Onboard Television Transmission from A Supersonic Vehicle

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Abstract

A telemetry system designed to photograph and transmit views of a working recovery system. The system utilizes a 5-inch diameter vehicle fitted with a 1/1000-second electronically shuttered video camera and a wideband telemetry transmitter with a pulse code modulation [PCM] signal sent via a second radio frequency [RF] channel.

1 Introduction

Test engineers have always desired a way to see the close-up movement of distant devices under "real" operating conditions.[1] Until recently, test engineers have had to depend on long range, ground-based, chase plane, or occasionally on-board film cameras. With the advent of low-cost solid-state television cameras, the Naval Weapons Center [NWC] at China Lake has extracted video data from an in-flight supersonic 5-inch diameter Sidewinder missile.

2 Requirement

The requirement to develop a recovery system for the Sidewinder guidance section was tasked to the Aerosystems Department at NWC. The Naval Weapons Center and the Aerosystems Department were instrumental in the development of the current Sidewinder telemetry systems and are continually involved in updating and improving the efficiency of the systems. The concept of recovering a portion of the missile has both economical and technological benefits. Current telemetry systems can now indicate what failed, not why it failed, by use of a recovery system to determine the cause of failures. In addition, improvements to missile component reliability will be greatly enhanced by the ability to analyze the data and hardware retrieved by the recovered missile.

3 System Description

The electronic timing and firing circuit consists of off-the-shelf components used in a circuit design originally intended and used in various parachute recovery packages. For safety of flight, a standard Sidewinder Safe and Arm [S&A] device was used to prevent any explosive devices from operating while the missile was attached to the launcher. The parachute system consists of a drogue chute which is deployed four seconds prior to the main chute which operates for the remainder of the flight. The video system consists of a video camera, video transmitter, and antenna as shown in Figure 1.

3.1 Telemetry System

A standard AN/DKT-31 or AN/DKT-58 Sidewinder telemetry system replaces the warhead unit. For this test, however, a “recovery-type” system was used, which contains not only the telemetry system, but a parachute recovery package. The telemetry system contains a 32-channel analog data multiplexer, transmitter, and thermal battery, but no accelerometers and gyro as found in the standard telemetry units. The telemetry system registers the timing of events critical to deployment of the internal recovery system, as well as the missile guidance functions. The television picture returned by the added system allowed correlation of data to events observed in the picture.

3.2 Video System

The video system is housed in the case normally occupied by the target detecting device [TDD] for the Sidewinder missile. The TDD housing has windows through which laser diodes normally detect target proximity, although in most tests the TDD is not actually used.

3.2.1 Video Camera

The video camera is a standard monochrome type with an internal electronic shutter operating at 1/1000 second. The rapid shutter is necessary to stop the motion of the elements in the picture to make an unblurred still field[1] image 60 times per second. Salient camera characteristics are shown in Table 1.

[1] A television field has 240 vertical lines of resolution; “optimum” horizontal resolution is 320 pixels, about what can be obtained with a VHS tape recording. A noninterlaced synchronization pattern is used for best results with still pictures.

3.2.2 Optics

The video camera lens faces out of the container through a 1-inch diameter window. A 90 degree prism was installed on the exterior of window with optical cement. To reduce wind resistance, a machined protective shroud (see Figure 2) facing aft was also added.

3.2.3 Video Transmitter

The video transmitter is a standard type intended for analog video transmission in the 1710 to 1850 megahertz [MHZ] bandwidth with 2 to 3 Watts of output power. Modification of the transmitter for installation into the restrictive TDD housing consisted only of removing the rather large power and input connectors and substitution of hard wiring. The RF output signal was fed through a power divider to two flush-mount antennas on opposite sides of the container, operated electrically in phase.

Table 1: Camera Characteristics

Pick-up device	Interline transfer CCD
Number of active picture elements	542 (horiz) x 492 (vert)
Number of effective picture elements	512 (horiz) x 492 (vert)
Image size	6.4 x 4.8 *mm*
Scanning method	2:1 interlace or non interlace
Television method	525 lines 60 fields
Synchronizing method	Internal or external
Resolution	Horizontal: 380 TV lines Vertical: 350 TV lines
Power	12 VDC @ 250 milliamps

3.3 Power

The original system design for ground and sled testing involved the use of a rechargable nickel-cadmium [NiCd] battery, however, such batteries were incompatible with the air launch requirements due to the temperature extremes expected, and because of the limited amount of operating time available. The television system battery was activated immediately prior to launch by the same circuits that fire the telemetry and guidance system batteries.

For air launch testing, 12-volt power for the camera and 28-volt power for the transmitter were provided through an umbilical connection to the aircraft prior to deployment and thereafater from a thermal battery with the dummy fuze case. Due to relatively low power draw from the camera (250 milliamperes), power was provided through a 7812 series regulator, with the regulator thermally connected to the system case.

3.4 Parachute System

The parachutes were pressure packed and released in proper sequence by electronic timers firing cable cutters and exploding bolts.

3.5 Video Receiver

A special-purpose receiver manufactured by Emhiser Research with the telephone network standard of 70 MHZ intermediate frequency [IF] was utilized for testing. Due to the bandwidth used by the video signal (20 to 30 MHZ), standard telemetry receivers which have a final IF of 10 or even 20 MHZ could not be utilized.

4 Ground Testing

Various tests were performed at the Naval Weapons Center Supersonic Naval Ordnance Research Track [SNORT], including deployment of the speed brakes at supersonic speeds. The 2 square-inch speed brakes were constructed of a hardened steel alloy with a lead extrusion system to slow down the deployment, preventing the brakes from shearing off with the initial loading shock. The SNORT tests included photo and video coverage which proved that the system functioned successfully during ground testing.

5 Flight Testing

The objective of flight testing was to test the recovery system and speed brakes traveling well above supersonic speed and operating at 5,000 feet above ground level. The system proved successful and provided useful data in one successful deployment and one unsuccessful deployment. Figure 3 shows the recovered video launch aircraft as seen from the departing missile. Figure 4 shows the recovered video of speed brake deployment.

6 Future Systems

The video system built for this project showed us that commercial equipment can be modified for use in military test applications. Since the system described here was built and flown, smaller cameras and cameras with detached heads have become available, both of which have been used in subsequent applications. The Sidewinder missile is only 5" in diameter; other candidate missiles are generally larger, simplifying the design.

Combining the video and telemetry signals with the telemetry signal on a subcarrier can eliminate one transmitter and has no significant effect on the video signal bandwidth, although the 4.5 MHZ ±25 kHz subcarrier used in commercial broadcasting is not a good choice. A good choice appears to be 7.5 MHZ, with a deviation on the order of ±500 kHz or so. Receivers can be made with an internal discriminator for this subcarrier provided, or a tunable discriminator at the ground station can be used. The greatest difficulty appears to be in convincing the ground station operators to provide the correct wide IF even with receivers equipped to handle them.

When encryption or lower transmitting bandwidths are required, use of a video digitization system such as HORACE[2, 3] is required. In such cases, telemetry data is combined with the digital data into a single encrypted digital bitstream.

Color pictures can be dealt with by sending a composite NTSC color picture in the analog case, and in a number of ways with higher and lower color resolution with digital transmission. Miniature color cameras can be the same size as black-and-white cameras, but generally require more support circuitry and produce a lower-resolution monochrome image.

Future uses may also include systems with frame rates greater than those of standard television to capture rapidly-occurring events.

References

[1] Karrer, Art: **Missile Recovery System Tests**, NWC TM 6590, September 1989

[2] Rieger, James L., and Gattis, Sherri: **Draft Standard for Digital Encoding of Television Signals RCC/TCG-209**, NWC Technical Publication TP-7025, July 1989

[3] Range Commanders' Council, Telecommunications Group: **A Standard for Digital Encoding of Television Signals**, White Sands, New Mexico, 1990

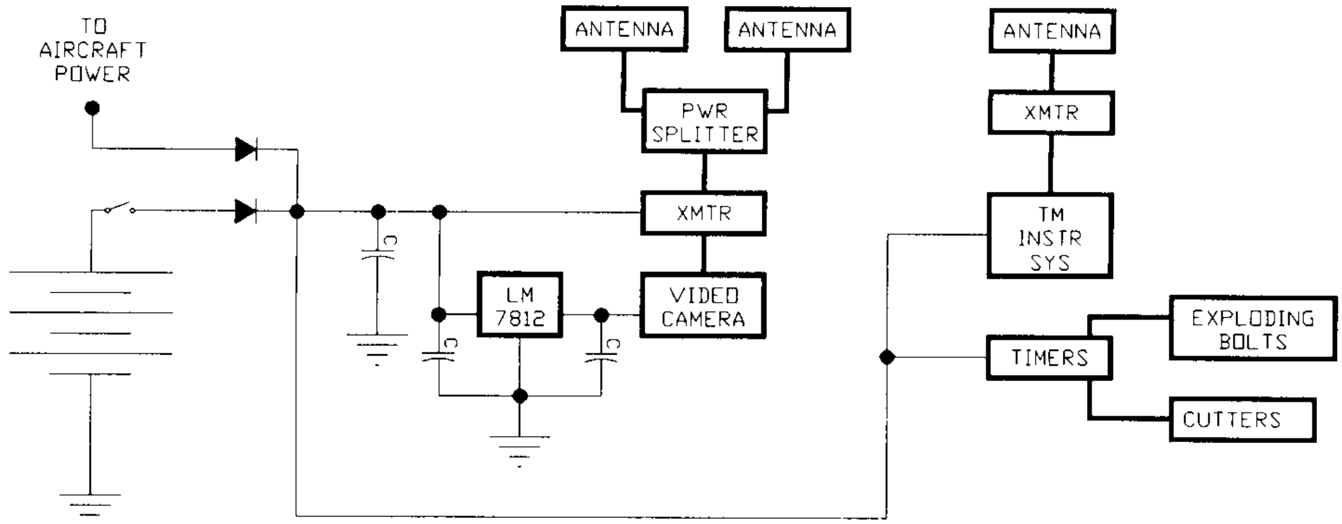

Figure 1: Electrical System

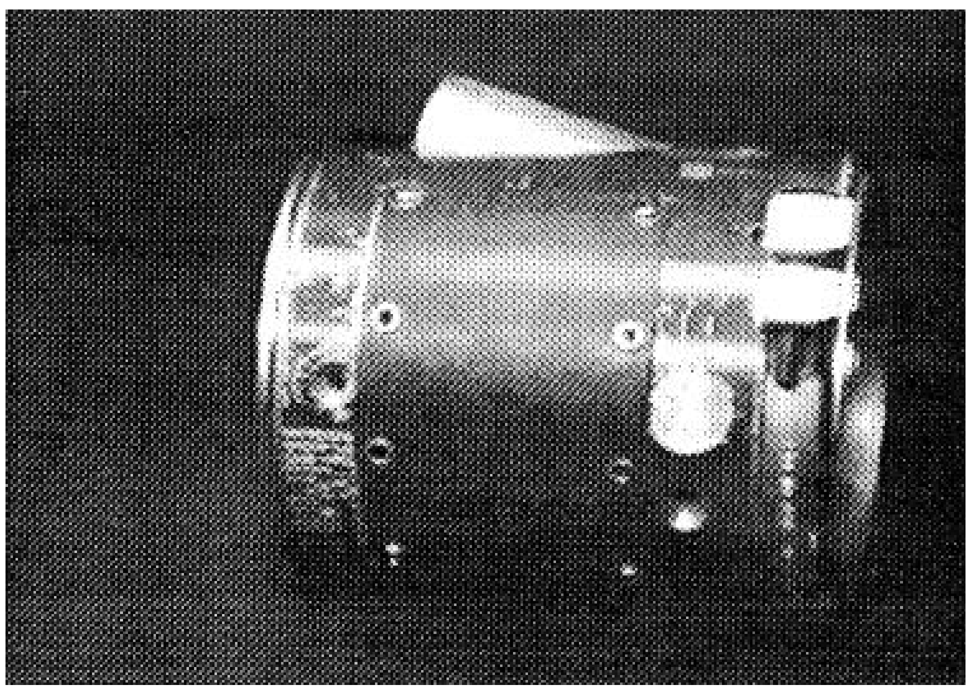

Figure 2: Television Camera and Transmitter in Modified TDD Housing

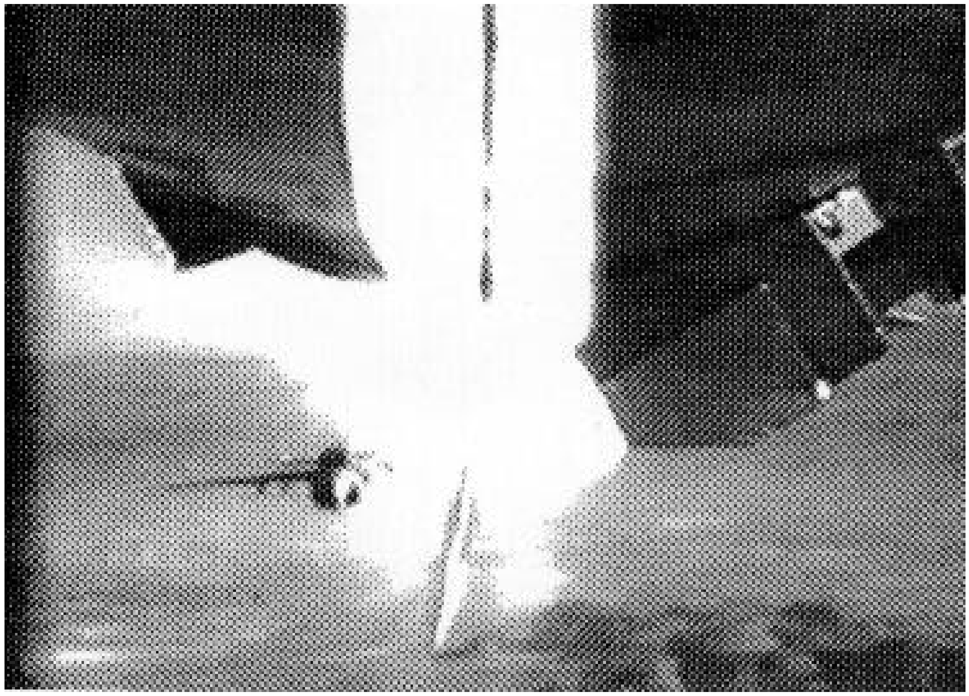

Figure 3: Recovered Video-Launch Aircraft as Seen from Missile

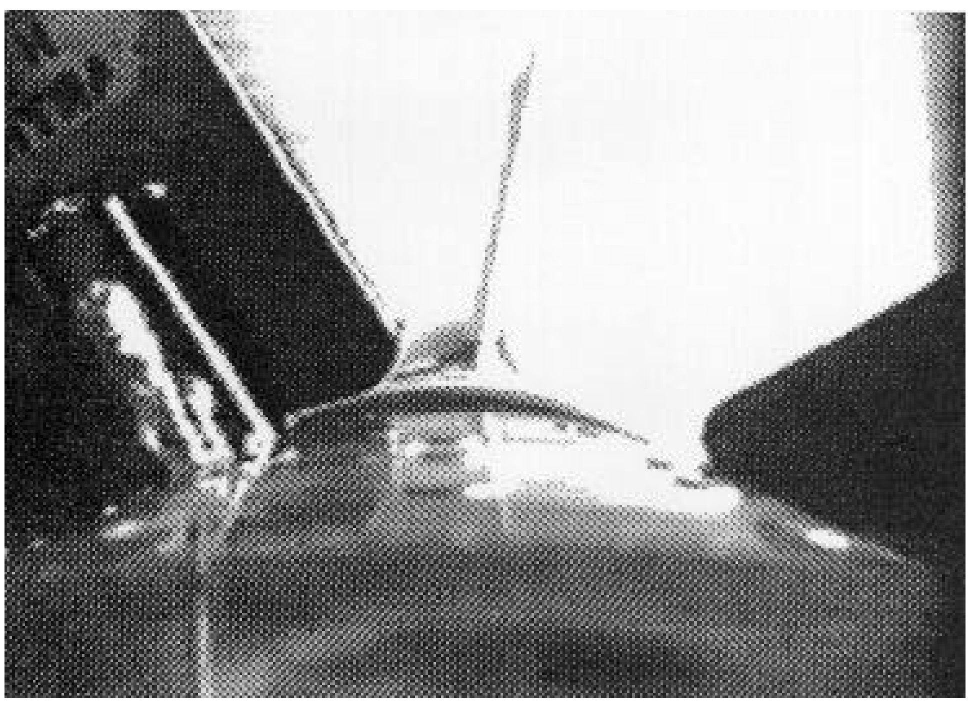

Figure 4: Recovered Video-Speed Brake Deployment