Air Combat Electronic Warfare (EW) Concepts of Operations (ConOps) and Operational Requirements

Abstract

Nowadays, Modern Electromagnetic warfare has become necessary to be integrated into any combat and electronic warfare operations. The document offers an explanation of the concept of operations and operational requirements for AI-enabled EW about achieving surprise, protection mechanisms, real-time combat scenarios, formations of real-time combat aircraft, and how electromagnetic warfare helps in war field. It also elaborated on some key requirements that make the effectiveness of the EW operations, supported and referenced with images, case studies, and examples of real-time action.

1. Introduction

The technological progress has changed combat strategies and, in turn, electronic warfare operations. This document aims to provide information on Combat EW ConOps and the fulfilled operational requirements that can suit modern military scenarios.

2. Surprise in the Battlefield

Who will win the war what are the qualities required for winning the war

Surprise attack - According to Klausewitz(Prussian general and military theorist), the strategic surprise appears in war as a whole, and the tactical one – on the field of battle. There, the strategic one is more important for the achievement of victory, because a strategic advance, unexpected by the enemy, may lead to victory in the entire war.

- **Achieving Surprise:**
- **Speed**: Rapid manoeuvring is critical in surprising the enemy. AI algorithms optimise flight paths for maximum speed.
- **Stealth**: Advanced stealth technology and AI-driven tactics help in hiding aircraft from enemy radar.
- **Early Detection**: AI-enhanced sensors enable early detection of enemy units, providing a tactical advantage.
- **Swift Return**: Strategies for quick return to base after a mission to maintain operational readiness.

  Suprise attack on pearl harbour

  Trojan war

3. Countermeasures for a Surprise Attack

How to kill the surprise attack

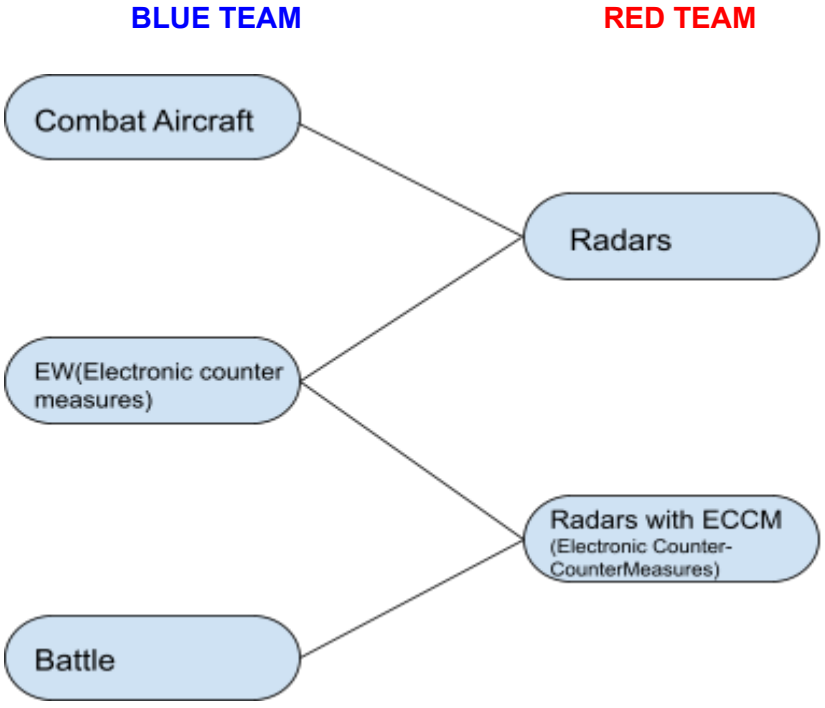
1. **Preparation and Early Warning:**
    - **Intelligence and Surveillance:** Continuously gather intelligence and use advanced surveillance systems like radars, satellites, and cyber monitoring to detect potential threats early.
    - **Training and Simulations:** Conduct regular training exercises and simulations to ensure readiness. Red teaming exercises can help identify vulnerabilities and improve defenses.

      Counter attack by US

2. **Rapid Response and Defensive Measures:**
    - **Quick Reaction Forces:** Deploy mobile and rapid response units to address threats swiftly. Pre-positioning critical equipment in strategic locations ensures quick access.
    - **Physical and Electronic Defenses:** Strengthen physical defenses such as bunkers and barriers. Use electronic warfare techniques to disrupt enemy communications and targeting systems

      For more detailed insights on counterattack

4. How a Aircombat starts



Radars with ECM and ECCM:

- **Electronic Countermeasures (ECM)**: Techniques to disrupt enemy radar.
- **Electronic Counter-Countermeasures (ECCM)**: Methods to protect friendly radar from enemy ECM.

5.Real-Time Battle Scenarios:

In a real combat mission, many tasks could be assigned to an aircraft: intercepting enemy fighters or bombers, dogfighting, or strike missions against ground targets. For instance, in an air-to-air mission, the radar detects an enemy plane at distance. After engagement, the pilot flies to gain a tactical advantage, manuevering to bring the aircraft behind the enemy for a clear shot. Advanced modern aircraft come with beyond-visual-range missiles that allow them to attack a target from a distance; however, close combat, or dogfighting, still requires brightly skillful maneuvering.

Real-Time Battle Scenarios:

- Integration of ECM and ECCM in combat operations.
- Real-time examples showcasing the effectiveness of these systems.

6.Duration of real combat

- Typically a aircraft combat missions does not take few minutes only it's all based on the mission
- In world war time mission can extend with help of in-air fueling
- B-2 (US Bomber) missions often lasted for more than eight hours and struck at targets deep within enemy territory. Because of their long-range capability

US bombing on Afganistan - full paper on how U.S bomber on Afganistan with B-2

Duration of real combat

Typical Mission Duration:

- **Fighter Missions:** Generally range from 1 to 2 hours but can extend to several hours with refuelling.
- **Bomber Missions:** These can last several hours, particularly for long-range strategic bombing runs.
- **Surveillance and Patrol:** Often last 4-8 hours or more, depending on the area covered and mission requirements.

7. What we need EW protection

EW Protection Necessity:

- Electronic warfare can also be considered as an invisible war.
- We need electronic warfare support and protection for a few minutes only.

8.Enemy Detection Methods

How do jet pilots confirm whether it's an enemy or friend at night ?

In all military aircrafts there is a system known as IFF (Identification of Friend or Foe) this system uses some sort of radio waves or radar waves in order to contact the approaching aircraft and confirm if it's a friend or enemy/ unknown aircraft. This system is linked to radar systems and other sensors so it can send confirmation code. If desired response is received then the aircraft is friendly and if not then it's an enemy / unknown aircraft.

> **There are some sort of techniques also used by adversaries to detect friendly aircraft:**

- Radar system
- ELINT-(electronic intelligence)
- IRST-(infrared search track)

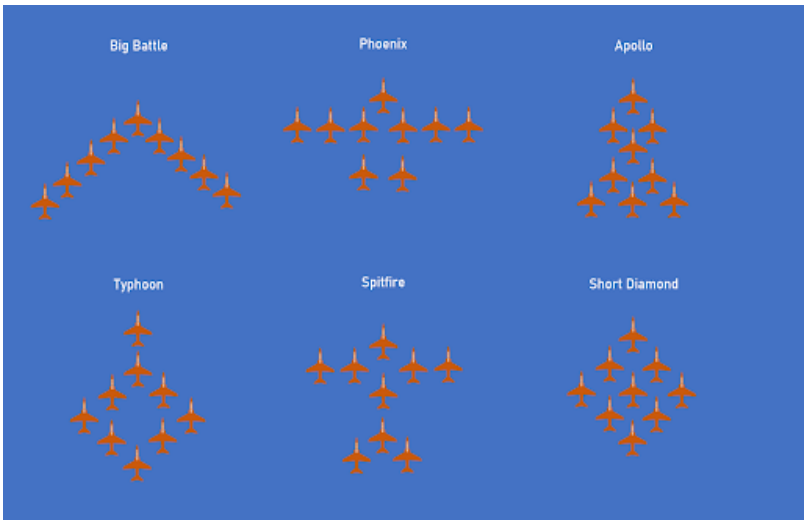
Battle and ConOps(Concept of Operations)

Definition and Purpose:

A generally accepted concept of operations typically describes any vision, goals, and operational strategies concerning a system or project. It gives details on how the system is intended to function, the tasks it is required to accomplish, and under which conditions it shall operate. On the lowest level of its usage, CONOPS explains exactly how the system is intended to be used and operated, hence communicating the operational framework in which a system is going to execute its mission to all stakeholders.

9. IN BATTLE:

Formations—formation flying—are one of the most basic precepts of military flying. They are useful in enhancing situational awareness, operational efficiency, force protection, and psychological impact while, overall, promoting safety. This explains its continued use in various military operations across the world. Operations in formation, preplanned, are executed according to plan.



- **Flying low** - flying low offers significant tactical advantages by reducing detectability, evading enemy defenses, and increasing the accuracy of strikes, thereby playing a vital role in modern combat operations.

Fly low to avoid detection by surface-to-air missiles

EW system saves pilots - Any modern military aircraft is equipped with an Electronic Warfare (EW) system. This is one of the most important systems for aircrew survival in combat. Here are the key ways that EW systems save pilots:

Threat Detection and Identification:

Radar Warning Receivers: Most EW systems are fitted with radar warning receivers that detect radar emissions from enemy air defense systems and aircraft. The receivers warn the pilot of the potential or actual threat, characterised by a missile-guidance tone or the 'break-lock' tone of hostile radar, hence allowing an opportunity to undertake evasive manoeuvres or dedicate countermeasures.

Electronic Counter Measures:

Jamming: Systems that can emit signals to interfere with enemy radar, virtually "blinding" it and rendering it unable to track or target the aircraft accurately. This can make all the difference between escaping a radar-guided missile or just evading detection in general.

10.Real-world Examples and Sources

- **F-22 Raptor and F-35 Lightning II**: These advanced fighter jets are equipped with sophisticated EW suites that include RWRs, jamming capabilities, and IRCM systems, showcasing the integration and effectiveness of EW in modern combat aircraft .
- **Operation Desert Storm**: During this conflict, coalition aircraft used EW extensively to neutralise Iraqi air defences, demonstrating the life-saving capabilities of EW in real-world scenarios .

- ## 11. Chaffs and Flares: The Last Line of Defense for a Flying Pilot

- Of all the countermeasures that any flying military pilot would fly with, chaff and flares are the most important to avoid enemy missiles and keep oneself safe during combat. These devices are often dubbed a last line of defense when an aircraft comes under direct threat from missile attacks.

- **Chaff:** Chaff comprises a number of small thin pieces of aluminium or metallic-coated fibres. These pieces scatter in the air and form a cloud that reflects radar signals when it is deployed.
- Chaff is normally released in bursts, and its effectiveness is entirely dependent on the timing and pattern of the release. Pilots mostly drop chaff in coordination with evasive manoeuvres for maximum effect.

- **Flares :** Flares are pyrotechnic devices that burn at high temperatures and emit high-intensity IR radiation.
- Flares are usually fired in patterns to optimum effect. Flares might be fired as the pilot is executing a hard turn or climb to further muddy the missile's tracking system. The combination of the high heat and aircraft maneuvering together makes for an unlikely scenario whereby the missile holds its lock on the aircraft.

Surface air missile

11. Operational requirement

Two broad requirements

Detect the enemy as early as possible: Aerial supremacy, also referred to as air superiority, is the degree of control of the air power in conflict exercised by one side over opposing forces. The different degrees and types of control of the air in aerial warfare number in the dozens. Control of the air is the aerial equivalent of command of the sea.

Enemy radar jamming: Radar jamming, together with electronic 'deception, is intended to confuse the radar operation with the introduction of incorrect information and noise. This is an intentional emission of radio-frequency energy. There are two types of radar jamming: electronic and mechanical.

–Electronic jamming is part of the warfare operation where jammers radiate sundry signals toward the radar of the enemy so that Signals interfere with its functionality. Repeater and noise techniques are the two most common important techniques used in this procedure.

– Mechanical jamming, you need tools that can rereflect or reflect their radar's energy back to it. Because of this technique, it gives the appearance that there is a false target. Corner reflectors, decoys, and chaff are three main components of tools that assist in mechanical jamming.

Those two requirements need the following chain requirement

Operational Requirements for Effective Electronic Warfare (EW)

Overview of Broad Operational Needs

Effective Electronic Warfare is one of the prime requirements of air superiority and protection of own forces while conducting combat operations. The basic operational needs for effective EW are to detect, analyze, and counter enemy electronic systems while having a like set capable of counter-counter measures to ensure friendly systems protection. Advanced technologies enhance these capabilities to ensure real-time decision-making and strategic advantages through AI and integration.

Chain of Requirements

1. Detection

Basically, the first step of EW operations is the detection of enemy aircraft and related electronic systems. This includes advanced methods and technologies of detection that can enter into service and identify potential threats at a very early stage.

2. Clustering

After the detection of signals, clustering techniques are applied to group these signals in such a way as to give meaning to effective analysis and understanding.

Effective clustering techniques mean that a system could identify multiple targets and their behaviours. Key approaches include:

Machine Learning Algorithms: Signals are classified under various unsupervised learning techniques, such as K-means clustering, in an unsupervised manner.

Example: Clustering algorithms in ELINT systems group radar signals to highlight which are unique radar systems and how they are being operated.

3. Generation of Radar Tracks

For assessing the adversary's movements and taking appropriate decisions, accurate radar tracks are needed. Raw radar data has to be processed and filtered to present coherent tracks.

4. Radar Classification

Radar classification refers to the process of identification of the type of radar and signal used. It's simply the form by which differentiation amongst a wide variety of radar types and signals is done so as to identify the generic nature and capabilities of enemy systems. Effective classification involves:

Analysis of signals: This is an examination into the characteristics of the radar signals, pulse width, repetition frequency, modulation type.

5. Precise Localization

A correct location of enemy assets is necessary for targeting and engagement. Precise localization involves:

• **Triangulation:** This is a process of determining the location of the source of a signal by using multiple sensors and calculating the time difference of its arrival.

• **Geolocation Algorithms**: Complicated mathematical models used to calculate the exact position of a target.

• **Integration with GIS**: localization data integrated into geographic information systems can help in creating a detailed situational awareness.

6. Jamming the Radar

This is yet another important aspect of EW. The techniques of jamming are:

Noise Jamming: A transmission of high-power noise with the purpose of saturating the enemy radar receiver.

Deceptive Jamming: The transmission of false signals with the view of misleading the enemy radar on target speed, position, and movements.

Barrage Jamming: This covers a wide frequency band to block the use of radar equipment of enemies.

Example: EA-18G Growler aircraft against enemy radar and communication devices using noise and deceptive jammers.

7. Identification of Radar

The ability to identify specific radar models and hence their potential capability accurately is extremely useful for EW operations.I

Conclusion

This document provides a detailed exploration of Combat EW ConOps and the operational requirements essential for modern military operations. The integration of AI in EW enhances the effectiveness and protection of combat aircraft, ensuring mission success.

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Appendix A: Glossary of Terms

- **Electronic Warfare:** The engagement of the electromagnetic spectrum for detecting, neutralizing, or degrading enemy electronic systems.
- **Electronic support warfare**: Actions that support countermeasures
- **Electronic Countermeasures:** Actions that prevent or seriously degrade an enemy's effective employment of the electromagnetic spectrum.
- **Electronic Counter-Countermeasure**: Techniques that secure friendly electronic systems against enemy countermeasures.
- **Radar**: A system using radio waves for the detection and location of objects.
- **Triangulation**: A technique of finding the position of a point by measuring the angles between it and known points, forming triangles to it from known points.
- **KJamming:** Intentionally sending radio signals that would interfere with the working of enemy radar equipment.
- **Clustering:** The process by which a set of objects is divided into classes or categories consisting of items similarly matched with each other.
- **Signal Processing:** A study that comprises an analysis, interpretation, and manipulation of signals.