Australian Government
Department of Defence
Capability Acquisition and Sustainment Group

Considerations towards a Sovereign E3 & HERO Test & Evaluation Capability in Support of a Sovereign GWEO Enterprise

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Defending Australia and its National Interests
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Foreword

Image from T. Duggan, Military Aircraft Electromagnetic Compatibility: Release to Service Testing in the United Kingdom, Past, Present and Future, IEEE International Symposium on Electromagnetic Compatibility, 2007

- A paper with the same title as this presentation has been co-authored with Mr Thinus Neethling (EMB EEH & Fuzes Desk Officer).
- The paper provides a top-level gap analysis for the conduct of E3 testing on EO used by the ADF.

Agenda

- Introduction – T&E and the GWEO Enterprise.
- What is E3 and HERO?
- Australia's Current E3 Test Capability – what we do well.
- Where we are Lacking.
- Other Opportunities.
- The Crux of the Matter
  (Why we need to invest).
- Conclusion.

Image: M1A1 Abrams Tank in Anechoic Chamber, ECL at Monegeetta Proving Ground, VIC, Australia

Introduction

- On the 31st of March 2021, the Australian Federal Government announced the acceleration of the Australian Sovereign Guided Weapons (GW) and Explosive Ordnance (EO) Manufacturing Capability.
- There are known deficiencies in the T&E capabilities specific to electrically-initiated EO including:
  - Electromagnetic Environmental Effects (E3) testing.
    - Which includes Hazards of Electromagnetic Radiation to Ordnance (HERO) testing, among others.
- A top-level gap analysis concerning current E3 T&E capabilities is presented.

What is HERO?

- **HERO**: Hazards of Electromagnetic Radiation to Ordnance.
- Electromagnetic radiation may induce undesired currents in the firing circuits and Electro-explosive Devices (EEDs) of electrically initiated EO items.
- Consequences include both safety (premature firing) and reliability (dudding or altered functional characteristics).
- Require a facility and equipment that can radiate EO from 0.01 MHz to 50 GHz.
- Requires a facility with a dust-free, clean room and specialised equipment to construct instrumented EEDs.

Australia's Current E3 Test Capability

Image: ECL, RF Emissions Testing on a MAN HX-77 MHC Truck

- What we do well now:
  - The Electronics and Communications Laboratory (ECL) at Monegeetta VIC, can conduct various tests, including RADHAZ tests and EMC in accordance with MIL-STD-461.

The Current Gaps in Australia's E3 Test Capability

- This is where we are lacking:
  - EED Characterisation
  - HERO testing (some past HERO testing has been done)
  - Personnel Electrostatic Discharge (PESD)
  - Helicopter Electrostatic Discharge (HESD)
  - Electromagnetic Pulse (EMP)
  - Lightning (Near Strike and Direct Strike)
  - High Power Microwave (HPM)

EED Characterisation

- A requirement that is dictated by DEOP 102 – Safety and Suitability for Service of Defence EO.
- EEDs are subjected to a suite of tests to qualify them for use, but also to derive important parameters like no-fire & all-fire thresholds and bridge resistance values (including tolerances).
- Provides confidence in repeatable and predictable performance when initiated.
- During HERO tests, it is essential to describe the ratio of an induced current in the EED, versus its no-fire threshold current (NFTC) – and to confirm whether appropriate margins are maintained.
- EED characterisation would need to be done in an explosives laboratory as there would be deliberate firing of EEDs.

HERO Testing

- Aim of HERO Testing: Determine how EEDs respond to the EME that could be encountered by the EO throughout its service life.

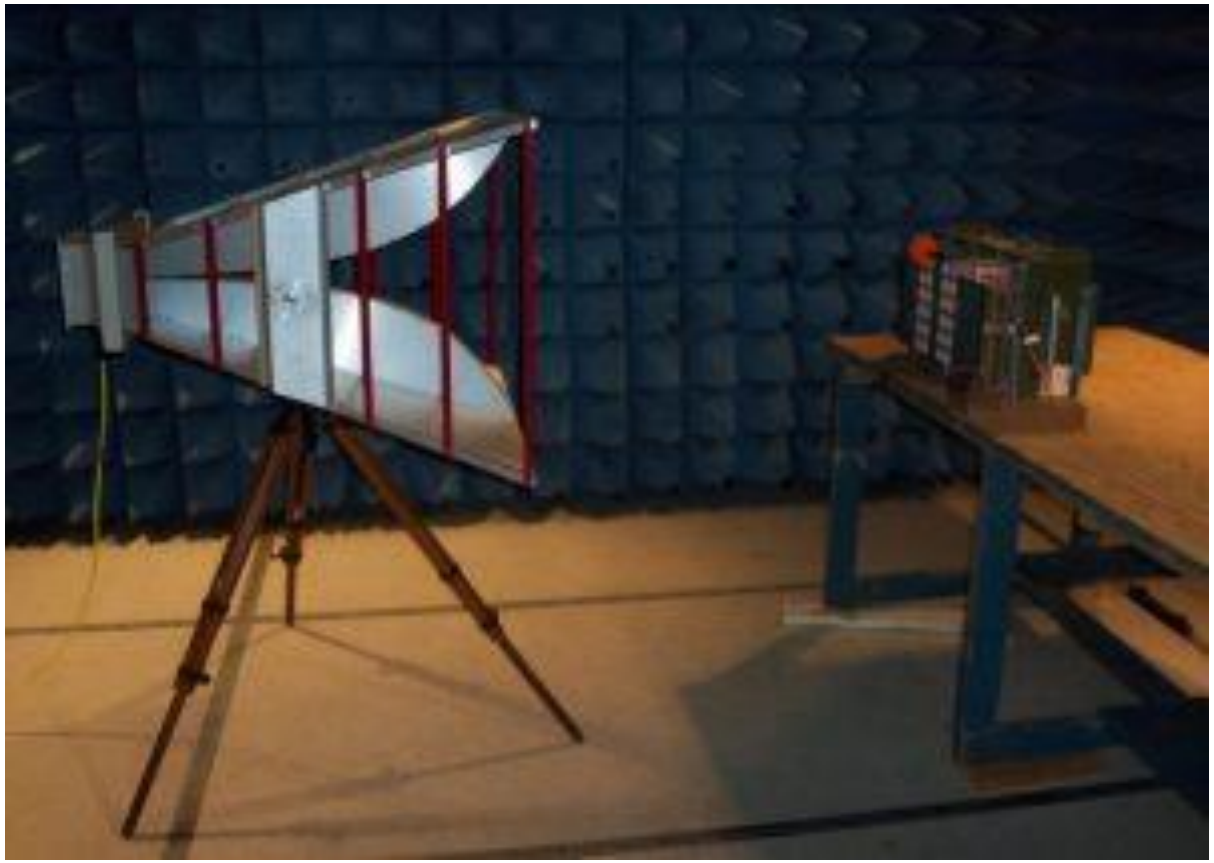


Image: Chemring M34 Flares in launcher configuration during HERO test 200 MHz – 1 GHz, https://nts.com/ntsblog/hero-testing/

- HERO testing is used to quantify induced currents in EEDs, during RF irradiation.
- Used to determine the maximum allowable environment (MAE) for EO items and weapon systems containing EEDs.
- MAE data used to assess HERO risks and develop effective control measures to mitigate those risks.

Past HERO Test Programs – A Few Examples

- Some HERO testing has previously been conducted with instrumented EEDs in Australia.
- EO items tested include:

AIM-132 ASRAAM Missile at Defence Science and Technology Organisation (DSTO) in 2001.

Image; F/A-18 Positioned in the DSTO Reverberation Chamber. Reference: D. A. Pierens, F/A 18 / AIM-132 ASRAAM Integration, Test and Clearance program, RAAF Base Edinburgh Australia

Past HERO Test Programs – A Few Examples

https://www.joint-forces.com/wp-content/uploads/2022/02/Rheinmetall-Maske76.jpg

https://www.globalsecurity.org/military/systems/munitions/images/jdam-er-image01.jpg

- 76mm MASKE smoke grenade at Land Engineering Agency (LEA) in 2008,
- Guided Bomb Unit (GBU)-65 JDAM DMER at the Air Warfare Engineering (AWE) Squadron, at its Electromagnetic Test Facility in 2017.
- HERO test capability has essentially been lost due to site and/or equipment repurposing and the loss of technical expertise.
- Without a local HERO T&E capability, the ADF relies heavily on OEM test data.
- We cannot claim that a local HERO T&E capability exists.

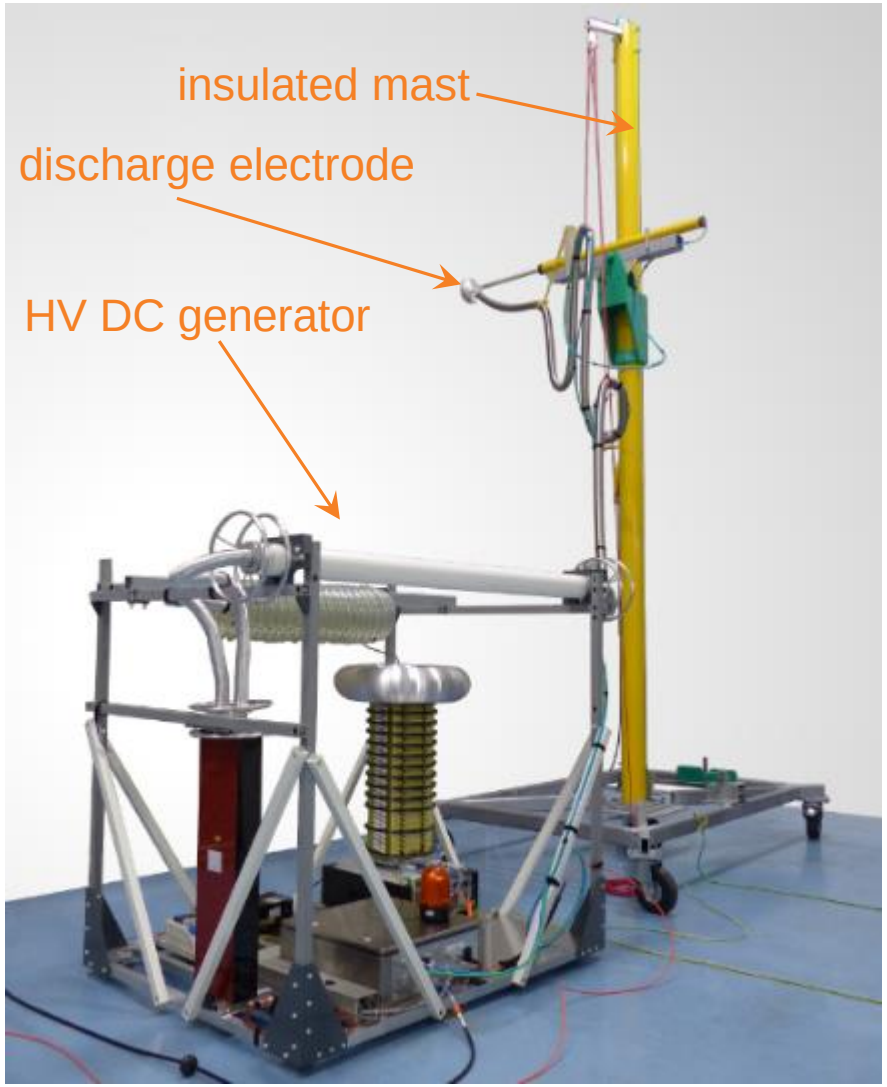
PESD Testing (per JOTP-062)

- MIL-STD-331 and MIL-STD-464 specify the PESD parameters for testing EO.
- The guidance for testing can be found in JOTP-062.
- Supporting test equipment e.g. ESD test gun. Different probe sets (R/C networks & tips) 500 pF / 500 Ω.

ESD Simulator Gun System

Image: https://www.theemcshop.com/30-kv-esd-simulators-generators/1082-em-test-esd-nx30-electrostatic-discharge-simulator-gun-system-for-up-to-30kv-testing.html

HESD Testing (per JOTP-062)



- Dedicated test equipment required for HESD testing e.g. high-voltage (HV) DC generator, discharge electrode fitted on a pneumatic piston, pulse control computer and fibre-optic interface to the HV DC generator.
- Test equipment can also be configured for P-static testing.
- HESD and P-Static testing not currently performed in Australia.

Image provided by Montena Technology SA, Switzerland. See https://www.montena.com/ for more detail.

Testing for Direct & Indirect Effects of Lightning

- Lightning is one of the most severe EEH due to the exceptionally large amounts of electrical energy transferred during a lightning strike.
  - Transfers large amounts of electrical current.
  - Generates significant electromagnetic fields in the vicinity of the strike.
- Lightning tests are not currently performed in Australia.

Image: Lightning Test on AGM-114 Hellfire Missile RTC, https://www.army.mil/article/163252/rtc_lightning_tests_are_one_of_a_kind

EMP Testing

- Covered under MIL-STD-461G RS105: Radiated susceptibility, transient electromagnetic field.
- Test equipment range from NEMP desk top testers (Montena) to full EO weapon systems testing (WSMR).
- Not tested in Australia at present.

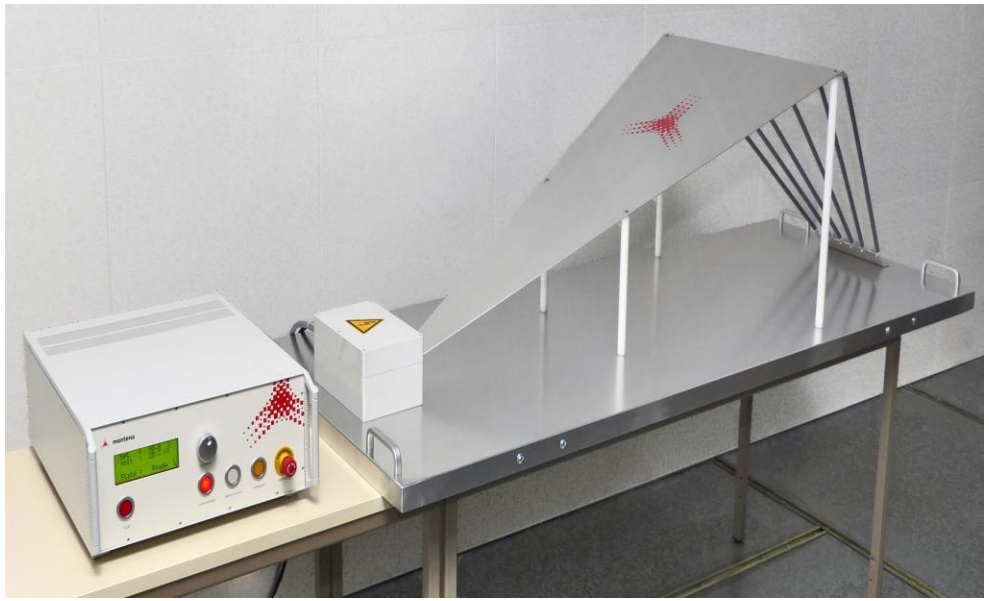


Image: https://www.montena.com/fileadmin/technology_tests/documents/datasheets/Data_sheet_EMP25K-2-23_and_RL50_50.pdf

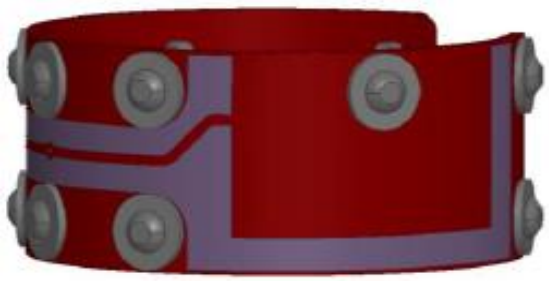
Image: White Sands Missile Range Presentation: "Cradle-To-Grave" E^3 Survivability Capabilities and Facilities of 23 Oct 08

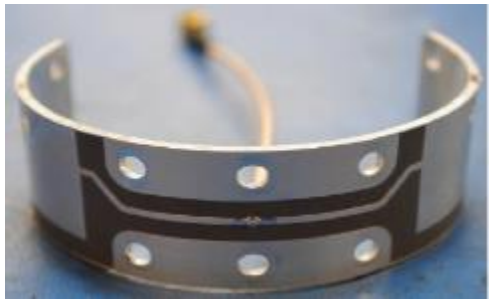
High Power Microwave & Directed Energy Hazards

- Not tested in Australia.
- The adoption of RF Directed Energy Weapons (DEWs) may alter the criteria EME (MIL-STD-464) for military assets, including EO.
- The White Sands Missile Range (WSMR) in the US provides detail on their HPM testing facility which helps define the RF intensities and field strengths required for this modality of E3 testing in Australia.
- The WSMR system provides testing for electronics, electro-optics and munitions, and assesses system level survivability (commonly via go/no-go testing).
- HERO certification protects EO from inadvertent detonation or dudding at the EID, but a complex GW EO system has more vulnerable subsystems (e.g. guidance & control).

3D Computational Electromagnetic Modelling & Simulation

- Design, modelling, simulation and optimisation of wrap-around antenna that is used for S-band telemetry on a course correcting fuze (CCF), which is fitted to a 155 mm artillery round. The antenna was designed using a combination of electronic computer-aided design (CAD), mechanical CAD, and 3D CEM tools.





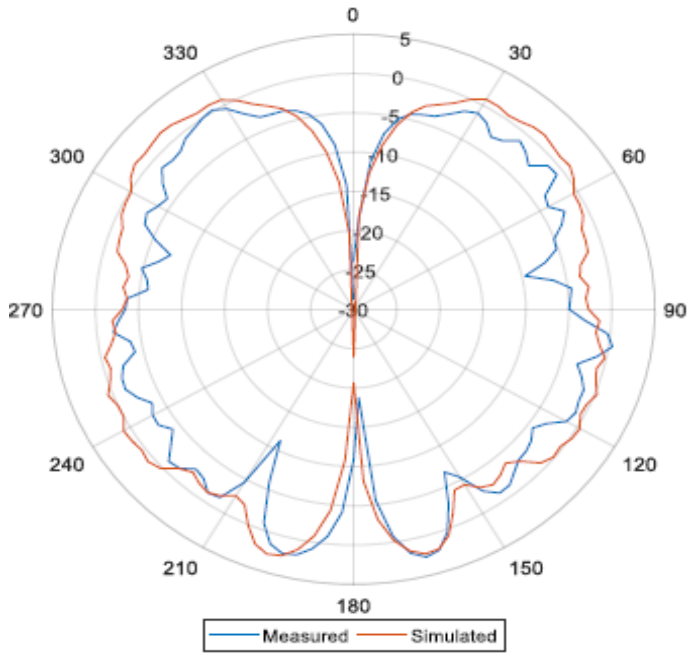


Image: *A. Barton, Wraparound Antenna for S-Band Telemetry, Technical Report ARMET-TR-18051 of Jul 20*

Bespoke E3 Testing – Broadband RF Shielding Effectiveness Tests

- Packaging, which can provide RF shielding to the contents, is one way of protecting electrically initiated EO against particular EMEs.
- It should not be assumed that conductive ammunition and EO containers offer effective broadband RF shielding effectiveness (SE).
- Due to slots, gaps and paint-on-paint seals, these boxes and containers may be prone to cavity resonances. At the resonant frequencies, the SE could drop to 0 dB.
- Effective only across certain frequency bands.
- Requires inner packaging with broadband RF shielding performance, or bespoke designs.
- Necessitates the need for broadband SE testing & characterisation.

Bespoke E3 Testing – Impact of physical structures to RF susceptibility of EO items

- Bespoke HERO testing may be required when certain handling equipment did not form part of the HERO test program.

ATM-84J Harpoon in readiness for loading.

ATM-84J Harpoon, loaded onto P-8A Poseidon

- The structure of the loading equipment may change the RF susceptibility of the EO item.
- Also consider currents induced on crane structures and cables.

Bespoke E3 Testing – Platform EME & New Capabilities

- Incorporation of a Next Generation Jammer on the EA-18G required 400 hrs of E3 testing over a period of 3 months.
- The E3 tests hint towards some of the T&E requirements of such a facility i.e. large, anechoic chamber, heavy lift capability, RF test equipment, antennas and sundries.

US Navy EA-18G with two NGJ-MB pods in the Patuxent River anechoic chamber. (Photo Credit: US NAVY)

Reference: *https://adbr.com.au/next-gen-jammer-mid-band-completes-e3-testing/ & https://adbr.com.au/australia-goes-all-in-on-next-gen-jammer/*

The Crux of the Matter – Why We need to Invest

- Having the capability to perform in-country E3 and HERO testing is essential if there is local manufacture of GW in Australia.
- No-one who builds a GW neglects to test it for E3, and HERO especially.
- With local E3 testing, it is possible to introduce complex GW systems into service quicker.
- If Allied Nations wish to establish Australia as an alternative source of supply for GW systems, they will expect E3 and HERO testing to be conducted and E3 data to be available.

The Crux of the Matter (Cont'd)

- We require a trained work force and the ongoing development of their technical skills.
- Building expertise and a capable workforce are the longest lead time items for developing a solid local E3 test capability.
- If Australia is going to build GW and complex EO domestically, a requirement for E3 testing is imperative.

Conclusion

- E3 test modalities concerning lightning, HESD, PESD, HPM, EMP and HERO have been recognised as essential requirements of a sovereign EO T&E capability, but which are generally lacking in the Australian context.
- Equivalent E3 systems and facilities are currently operating in the US and UK. These Allies may become key advisory contributors to the Australian program.
- The success of the GWEO Enterprise requires implementation of these facilities and E3 T&E test modalities in Australia.

Questions?

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