INDIVIDUAL ELECTRONIC COUNTER MEASURES (IECM)

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INTRODUCTION

Radio Controlled Improvised Explosive Devices (RCIEDs) are a ubiquitous weapon of choice for criminals, terrorists, insurgents and state actors wishing to impose their will or exercise geopolitical influence across the globe. On the battlefield, this threat is traditionally countered using a combination of large vehicle and man mounted Electronic Countermeasure (ECM) Systems. These systems provide protection to individuals as long as they stay within the "protective bubble". However, this restricts manoeuvrability and can even leave individuals in vulnerable positions outside of the direct line of sight of the ECM. A solution to this is to equip each person with their own Individual ECM (IECM).

ECM technology has advanced significantly since its globalisation in the period 2003-2010. The revolution in signal processing and battery technology has allowed ECM to get smaller and be more capable. This opens up greater opportunity for novel ECM solutions to meet the pace and complexity of modern asymmetric operations, and the need for greater spectrum and operational management coupled with a change in conventional thinking regarding ECM deployment. IECM is not limited to the specialist user; there are applications ranging from VIP close protection and peace keeping, through to bomb disposal and police use. This article considers the ways this technology can be used to equip each user with their own IECM and to assess and present the suitability of IECM systems against a variety of end-user requirements and operational conditions.

THE REQUIREMENT FOR ECM

The Command-Initiated IED offers the attacker the optimum moment of initiation and the ability to select their specific target. Within the Command IED category the RCIED is the most prevalent. Due to their operational flexibility, they are often used for the assassination of high-ranking personnel. They are ideally suited to engage mounted (vehicle) and dismounted (on foot) military, security force and law enforcement personnel where routes are known but exact timing cannot be predicted. There is also the continuing tactic of RCIED as a backup to suicide bombing attacks. Historically, dealing with this threat, particularly in contested and congested operational environments, has led to the procurement of multiple portable and vehicle mounted ECM systems that are heavy, large and power hungry. This imposes a burden on the end user that is an encumbrance on their primary mission and a challenge for those conducting electromagnetic battle management (EMBM).

It should be remembered that the main purpose of deploying ECM systems is to enable the user to conduct an operational task that is not necessarily related to defeating the RCIED.

Purpose of ECM:

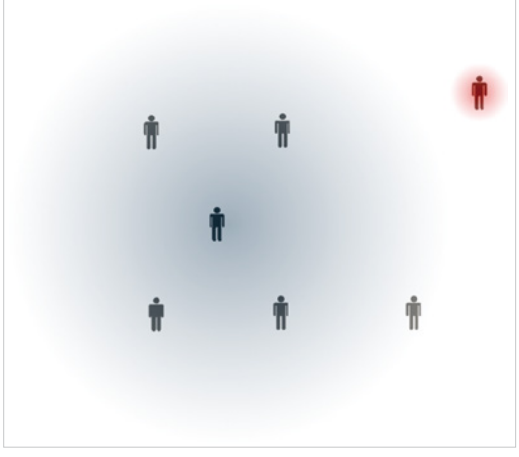
- Allow users freedom of manoeuvre
- Protect users in higher risk environments such as Explosive Ordnance Disposal, high risk search operations and special forces
- Protect key installations or buildings
- Protect operational personnel in active engagements, search, patrol and peace-keeping operations
- Provide security when moving key VIPs and other high-profile targets

The modern war fighter has an increasing mission load burden that affects the effectiveness of individuals and teams. Following on from lessons learned in modern asymmetric conflict, there is a demand to reduce the Size, Weight, Power consumption and Cost (SWaP-C) of ECM systems. This emphasis has in turn promoted the utility and attractiveness of IECM systems over more traditional ECM solutions.

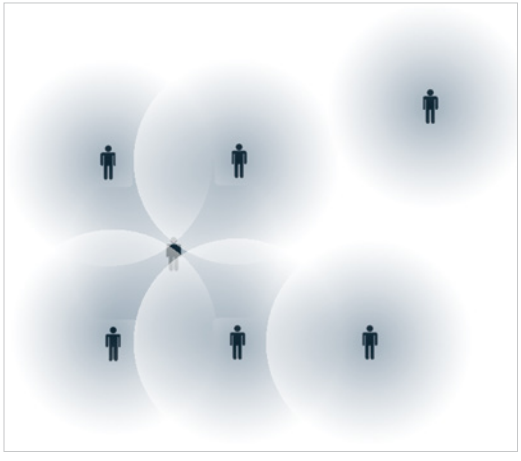
THE CONCEPT OF IECM

Traditional tactics, techniques and procedures (TTPs) deploy manpack ECM on one or two individuals to provide protection for a whole section or a squad. Each manpack provides an invisible “bubble” of protection. Providing each person remains within the “bubble”, they will benefit from the protection provided by the ECM.

IECM is smaller than traditional manpack ECM, allowing for a much greater flexibility and freedom of movement.



Section protection with manpack ECM.



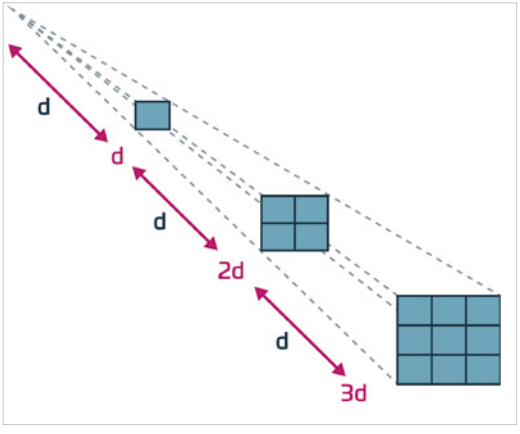
Section protection with Individual ECM.

Individual ECM equips each individual within a section or squad. Every person is free to manoeuvre whilst maintaining ECM protection.

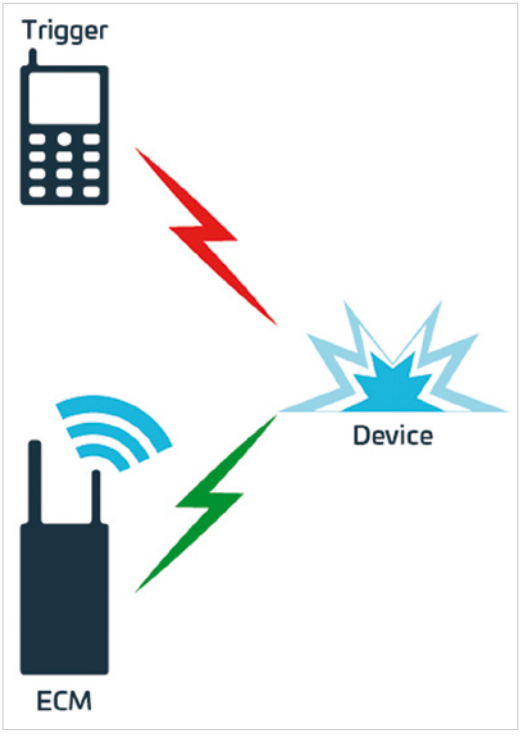
THE POWER BATTLE

The primary purpose of an ECM system is to defeat the signal from the RCIED trigger and to prevent it from being processed by the threat receiver. Each type of user group faces its own specific challenges when 'trying to win the power battle'. Typically, this effect is achieved by providing sufficient jamming power at the threat device to overcome the trigger's transmitter output power. This jamming power to signal power ratio (or J/S) at the device may be influenced in a number of ways including: transmit power, distance to the device, geometry and signal polarisation.

J/S is quite simple; the higher the trigger's transmit power, the higher the jamming power needed at the device to defeat it. For static and vehicle mounted systems, increasing the power is feasible but for dismounted systems, the power is limited by the size of the battery. More power means a bigger battery or a shorter mission life, neither of which is desirable.



The Inverse Square Law (path loss exponent = 2) dictates that power from the ECM dissipates over distance; mathematically this means that increasing the power of the jammer does not lead to a linear increase in protection radius. In built up environments the signal may fade much more strongly, particularly where there is no line sight to the device (path loss exponent ~4-6).



The primary purpose of an ECM system is to defeat the signal from the RCIED trigger and to prevent it from being processed by the receiver in the threat device.

In most operational scenarios, the distance between the ECM system and the threat device and the distance between the threat transmitter and the threat receiver alter by factors that are largely outside the operator's influence. What is true is that, with very few exceptions, the closer the ECM is to the RCIED the more effective it becomes.

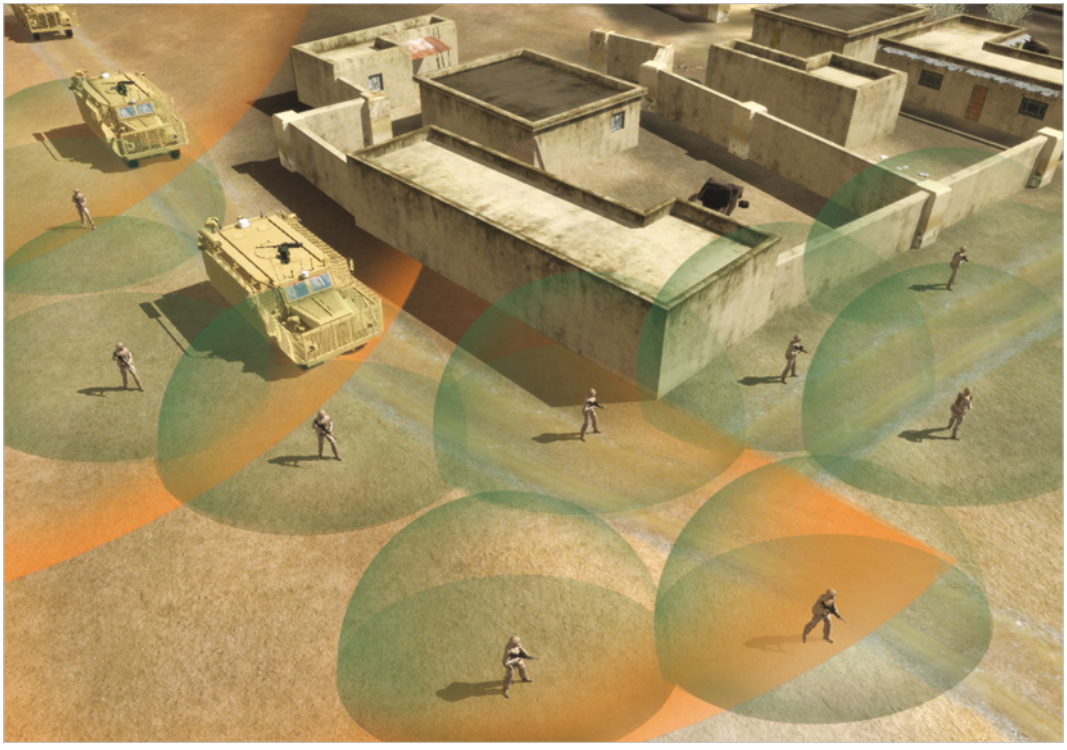
Take for example dismounted ECM systems. A typical IECM may transmit a jamming signal that is an order of magnitude lower than a man pack ECM. Because of the way that radio waves propagate through free space the jamming signal energy drops off due to spreading loss which is an inverse square law. The overall effect is that a ten-fold increase in power does not equate to a ten-fold increase in the protective radius – far from it – with the difference in distance potentially less than a

Centralised ECM does not go around sharp corners.

tenth of the proportional increase in power when other fading conditions are also considered.

Successful ECM deployment is often based on the distance from the threat device receiver and the radio path length rather than the raw power of the transmitter. Ultimately, it is a combination of tactical and technical measures combined with good training that leads to ECM systems being effective. Tactically moving the perpetrator (trigger) away from the device can move the literal 'balance of power' towards the ECM, as will moving the ECM closer to the device. A key factor with IECM is that by its nature, everyone in the team is carrying one; it is therefore more likely that one of the IECM is closer to the device than the manpack, which is typically in the centre of the section.

The basic geometry and power analysis of the 'Trigger', the 'ECM' and the 'Device' does make for a simple but compelling case for IECM over manpack ECM but, it is when we consider the environmental geometry of complex built up situations where IECM comes into its own. As previously mentioned, fading conditions in cluttered environments where the line of sight to the target is obstructed can cause fading that varies inversely with the distance with an exponent of four to six (Rayleigh type fading). Of particular concern is the area directly around corners where the signal from the ECM is very weak due to knife-edge diffraction. For manpack ECM, protection may be limited for individuals who are around the corner of a building or wall. IECM does not suffer from this scenario as the individual brings the protection with them. In this scenario, the IECM has both a higher effective power (direct line of sight) and is closer to the threat device; the IECM is winning the power battle.



If the soldier goes around the corner, so does the IECM protection.

An interesting corollary of the geometric discussions around ECM deployment is the failure case. If a manpack providing the ECM protection for a section or squad fails, everyone is rendered unprotected. With IECM, if one device fails, a limited level of protection is provided by other IECM in the vicinity. If the failure is identified (warning light/sound) then the person with the failed ECM can actively mitigate their risk by moving closer to another individual.

ENABLING TECHNOLOGY

IECM is not a new idea but what is new is the underlying technology that enables it. When ECM technology and requirements developed in the 2000 – 2010 period, the range of threats and the available components were more limited than today. Manpack ECM was a suitable form factor to meet the challenges with the technology available at that time. Bulky batteries and power hungry processors necessitated this size of solution. These two areas, batteries and processing, have evolved greatly since then and enable the technology that underpins IECM as a replacement for manpack ECM. In this sense, it is better to think of IECM as the evolution of manpack ECM rather than as an alternative or competitor to it.

Originally, ECM processing was a combination of discrete FPGA and CPU or DSP elements with dedicated memory for each. Now System on Chip (SoC) technology is widely available, these processing elements can be combined into a single package. Not only is this space efficient on the board but it is also highly advantageous for the inter-domain communication speed and power consumption as all elements are co-located on the same piece of silicon.

External memory elements may also be reduced as a single memory chip can be used to support all internal domains within the SoC. This highly integrated, power efficient architecture enables lightning fast processing and the flexibility to counter emerging waveforms. Rather than a limited hardware defined jammer, an IECM can be a Software Defined Radio (SDR) optimised for ECM with fast, wideband front end signal processing and a low power, low weight form factor.

Over the last decade, battery technology has been driven by advancements in mobile phones, portable electronics (cordless power tools, vacuum cleaners etc.) and electric vehicles. A 2019 report from Bloomberg claimed that the cost per Watt-hour of battery technology has fallen by 18% per year for the last decade. Some of this drop in price is driven by the increase in production volumes of batteries, but much of this decrease is attributable to the advancement in lithium-ion battery technology and the underlying energy density of the cell technology in particular. The availability of smaller, powerful portable batteries is a key enabler for IECM. By reducing the weight of the ECM, the user experience is improved through greater manoeuvrability and flexibility whilst maintaining high levels of RCIED protection.

Processing, battery technology along with a host of other technological advancements such as amplifiers, antennas and sampling, allows IECM to be much smaller and lighter than traditional manpack ECM. IECM systems are easy to operate. They have the look and feel of a personal role radio and can be carried in a similar manner. The profile of IECM by its nature makes it stand out less when carried by a user and therefore may not draw as much attention to its presence. With an all-up weight of typically 1 - 2 kg and the corresponding smaller volume, IECM is 4 to 5 times lighter than a typical manpack system. In the modern battlespace when a soldier is expected to carry more and more equipment, this reduction in mission weight-burden offers a palpable tactical advantage. Additionally, the cost of an IECM system is typically considerably lower than FP ECM systems.

ROLE BASED ASSESSMENT

This final section examines the additional roles IECM can fill. This includes many situations where manpack ECM is either too heavy or too large to have been suitable.

Force Protection

Traditionally the role of IECM is for users that are working in the dismounted role. Users who need to dismount temporarily from their vehicles can also employ it. Dismounting to work with vehicle borne systems extends the reach of ECM protection, particularly against those threats considered hard to kill.

Special Forces

The IECM concept has a particular application in supporting the Special Forces or Firearm Response communities. In these roles, ECM is often discounted simply because it is too bulky to incorporate into their standard concepts of operation where speed, agility and freedom of manoeuvre are critical and friendly communications are imperative.

Peacekeeping

Peacekeeping, non-government aid and humanitarian organisations frequently operate in potentially hostile environments either in the lead up to or post hostilities where the IED threat and explosive remnants of war (ERW) are difficult to assess and usually unpredictable. Irrespective of whether the environment is permissive or non-permissive these organisations must maintain a neutral, unprovocative stance when it comes to self-protection and, in most cases, do not have the opportunity to use full force-protection when it comes to defeating RCIEDs. In addition to the freedom of manoeuvre advantages that IECM has, the small size and low RF power output of IECM system makes them as unobtrusive as possible and minimises any fratricide effect.

Close Protection

At present, a typical operational scenario is for ECM to be provided “in-vehicle” to provide protection to and from a venue. However, once a VIP arrives at a

venue ECM is discontinued as security is maintained by physically searching and securing the venue. Many VIPs increasingly wish to engage with spectators or well-wishers deviating from secured locations. To mitigate the risk, Personal Protection Officers (PPO) who are close to the VIP are able to carry IECM to provide them with RCIED protection should they deviate from secured locations.

Bomb Disposal

EOD operators and their teams have the ability to use IECM for pre-emptive EOD tasks, direct EOD tasks, planned operations and, in particular, assault EOD. The SWaP-C advantages of IECM offer the potential to reduce the volume of equipment to be carried or remotely deployed. Beneficial size and weight mean that IECM is ideally suited for remote deployment using a vehicle of opportunity such as a remotely operated vehicle (ROV), mini robot or even a drone to counter suspected or confirmed RCIED threats.

Law Enforcement

There are many ways in which IECM can be used in the law-enforcement role. Due to the size and the relatively low cost compared to traditional systems, IECM could be employed in various tactical situations by the police called to certain situations, or as standard equipment for SWaT teams.

For many countries, EOD falls into the law-enforcement domain and is undertaken by active duty police, fire departments or stand-alone organisations. One advantage of IECM for this group is the relatively low power output of the unit and the lower interoperability impact with other equipment and systems, particularly in benign operating environments where the EOD team are not necessarily the target for the perpetrator. In some countries ECM is subject to strict legislative constraints that may impact on the law-enforcement community's ability to use it freely. The lower power of IECM may make this type of system more acceptable to licensing authorities.

The requirement to deny communications crosses over almost all of the roles covered in this section. Communications ECM (CECM) and Electronic Attack (EA) is a key part of the military arsenal. Where legislation permits, it is increasingly attractive to law enforcement personnel, in particular SWaT /SF, and personnel who are required to undertake "forced entry" operations. The ability to deny communications against intelligence led or narrowband targets is an aspiration for many operational units. The lower power of IECM, again, lends itself to this type of operation, while at the

IECM Feature	Advantage
Each soldier wears an IECM	All soldiers are protected, no matter the footprint of the squad
Embedded digital and RF has miniaturised	A critical mass of capability can now be deployed on the man
More likely to be closer to the threat increasing J/S	Win the RF power battle
Avoids blind spots due to structures	True freedom of manoeuvre
More units provide safety through redundancy	One ECM failure won't stop the mission
Physically small unit	Discrete units that can be hidden
Low weight unit	Reduces soldier burden

same time working within legislative constraints, or at least tackling those constraints in a more discrete manner. Interoperability is maintained, reducing the effects to other critical systems and missions. The low-power nature of IECM also presents minimal non-ionising radiation levels to operators, ordnance and fuel.

CONCLUSIONS

The pace and complexity of modern operations, the need for greater spectrum and operational management and a change in conventional thinking regarding electronic countermeasure ergonomics have opened up greater opportunity for Individual ECM. Traditional manpack ECM fitted the operational and technological requirements and constraints that were present when they came on to the market. Over the last ten years, the hardware required to provide the required inhibition for force protection has been miniaturised and the underlying processing revolutionised. IECM was not an option when many of the world militaries developed their tactics, techniques and procedures (TTPs). By equipping each person with an individual ECM, those TTPs can be improved greatly through the freedom of manoeuvre and the enhanced protection (particularly in built-up areas) that is afforded by IECM. The size, weight, power and cost of IECM provide a variety of user groups with hitherto unachievable operational options. Dynamic tactics and threat assessments mean that protection against RCIEDs requires flexible solutions. IECM, in the tool bag of operational ECM solutions, offers freedom of manoeuvre and rapid response to new and existing threats. ■

ABOUT THE AUTHOR

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