Electromagnetic Susceptibility of the Area Denial Weapon System (ADWS)

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ABSTRACT

A practical realisation of Electromagnetic Immunity/Compatibility (EMI/EMC) testing of ordnance weapons with electrical initiation according to compliance standards is described. The Area Denial Weapon System (ADWS), which is electrically initiated and electronically controlled, was exposed to electromagnetic interference of a known intensity in an anechioic chamber by injection of induced current, in accordance with the requirements of the USA MIL-STD-461E standard [1] and of the UK's Ordnance Board Pillar Proceeding P101 (Issue 2) [2]. Compliance of ADWS was confirmed. This report describes the test plan, procedures and results.

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Executive Summary

The Weapons Systems Division (WSD) Novel Ordnance Systems Group has been involved in the Concept Technology Demonstrator (CTD) of the Area Denial Weapon System (ADWS). ADWS is an ordnance system which aims to provide an area denial capability for defence forces, a role which was previously served by landmines. According to the Ottawa Treaty (1997), to which Australia is a signatory, any future area denial capability and its associated munitions/ordnance needs to be command controlled by a "man-in-the-loop" system. ADWS consists of a Sensor System module, a Command and Control module, and a munitions module. The command and control system contains electronics which are susceptible to electromagnetic interference and hence the possibility of an inadvertent misfiring exists. Before being certified for man firing, the weapon must be tested for susceptibility to electromagnetic interference against industry standards, and an approval from the Director of Ordnance Safety (DOS) is necessary before the weapon system can be approved for manned firing.

A test program was developed to assess the ADWS's electromagnetic susceptibility according to US military standard MIL-STD-461E, and the testing was conducted using the support of the Electromagnetic Test Section of the RAAF's Aircraft Research and Development Unit (ARDU). The ADWS Fire Control Unit was exposed to electromagnetic radiation at a prescribed intensity across a range of frequencies and waveforms.

The results from the testing of the Fire Control Unit for conformance to MIL-STD-461E provided data to ensure the safety and usability of the ADWS for preliminary testing at the Pt Wakefield Proof and Experimental Establishment Range where the background level of interfering electromagnetic radiation was known.

This Report contains a copy of the Test Plan and Procedures and results of testing derived from the ARDU report.

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Contents

1. Introduction

1.1 Introduction

Most electro-explosive systems are susceptible to uncommanded initiation by conducted and radiated electromagnetic radiation (EMR). It is mandated that newly developed ordnance systems are tested for susceptibility to EMR, (the term "susceptibility " is used by the military, while civilian industry uses the term "immunity", to encompass both electromagnetic immunity and electromagnetic compatibility.)

Electromagnetic fields can initiate electro-explosive devices directly as a result of currents induced in an electro-explosive device (EED), or indirectly as a result of uncommanded operation of firing circuit switches or control systems. Electronic devices, microprocessors and software controlling the firing circuit of the electro-explosive device must be considered in assessing susceptibility [3].

The 'dudding' effect of the electro-explosive device also needs to be considered. A device when subjected to a current may permanently alter its operation characteristics rendering it ineffective for firing initiation, or resulting in reduced sensitivity to initiation within the specified range of operating characteristics. As a consequence, the system may not function when required, and is thus rendered inoperable.

Electrical Explosive Hazard (EEH) assessments are performed to determine the susceptibility of a weapon, system or a device to a specified minimum level of electromagnetic in-service environment. Ordnance susceptibilities may be either calculated, or measured using instrumentation, or based on results taken from published data. Appropriate allowances for test factors and for safety margins have to be taken into account.

A theoretical analysis of the weapon for EEH can be conducted by direct calculation of electrical field strength using a simplified geometry model of the weapon. Computer modelling is used increasingly as a precursor to EEH trials. A detailed computer model of the ordnance is created and the coupling between the EM emission and the electro-explosive device are computed as a function of field orientation. If the result of this theoretical analysis is unacceptable, an EEH trial is conducted to obtain more accurate data.

Devices are tested for EMC by exposing them to electromagnetic interference of a known intensity according to specified rules listed in the industry standards. The usual facilities for the EMR generation are anechoic chambers and mode-stirred chambers. These anechoic chambers allow uniform fields of a known intensity and polarization. One disadvantage is often the limited size of these chambers as the ordnance systems might not fit into the uniform field section of the chamber. Another possibility is to use

a mode-stirred chamber which, for example, is used for testing full scale aircraft. The disadvantage of this method is that these chambers provide isotropic and randomly polarised fields, thus the operator does not receive any information of either the direction or polarisation of the field which might causes the device to fail; this is information required by most standards [4].

The challenge for testing this type of equipment is to be able to check the electro-explosive device fitted with an ordnance round loaded ready for firing. The performance of the ordnance system during the exposure to EM radiation is divided into 5 levels: 1) when the performance of the device is not affected, 2) minor effects, 3) major disruption during only EM interference, 4) permanent disruption requiring the operator restart, and 5) permanent disruption requiring repair. The EM testing systems and environment should provide an accurate performance assessment against these levels.

The standard test procedure is to remove the explosive component from an ordnance item, and a sensor is used to measure the temperature of the igniter during exposure to the EM interference. Such an arrangement allows detection of the rise in temperature of the igniter, and hence the prediction of when the igniter is about to initiate. The high cost of such temperature sensors normally precludes taking the igniter all the way to the ignition point and the test is stopped just short of the ignition temperature.

Compliance of devices to EM safety in Australia is governed by such rules as AOC Pillar Proceeding 236.94 issued in 1994 [5]. The facilities needed to test new developments against the rules are costly, and are not readily available or easily accessible. The objective of this study was to develop a cost-effective and realistic methodology for testing the EMC vulnerability of ordnance system. The ADWS was used to qualify the developed testing methodology.

The ADWS team developed a realistic approach to EMC testing of the ordnance system. This paper provides an outline of an EMC testing methodology, with particular reference to its application for the ADWS which is currently in development at DSTO [6].

2. Experimental

2.1 Test Planning

2.1.1 Scope

The requirements imposed on the demonstration version of the weapon will not be as severe as those imposed on a final production version, because the demonstration version is trialled in a tightly controlled and relatively safe condition. Therefore, the

weapon system was only safety tested for use within the confines of a firing range and then in handling areas with known EM environments.

2.1.2 Area Denial Weapon System

The ADWS is composed of a command and control unit, fire control unit, electrically controlled mount and a weapon and munition unit containing the 40mm rounds. The ADWS fitted to its mount is shown in Figure 1.

Figure 1: Mount of ADWS.

The fire control unit is microcontroller based (described in more detail in the Appendix A, EMC Test Plan), and it is this unit for which the EM susceptibility criteria has to be determined. The microcontroller was designed to transmit a periodic pulse, which would verify that it was working normally, and EM susceptibility tests can check this is still functioning. Another test criterion consists in measuring the circuit supply current without EM interference as a reference, such that in the presence of EM interference, the microcontroller unit is considered inoperable when an excessive current flow is detected on the power supply rails [7].

The former test approach was chosen. In this test a laptop sends a command to the microcontroller, and the latter instructs the programmable logic controller (PLC) to generate a sequence of firing currents. The generated currents are conditioned by the current booster unit. The voltage and current across the electrical igniter during firing are measured and compared against a standard. The microcontroller sends a signal back to the laptop indicating whether or not the firing was successful.

When subjected to an EM disturbance, the chances for an error occurring in the laptop, such that the laptop generates a command to cause the microcontroller to misfire, are negligible. Therefore, it is not necessary to impose strict requirements for EM immunity on the laptop. The microcontroller in the fire control unit may crash and restart, which will not cause a misfiring event.

The weapon system test was conducted in accordance with relevant military and civil standards [1], [2], and [8].

2.2 Test Methods

2.2.1 Radiated Susceptibility

EM interference can be radiated into equipment from external electromagnetic sources. Any weapon should be tested according to the requirement RS103 of MIL-STD-461E, "Radiated Susceptibility, Electric Field" over the range 2 MHz to 40 GHz.

However, the ADWS has been planned to be demonstrated at a test range where the EM radiation environment would be expected to be much lower and at a relatively constant level. Therefore, it is concluded that the ADWS should be safe at EM radiation limits equal to or below those allowable for the general public, as is shown in the section on the EMC Test Plan. These EM radiation limits are available from Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Radiation Protection Standard, RPS 3 [8].

For safety reasons, the ADWS should ideally be immune to EM radiation of a higher strength than that which can be encountered at the test range. The ADWS was trialed in a go/no-go test in the applied EM field. No variability margin is allowed as 100% of components and systems are tested. The safety margin is prescribed to be 3 dB according to ARPANSA Radiation Protection Standard, RPS 3 [8].

The 'safe' electric field strength is defined by the ARPANSA RP 3(8) standard as 50 V/m across the frequency range 2 MHz to 18 GHz. Therefore, the electrical field strength at the test range must not exceed 35 V/m for the same frequency range.

All of the projectiles used for the trial firing are to be tested for immunity to EM radiation, with a safety margin which is the same as for testing the complete ADWS weapon.

During the testing procedure in the anechoic or reverberation chamber, the display of the laptop is monitored through a closed-circuit TV camera.

During the munitions test a rubber balloon was placed over the projectile. If a projectile fails (and the igniter fires), the balloon will inflate, which will be easily noticeable on the closed-circuit TV.

2.2.2 Conducted Susceptibility

EM interference can couple from outside equipment to the inside through Input/Output (I/O) cables, signal leads or power lines. The system is to be tested according to the procedures and requirements of MIL-STD-461E for conducted susceptibility, CS114, CS115, and CS116 [1]. The requirement CS114 "Conducted Susceptibility, Bulk Cable Injection" is applicable to all electrical cables interfacing with the device. The concept of the requirement is to simulate currents that will be developed on platform cabling from electromagnetic fields generated by antenna transmissions. The current injection probe from *Solar* shall be clamped over the cable connecting the fire control unit and the 4-barrel pod.

The requirement CS115 "Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation" is applicable to all electrical cables interfacing with the device. The basic concern of the requirement is to protect the equipment from fast rise and fall transients that may be due to platform switching operations and external transient environments such as lightning and electromagnetic pulse. To determine the exposure levels, the device is classified as Army (Ground). A current impulse wil be injected into the cable connecting the fire control unit with the pod (that is, with the electrical igniters).

The requirement CS116 "Conducted Susceptibility, Damped Sinusoid Transients, Cables and Power Leads, 10 kHz to 100 MHz" is applicable to all electrical cables interfacing with the device, and also individually on each lead. The basic concept is to simulate electrical current and voltage waveforms occurring in platforms from excitation due to natural resonances. Damped sine waveforms are common present on platforms from both external stimuli such as lightning electromagnetic pulse and from platform electrical switching phenomena. The equipment is classified as an Army item, and therefore, the maximum current amplitude will be 10A. The performance of the fire control unit will be monitored through checking the successful performance of the command set, with the graphical output on the display of a laptop.

3. Results

The ADWS fire control unit was tested for radiated susceptibility by ARDU in the ARDU anechoic chamber. ARDU performed their standard EMC tests and delivered the EMC Test Report [9].

The fire control unit passed the radiated susceptibility test RS103 successfully. The laptop did not detect any failures of the ADWS fire control unit to complete an ADWS microprocessor test sequence.

The fire control unit was found to withstand the injected currents according to the conducted susceptibility requirements CS114, CS 115, and CS116 without any perceived deterioration of fire control unit performance.

4. Discussion and Conclusions

The ADWS fire control unit was tested according to the methods described using the Aircraft Research and Development Unit (ARDU) anechoic chamber for the radiated susceptibility test.

The fire control unit has passed the radiated susceptibility test RS103 successfully. The laptop did not detect any error signals indicating non-completion of the test sequence.

The fire control unit was found to withstand the injected currents according to the conducted susceptibility requirements CS114, CS115, and CS116 without deterioration of the fire control unit performance.

The EMC Test Plan and the test report are given in the following sections. This report describes the EMI/EMC testing methodology for the particular unit to be operated in a specific environment. A different methodology may apply to EMI/EMC testing of the production version of the weapon.

5. References

[1] Department of Defense Interface Standard – "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment", MIL-STD-461E.

[2] *Ordnance Board Pillar Proceeding* P101 (Issue 2) – "Principles for the Design and Assessment of Electrical Circuits Incorporating Explosive Components".

[3] A. Nott, "Armament Electrical Explosive Hazard Testing in Australia", *Journal of Battlefield Technology*, 3(1): 10-17, 2000.

[4] K. Goldsmith, "Reverberation Chambers – What Are They ?", *IEEE EMC Society Newsletter*, Fall 1999.

[5] Australian Ordnance Council, "Guidelines for the Preclusion of Electro-Explosive Hazards in the Electromagnetic Environment", *AOC Pillar Proceedings*, 236.94, Oct 1994.

[6] J. Pitman, V. Puri, and J. Teague, "Area Denial Weapon System (ADWS): Systems Engineering Study", DSTO Industrial Report, in preparation.

[7] S. Baffreau, S. Bendhia, M. Ramdani, E. Sicard, "Characterisation of Microcontroller Susceptibility to Radio Frequency Interference", *International Caracas Conference on Devices, Circuits and Systems (ICCDCS) 2002*, Aruba, Venezuela (April 2002).

[8] ARPANSA Radiation Protection Standard – "Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz", Radiation Protection Series No. 3.

[9] ARDU Engineering Report EMTS04/067, Task E2602 "Firing Control Unit EMC Testing".

Appendix A: EMC Test Plan

A.1. Scope

This document describes the requirements and procedures for testing the ADWS for electromagnetic compatibility.

This document only covers testing of the concept demonstration version of the ADWS and is referred to as the "ADWS".

This document covers the implementation version of ADWS with only the Fire Control, and not involving the Position Controller (the weapon can fire but there is no function to train the barrel).

A.2. Applicable Documents

The weapon system should be tested in accordance with relevant military and civil standards:

MIL-STD-461E	Department of Defense Interface Standard – "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment"
Radiation Protection Series No. 3	ARPANSA Radiation Protection Standard – "Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz"
Pillar Proceeding P101(2)	Ordnance Board Pillar Proceeding P101 (Issue 2) – "Principles for the Design and Assessment of Electrical Circuits Incorporating Explosive Components"

A.3. ADWS

A.3.1 Description

The ADWS comprises the pod with four barrels mounted on a trainable mount system. Each barrel has a capacity for five stacked rounds. Each round has an electrical igniter which is initiated through an electrical contact. The ADWS control system consists of a PC laptop which sends firing commands to the Fire Control Unit, which in its turn generates a sequence of firing currents to the electrical igniters in the rounds.

A.3.2 Electrical Interfaces and Connectors

The Fire Control System and interface cabling diagram of the ADWS are shown in Figure A.1. The suitability of tests for EMC/EMI will be determined from this

schematic. According to the standard MIL-STD-461E, the electronically controlled tube launch weapon is classified as the ground system for Army.

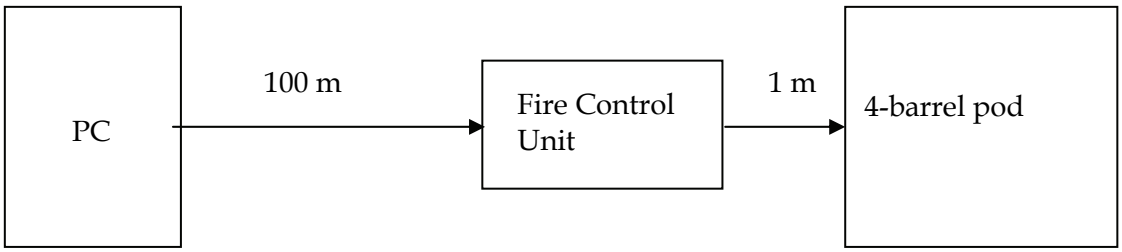

Figure A.1: Diagrammatical representation of electrical interconnections between modules in ADWS' Fire Control System.

The Fire Control Unit is microcontroller based, as is shown in Figure A.2. The laptop sends a command to the microcontroller, and the latter instructs the Programmable Logic Controller to generate a sequence of firing currents. The generated currents are conditioned by the Current Booster. The voltage and current across the electrical igniter during firing are measured and compared against a reference standard. The microcontroller sends a signal back to the laptop indicating whether firing was successful or not.

It is unlikely that EM interference will affect the laptop or in the connecting cable the stream of zeros and ones which constitute a firing command. Therefore, we do not impose strict requirements for EM immunity for the laptop. The microcontroller in the Fire Control Unit may crash and restart, which will not cause a misfiring event.

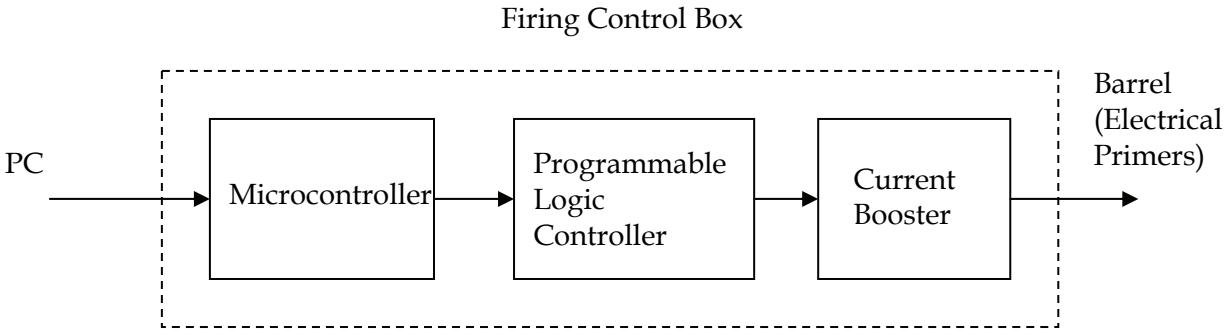

Figure A.2. Structure of the fire control unit of the fire control system, relevant to EMC testing.

A.3.3 EMI/EMC Model

The most general EMC model consists of a source, a sink (victim) and a coupling path. An electromagnetic disturbance is generated in the source device, emitted as either a conducted or radiated signal (or a combination of both), and experienced by a sink device where it may cause degradation of performance, as is shown in Figure A.3.

ADWS is a sink device, and the source of EM disturbance is the environment. Therefore, while the EM disturbance signal can be transferred from source to sink by radiation or inductive or capacitive coupling, there is no transfer of energy by conductance.

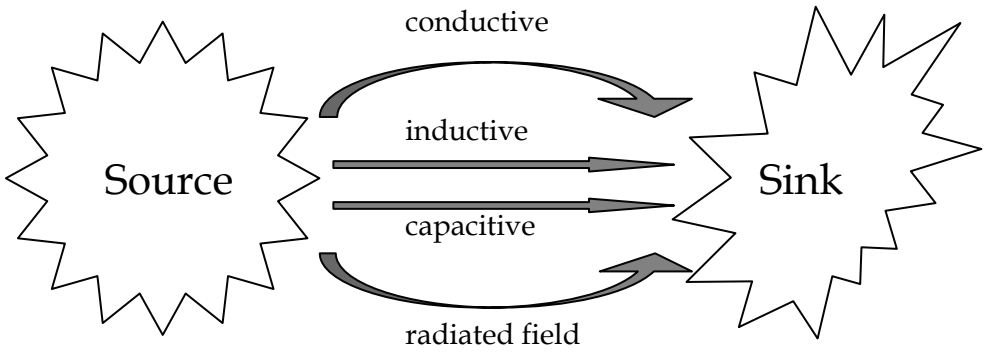

Figure A.3 . EMI/EMC model.

A.4. Test Methods

A.4.1 Emission

The ADWS concept demonstrator will only be used within a test environment with no other EM radiation-susceptible equipment nearby. Therefore, no EM emissions testing will be conducted.

A.4.2 Susceptibility

A.4.2.1 Conducted Susceptibility

A.4.2.1.1 Conducted Susceptibility, Bulk Cable Injection

The device is to be tested according to the procedures and requirements of MIL-STD-461E CS114, over the frequency range 10 kHz to 200 MHz. For the purpose of testing exposure levels, the device is classified as Army (Ground). The injection probe is clamped over the cable connecting the Fire Control Unit and the 4-barrel pod (Figure 1), adjacent to the former. The 4-barrel pod contains 5 electrical igniters which are electrically passive components; therefore it was not thought necessary to attach

the injection probe immediately next to the 4-barrel pod. The cable, connecting the laptop and the Fire Control Unit, is not normally a part of the Fire Control System, and therefore, no current injection will be made into that cable.

A.4.2.1.2 Conducted Susceptibility, Bulk Cable Injection, Pulse Excitation
A current pulse will be injected into the cable connecting the Fire Control Unit to the pod (i.e. at the electrical igniters). The current-inducing probe will be located near the Fire Control Unit.

A.4.2.1.3 Conducted Susceptibility, Bulk Cable Injection, Damped Sinusoidal Transients
A dumped sinusoidal transient current will be induced into the cable which connects the Fire Control Unit with the pod (that is, with the electrical igniters). The *Solar* current-inducing probe will be located immediately adjacent to the Fire Control Unit. Compliance will be demonstrated at the standard frequencies: 0.01, 0.1, 1, 10, 30 and 100 MHz. The equipment is classified as an Army unit, and therefore, the maximum current amplitude is 10 A. The performance of the Fire Control Unit will be monitored by checking the successful performance of a set of commands, displayed as graphical output on the laptop display.

A.4.2.2 Radiated Susceptibility

A.4.2.2.1 Radiated Susceptibility, Magnetic Field
Not required.

A.4.2.2.2 Radiated Susceptibility, Electric Field

A.4.2.2.2.1 Standard used
The device is to be tested according to the procedures and requirements of MIL-STD-461E RS103, over the range 2 MHz to 40 GHz.

A.4.2.2.2.2 Limits
The ground-based Army equipment should be exposed to defined field strengths within the frequency bands according to RS103 as outlined in Table A.1.

Table A.1. Field strength limits according to RS103.

Frequency range	**Limit level (V/m)**
2 MHz - 30 MHz	50
30 MHz – 1 GHz	50
1 GHz – 18 GHz	50
18 GHz – 40 GHz (testing optional)	50

However, ADWS will be demonstrated on the firing range where the EM radiation environment could be lower and is extremely well known and controlled. Therefore, the ADWS should be safe at EM radiation limits equal to or below those allowable for the general public, as is outlined in Table A.2 below which is adapted from ARPANSA's Radiation Protection Standard, RPS 3.

Table A.2. Reference levels for time averaged exposure to RMS electric fields, as shown in the ARPANSA's Radiation Protection Standard, Radiation Protection Series 3.

Frequency range	**E-field strength (V/m)**
1MHz-10MHz	$86.8/f^{0.5}$ (27.4)
10MHz-400MHz	27.4
400MHz-2GHz	$1.37 \times f^{0.5}$ (27.4)
2GHz-300GHz	61.4

A.4.2.2.2.3 Safety Margin

For safety reasons, the ADWS should be immune to EM radiation of a higher strength than that which can be encountered at the firing range. The ADWS should be trialed in a go/no-go test in the applied EM field. No variability margin is allowed and 100% of components and system are to be tested. The safety margin is prescribed to be 3 dB.

The electric field strength is 50 V/m for all frequencies from 2 MHz to 18 GHz. Therefore, the electrical field strength at the firing range should not exceed 35 V/m for the same frequency range.

A.4.2.2.2.4 Procedure Variables

An anechoic chamber will be used. The laptop will be outside the chamber. The serial cable from the Fire Control Box in the chamber to the laptop outside the chamber will be closely tapped to the floor, and covered with aluminium foil.

A.4.2.2.2.5 Procedure Variations

The RS103 standard recommends measurement between 18 GHz to 40 GHz but this is optional and is difficult to conduct, and accordingly was not adopted for this certification process.

A.4.2.2.2.6 Fire Control Unit monitoring

The Visual Basic program on the laptop fires a sequence of test commands every 1 second. The program runs the command FDELAY to set the status of the microcontroller in the Fire Control Unit, and the initiates the firing command sequence LRPB FRPB FIRE ETSTAT. The FDELAY command checks the normality of operation of microcontroller and PLC, and LRPB FRPB FIRE checks the normality of operation of microcontroller, PLC and current booster. The microcontroller sends responses to the laptop about the status of completion of the commands. If the commands are completed successfully, which was identified as a confirmation of the undisturbed function of the Fire Control Unit, then the laptop's display is turned green. If the status of the successful completion of the series of testing commands is not received by the

laptop, then the laptop display is turned red. This sequence of test commands is then repeated.

A.4.2.2.2.7 Procedure in case Fire Control Unit fails
The procedure in the event of Fire Control Unit failure is:

1. Restart the laptop, and press the "Continue" button.
2. If the test program indicates "red", then turn the Fire Control Unit off and then on, thus switching it from an "armed" to "safe" state and then back to "armed".
3. Initiate the test program.
4. If the test program cannot be initiated or shows "fail" (that is, red screen), then the Fire Control System needs to be sent for repair.

A.4.2.2.2.8 Effects Level Classification
Table 3 shows descriptions of the five effects levels.

Table A.3. Effects Level classification.

Effects Level	Description
1	No discernible effect
2	Minor effects observed only during period of EM interference, e.g. instability of display units
3	Major disruption to normal operation only during period of EM interference, e.g. generation of spurious electronic signals
4	Permanent disruption to normal operation after period of EM interference which require operator reset
5	Permanent disruption to normal operation after period of EM interference which require expert servicing

A.4.2.3 Radiated Susceptibility, Electrostatic Discharge
Not required.

A.5. Summary of Test Requirements

Table A.4 shows the list of Test Requirements and their applicability to the ADWS components.

Table A. 4. Test Requirements as identified in Test Standards.

MIL-STD-461E test	Notes on test	Why not perform test	Perform test
CE101	Conducted emissions on power leads for aircraft and submarines		Not required
CE102	Conducted emissions on power leads, 10 kHz to 10MHz		Desirable
CE106		The weapon does not contain antennas	Not required
CS101	Conducted susceptibility on power leads, 10 kHz to 150 kHz		Required
CS103		The weapon does not contain antennas	Not required
CS104		The weapon does not contain antennas	Not required
CS105		The weapon does not contain antennas	Not required
CS109		Not sensitive at <1μV	Not required
CS114	Bulk cable injection, 10 kHz to 200 MHz		Required
CS115	Bulk cable injection, pulse excitation	Not in a vehicle	Not required
CS116	Bulk cable injection, damped sinusoidal transients	No AC source connected	Not required
RE101			Not required
RE102	Radiated emissions, electric field, 10 kHz to 18 GHz		Desirable
RE103	Radiated emissions to 40 GHz		Not required
RS101	Radiated susceptibility, magnetic field, 30 Hz to 100kHz	No mine-sweeping capability in vehicle	Not required
RS103	Radiated susceptibility, electric field, 2 MHz to 40 GHz		Required
RS105	Radiated susceptibility, transient electromagnetic field		Not required

A.6. Report Requirements

A Report is required which indicates Pass/Fail compliance for each specified frequency of the specified amplitude.

Appendix B: Summary of EMC Test Report

B.1. Introduction

A summary of the ARDU Engineering Report EMTS04/067, Task E2602 "Firing Control Unit EMC Testing" is given below. The completed ARDU tests included MIL-STD-461E CS114, CS115 CS116 Conducted Susceptibility, RE102 Radiated Emissions and RS103 Radiated Susceptibility evaluation.

B.2. Test Method

All EMC measurements were performed with the Equipment Under Test (EUT) installed in the shielded anechoic chamber. To simulate the actual installation, all testing is conducted with the test items placed on a conductive surface and isolated from the electrical ground plane. Figure B.1 shows the test set-up for the EUT.

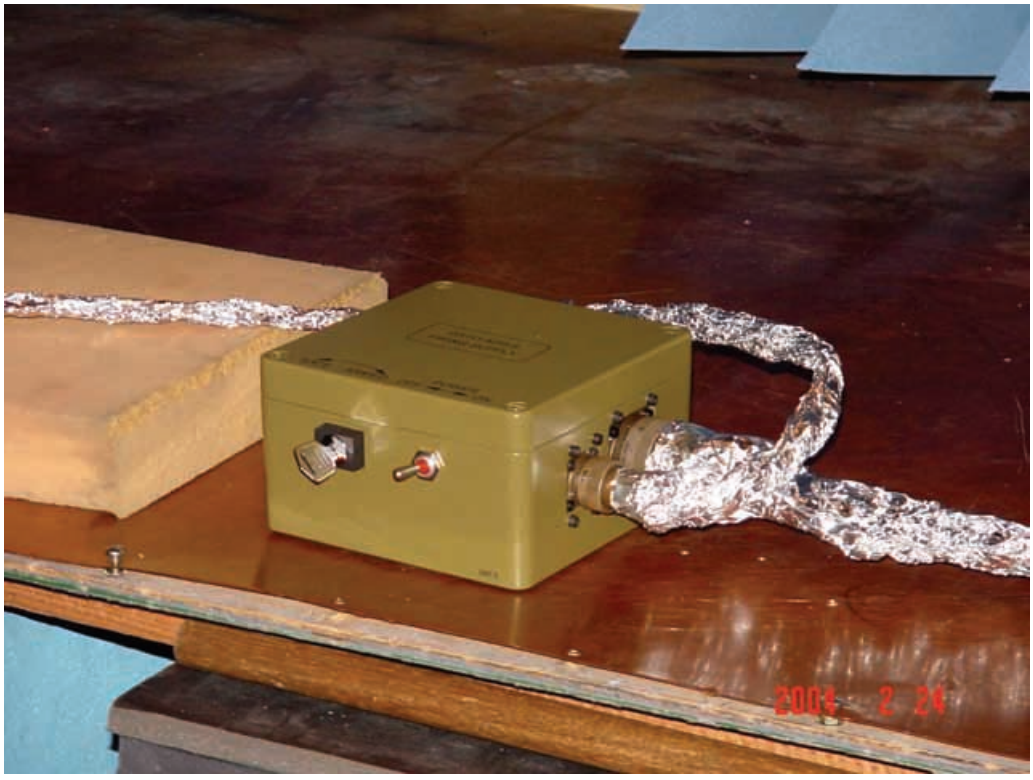

Figure B.1. ADWS Fire Control Unit under test

B.2.1 Conducted Susceptibility, Bulk Cable Injection CS114

The CS114 Conducted Susceptibility test is used to verify the ability of the EUT to withstand RF signals coupled onto EUT associated cabling. The test equipment is configured as shown in Figure CS114-3 of MIL-STD-461E to measure the forward power (input power) required to produce the current level specified at the applicable limit. The EUT is monitored for degradation of performance during testing.

B.2.2 Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation CS115

The CS115 Conducted Susceptibility test was used to verify the ability of the EUT to withstand impulse signals coupled onto EUT associated cabling. The test equipment is configured as shown in Figure CS115-2 of MIL-STD-461E to verify the rise time, fall time, pulse width, repetition rate and amplitude of the waveform that is specified in the requirement. The EUT is monitored for degradation of performance during testing.

B.2.3 Conducted Susceptibility, Damped Sinusoidal Transients, Cable and Power Leads CS 116

The test equipment was configured in accordance with Figures CS116-3 and CS116-4 of MIL-STD-461E to verify the waveform. The EUT is monitored for degradation of performance during testing. The test is conducted for power on and power off condition.

B.2.4 Radiated Emissions, Electric Field RE102

MIL-STD-461E RE102 Radiated Emissions test was used to measure electric field emissions radiating from the EUT and its associated cabling over the frequency range of 2 MHz to 10 GHz.

B.2.5 Radiated Susceptibility, Electric Field RS103

MIL-STD-461 RS103 Radiated Susceptibility test was used to verify the ability of the EUT enclosures and associated cabling to withstand external electric field, generated by antenna transmissions.

B.3. Results

The results for the several tests performed according to standard MIL-STD-4611E are shown below:

B.3.1 Conducted Susceptibility, Bulk Cable Injection CS114

Frequency Ranges	Pass of Susceptibility Threshold
10 kHz – 200 MHz	Pass

B.3.2 Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation CS115

Induced Current (A)	Pass or Susceptibility Threshold
5	Pass

B.3.3 Conducted Susceptibility, Damped Sinusoidal Transients, Cable and Power Leads CS116

Frequency (Hz)	Induced Current (A)	Transient Generator Setting	Pass or Susceptibility Threshold
10 k	100 m	192	Pass
100 k	1	49	Pass
1 M	10	711	Pass
10 M	10	730	Pass
30 M	10	346	Pass
100 M	3	95	Pass

B.3.4 Radiated Emissions, Electric Field RE102

Frequency	Emission Threshold
2 MHz to 1 GHz	Fail (emission 2 dB over limit at 3.2 MHz)
1 GHz to 2.9 GHz	Pass
2.0 GHz to 10 GHz	Pass

B.3.5 Radiated Susceptibility RS103

Frequency Ranges	Applied Field Strength (V/m)	Pass of Susceptibility Threshold
2 MHz – 18 GHz	50	Pass

B.4. Conclusion

MIL-STD-461E tests CS114, CS115, CS116 and RS103 have been performed for the Fire Control Unit.

The Fire Control Unit conforms to CS114, CS115 and CS116 test requirements of MIL-STD-461E.

The Fire Control Unit does not conform to test requirement RE102 of MIL-STD-461E. This non-compliance is, however, considered negligible.

The Fire Control Unit conforms to test RS103 requirements of MIL-STD-461E.

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Valerian A. Kuznetsov and Vinod P. Puri

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19. ABSTRACT

A practical realisation of Electromagnetic Immunity/Compatibility (EMI/EMC) testing of ordnance weapons with electrical initiation according to compliance standards is described. The Area Denial Weapon System (ADWS), which is electrically initiated and electronically controlled, was exposed to electromagnetic interference of a known intensity in an anechioic chamber by injection of induced current, in accordance with the requirements of the USA MIL-STD-461E standard [1] and of the UK's Ordnance Board Pillar Proceeding P101 (Issue 2) [2]. Compliance of ADWS was confirmed. This report describes the test plan, procedures and results.