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Battle Damage Assessment Telemeter (BDAT) System Impact Test

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Abstract

This report describes the live-fire testing (LFT) that was performed by the Advanced Munitions Concepts Branch (AMCB) of the U.S. Army Research Laboratory (ARL) and the Fuzes Technology Branch (WM/MNMF) at Eglin Air Force Base, FL, in support of the Battle Damage Assessment Telemeter (BDAT) project. In this testing, three aluminum canisters were instrumented with an ARL p-band telemetry system. Each canister was inserted into the aft end of a penetrator vehicle and launched from a gun into a 1-ft-thick concrete target 500 ft from the gun muzzle. The objective of this testing was to determine if the telemetry system would be able to operate during the high shock of impacting a concrete target. The data acquired from these tests were less than ideal. The amount of noise present in the data was a result of the weak RF link between the telemetry and receiving antennas and the broad-band noise near the transmitter frequency. Since the subcarrier oscillator was detected on all the canisters after impact, the telemetry components, other than the antenna that was damaged in each of the three tests, will survive multiple shocks caused by launch and impact.

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1. Introduction

This report describes the live-fire testing (LFT) performed by the Advanced Munitions Concepts Branch (AMCB), Weapons Concepts Division, Weapons and Materials Research Directorate, U.S. Army Research Laboratory (ARL), and support provided by the Fuzes Technology Branch, Wright Laboratory (WL)/MNMF, Eglin Air Force Base, FL, of the Battle Damage Assessment Telemeter (BDAT) project. Testing was done during the week of 13 October 1997 at Eglin Air Force Base.

2. Objective

The object of this test was to determine if the ARL p-band telemetry system would be able to operate during the high shock of impacting a concrete target.[1]

3. Test Plan

Three aluminum canisters were instrumented with an ARL p-band telemetry system. The telemetry system utilized a nicad (nickel-cadmium) battery power supply, a signal-conditioning circuit (sensor input), a subcarrier oscillator, a transmitter, and an antenna. Each canister was to be screwed into the aft end of a penetrator vehicle and launched from a modified 155-mm howitzer (with a 170-mm smoothbore, 600–800-ft/s muzzle velocity, and 6–10-ksi breech pressure at launch) into a 1-ft-thick concrete target 500 ft from the gun muzzle. One canister had an Endevco 7072A accelerometer to sense shock. The other two had no accelerometer, but had the same electronic circuitry as the sensored canister. The sensor inputs in the two nonsensored canisters were wired to a constant reference voltage instead of an accelerometer. The telemetry receiving station would monitor and record data transmitted from the canisters. Data from the nonsensored units would

[1] Ferguson, E., and D. Vazquez. "Battle Damage Assessment Telemeter RF Link Characterization Test." ARL-MR-344, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, April 1997.

serve as a baseline, and the sensored unit would provide shock information during impact. Figures 1 and 2 show the telemetry canister and how it interfaces with the projectile. (Total canister/projectile mass at launch was approximately 50 lb_m.)

Anechoic chamber measurements taken after the canisters were assembled revealed that insufficient radio frequency (RF) power radiated from them when they were placed in the penetrator vehicle. This was contrary to the measurements taken prior to assembly. ARL designed and retrofit an antenna that would allow sufficient, albeit marginal, RF power to be radiated from the units. This new antenna configuration was shock tested and survived 21,000 g when inclined 10° off axis.

4. Field Test

The gun, target, and telemetry receiving antennas were positioned approximately as shown in Figure 3. A telemetry canister was turned on, fitted into a penetrator and placed at several points along the line of fire to check the RF link. The amount of activity in the band and the relatively low RF power radiating from the canister made it difficult but not impossible to tune to the test unit. An adequate link was achieved through the entire line of fire.

When a canister was about to be launched, it was first turned on near the receive antennas so that the telemetry receivers could be tuned to it more easily. The canister was then screwed into the penetrator and taken to the gun for loading. The gun shielded the RF energy from the receiving antennas when the penetrator was loaded. The RF link would be re-established once the penetrator left the gun muzzle.

The first canister launched, canister no. 1, did not have an accelerometer onboard. This unit fell short and bounced off the ground into the target. Although it hit the target, it did not penetrate it. Data were telemetered and received during its flight. When the unit was retrieved, it was apparent that about 1 inch of the rearward facing antenna tip had been broken off. The telemetry system, after

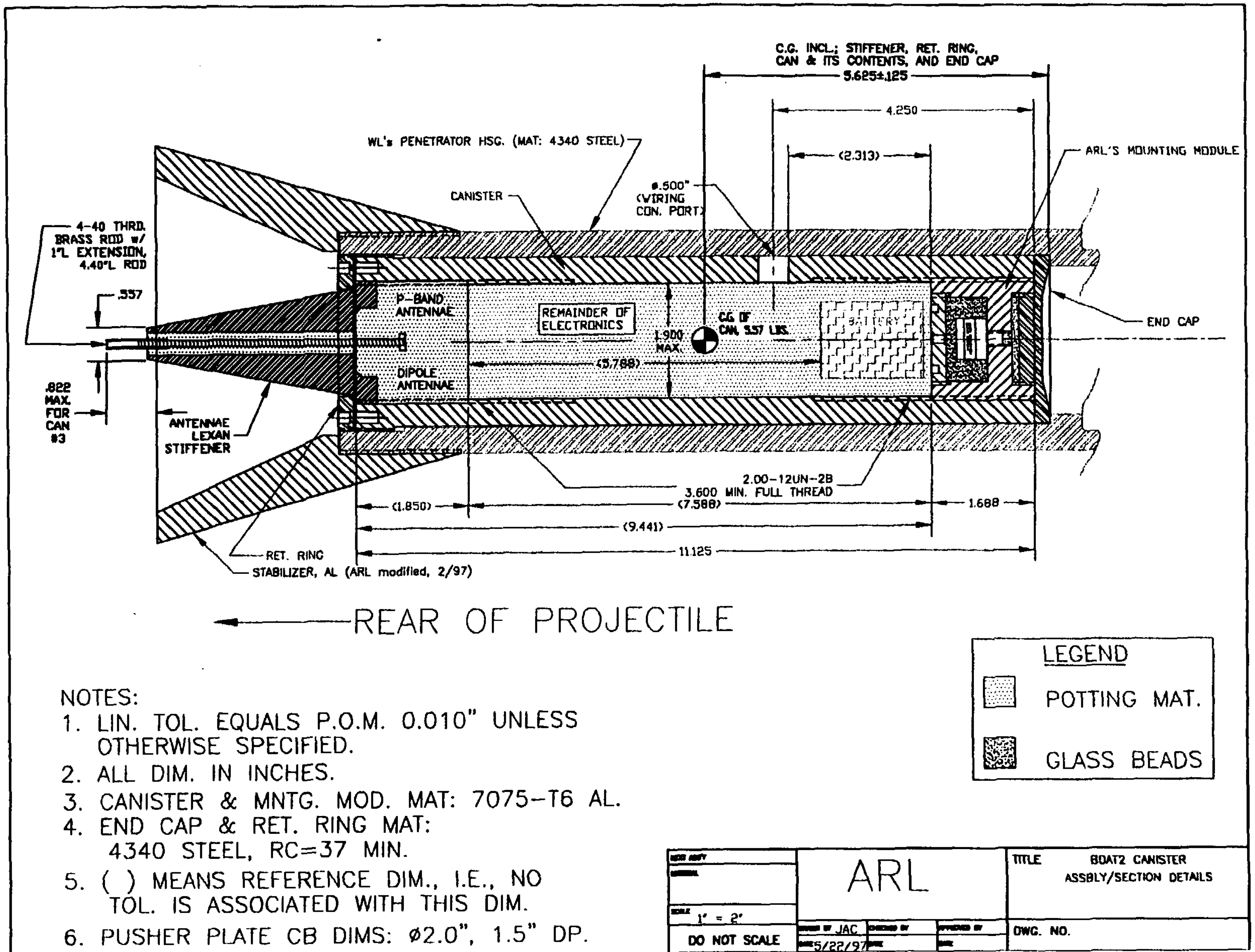

Figure 1. Mechanical Drawing of the Telemetry Canister Inserted in the Projectile.

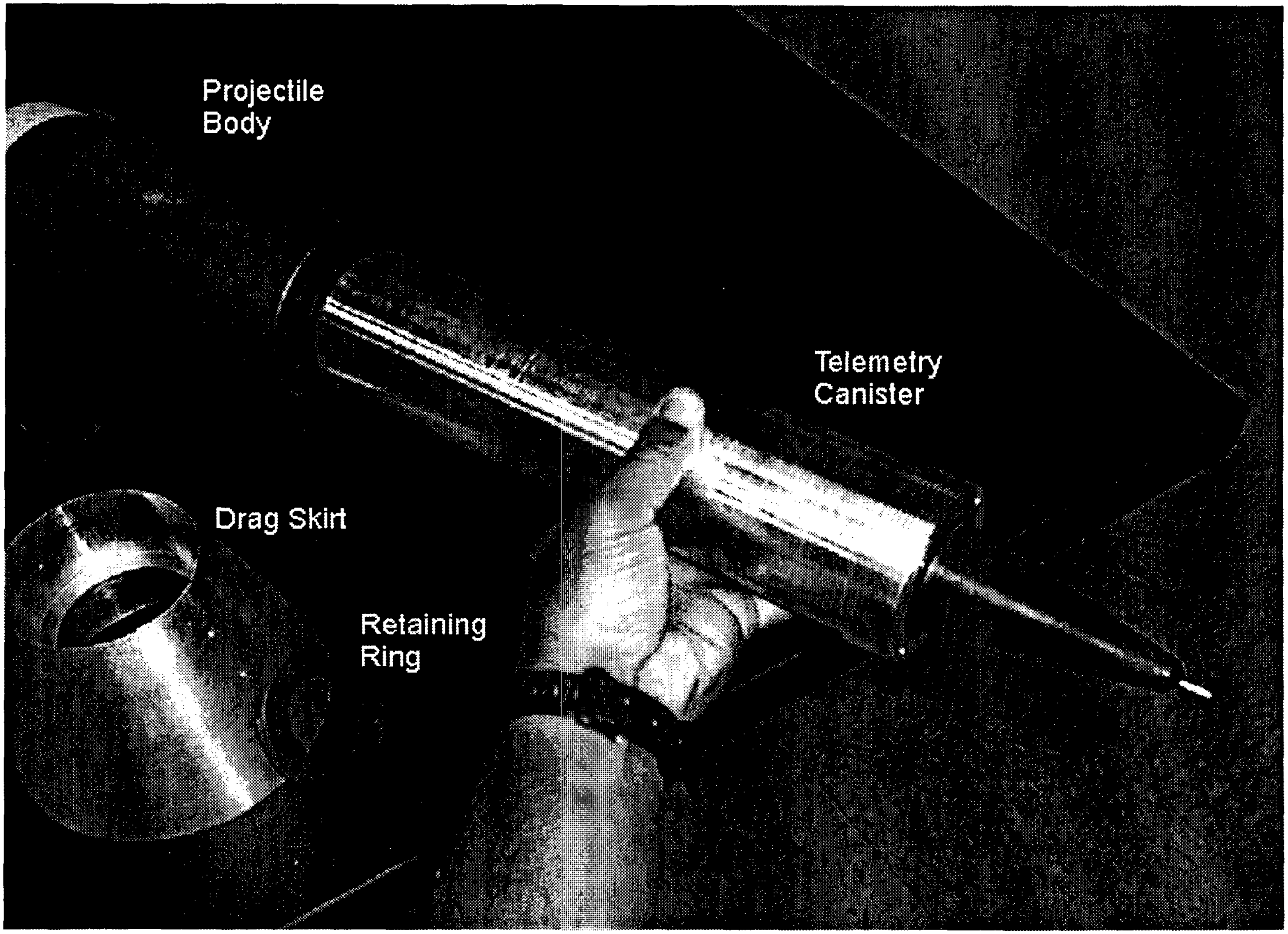

Figure 2. Insertion of Telemetry Canister Into Projectile.

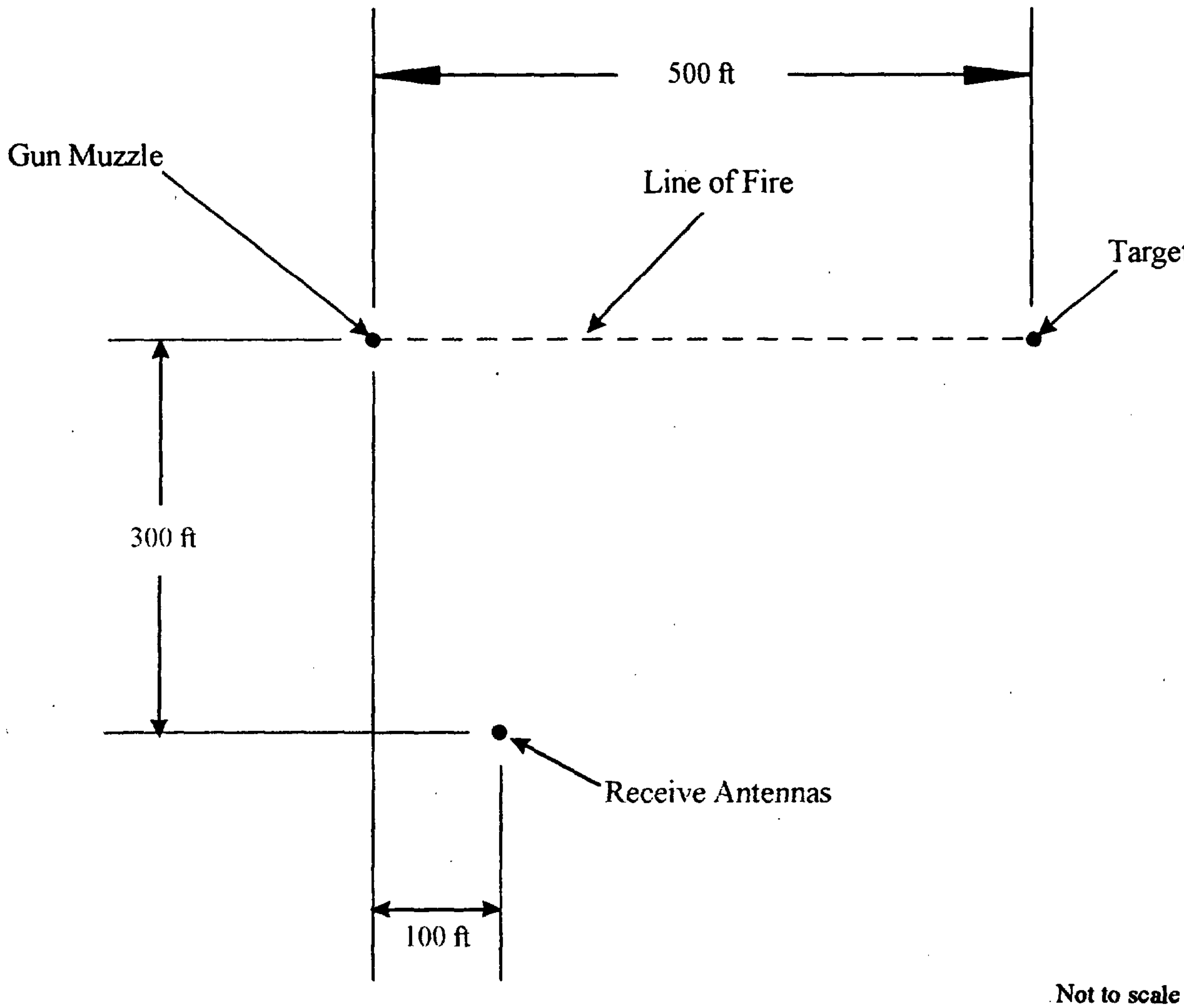

Figure 3. Approximate Positions of the Gun, Target, and Antennas.

recovery, still had enough RF power to be received when brought close to the receiving station, and the subcarrier oscillator was working.

Canister no. 2 was fired next. This unit had no accelerometer either, but it did hit and penetrate the target. Unfortunately, the receiving station was not able to acquire any data from this unit during its flight. The antenna tip had broken off just as it did on canister no. 1. The telemetry system was checked after retrieval, and it was still working.

The final unit, canister no. 3, had an accelerometer onboard. This unit hit and penetrated the target. Data were transmitted and received during its flight. As with the previous units, this one also had a broken antenna tip. The telemetry system was found to be working after impact as well.

5. Results

Data were acquired and analyzed for canisters no. 1 and no. 3 only. The received subcarrier oscillator data were processed to obtain the plots shown in Figures 4 and 5. Since data were acquired in-flight, it was inferred that the antenna tips broke during impact with the concrete target. The radar data were used to establish the time base, and it was assumed that the radar lost track at target impact. High-frequency pulses appear in the plots pre- and post-impact, but they are believed to be noise. Canister no. 3's lower frequency pulse at impact has characteristics different from the surrounding noise pulses and could contain the partial leading edge of the accelerometer pulse. If some accelerometer data were transmitted prior to antenna failure, as this may suggest, then evidence exists that the telemetry system was able to transmit data during the high-shock event.

6. Conclusion

The data acquired from this test were less than ideal. The amount of noise in the data is a result of the weak RF link between the telemetry and receiving antennas and the broad-band noise near the transmitter frequency. The transmitting antenna was designed and shock-table tested to withstand 21,000 g's of shock 10° off axis. Shock-table tests performed after the gun-launch test showed that the antenna could withstand over 28,000 g's of shock 10° off axis. Perhaps the actual shock levels exceeded the tested limits [in peak and/or duration] and caused the failure. The data presented here do not offer a definitive answer to the robustness of the telemetry components under high shock. The data are just too noisy, but those extracted near the time of impact do suggest that the telemetry system could transmit data during a high-shock event if the antenna could survive. Since the subcarrier oscillator was detected on all the canisters after impact, we now know that the telemetry components other than the antenna will survive multiple shocks caused by launch and impact.

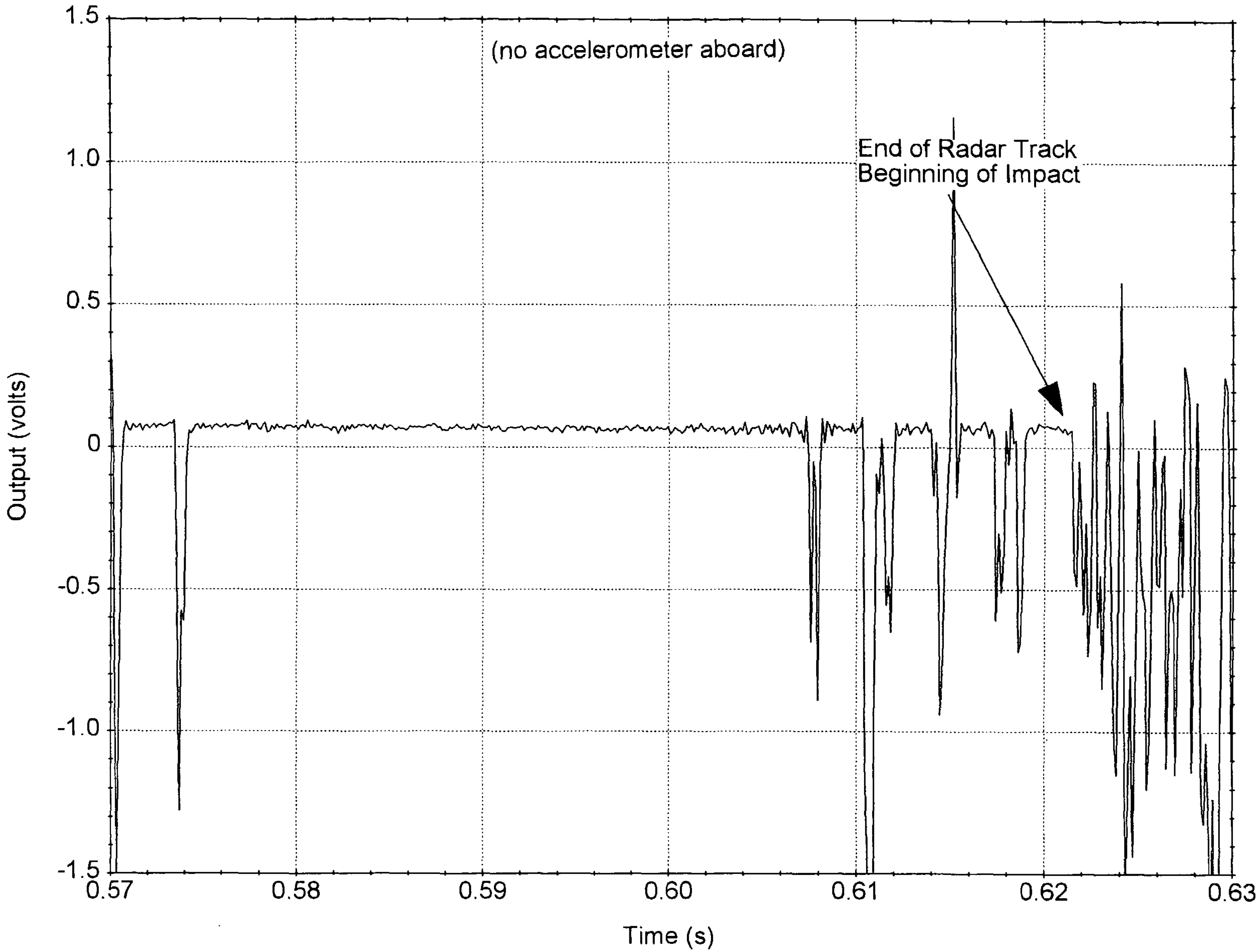

Figure 4. Canister No. 1 Reduced Subcarrier Data.

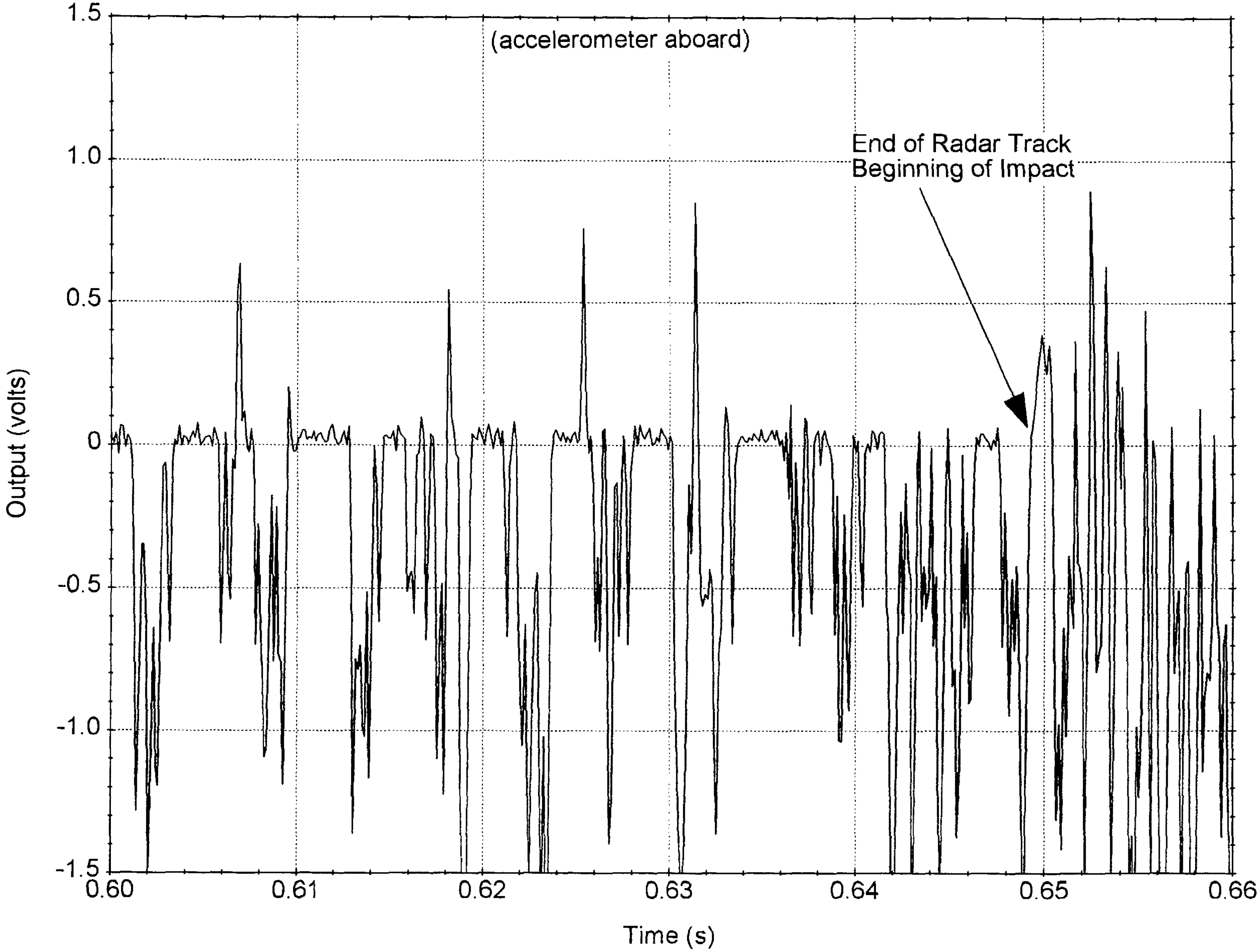

Figure 5. Canister No. 3 Reduced Subcarrier Data.

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