Research on Kill Efficiency of Double Dogfight Weapon Fusillade in Complex Electromagnetic Environment

Hongli Lei
College of Astronautics
Northwestern Polytechnical University
Xi'an, China
Leihongli123@yeah.net

Zhaohui Hu
The Engineering Institute
AFEU
Xi'an, China
Huzhaohui123@163.com

***Abstract*—In order to improve the kill efficiency of the fighter aircraft under the complex electromagnetic environment, the anti-interference capability of all kinds of dogfight weapon is analyzed, a method of the double dogfight weapon fusillade is adopted to improve the kill capability of fighter aircraft. This paper builds up the attacking efficiency models of dogfight weapon, and proposes the optimized plan of the combination of the dogfight weapons by comparing the attacking efficiency, and provides the theoretical method to improve the kill capability of the fighter aircraft under the complex electromagnetic environment.**

Keywords-dogfight weapon; kill efficiency; double dogfight weapon fusillade; model

I. INTRODUCTION

The fighter aircraft usually gets better attacking efficiency by launching only one missile in the dogfight. However, under the complex electromagnetic environment, the attacking efficiency is greatly reduced owing to the influence of the electronic interference to the airborne radar and seeker [1][2][3].

In the certain condition, double dogfight weapon fusillade (DDWF) can improve the attacking efficiency by difference anti-interference capability of the weapons. In order to study the attacking efficiency of DDWF, this paper builds the models of the DDWF attacking efficiency, then estimates the combination plan of the DDWF, proposes the optimized plan of the combination of the dogfight weapons, and at last provides the idea to improve the kill capability of the fighter aircraft under the complex electromagnetic combat environment.

II. COMBINATION WEAPON PLAN IN DOGFIGHT

A. The Composition of Airborne Weapons Control System (AWCS)

The AFCS is used for searching, identification, capturing, escorting and aiming at target, it is used to control weapon launching direction, moment and density in the dogfight, and it can guide missile to hit the target. The AFCS mainly consists of the integrated radar systems, fire control subsystem and dogfight weapons, the composition of AFCS is shown in Fig.1. The integrated radar systems consist of radio radar, photovoltaic radar, HUD and helmets, which can search, identify, and escort target. The fire control subsystem is mainly used to control radar system and weapons. The dogfight weapons are used to attack the target, which mainly include infrared guided missile (IRAAM), active radar guided missile (ARAAM), passive radar guided missile (PRAAM) and gun pod.

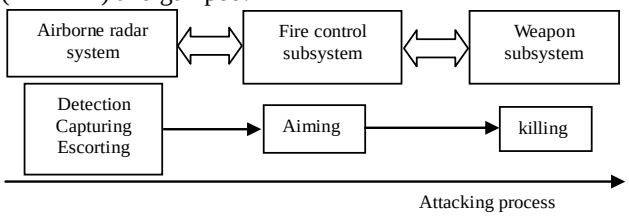

Figure 1. Attacking process of the AFCS

B. Combination DDWF Plan

The DDWF plan refers to launch kinds of dogfight weapons in order to improve the kill capability of fighter aircraft in one attacking.

In order to calculate the efficiency of DDWF in complex electromagnetic environment, first typical electronic jamming methods in dogfight must be comprehended, then the anti-jamming capability and launching requirements of various types of weapons must be analyzed, finally the DDWF efficiency is calculated.

1) Typical electronic interference: Electronic interference in dogfight mainly includes electromagnetic jamming and photoelectric jamming. The electromagnetic jamming includes deceiving, clutter, suppressing and etc, the target noise suppressing jamming is the main electromagnetic jamming. Photoelectric jamming includes decore, smoke screen, jammer, laser suppressing and etc, infrared decore is the main photoelectric jamming.

2) Anti-interference of dogfight weapon: IRAAM is the main weapon in dogfight, it has the merit of anti-all-electromagnetic jamming, and it has a little capability of anti-IR jamming. ARAAM and PRAAM are inferior to IR dogfight missile in motion, they have the merit of anti-all-infrared jamming, and they have a little capability of anti-electromagnetic jamming. The gun pod has the merit of anti-all-electronic jamming. The main characteristics of the various types of weapons is shown in Fig.2.

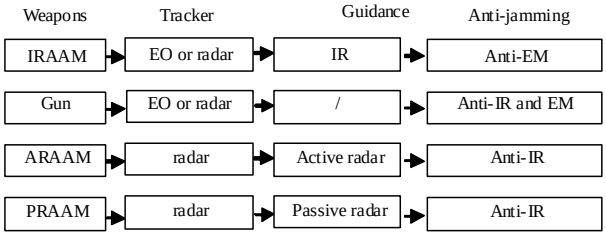

Figure 2. Typical dogfight weapons performance

3) DDWF in complex electromagnetic environment: According to DDWF plan, a fighter aircraft can launch two dogfight missiles during one attack, the DDWF plan is shown in Fig.3.

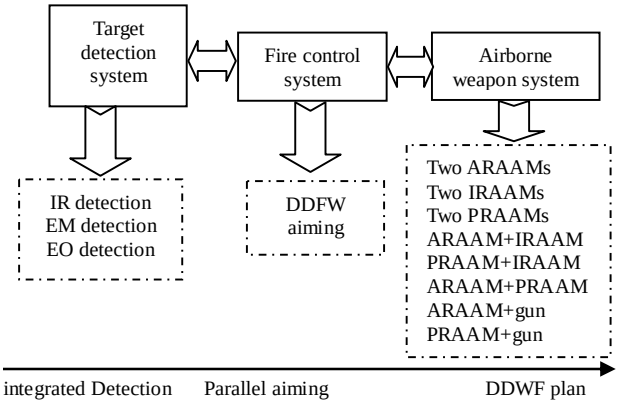

Figure 3. The DDWF plan

III. THE MODELLING OF DDWF EFFICIENCY

The attacking efficiency of the fighter aircrafts has relationships with the efficiency of many other subsystems, such as weapons, radar, and fire control system. The mobility and electronic jamming performance of target have some effect with the attacking efficiency [4].

The attacking efficiency of fighter aircraft is:

$$P_1 = P_r \cdot P_a \cdot P_m \cdot P_J \tag{1}$$

In (1), the P_1 is the attacking efficiency of fighter aircraft; the P_r is the efficiency of the radar system; the P_a is the efficiency of the fire control system; the P_m is the kill efficiency of weapon; the P_J is the target jamming efficiency.

The airborne radar efficiency includes the intercept and capture efficiency of integrated radar system in one attack [5]. The model is shown as follows:

$$P_r = P_{EO} \cup P_{radar} \cup P_{passive\_radar} \cup P_{see\ker} \tag{2}$$

In (2), the P_{EO} is the EO efficiency; the P_{radar} is the radar efficiency; the $P_{passive\_radar}$ is the passive alarming radar efficiency; the $P_{see\ker}$ is the missile guidance efficiency.

The AFCS aiming efficiency is the key in launching weapon when the integrated radar system capture and tracing a target. The aiming efficiency includes direction aiming efficiency and distance aiming efficiency, that is the probability of missile launching accurately.

$$P_a = P_{angle} \cap P_D \cap P_Y \tag{3}$$

In (3), the P_{angle} is the direction aiming efficiency; the P_D is the distance aiming efficiency; the P_Y is the efficiency of some conditions for launching weapon accurately.

The kill efficiency of weapons includes missile guiding efficiency and missile destruction efficiency.

$$P_m = P_{lead} \cap P_{de} \tag{4}$$

In (4), the P_{lead} is the missile guidance efficiency; the P_{de} is the missile destruction efficiency.

The gun attacking efficiency is:

$$P_G = \sum_{m=1}^{n} P_{nm} G(m) \tag{5}$$

In above equation, P_{nm} is the gun hit probability; $G(m)$ is the gun kill probability.

The jamming efficiency of the target includes the jamming efficiency to radar, missile seeker and the weapon fuse. The model is:

$$P_J = P_{J\_radar} \cap P_{J\_see\ker} \cap P_{J\_fuse} \tag{6}$$

In above equation, the P_{J_radar} is the jamming efficiency to radar; the $P_{J\_see\ker}$ is the jamming efficiency to the leading head; the P_{J_fuse} is the jamming efficiency to weapon fuse.

The interception and capture efficiency of the detecting system under electronic jamming is:

$$P_{J\_S} = (1 - P_J) P_r \tag{7}$$

The kill efficiency of the missile under effective interception is [6]:

$$P_{J\_m} = (1 - P_J) P_m \tag{8}$$

The DDWF efficiency of the fighter aircraft is:

$$P_2 = 1 - \prod_{i=1}^{2}(1 - P_{1i}) \quad (9)$$

In above equation, the P_{1i} is the kill efficiency of a type weapon.

IV. SIMULATION

A. The attacking efficiency parameter

1) Computing the kill efficiency of weapon: If the weapon efficiency is known, the weapon efficiency under jamming can be calculated by equation (4)-(6).

TABLE I. TYPICAL WEAPON ATTACKING EFFICIENCY

Weapon	Efficiency			
	No Jamming	*Noise Jamming*	*EO Jamming*	*Integrated Jamming*
ARAAM	0.63	0. 4	0.0	0.44
IRAAM	0.81	0.0	0.3	0.57
PRAAM	0.45	0.2	0.0	0.36
gun	0.5	0.0	0.0	0.5

2) Computing the efficiency of the target detecting system: If the target detecting system efficiency is known, the target detecting system efficiency under jamming can be calculated by equation (3) and equation (6).

TABLE II. TYPICAL DETECTION SUBSYSTEM PROBABILITY

Detection Subsystem	Detection Probability		
	No Jamming	*Noise Jamming*	*EO Jamming*
Radio radar	0.95	0.3	0.0
EO radar	0.92	0.0	0. 2
Passive radar	0.94	0.1	0.0
Passive radar seeker	0.93	0.2	0.0
IR seeker	0.9	0.0	0.3
Active radar seeker	0.85	0.3	0.0

3) Aiming efficiency of AFCS: Aiming efficiency of AFCS is assumed in Table III:

TABLE III. THE TYPICAL AIMING EFFICIENCY OF AFCS

Weapon	Aiming Efficiency
ARAAM	0.95
PRAAM	0.95
IRAAM	0.95
Gun	0.7

B. Analysis the weapons attack efficiency

1) Attack efficiency of a weapon: In dogfight, the Attack efficiency of a weapon in jamming environment can be calculated by equation (1)-(8):

TABLE IV. ATTACK EFFICIENCY OF A WEAPON

Detection Subsystem	Kill Efficiency		
	No Jamming	*Noise Jamming*	*EO Jamming*
a ARAAM	0.48	0.19	0.48
a IRAAM	0.64	0.64	0.25
a PRAAM	0.37	0.22	0.37
Gun	0.32	0.32	0.32

2) Attack efficiency of DDWF： In dogfight, Attack efficiency of DDWF can be calculated by equation (1)-(9):

TABLE V. ATTACK EFFICIENCY OF DDWF

Detection Subsystem	Kill Efficiency		
	No Jamming	*Noise Jamming*	*EO Jamming*
Two ARAAM	0.73	0.34	0.73
Two IRAAM	0.87	0.87	0.44
TwoPRAAM	0.60	0.39	0.60
ARAAM + IRAAM	0.81	0.71	0.61
PRAAM + IRAAM	0.77	0.72	0.53
ARAAM + PRAAM	0.67	0.37	0.67
ARAAM +gun	0.65	0.45	0.65
PRAAM +gun	0.57	0.47	0.57
IRAAM+gun	0.76	0.76	0.49

From Table V, same weapons fusillade can improve the attacking efficiency, and only different weapons fusillade can improve the attacking efficiency under complex electromagnetic environment.

V. CONCLUSION

This paper mainly analyses the efficiency of the DDWF in complex electromagnetic environment. By efficiency models, the optimized DDWF plan is calculated, it can improve the kill efficiency of the fighter aircraft under the complex electromagnetic combat environment.

REFERENCES

[1] Pei yun, “Analysis of the self-defence ECM system to fighter airplane’s operational effectiveness,” Electronics Optics &Control, vol.13, pp.19–24, June,2006.

[2] Sergei A. Vakin, Lev N. Shustov, Robert H. Dunwell, “Fundamentals of electronic warefare,” Publishing House of Electronics Industry, 2004.

[3] David L.Adamy, “Introduction to electronic warfare modeling and simulation,” PublishingHouse of Electronics Industry, 2004.

[4] Li Haijun, Liu Qiangchang, Zhou Lijun,” influences of electronic interference on the combat effectiveness of air-to-air missile,” journal of projectiles, rockets, missiles and guidance, vol.29, pp. 314-316, April, 2009

[5] Guo Wanhai, Zhao Zhe, “Efficacy evaluation of shipboard radar,” Publishing House of National Defence Industry, 2003.

[6] Fang Yangwang, Wu Youli, Fang Bin,”Airborne missile weapon system’s operational effectiveness,” Publishing House of National Defence Industry, 2010.