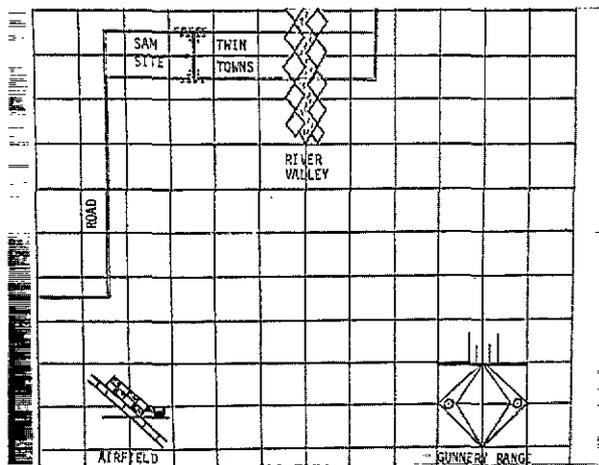
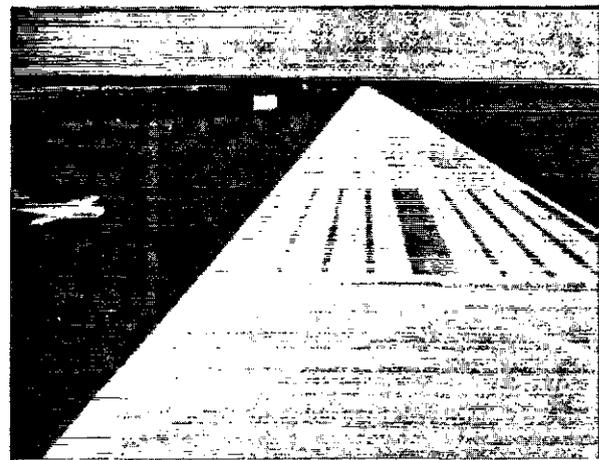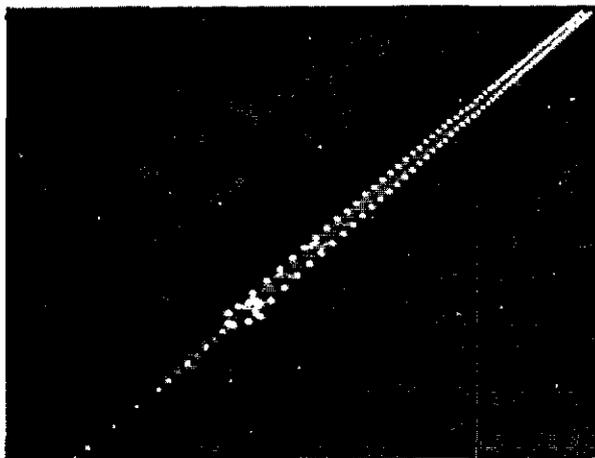Figure 2. Environmental Gaming Area

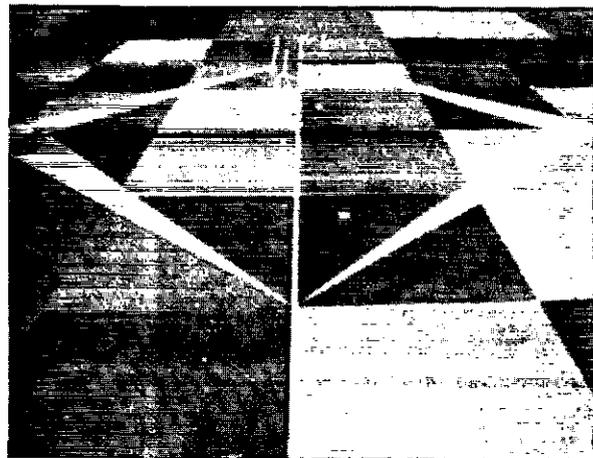Figure 4. Threshold

Figure 3. Airfield at Dusk

Figure 5. Gunnery Range

One of the tactical ranges consists of two small towns about four miles apart with a surface-to-air missile (SAM) site located between them. As may be seen in Fig. 7, a convoy of trucks is departing the northern town. The other tactical area is located in a river valley between two mountain ranges spanned by a pair of bridges as shown in Figs. 8 and 9. In the vicinity of one bridge is an island containing a munitions manufacturing facility. Contained in the munitions complex are a factory, ammo dump, watch towers, barracks, warehouses, dock, ship, jeeps, trucks, ambulance, tanks, antiaircraft artillery emplacements, helipad (see Fig. 10) and helicopter. The mobile features in this area change their locations during the day, dusk, and night environments.
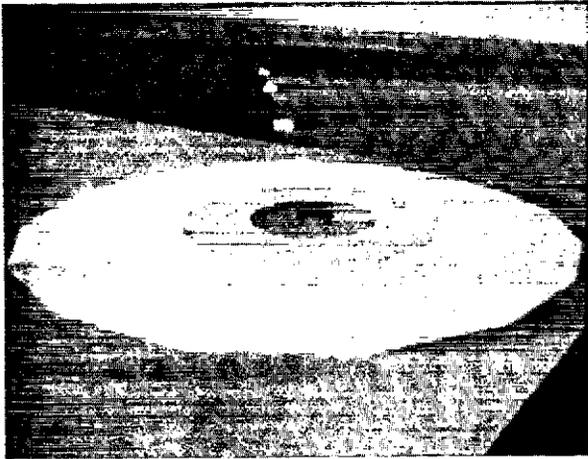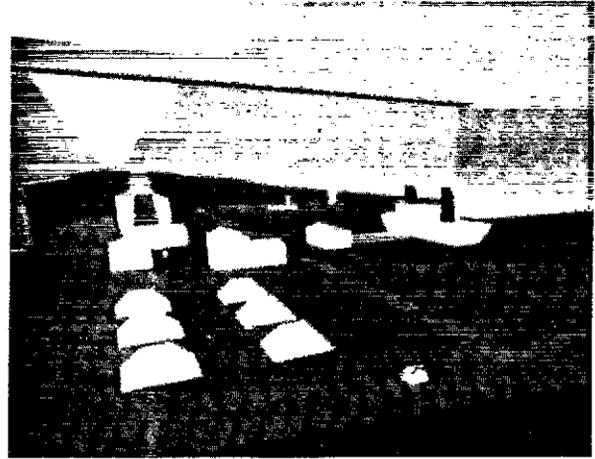
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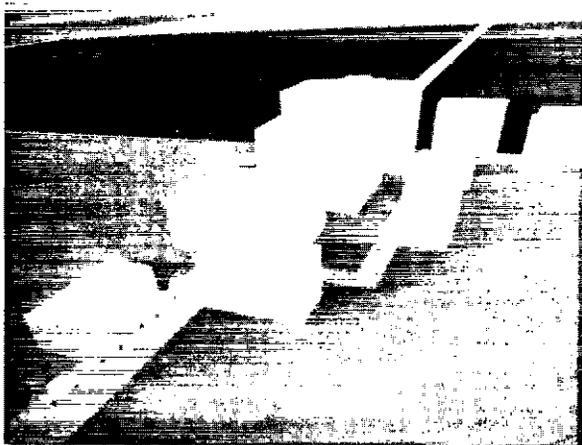Figure 6. Bomb Circle

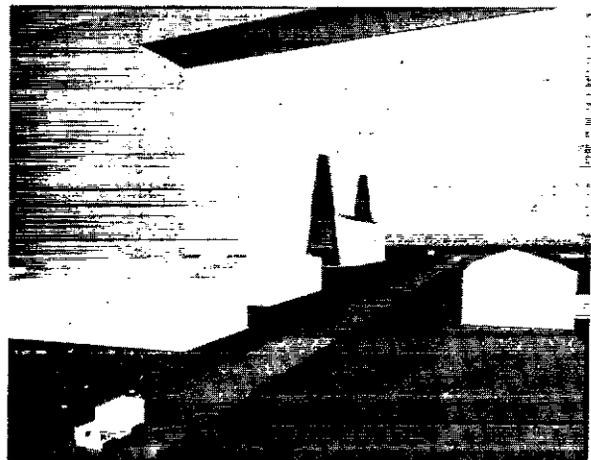Figure 8. River Valley

Figure 7. Truck Convoy

Figure 9. Munitions Complex

Within the environment, the pilot may "fire" the cannon and "drop" bombs at will. Visual ground impacts are displayed for both strafe and bomb, and when a three-dimensional feature is hit, it is deleted from the display scene. This may be observed in Fig. 11, depicting a circular white impact near the center of the bomb circle. Since a "hit" occurred, the truck has been omitted from the display scene.

Two graphics displays have been reprogrammed to provide monitoring and scoring of the A/S

weapons delivery tasks for selected targets at the advanced instructor operator station (AIOS). These displays are shown at the lower left and right portions of Fig. 1. The Aircraft Delivery Parameter Display depicted in Fig. 12 presents real-time heading, altitude, airspeed, dive angle, and G-load as digital data at the top edge of the display. The remainder of this display is divided into two parts. The top half presents a side view with fixed dive angle lines (15°, 30°, 45°, 60°) radiating from target and a dynamic aircraft image moving from right to left on
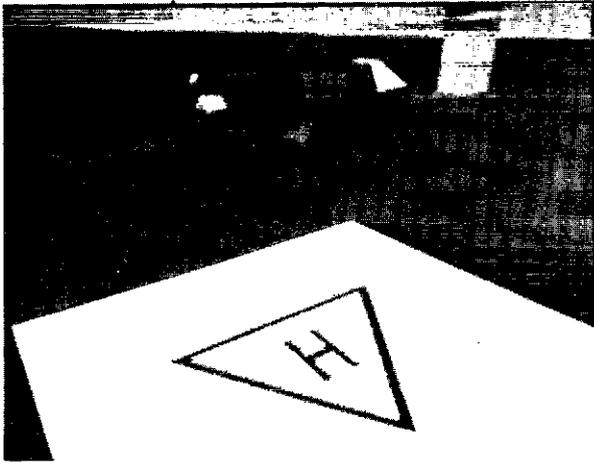
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Figure 10. Helicopter

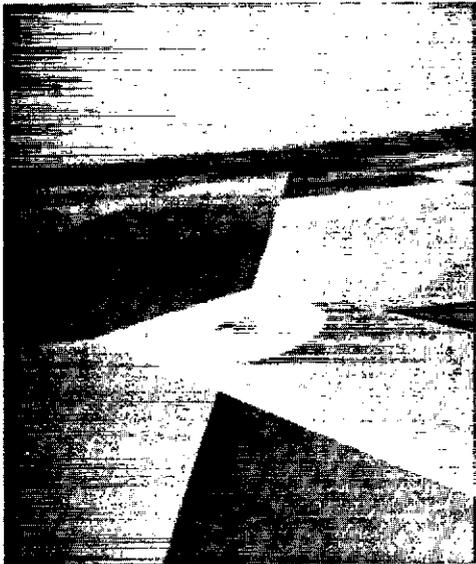Figure 12. Aircraft Delivery Parameter Display

Figure 11. Ground Impact

the screen leaving a trail of dots in its wake as shown below the 15° dive angle radial. The bottom half is a top-down view-oriented true north also portraying a dynamic aircraft image on northerly heading with trail as shown. For strafe tasks this display also gives scoring information as a percentage
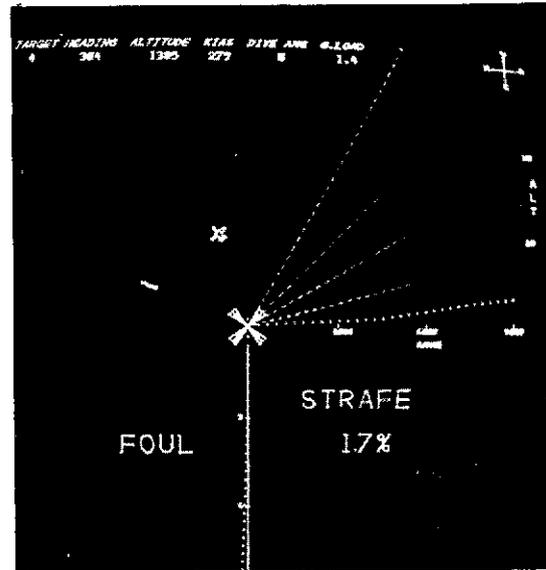
of projectiles fired through the target and displays a "FOUL" if the pilot presses beyond the range foul line. (See Fig. 12). The Target-Impact Display pictured in Fig. 13 is a top-down view of the target center oriented true north with radial lines through the o'clock positions and concentric circles at 150' and 300' radius. Bomb drop impacts are indicated in their relative positions as a circle with pass number. Heading, altitude, airspeed, G-load, dive angle, and winds at time of release, in addition to radial distance of the impact from target center are accumulated for up to ten passes at the bottom of the display. A hardcopy printout of this information is also available.

With both cockpits "flying" independently, each viewing the other as the moving model, formation, mutual support and forward air control mission may be performed. An image size control program was implemented to introduce a deadband range for which the moving model perspective image remains constant. Upon reaching the limits of this range, the image's size will again commence perspective changes. This was done in an attempt to alleviate the resolution problem occurring with the aircraft at ranges in excess of 2500 feet. Fig. 14 shows the moving model of the T-37 aircraft which is used for formation flight. A more simplistic
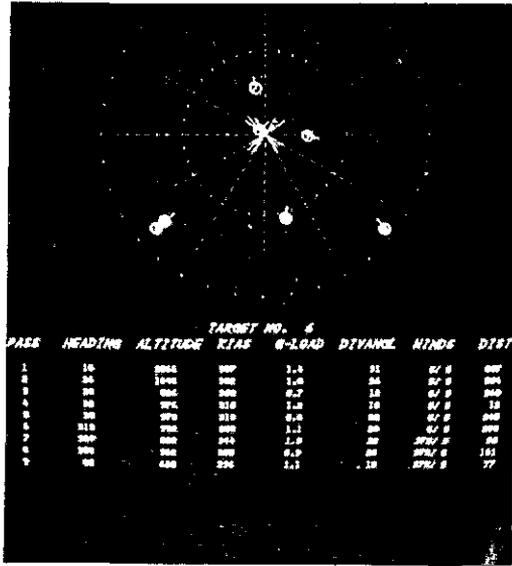
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Figure 13. Target Impact Display

model is used for the lead and forward air
control aircraft. Indication of a target by
a forward air control aircraft is simulated
by "smoke" marking of the convoy which may
be turned on and off at the operator
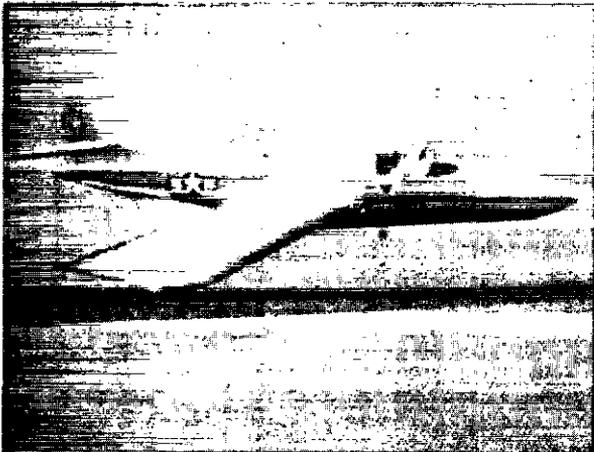station (see Fig. 7).

Figure 14. Formation Aircraft

Ground Fire is simulated by muzzle flashes of
the antiaircraft artillery (see Fig. 15).
and tanks. Aerial flak bursts also accom-
pany the antiaircraft artillery in the
vicinity of the munitions complex. A missile
may be repeatedly launched from the SAM site

(See Fig. 15) and will track the aircraft. In
Fig. 16, the launch of the SAM is observed
through the gunsight in the simulator cockpit.
The missile may be averted if proper evasive
tactics are performed in response to the
missile's trajectory; otherwise a "kill" is
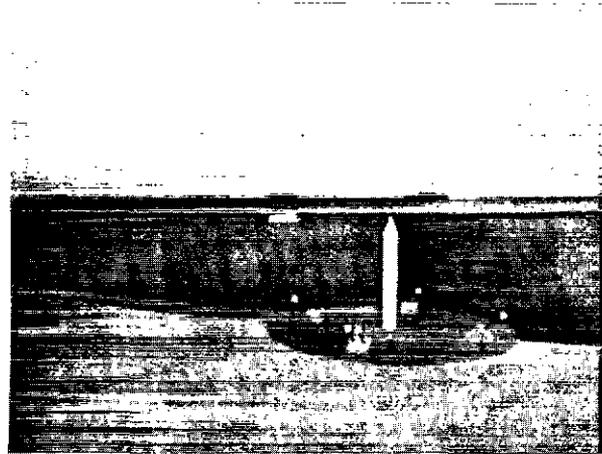experienced which results in a simulator
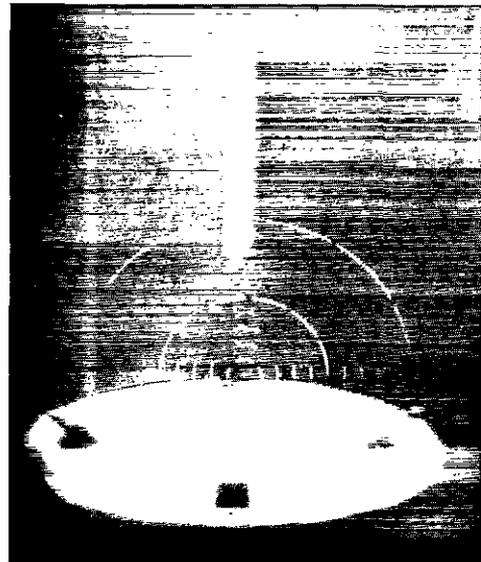crash condition.

Figure 15. SAM Site

Figure 16. SAM Launch

Patrolling the SAM site and the highway between the two towns is a tank. When attacked and experiencing a "near miss," the tank will leave the road, randomly changing speed and direction to confuse the attacker. Following an appropriate interval, the tank will resume its normal patrol.

CONCLUSION

In February 1976 an evaluation of the system was performed by six Tactical Air Command fighter pilots highly experienced in air-to-surface weapons delivery. Each pilot "flew" ten mission scenarios of approximately one hour each. These scenarios were representative of all phases of A/S missions including takeoffs, landings, traffic patterns, aerobatics, formation, low level navigation, conventional range operations and deliveries and tactical operations and deliveries. The range deliveries included 10, 15, 20, 30, 45, and 60 degree bomb, and both high and low angle strafe. Tactical missions involved armed reconnaissance, locate and identify target, terrain masking, mutual support,

ordnance adjustment, moving target, and FAC operations in addition to the various aforementioned delivery modes. During this interval a system reliability rate of 94% was maintained, and after a total of 60 hours system time the pilots were still enthusiastic about "flying" the simulator.

As a result of the highly successful completion of the engineering modifications and system demonstration of the ASUPT phase, Project 2235's major conclusion is that computer image generation is the most viable approach to air-to-surface full mission visual simulation.

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ABOUT THE AUTHOR

MR. ERIC G. MONROE is ASUPT CIG Visual System's Project Engineer for the Air Force Human Resources Laboratory's Flying Training Division at Williams Air Force Base, Arizona. He has been involved in visual flight simulation for the past four years. For the past two years, he was with the Air Force. Prior to that, Mr. Monroe was a systems engineer with General Electric's Space Division, Ground Systems Department, Daytona Beach, Florida. As Project Engineer for the ASUPT phase of Project 2235, Air-to-Ground Visual Evaluation, he was responsible for the project's coordination, supervision, and management in addition to other technical work. He holds the B.A., M.A., and M.S. degrees in mathematics from Washington and Jefferson College, Duquesne University, and Stetson University.