INTENTIONAL ELECTROMAGNETIC INTERFERENCE TEST

OF A FACILITY SECURITY ENTRY SYSTEM

Richard J. Carter[(1)], Michael G. Grothaus[(2)], and Jeffrey H. Lucas[(2)]

(1) Office of the Secretary of Defense, Operational Test and Evaluation, Live Fire Test and Evaluation
1700 Pentagon, Room 1C742, Washington, DC 20301-1700 United States of America
rcarter@dote.osd.mil

(2) Southwest Research Institute, Automation and Data Systems Division
6220 Culebra Road, P.O. Drawer 28510, San Antonio, TX 7 8228-0510 United States of America
mgrothaus@swri.edu

(3) As (2) above, but E-mail: jlucas@swri.edu

ABSTRACT

An intentional electromagnetic interference test was conducted at an outdoor range. The commercial off-the-shelf equipment that was evaluated during the test is a facility security entry system. This security system was tested against two high power microwave wideband sources. During the test, the sources were positioned at four different ranges and six different source parameters were varied. The instrumentation suite employed during the testing allowed for multi-channel, simultaneous data acquisition. It also characterized incident electric field and pattern and actual field incident on the asset. Any test system effects observed and recorded were assigned a specific effect level; the operational impact of the effects was subsequently determined.

INTRODUCTION

The live fire test and evaluation (LFT&E) program in the Office of the Secretary of Defense (OSD) is oriented towards providing a timely and realistic assessment of the survivability (of systems designed to provide user protection) and lethality (of missiles, rockets, and munitions) of a military system as it progresses through its development cycle and prior to full-rate production. The LFT&E initiative covers air, land, and sea platforms, as well as a variety of weapons from small arms to national missile defense systems. The program is particularly aimed at providing information to decision makers on potential user casualties, survivability, vulnerability, and lethality, taking into equal consideration susceptibility to attack and combat performance of the system. It is also directed towards ensuring that knowledge of user casualties and system vulnerabilities or lethalities are based upon testing of the system against "expected threats" under realistic combat conditions.

LFT&E requires that testing be done not just against current threats, but also against expected threats that would exist when the system under development is fielded and beyond. The term expected threat, in this context, consists of the current and projected threat. LFT&E also addresses the reactive threat to the degree to which a potential adversary might readily implement an expected response.

Live fire testing initially was primarily focused on conventional, ballistic threats (e.g., small arms, fragmenting projectiles, shaped charges, kinetic energy rods, self-forging fragments, and high explosives). As the projected threats have changed, so have the test plans to incorporate them. These new, non-ballistic threat types include: low, medium, and high-energy lasers, incendiaries, blast/fuel air explosives, charged particle beams, and high-power microwave (HPM).

LFT&E addresses the effects of directed energy weapons with regard to system vulnerability or lethality. Typically this excludes what would be termed electronic warfare. LFT&E addresses any effects to systems that persist after the directed energy is removed (i.e., the damage or degradation remains after the target ceases to be engaged by the source) and which will either cause the mission to be degraded or aborted, or cause loss of combat capability if the mission is continued. LFT&E includes effects that might even result in loss of the target system.

PRIOR INTENTIONAL ELECTROMAGNETIC INTERFERENCE TESTING

The LFT&E program has been testing and evaluating the on-target effects of potential HPM sources (intentional electromagnetic interference [EMI]) over the past five years. This endeavor has been a small, but pioneering, effort. An open-air intentional EMI test was conducted in late 1997 on the United States (U.S.) West Coast. Sources included both conventional HPM and high power transient electromagnetic sources (HPTES). The testing was performed on various computer systems, computer networks, and security systems. The test, sponsored by the Live Fire Test and Evaluation Office, OSD, was a cooperative effort between the Department of Defense (DoD) and the Department of Energy. The purpose of the test was to develop and demonstrate the methodology required to perform HPM source live fire test intentional EMI testing.

A follow-on test was performed during 1998 with an HPTES provided to DoD by a private company. The purpose of the effort was to test and evaluate a number of HPM ultra-wideband sources constructed using a "terrorist mind-set". The contractor was asked to design and build three inexpensive sources (using a natural progression of device maturity) characteristic of what a rogue nation or terrorist could fabricate using only "open source" information and commonly available hardware components. The three sources were characterized at a range on the West Coast of the U.S.

Upon conclusion of the two tests, it was determined that a permanent ultra-wideband HPM source should be developed to facilitate future intentional EMI testing. Specifications included the capability of having a reconfigurable source in regards to waveform characteristics, rise time, pulse rate, and power levels. The source was developed and subsequently delivered in October 1999.

An intentional EMI test was conducted in the summer of 2000 at a test facility on the West Coast of the U.S. The commercial off-the-shelf (COTS) equipment that was evaluated during the test includes a VCDX telephone-switching technology and an X-ray baggage-screening device. The telephone-switching technology is the type of equipment one would see in a city with a population of between 30,000 and 40,000 people. The X-ray baggage-screening technology is a state-of-the-art device that is used in commercial airports around the world to screen and check carry-on baggage. The COTS technologies were tested against two HPM wideband sources. The first source is the system described in the paragraph above and utilizes a transient electromagnetic horn antenna. It was developed by a U.S. Government contractor and co-funded by the Live Fire Test and Evaluation Office and an U.S. Navy test facility. The second source tested, developed by an U.S. Air Force research laboratory, uses an impulse-radiating antenna. The COTS technologies were evaluated within a 16-foot square portable building, which was situated on a movable turntable. The building was constructed out of cinder blocks; each side of the building had a different facade. One side was solid cinder block. The other three sides had a window and a single door, a window, and a double door respectively. During the test, the turntable was rotated so that the building could be positioned in three different aspects angles in relation to the HPM sources. Figure 1 exhibits the portable building used during the test.

Figure 1. The portable cinder block building on the turntable

INTENTIONAL EMI TEST OF A FACILITY SECURITY ENTRY SYSTEM

The Live Fire Test and Evaluation Office sponsored an intentional EMI test in November 2001 over a two-week period of time at a test facility on the East Coast of the U.S. It was an outdoor, live fire, open-air test. The test was oriented towards assessing the potential vulnerability of electronic systems representative of the U.S. commercial and military infrastructure to high-power ultrawideband illumination under "operationally relevant" conditions. The focus of the effort was on developing live fire test methods, not on conducting research and development.

Asset Evaluated

The COTS equipment that was evaluated during the test is a facility security entry system. The security system is a unit that would typically be found in small business facilities. It consists of a control board housed in a NEMA style box that contains the primary control programming. The control board is capable of interfacing with up to 8 keypads, 32 sensor modules, and a siren or light. For this test, a siren/light combination was chosen with a single keypad and eight sensors. The sensors used include: two door contact sensors, two glass breakage sensors, two shock detection sensors, one programmable infrared (PIR) sensor, and one combination PIR/motion detection sensor. Although the system is capable of telephone/cellular phone and fire detection interfaces, these options were not utilized during the test. The security entry system technology was evaluated while its subsystems were fully operational.

Sources Tested

The security entry system was tested against two HPM wideband sources. One was an elevated source with horizontal polarization; the other was a ground-based source with vertical polarization. A stationary crane raised the elevated source. During the test the sources were positioned at four different ranges. The test asset was situated within a 16-foot wide by 50-foot long motor home. The HPM devices were pulsed while the motor home was in both a static (stationary) and dynamic (moving) mode. In the dynamic mode, a heavy-duty diesel tractor towed the motor home on a smooth roadway while being illuminated by the source.

Source Parameters and Object Exposure Protocol

Six different source parameters were varied during the test. They include: pulse repetition frequency, burst length, range (close, near, medium, and far), linear polarization, azimuth (in the case of the elevated source), and reproducibity of five shots per condition. A test object exposure protocol was followed during the test. It is listed in Table 1.

Table 1. Test Object Exposure Protocol

Start exposure at near distance
If little or no effect, move to close distance
If no effect, end
If effects, reduce exposure parameter set based on optimum coupling/effects
Move to medium distance
If no effects, end
If effects, move to far distance
After far distance, end test sequence

Instrumentation Suite and Data Collection Approach

The instrumentation suite employed during the testing allowed for multi-channel, simultaneous data acquisition and near real time data retrieval, storage, and reduction. It also characterized incident electric field and pattern and actual field incident on the asset. In addition, the instrumentation contained multiple video channels to record visual evidence of upset and audio monitoring of the asset facility and device under test. A picture of the inside of the instrumentation van is shown in Figure 2. The data collection approach used during the test is exhibited in Table 2.

Categorization of Effects and Measures of Effectiveness

Any test system effects (upsets, anomalies, and/or failures) observed and recorded were assigned a specific effect level. The level was based on the actions required to recover the equipment to pre-test operational readiness. The

Figure 2. The inside of the instrumentation van

Table 2. The Data Collection Approach

Characterize incident electric field, pattern, and spectral content
Execute a priori checklists to baseline asset, record effects, and recovery actions
Multiple internal video channels to supplement operator's first hand record
Pre-choreographing of test scenarios to speed turnaround time
Populate a database for post test analysis and correlation
Evaluate operational impact of correlated effects

categorization scheme is presented in Table 3. The operational impact of the effects (i.e., how the aggregate individual effects on the various systems and subsystems impact and/or affect the mission or operational scenario) was subsequently determined. The impact was derived via detailed discussions with normal users of the facility security entry system. These measures of effectiveness are displayed in Table 4.

Table 3. Categorization of Effects

Effects Level	**Response**
0	No observed effects
1	Effect(s) present only during illumination (no intervention required to restore corrected action)
2	Operator intervention required (soft reset)
3	Operator intervention required (hard reset)
4	Maintenance action required (effect(s) that could not be corrected by an operator and requires a maintenance action to return the unit to full operational capability)
5	Damage

Table 4. Measures of Effectiveness

Mission Category	**Operational Impact of Effects**
I	None
II	Nuisance (does not degrade or impact mission performance)
III	Degraded (requires operator/maintenance intervention resulting in reduced effectiveness)
IV	Abort/Disabled (serious safety or mission impact)