TOW MISSILE SIGHT VIDEO TRAINING SYSTEM

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INTRODUCTION

Maintaining a high first round weapon system kill probability through effective gunner training has become increasingly important with escalating cost per round. Recent advances in the state-of-the-art in video cameras employing all solid-state, charge-coupled device (CCD) technology have prompted a reevaluation of current training techniques and devices. This paper discusses the application of this new technology in a training environment.

The Fairchild TOW Missile Sight Video Camera System (TMSVCS) provides a capability for real-time monitoring and assessment of gunnery performance and immediate post-mission playback and analysis of gunner-aim point during live or simulated firings of the TOW Weapon System.

In this helicopter application, the gunner, located in the front seat of the AH–IS TOW COBRA, utilizes a stabilized Telescopic Sight Unit (TSU) with which he can detect and accurately track a target. As an aid to gunner training, and for effectiveness evaluation, provisions for a 16mm film gun camera form a part of the TSU. Training benefits of this film record are minimal because of the several day delay between exposure and screening of the film due to film processing requirements. Additionally, light level variations limit the usefulness of film cameras. Another training aid, the Gunner Accuracy Control Panel (GACP) displays azimuth and elevation gunner errors to the instructor-pilot (IP) in the second seat of the helicopter, but this system is usable only with specially conditioned targets.

The TMSVCS overcomes these shortcomings by providing the instructor-pilot with a real-time image of gunner's field-of-view, including the TSU reticle, on a high-brightness video monitor. In a training exercise, the IP can observe and verbally correct the way in which the gunner sights on the target and maintains position from initial acquisition to impact. Tracking errors and jitter in azimuth or elevation can be observed dynamically and corrected instantaneously.

For immediate detailed review of gunner performance upon return to base, the on-board video tape recorder (VTR) can be utilized. The video tape cassette, removed upon landing, can be replayed on a VTR and displayed on a video monitor for performance review, assessment and correction; this procedure can take place much more rapidly than in the case of 16mm film and therefore represents a significant training aid improvement for the IP and student. Relative advantages of the TMSVCS are summarized in Table 1.

TABLE 1.

VIDEO TRAINING BENEFITS

- No Target Conditioning Required
- Real Time IP Observation/Verbal Queing
- Immediate VTR Playback on Landing
- 40 Simulated Firings on a Single Cassette
- Reusable Tape Cuts Cost
- Short Term Record to Demonstrate Improvements
- Modular Growth
- Operational Value
  - RECCE
  - Damage Assessment
  - Landing Aid

TMSVCS CAMERA SYSTEM DESIGN

The Fairchild TMSVCS is made possible by the recent availability of small, rugged low light level TV cameras, high brightness monitors, and video tape recorders ruggedized for use in the helicopter environment. The smallest, most rugged and reliable TV cameras available employ a solid-state imaging device rather than a vidicon tube. Fairchild has developed solid-state charge-coupled device (CCD) area imaging arrays and cameras which are ideally suited to this requirement. Operation at the low-light levels available from the TSU beam splitter is possible because of the superior CCD sensitivity.

The CCD camera is mounted in a special bracket which maintains the same TSU interface as the previous film camera. The dynamic range and AGC characteristics of the CCD camera permit effective operation over a wide range of scene brightness without exposure control. This provides a state-of-the-art system with high reliability at a modest cost.

The TMSVCS camera is depicted in Figure 1. The CCD camera output feeds both a video tape recorder and high brightness monitor. TMSVCS power is switched manually via a remote switching and control panel conveniently located for operation by the IP. Automatic tape recorder shut-off is provided with a manual override as a tape saving feature and assures that the recorder is not inadvertently left in a RECORD mode for extended periods.

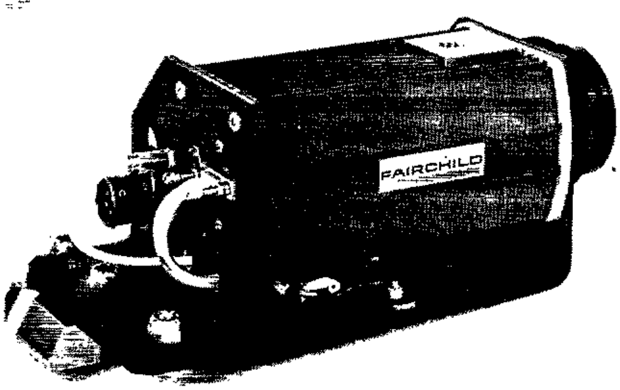

Figure 1. TMSVCS Camera

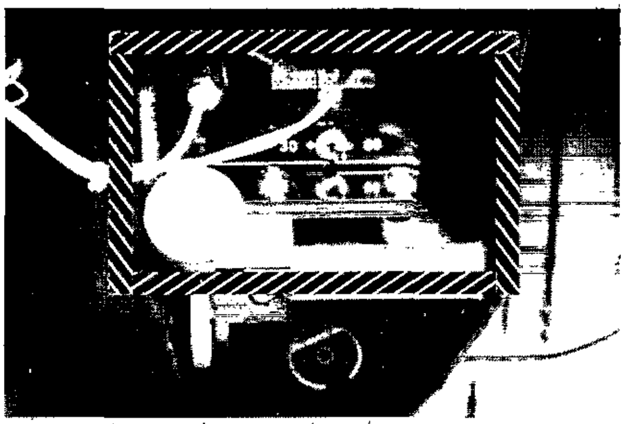

Figure 2. Installation of TMSVCS Camera in the TSU

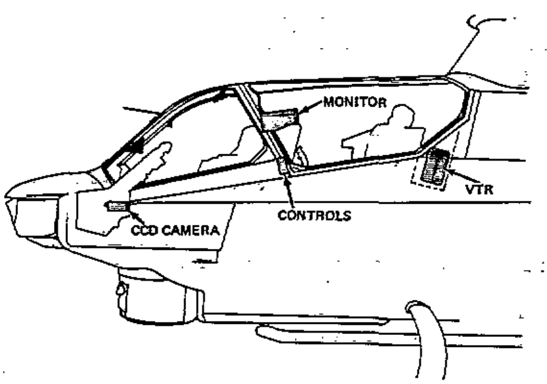

Figure 3. TMSVCS Installed in AH-1S Helicopter

The CCD television camera uses a modified positioning ring and retaining shoe similar to those used for the film camera body. This assures that the mechanical and optical interface is maintained without modification to the TSU. Locating the small CCD format (7.2 mm diagonal) in the 16mm film image plane (12.6mm diagonal) reduces the displayed field-of-view to 57%. This provides improved target resolution and image magnification and enhances the instructor's ability to assess gunner accuracy at the projected time of target intercept.

Figure 2 shows the installation of the TMSVCS camera in the TSU. The small size of the camera is evident from the photograph, and clearly indicates that the camera does not interfere with the gunner during TOW System operation.

A performance specification for the CCD video camera is given in Table 2.

Higher resolution and/or a greater field-of-view can be provided with a full TV resolution CCD camera as requirements dictate. Specifications for the full resolution CCD camera are given in Table 3.

VIDEO TAPE RECORDER AND MONITOR INSTALLATION

A High-Brightness Video Monitor is mounted on the top of the gunners seatback for viewing by the instructor-pilot (Figure 3). The small size of the display serves to minimize obstruction of the IP's forward view in this location, and the increased visibility offered by use of the television camera more than compensates for the area blocked by the monitor. The video tape recorder and system power supplies also depicted in Figure 3 are located in the space immediately behind the pilot's seat.

RESULTS AND CONCLUSIONS

The last four figures, photographed from the television monitor, depict actual scenes viewed through the TSU/CCD camera system and illustrate the performance capability of the TMSVCS. In Figure 4 a tank located at a distance of 2,800 meters is shown at 13 x magnification (the high magnification setting of the TSU). To the right in the figure, a TOW missile approaching the target is barely discernible. A few hundredths of a second later, the missile strikes the target and approximately 70 milliseconds after missile impact the scene appears as shown in Figure 5. The two magnifications available with the TOW Sight are clearly illustrated in Figures 6 and 7 where the same helicopter is shown in the air at a range of 2,500 meters at both magnifications. All four pictures (Figures 4 through 7) were photographed at approximately 9:00 AM under overcast sky conditions.

Other closely related applications for the same basic Fairchild TMSVCS components include Aircraft Electronic Gunsight Cameras and potential use in any weapon systems employing optical sights or as visual confirming sensors for other types of scoring systems. On-board TV cameras, displays, and recorders should find increased application to real-time reconnaissance and damage assessment systems, as well as helicopter cockpit display recording. Field deployment will continue to disclose other applications of the TMSVCS and further add to a growing list of benefits of video systems in the institutional and field unit operational environments.

TABLE 2.

TMSVCS CAMERA SPECIFICATION

SENSOR	FAIRCHILD CCD ARRAY
SPECTRAL RESPONSE	0.45–1.06 MICROMETER
OPTICS	TSU COMPATIBLE; FIXED AND VARIABLE FOCAL LENGTH OPTICS AVAILABLE
LENS MOUNT	STANDARD "C" MOUNT
SENSITIVITY (NOTE 1)	SCENE BRIGHTNESS 0.0125 FOOT LAMBERTS; SENSOR ILLUMINATION 0.00125 FOOT CANDLES
ELECTRONIC AGC	$>$80:1 RANGE
GEOMETRIC LINEARITY	NO CAMERA DISTORTION
FRAME RATE	30 FRAMES PER SECOND
FORMAT	244 LINES; 190 PICTURE ELEMENTS PER LINE
SYNCHRONIZATION	2:1 STANDARD INTERLACE
VIDEO OUTPUT	1 VOLT PEAK–TO–PEAK COMPOSITE VIDEO (RS 170 COMPATIBLE)
VIDEO LINE OUTPUT	UP TO 500 FEET; 75 OHM
POWER	28±4 VOLT DC; 4 WATTS
CAMERA SIZE	2–1/2" W, 2" H, 3–3/4" L

NOTE: HIGHLIGHT SCENE ILLUMINATION WITH 2854°K SOURCE (TUNGSTEN) USING f/1.4 LENS FOR A S/N RATIO OF UNITY.

TABLE 3.

PRELIMINARY SPECIFICATIONS
FAIRCHILD MV–301 CCD–TV CAMERA

SENSOR	FAIRCHILD CCD 488 X 380 ARRAY
PERFORMANCE	
FRAME	488 LINES, 380 PICTURE ELEMENTS/LINE
SENSITIVITY	5 X 10^{-3} FT LAMBERTS SCENE BRIGHTNESS* 5 X 10^{-4} FT CANDLES SENSOR ILLUMINATION
SPECTRAL RESPONSE	0.45 TO 1.06 MICROMETER
GEOMETRIC LINEARITY	NO CAMERA DISTORTION. SYSTEM PERFORMANCE IS LIMITED BY OPTICS AND DISPLAY
OPERATING CHARACTERISTICS	
FRAME RATE	30 FRAMES/SEC
LINE RATE	15750 LINES/SEC
SYNC	2:1 STANDARD INTERLACE
VIDEO OUTPUT	1V P–P COMPOSITE VIDEO (RS170)
VIDEO LINE OUTPUT	500 FT, 75 OHM
AGC, ELECTRONIC	$>$ 80:1 RANGE
ALC, fl.4 SPOT–IRIS LENS	7 X 10^{4} RANGE
POWER	
CAMERA	±12VDC, 5 WATTS
AC ADAPTER	115V, 50–400 Hz
PHYSICAL DATA	
CAMERA SIZE	2–5/8" DIAMETER X 5–1/4" LONG
WEIGHT	1 LB.
OPTICS	STANDARD "C" MOUNT LENS

*HIGHLIGHT SCENE ILLUMINATION WITH 2854°K SOURCE (TUNGSTEN) USING fl.4 LENS FOR A S/N RATIO OF UNITY.

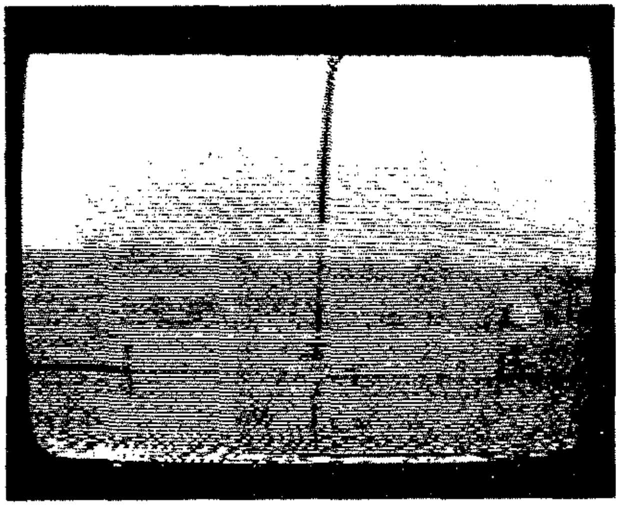

Figure 4. Tank Target: 2800 M; 13 x Magnification

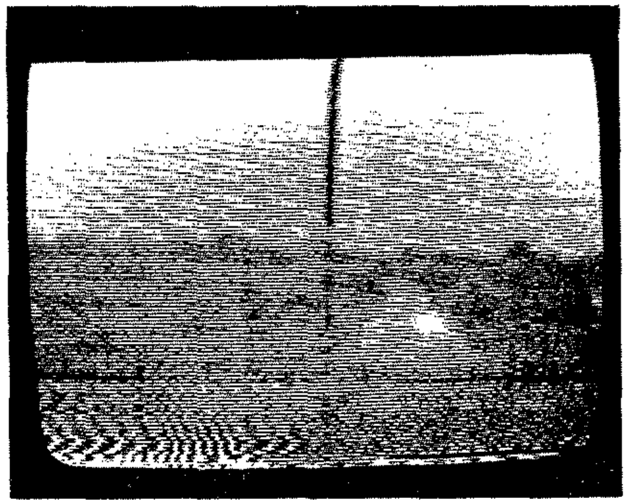

Figure 5. Same Target as Figure 4; Direct Hit

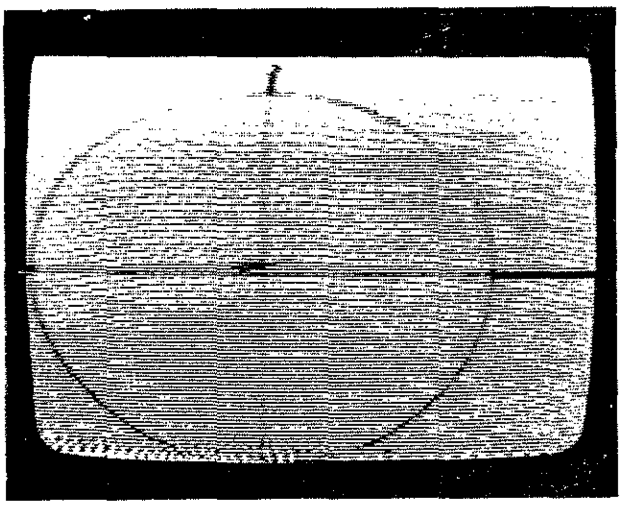

Figure 6. Huey Helicopter: 2500 M; 2 x Magnification

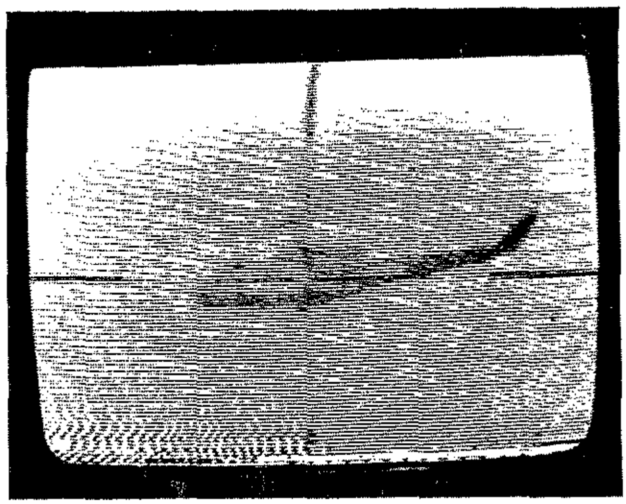

Figure 7. Same Target as Figure 6; 13 x Magnification

ABOUT THE AUTHORS

MR. NORMAN GUTLOVE is a Senior Consulting Engineer in the Imaging Systems Division of Fairchild Camera & Instrument Corporation, Syosset, New York. He is responsible for coordinating program activities involving charge-coupled device applications to military requirements. He has been responsible for coordinating experimental requirements for the Advanced Orbiting Solar Observatory (AOSO) vehicle and program evaluation in areas of optics, infrared, and solid-state physics. He has engaged in development of aerospace, electronic, optical, and photographic techniques with aircraft, rocket, and satellite vehicle characteristics, mission objectives, and ground facilities. He holds a B.S. degree in physics from New York University and an M.S. degree in physics from Cornell University.

MR. JOHN STANFIELD is a Marketing Manager for Electro-Optical Systems in the Imaging Systems Division, Fairchild Camera & Instrument Corporation, Syosset, New York. He is responsible for program development of charge-coupled device image sensors and processing for a variety of military applications. He has been responsible for development of fire-control computers for the B-58 and B-52, instrumentation for satellite payloads, a data storage system for the apollo spacecraft, and research and development programs for computer technology and digital image correlation techniques for spacecraft navigation and missile guidance. He holds a B.S. degree in physics from University of Missouri.