SA-Army Symposium

Electronic Warfare Notes

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1.1 Electromagnetic Spectrum as a Manoeuvre Space

Throughout the history of warfare, opponents have sought technology to gain an advantage. Those responsible for a nation's defense must appreciate the military's dependence upon the Electromagnetic Spectrum (EMS) to ensure success in all warfighting domains. The reality of increasing net-centric operations among widely dispersed, manoeuvring force elements requires military organizations to use EMS consistently to achieve and maintain their military strategic advantage.

The EMS is the medium for all operations in the Electromagnetic Operational Domain (EMOD) to include cyberspace operations involving networked electronic systems in the EMOD. Capabilities to exploit the EMOD change as technology, architectures, processes, and expertise co-evolve to produce new capabilities and operating constructs. Networked electronic systems operating in the electromagnetic operational domain allow high rates of operational manoeuvre that capitalize on decision quality information moving at speeds that approach the speed of light and enable operations across the domains of air, land, maritime, space, and cyberspace.

Since EMS transcends commonly defined organizational and geopolitical borders, it is readily accessible in varying degrees to other nations, organizations, partners, the private sector, and our adversaries. It is also the transportation medium for manoeuvre in the information environment.

Electronic Warfare (EW) is conducted in the EMOD to provide friendly freedom of action in all domains while denying freedom of action to adversaries. It is important to note that electromagnetic energy is a physical medium like air, land, sea, or space. Although EW can create effects in the information environment, it inherently involves control of electromagnetic energy, and is thus a physical activity. Physical activities do not necessarily need to be "kinetic" in nature.

1.2 What is the Electromagnetic Spectrum

The Electromagnetic Spectrum (EMS) is a continuum of all electromagnetic waves arranged according to frequency and wavelength. The electromagnetic spectrum includes the following different types of radiation (from lowest energy to highest): radio, microwaves, infrared, visible, ultraviolet, X-rays and gamma-rays.

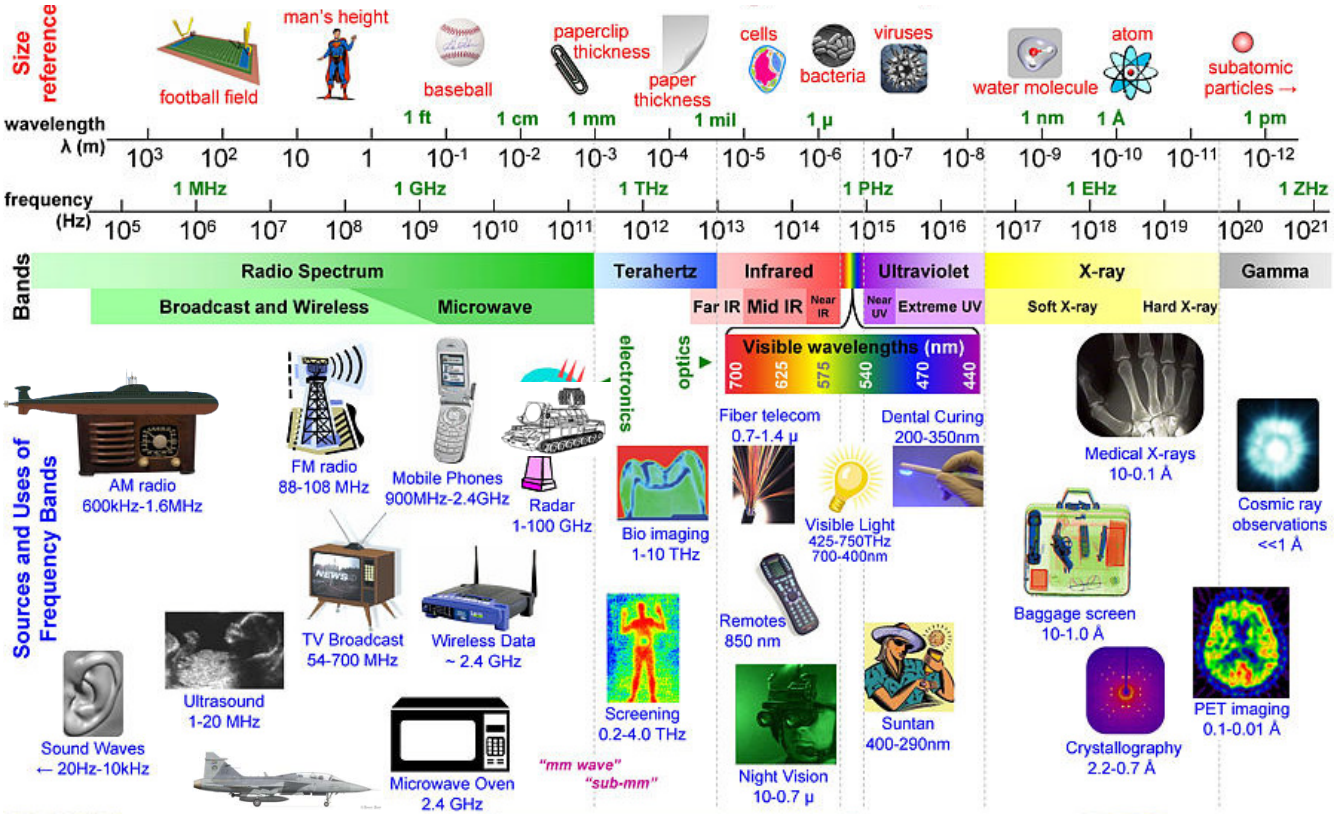

Figure 1: Examples of EMS applications and characteristics.

The portion of the EMS that EW is currently concerned with is the Radio Frequency (RF) region spanning from 3 kHz to 100 GHz, and the Electro-Optical (EO) band, consisting of the Infrared (IR), Visual and Ultra Violet (UV) regions. Figure 2 indicates how congested the RF EMS is, with no gaps in the spectrum, as well as multiple users that share the same allocated frequencies.

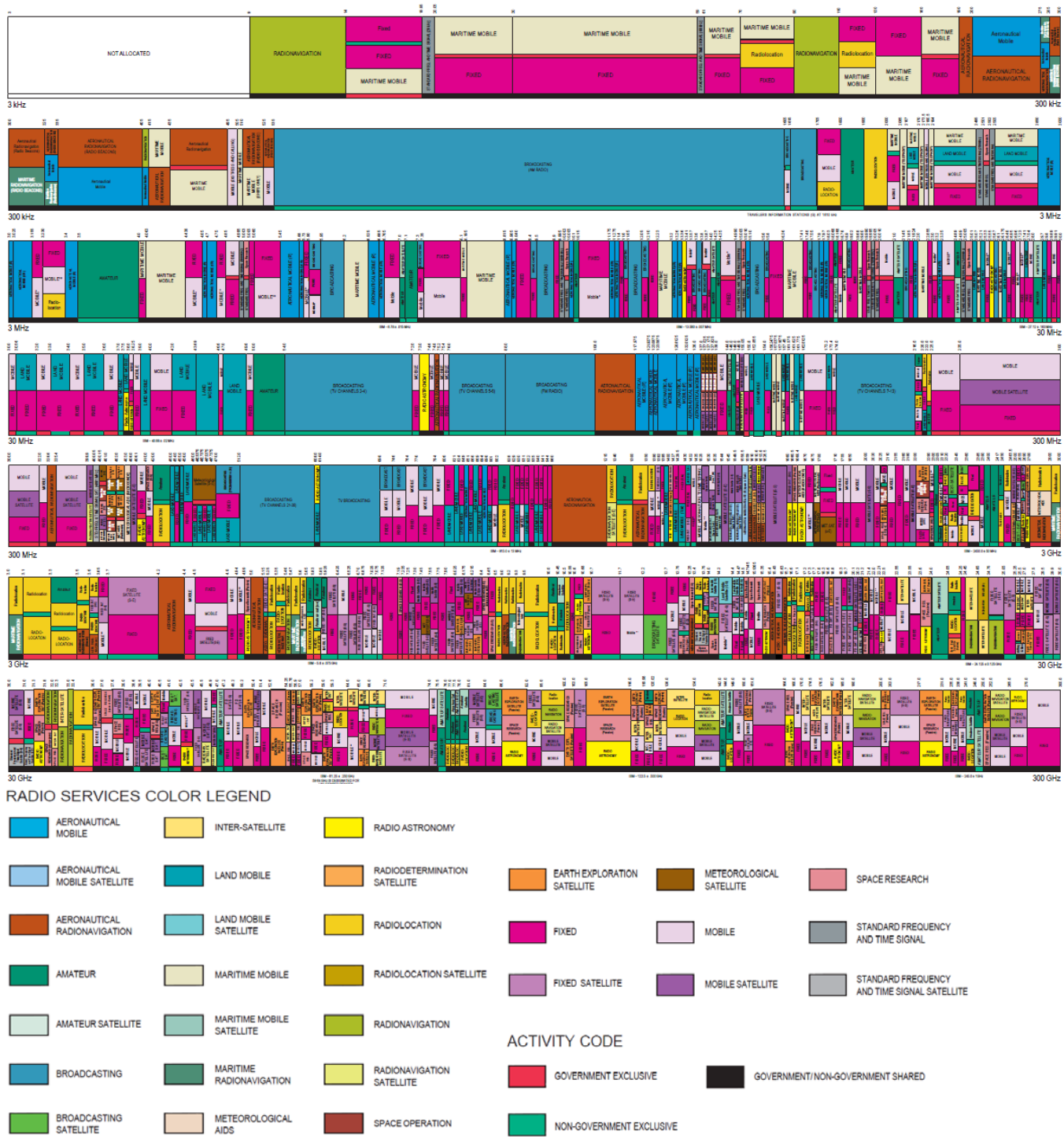

Figure 2: EMS allocation from 3 kHz to 300 GHz.

Electromagnetic propagation is the behaviour of radio waves when they are transmitted, or propagated from one point to another on earth, in water or in space. As a form of electromagnetic radiation, like light waves, radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering.

This propagation effects offers EW systems both advantages as well as disadvantages. Without going into too much detail on the subject, the important aspects are that the EM energy attenuates as a function of the distance squared as it travels through the atmosphere. Furthermore the lower the frequency, the more the signal is diffracted (bent) around/over objects (like the earth surface) and the higher, the more they tend to

be Line Of Sight (LOS) or a straight line. Between 1 and 30 MHz, the ionosphere can reflect the energy, and above 10 GHz water vapour (rain) has an significant attenuation effect on the signal. Atmospheric conditions, for example temperature inversions, can cause ducting, which can cause the EM wave to either propagates over longer or shorter distances, depending where the antennas are relative to the duct.

For radar signals that need to travel to the target and back as well, the atmospheric attenuation is proportional to distance to the power 4 – which leaves the ES receiver with a distinct propagation advantage, because the single has to travel in one direction only.

Due to these propagation effects, the effect of altitude above the surface have a pronounced influence on the number of signals that can be detected by an EW receiver. The higher, the larger the radio horizon, and the more signals will be visible. This, on the other hand, can be a distinct disadvantage, due to the large number of simultaneous emissions received, which can swamp the receiver's processing and recording capability.

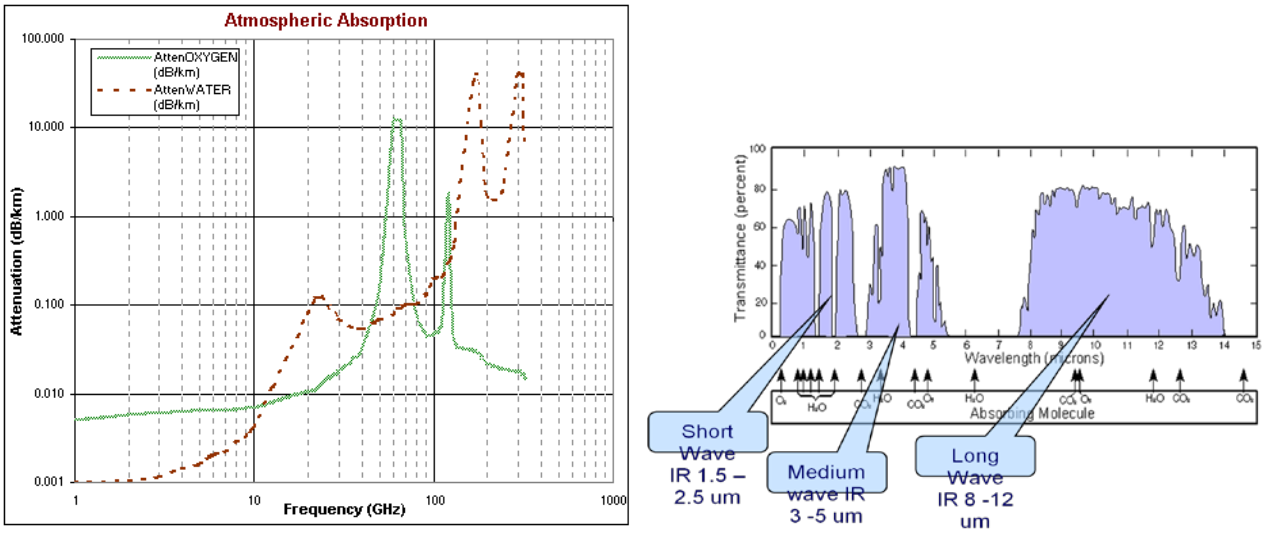

Figure 3: Atmospheric attenuation in the RF and EO regions - mostly due to oxygen and water vapour.

The electronic magnetic spectrum is going to become more and more key towards getting to the required influence effect, because it ties the various domains (land, sea, air, space and cyber) to the desired effect as shown in Figure 4.

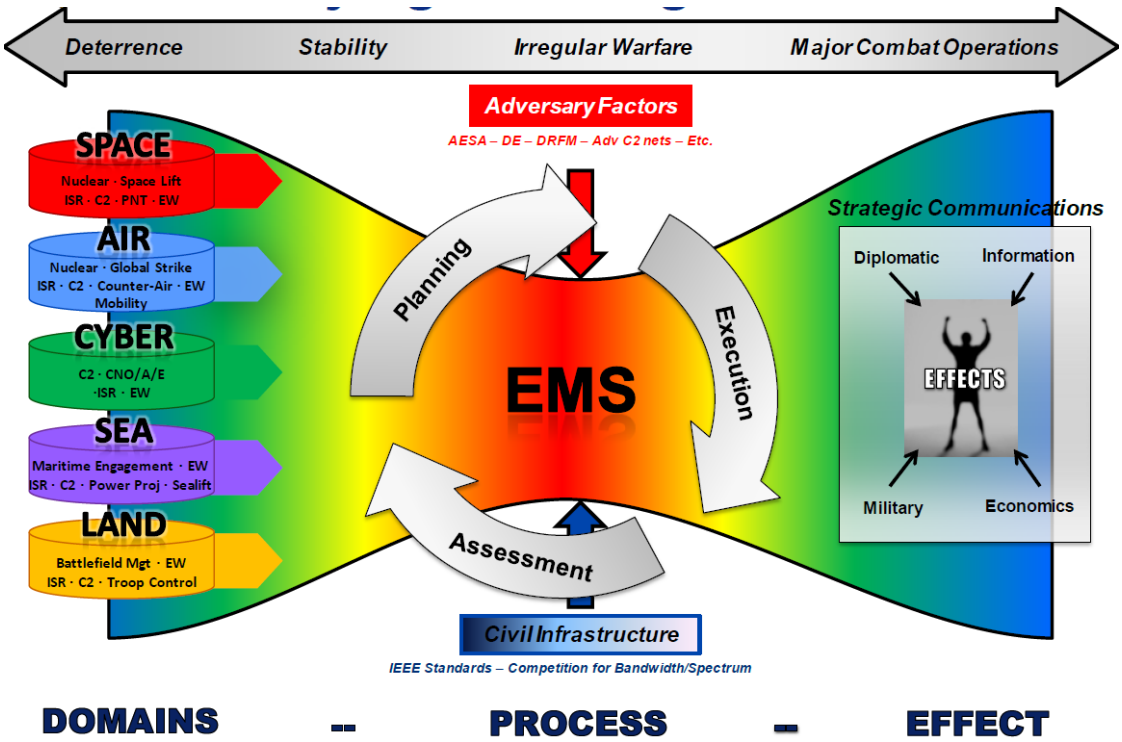

Figure 4: The EMS Choke Point - military only perspective.

In the past, defence focused on kinetic in their war plans. Recent operations has however shown that war plans should rather be on influence operations. The electronic magnetic spectrum is going to become more and more key towards achieving the required influence effect.

Encroachment remains a problem – there is no more wide-open spaces - people want to build things around them, have GSM, Wi-Fi, Wi-Max etc. and that is really affecting the environment. The military are more and more being challenged not to operate, or to operate in narrower frequency bands, and that's becoming increasingly more problematic.

The military and the civilian sector shares the same spectrum – so policies are required to ensure optimum utilization and interoperability. It is not simple to learn how to "speak policy" - How to explain to politicians and senior decision makers why they should care about the EMS?

The military remains fixated on big programs, which isn't the correct way anymore. Acquisition processes are getting longer whilst the adversary's acquisition cycle gets shorter. It's not large on large anymore, it's nimble on large, and it has to be nimble on nimble - it's a much more dynamic environment. The requirement is to get own capability into the theatre faster and cheaper whilst guarding against emerging technologies, and those scientific breakthroughs that'll make own previous systems obsolete.

Threats and Sensors are becoming more multi-function, multi-band, multi-mode (modeless), and more dynamic, and largely based on Commercial Off The Shelf (COTS) technologies.

Disruptive use of Commercial Technology:

- Disruptive thinking – rapid innovation using non-traditional technologies and concepts guided by technical experts.
- Commercial Technology Exploitation – modification of commercially available systems to rapidly develop and deploy new capabilities.
- Cost is coming down but the capability that we're being able to generate is increasing exponentially because we're able to network together so many things before that one couldn't.

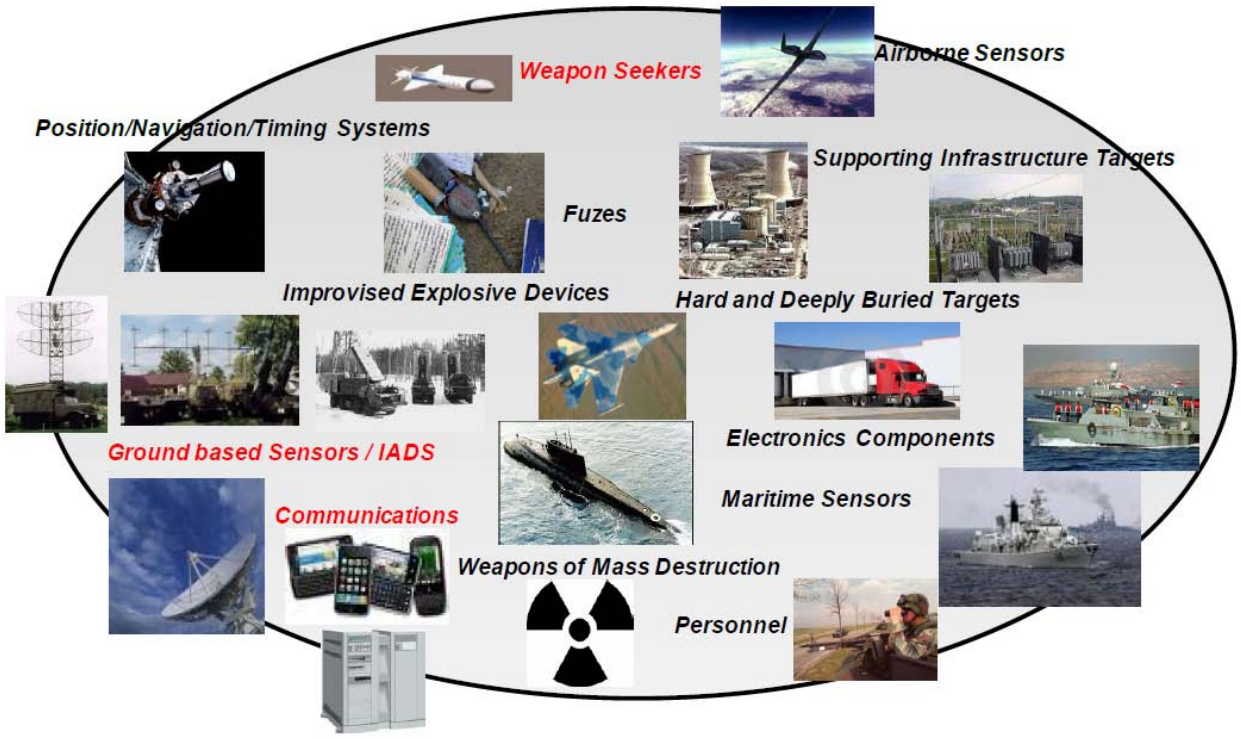

Figure 5: Advanced Concepts/technologies needed to counter increasingly diverse target set.

3G and 4G cell phone technologies have spurred a revolution in commercial electronic applications. These COTS solutions have allowed allies and adversaries alike to leverage cutting-edge capabilities without the extensive investments in resources and time. This creates a situation in which adversaries are able to identify their EW requirements earlier, acquire less-expensive systems faster and rapidly integrate those capabilities.

1.3 What is Electronic Warfare

Where the EMS provides the manoeuvre space that allows unified action across all warfighting domains, Electronic Warfare creates physical, informational, and cognitive effects through the use of electronic systems operating in the Electromagnetic Environment (EME) which create, control, exchange, and employ electromagnetic energy across the frequency spectrum.

The purpose of Electronic Warfare (EW) is to deny the opponent an advantage in the Electromagnetic Spectrum (EMS) operational domain and ensure friendly use of the EM operational domain at the time and place of their choosing.

EW effects can be delivered from any of the four natural Domains of Air, Sea, Land, Space and be delivered by manned and unmanned systems. EW is employed both to support and conduct military operations involving various levels of detection, denial, deception, disruption, degradation, protection, and destruction.

EW refers to any military action involving the use of electromagnetic (EM) and Directed Energy (DE) to control the EMS or to attack the enemy. Electronic Warfare consists of four elements: Electronic Attack (EA), Electronic Protect (EP), Electronic Warfare Support (ES) and EMS Control (EMC). EMC as part of EW is a new addition to allow for better effects based support.

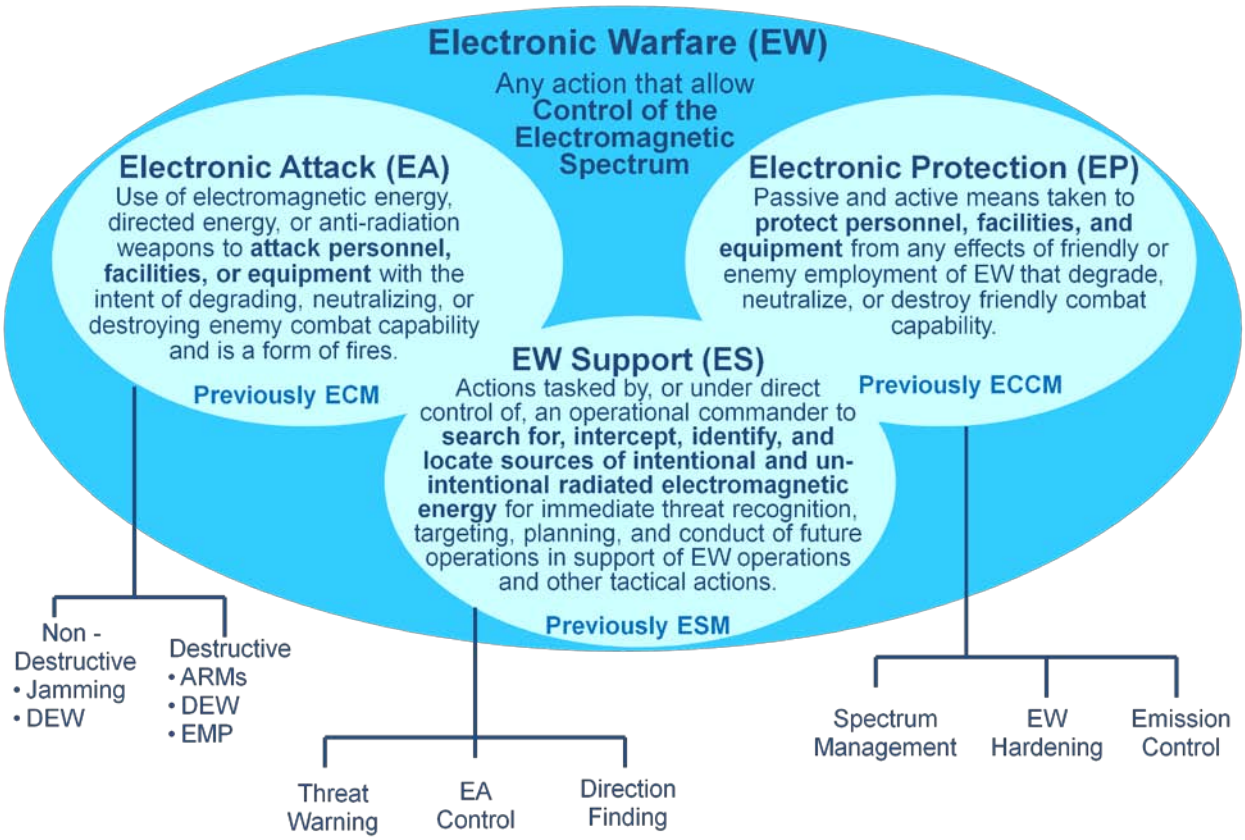

Figure 6: The Concept of EW (without the EMC component).

Electronic Attack (EA): Electronic Attack (previously referred to as Electronic Countermeasures or ECM) involves the use of EM energy, directed energy, or anti-radiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralising, or destroying enemy combat capability. EA can be offensive or defensive; offensive is self explanatory and defensive is focused on self-protection.

EA includes:

- Actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum, such as jamming and electromagnetic deception
- Employment of weapons that use either electromagnetic or directed energy as their primary destructive mechanism (lasers, Radio Frequency (RF) weapons, ultra-violet (UV), electro-optical / infra-red weapons (EO/IR), electromagnetic pulse (EMP) effects, particle beams, etc).