COGNITIVE ELECTRONIC WARFARE

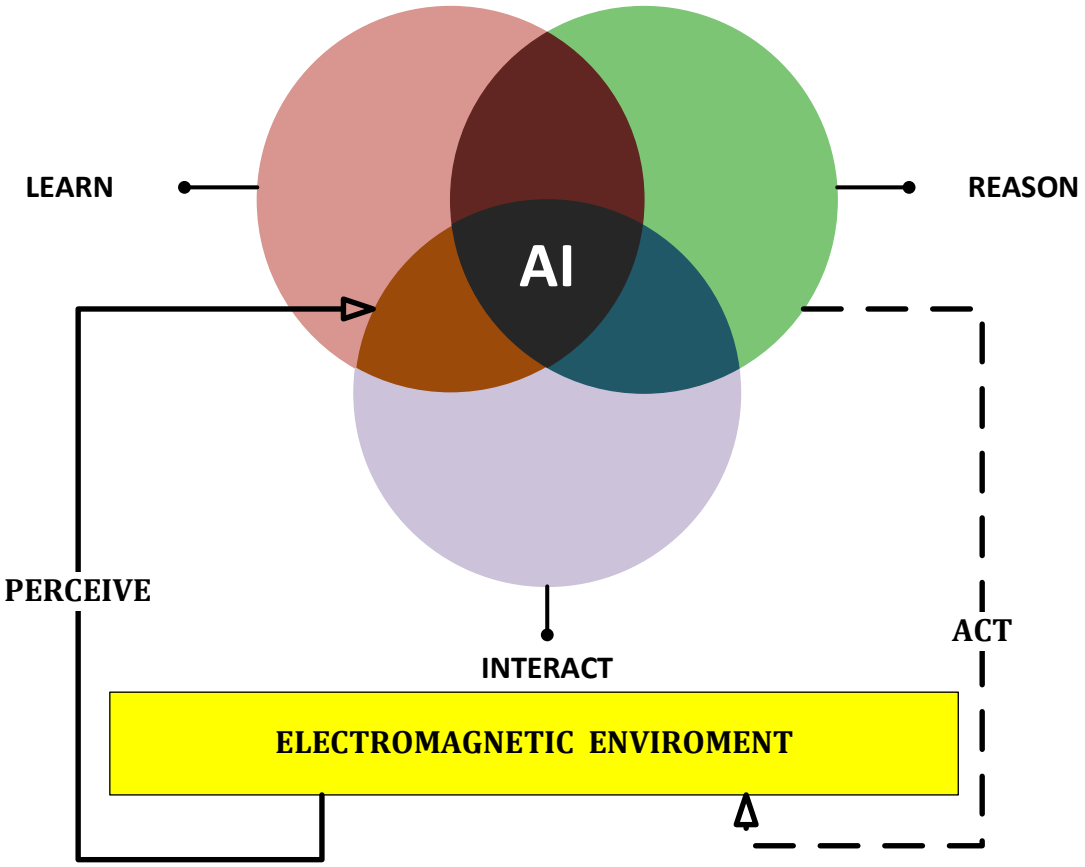
Time for detection, time to analyse, time to recognize, time to react. The constant variable is the time. Solution? Responding to incoming attacks with a precision and speed unachievable by human operators, automatically identifying, tracking, and assigning the best weapon to counter the threat, and, if in automatic, launching weapons to defeat it. Solution would be artificial intelligence algorithm?

As the threat evolves, specifically hypersonic missiles, the application of coordinated reactions requires synchronicity and timing that is difficult to apply to human capabilities. Such reactions require the control of Electromagnetic Emissions, weapons and Electronic Countermeasures control and Ships manoeuvring booth in force defence and self-defence

The challenges of modern EW are beyond the ability of traditional approaches to solve Incorporating AI techniques into EW systems is the only way to manage the complexity of this problem domain and its rapid timescales.

Creating a cognitive EW system is not a huge "all-or-nothing" hurdle.[i]

From an Artificial Intelligence standpoint, EP and EA differ only in their objectives: EP de-fines objectives with respect to oneself, while EA defines objectives with respect to the adversary. Likewise, AI is agnostic to whether the solutions apply to radar or communications problems. A cognitive system, or intelligence agent, perceives its environment and takes action to achieve its goals



ELECTRONIC SUPPORT (ES)

"Electronic warfare (EW) is any action involving the use of the electromagnetic spectrum (EM spectrum) or directed energy to control the spectrum, attack an enemy, or impede enemy assaults. The purpose of electronic warfare is to deny the opponent the advantage of, and ensure friendly unimpeded access to, the EM spectrum. EW can be applied from air, sea, land, and/or space by manned and unmanned systems, and can target humans, communication, radar, or other assets (military and civilian)." [ii]

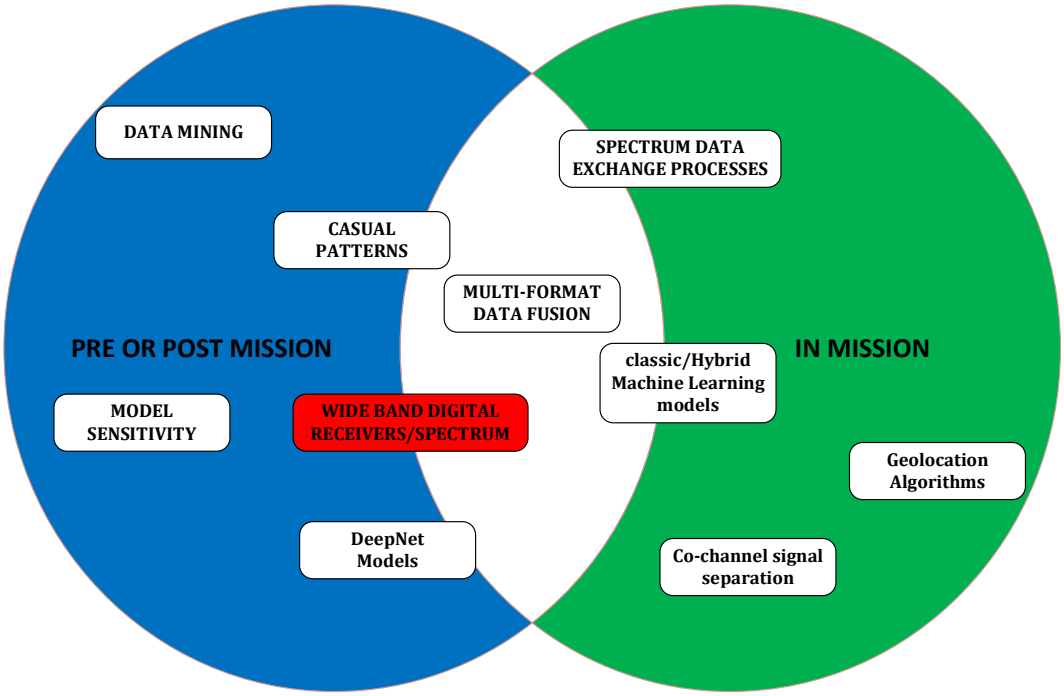
The first step in every cognitive EW system is ES to understand the RF spectrum. Known as situation assessment in the AI community, ES determines who is using the spectrum, where and when they are using it, and whether there are patterns that can be exploited.

AI/ML techniques that can be used for feature estimation, emitter characterization and classification, data fusion, anomaly detection, and intent recognition. ES analyzes the environment and creates the observables that drive Decision Maker (DM). The increasing complexity define Spectrum Situation Awareness (SSA) as "a means of collecting disparate information about spectrum use and processing this information to produce a fused spectrum picture." SSA collects, organizes, and processes the spectrum data required for EW. In addition to pre- and post-mission analysis, SSA needs to occur in rapid real time, according to the needs of the Decision Maker.

To reduce brittleness and handle novel emitters and adversaries, AI and ML capabilities can improve SSA at every level a view of these AI/ML technologies, in the context of other relevant SSA technologies. A complete EW system must have multifaceted SSA. Future SSA systems can be rained with deep learning models for latent feature generation, classical ML models for in mission-updates, and hybrid models to offset limited data.

Moreover, SSA does not have to solely rely on the RF data: It can be fused with non-RF data such as video and still imagery, free-space optics, or open-source, tactical, or operational intelligence.

Distributed data fusion across multiple heterogeneous sources must create a coherent battlespace spectrum common operating picture that is accurate in space, time, and frequency. Anomaly detection causal reasoning, and intent inference complete the picture to understand the impact of events and support DM



Electronic Support (ES)

The purpose of ES tasking is immediate threat recognition, planning and conduct of future operations, and other tactical actions such as threat avoidance, targeting, and homing. ES is intended to respond to an immediate operational requirement. [iii]

The first step in every cognitive EW system is Electronic Support to understand the RF Spectrum. Knows as Situation Assessment in the AI community, ES determine who is using the spectrum, where and when they are using it, and whether there are patterns that can be exploited.

Define SSA (Spectrum Situation Awareness) as “a means of collecting disparate information about spectrum use and processing this information to produce a fused spectrum picture.

EW comprises the following core concepts:

ES understands the spectrum—who is using it and how, when, and where.
ES needs to detect, intercept, identify, and locate EMS energy, understand how it is being used, and determine whether there are any identifiable patterns that can be exploited.

• **EP** involves actions taken to protect the friendly nodes from any undesirable effects due to changes in the spectrum such as jamming or noise.

This activity chooses strategies or countermeasures to maintain communications or radar performance.

EP conversations revolve around antijamming and radar countermeasure techniques; in this book we use EP equally to discuss techniques used to protect communication and radar systems.

Strategies may include frequency agility, waveform design, antenna direction, and signal processing to reduce jamming.

• **EA** denies the adversary access to its own RF spectrum. EA uses offensive EM energy to degrade or deny the adversary's access to the spectrum, or to deceive the adversary by conveying misleading information.

Deny, degrade, disrupt, deceive, destroy

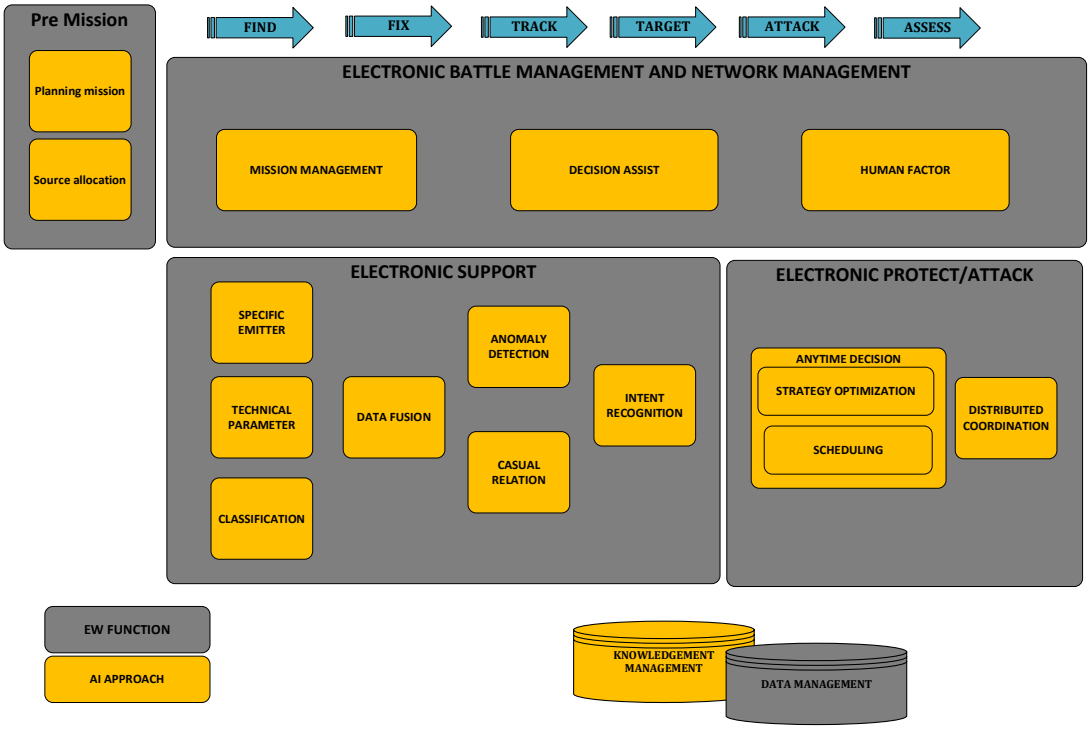
EBM (Electronic Battle Management) oversees all aspects of EMSO to increase mission effectiveness, including managing changing mission priorities, coordinating effects, and collaborating with other elements of mission command. A key aspect is to interact with and support the EW officer.

EW Domain challenges Viewed from an AI Perspective

Like any other intelligent system, Cognitive EW must overcome challenges associate with AI concept or stage of the cognition loop.

EW Activities and AI Counterpart

AI TERM	EW TERM
Situation assessment	Electronic Support
Decision Making	Electronic Protect and Electronic Attack Electronic Battle Management
Execution monitoring	Electronic Battle Management Assesessement
Learning	Electronic warfare reprogramming (data and software)



AI situation assessment, DM (Decision Making), and learning capabilities are relevant for all EW functions.

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[i] Cognitive Electronic Warfare Kareb Zita, Haigh Julia Andrusenko

[ii] Chairman of the Joint Chief of Staff, JP3-13.1 Electronic Warfare

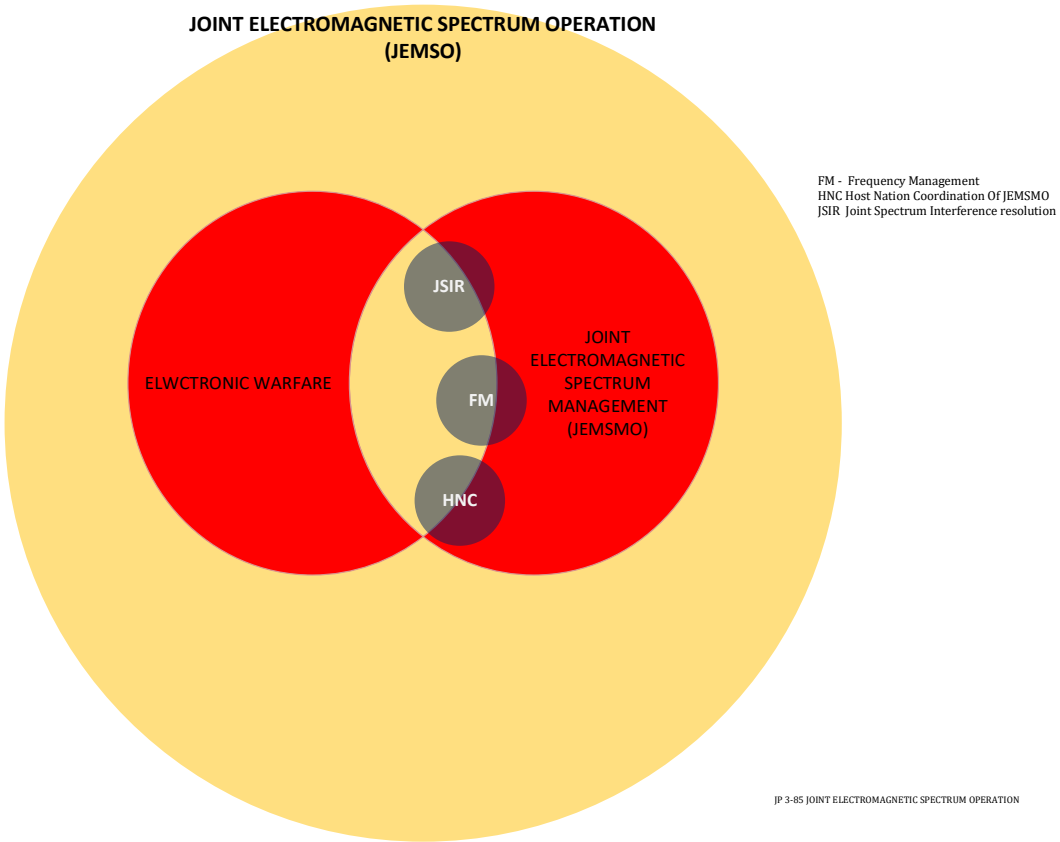
[iii] FM 3-36 Electronic Warfare

ELECTROMAGNETIC & SIGINT ENVIROMENT:

EMSO include all activities in military operation to successfully pla and execute joint or multinational operation in order to control the EMOE (Electromagnetic Operating Environment).

JEMSO is comprised of EW and JEMSMO (Joint Electromagnetic Spectrum Management Operations) and aims to exploit, attack, protect, and manage resorurce within the EMOE (Electromagnetic Operating Environment) and resolve EMI (Electromagnetic Mutual Interference) in order to achieve the commander's objective.

The primary goal of JEMSMO is to enable ES assets and system to perform their function in the intended environment without causing or suffering unacceptable *(JP 3-85 Joint Electromagnetic Spectrum Operation)*



Electromagnetic Environment (EME).

The EME is the actual EM radiation encountered in a particular operational area (OA). The EME is the resulting product of the power and time distribution, in various frequency ranges, of the radiated or conducted EM emission levels encountered by a military force, system, or platform when performing its mission in its intended OE. It is important to note that not all EM radiation encountered by joint forces will impact operations.

ElectroMagnetic Operational Environment

The EMOE is a composite of the actual and potential EM radiation, conditions, circumstances, and influences that affect the employment of capabilities and the decisions of the commander. It includes the existing background radiation (i.e., EME) as well as the friendly, neutral, adversary, and enemy EM systems able to radiate within the EM area of influence. This includes systems currently radiating or receiving, or thosethat may radiate, that can potentially affect joint operations.

The EMOE has the following attributes:

- Physical
- Pervasive
- Constrained
- Congested
- Contested
- Dynamic

Signals Intelligence. (SIGINT)

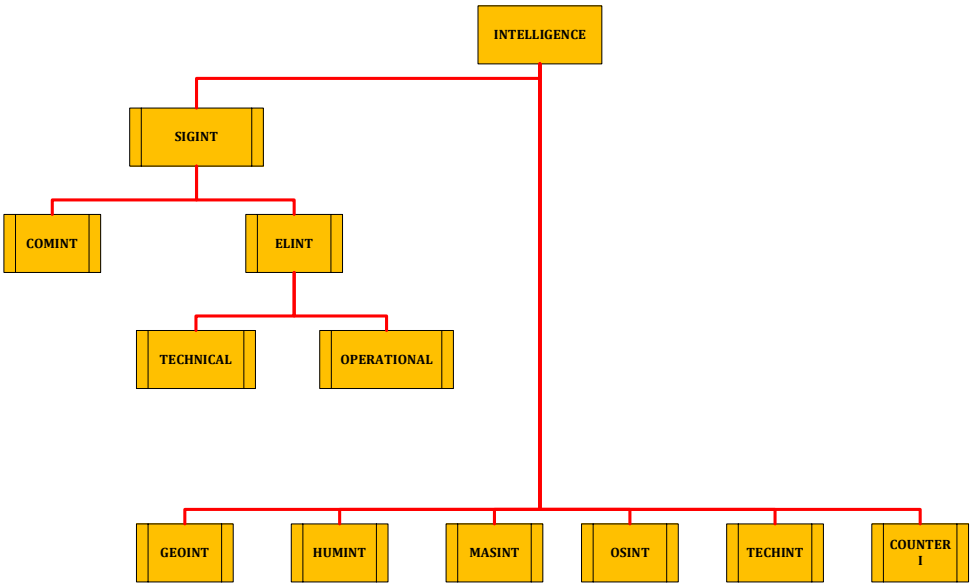
SIGINT is intelligence derived from the Electromagnetic Spectrum (EMS), and is defined as: The generic term used to describe Communications Intelligence (COMINT) and Electronic Intelligence (ELINT) when there is no requirement to differentiate between these two types of intelligence, or to represent fusion of the two'. COMINT and ELINT are respectively defined as:

COMINT is: 'Intelligence derived from electromagnetic communications and communications systems by other than intended recipients or users'.COMINT is typically derived through the interception of communications and data links. Such information may be collected in verbal form by the reception of broadcast radio messages, by the interception of point-to-point communications such as telephones and radio relay links, or as data through the interception of either broadcast or point-to-point data down links.

ELINT is: 'Intelligence derived from electromagnetic noncommunication transmissions by other than intended recipients or users. SIGINT is derived from the technical assessment of electro-magnetic non-communications emissions such as those produced by radars and by missile guidance systems. It also covers lasers and infrared devices and any other equipment that produces emissions in the EMS. By comparing information about the parameters of the emission that has been intercepted with equipment signatures held in databases, valuable intelligence about the equipment and its operator can be derived.

SIGINT is intelligence produced by exploiting foreign communication systemand non communication emitters.

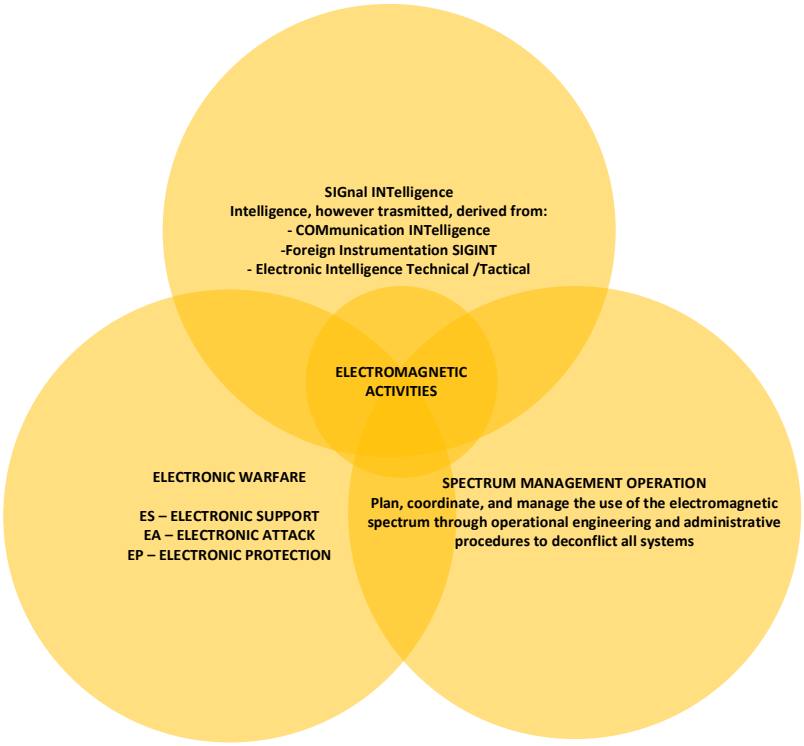
SIGINT provide unique intelligence information, complements intelligence derived from other sources and is often used for cueing other ensors to potential targets of interest



ELECTROMAGNETIC SPECTRUM OPERATION & SIGINT:

The coordination of heterogeneous operation is performed with Command & Control (C2) coordination system Joint Electromagnetic Spectrum Operation use the coordination of :

- Spectrum Management
- Electronic Warfare
- Signal intelligence



Electromagnetic Support and SIGINT.

ES is closely related to, but separate from, SIGINT.
The distinction between an asset performing an ES mission or an intelligence mission is determined by who tasks or controls the collection assets, what they are tasked to provide, and for what purpose they are tasked.

The distinction between ES and SIGINT is delineated by purpose, scope, and context. Operational commanders task ES assets to search for, intercept, identify, and locate or localize sources of intentional or unintentional radiated EM energy. In contrast a National Security Service, or an operational commander delegated SIGINT operational tasking authority, task SIGINT assets.

The purpose of ES is immediate threat recognition, support to planning, and conduct of future operations and other tactical actions such as threat avoidance, targeting, and homing.

ES is intended to respond to an immediate operational requirement. ES and SIGINT operations often share the same or similar assets and resources and may be tasked to simultaneously collect information that meets both requirements.
That is not to say that data collected for intelligence cannot meet immediate operational requirements.

Information collected for ES purposes is normally also processed by the appropriate parts of the intelligence community (IC) for further exploitation after the operational commander’s ES requirements are met.

As such, it can be said that information collected from the EMS has “two lives.”
The first is as Subprocesses information used by operational forces to develop and maintain Situation Awareness for an operationally defined period of time.

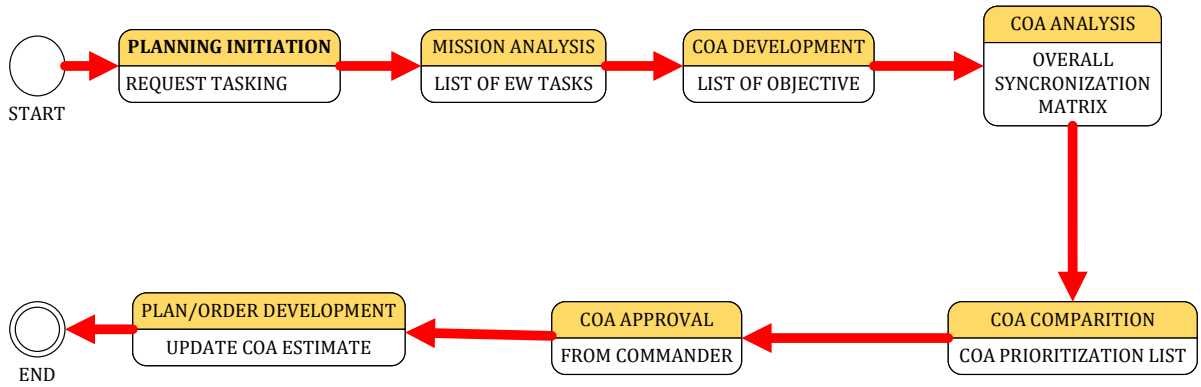
The second is as SIGINT, retained and processed under appropriate intelligence authorities in response to specified intelligence requirements.

SIGINT C2 & INTELLIGENCE PREPARATION BATTLEFIELD

Intelligence preparation of the battlefield is the systematic process of analysing the mission variables of enemy, terrain, weather, and civil considerations in an area of interest to determine their effect on operations. IPB allows commanders and staffs to take a holistic approach to analysing the operational environment (OE). A holistic approach

- Describes the totality of relevant aspects of the OE that may impact friendly, threat, and neutral forces.
- Accounts for all relevant domains that may impact friendly and threat operations.
- Identifies windows of opportunity to leverage friendly capabilities against threat forces.
- Allows commanders to leverage positions of relative advantage at a time and place most advantageous for mission success with the most accurate information available.

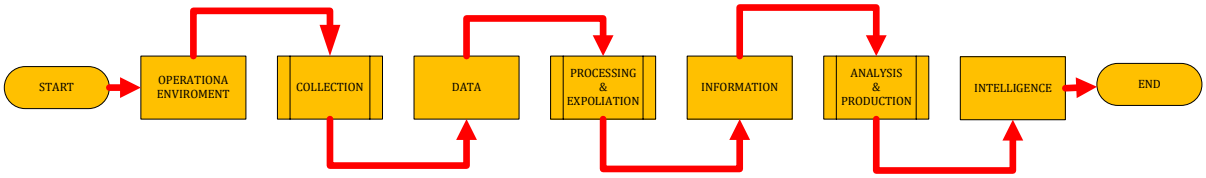
Planning process sequence



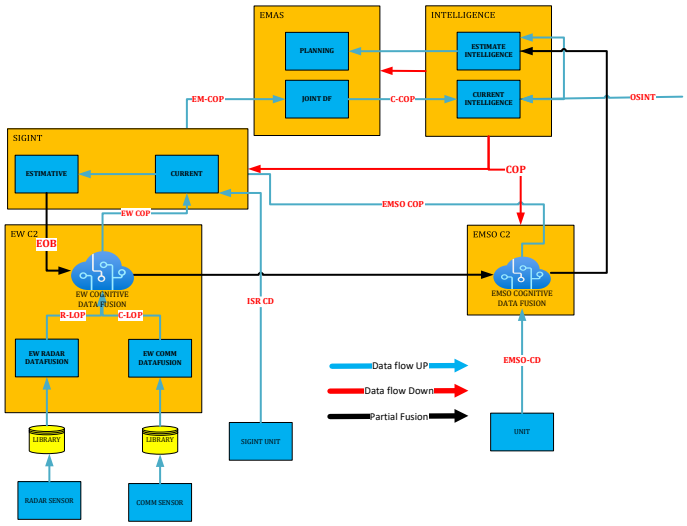
COMMAND & CONTROLL DATAFUSION PROCESS

One of the most demanding process in the display of proper information to the proper level is the datafusion.

Datafusion is the process that creates intelligence from operational environment . The process acts several level of the C2 stack. Higher levels have more fused and synthetic Common Operational Picture (**COP**)

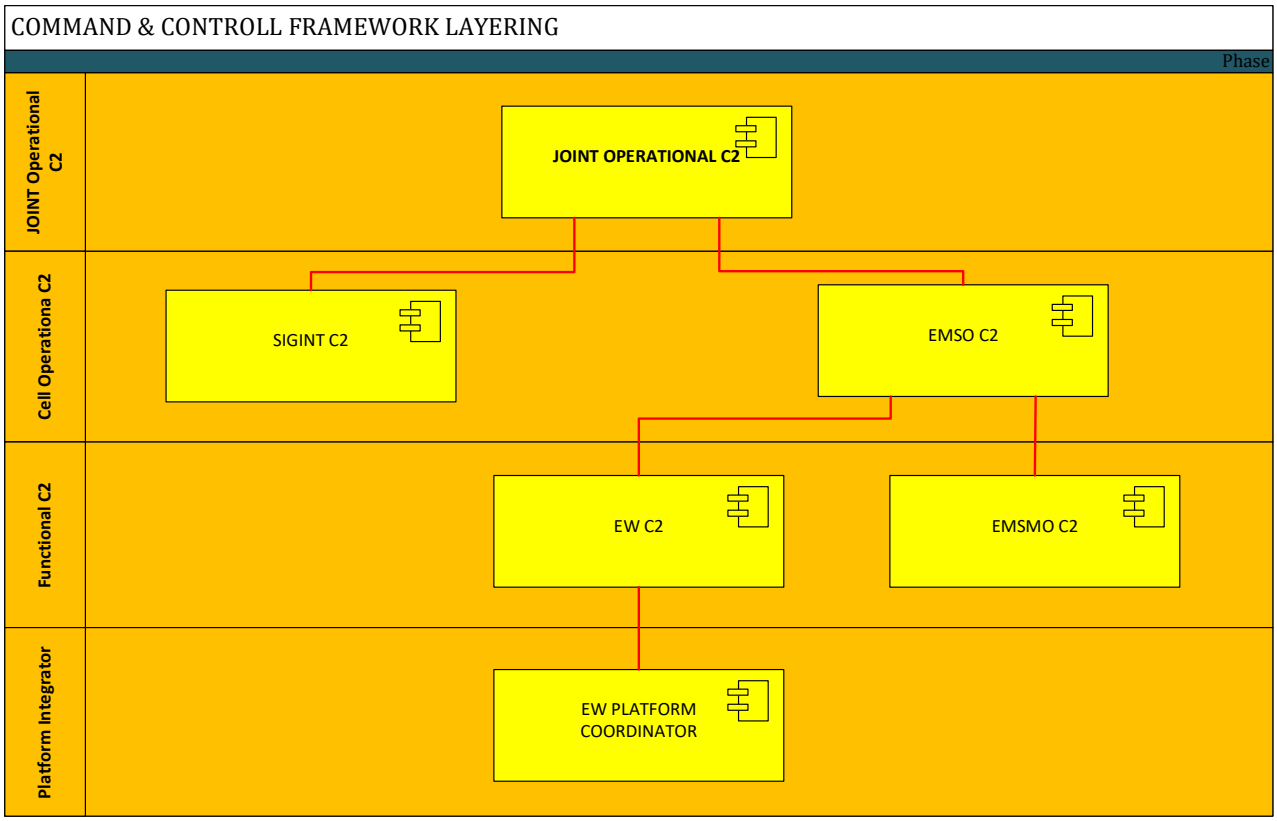


Many cognitive architecture learn rules of one form or another to help to make decisions. Many of these have been used in physical domains, such a fighter pilots the figure below shown C2 datafusion simple architecture



An overview of Command & Control layering in EMSO can be in brief resumed by the following figure.

Each Cell has a specific C2 specialised to plan, conduct ad review a specific operation with off course a dedicate staff.



CONCLUSION

No plan survives contact with the enemy, and no model accurately captures every detail of the environment. An EW system must respond to these unexpected, in-mission events and learn from its experiences. This chapter has discussed ways of achieving real-time in-mission planning and learning.

Specifically, it focuses on concepts of execution monitoring, in-mission replanning, and in-mission (machine) Learning. Unexpected observations, inferences, and changes must be promptly conveyed to the human users via the HMI.

Interaction with the real environment mandates constant oversight for planning, and it is the replanning that keeps the mission on track. Moreover, interaction with the real environment enables ML to improve empirical models; in-mission learning improves performance based on real experience.

Finally, execution monitoring closes the loop, because it ties he actions to the observations, the DM to the SA, and the EP/EA/EBM to the ES.

SIGINT must be included into ElectroMagnetic Activity to complete the Operational Environment dealing with Spectrum Management.

Information aggregation is highly automatable, DECISION NOT

The impact of a algorithm error or a fake data information can occur in seconds and be systematically estendend across the Command and Control system.

Introducing Artificial Intelligence, it’s a great step forward for grater improvement of the user but that should be used as a CONULTANT not a final Decision Maker.

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