3 AIRCRAFT JOINT TEST TECHNIQUES FOR AIR TO AIR SEMI-ACTIVE RADAR-GUIDED MISSILE RADIO FREQUENCY INTERFACE

Yuan Huixin, Tian Fuli
Chinese Flight Test Establishment, Xi'an 710089,China

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Abstract

This paper presents the test technique and practical test method of the radio frequency interface between air to air semi-active radar-guided missile and on-board fire control system—3 aircraft joint test（3 aircraft refer to missile-carrier aircraft, illuminating aircraft, and target aircraft ）. It analyzes theoretically the technical difficulties of 3 aircraft joint test and put forward the solutions. Complex and practical problems are solved with engineering method. This technique can be used as a reference for similar works in the future.

Introduction

The Air-to-air semi-active radar-guided missile is guided by the airborne fire control system and the interface between the airborne fire control system and the semi-active radar-guided missile is called radio frequency interface. During the process of the missile guidance, the direct wave receiver locks the direct wave signal transmitted from the carrier while the echo receiver receives and locks the echo signal reflected from the target. The target information and the antenna control loop information are extracted and tracked at the same time. The echo receiver analyzes and processes the target reflecting wave signal received by the echo antenna to make the guiding head lock the target reflecting wave signal and send the control command, formed on the guiding rule, to the auto pilot[1]. Thus the target is tracked by the antenna array. According to the guidance principle of the air-to-air semi-active radar guided missile, the attacker must shoot the target and missile by the continuous wave continuously to guide the missile after the missile launching[2]. The quality of the radio frequency interface signal will affect the missile guidance process and the target accuracy. Hence the testing of the radio frequency interface must be implemented before the missile launching. This paper describes the testing methods of the radio frequency interface, the three aircraft joint test technique.

1 The nodi and Their Solutions of the Three Aircraft Joint Test Technique

The so-called three aircraft joint test technique is a method by which the radio frequency interface information of the fire control system is checked. Three aircraft refer to a target aircraft, a missile-carrying aircraft and an illuminating aircraft. The illuminating aircraft simulates the carrier and continues to shoot the continuous wave to the target and the missile after the missile launching to guide the missile to hit the target. The missile-carrying aircraft simulates the carrier to carry the missile and completes the binding work of the required parameters. Moreover it simulates the missile launching process and is capable of making the missile work normally and search and track the target. In the meantime the following tasks can be completed smoothly: the missile scans and

tracks independently with single aircraft on the ground, the missile searches independently with two aircraft on the ground, three aircraft joint test in the air and on the ground, the missile searches independently with two aircraft, and the missile searches and tracks independently and the missile dual flight with three aircraft in the air. On the basis of the analysis of the test process mentioned above, the following problems exist:

1) The interference in the missile's homing head caused by multipath effect;
2) The affection on the missile's signal receiving capability produced by wave cutoff;
3) The affection on the test made by the main wave beam leakage caused by the position drift of the missile-carrying aircraft;
4) The affection on the test produced by asynchronism and the same frequency.

In addition to the problem of the interference of the asynchronism and the same frequency, which can be solved within the system, the other problems can only be compensated by the proper test techniques. For instance, the multipath effect is the echo produced by the reflection of the antenna beam that shoots on the target (or ground) and scatters and is reflected by the ground (or target). When there exists the multipath effect, the frequency of the Doppler effect is dependent on the motion speed of the target, but the relative motion of the mixed wave element has the function of expanding the Doppler signal frequency spectrum. Strictly speaking, the Doppler frequency spectrum of the multipath effect is the double function of the motion of the target and the mixed wave. In the case of three aircraft joint test the wings and fuselage scatter further complicates the source composition of the mixed wave of the Doppler frequency spectrum caused by the motion of the mixed wave. While a few short flight tests are not enough for us to make clear the source composition of the mixed wave, the more flight tests can cost much. Hence the engineering method can be adopted, in which the tests will be carried out in proper sequence and gradually to avoid the problems that cannot be solved for the time being and seek the feasible flight test plans. The three aircraft joint test has been divided into the following six procedures in accordance with different purposes:

a. The missile ground scanning test
The V-shaped groove of the variable wave-absorbing material is used to detect the ambient electromagnetic environment of the missile to determine the affection of the multipath effect.

b. The missile ground-to-air tracking test
Check the sensitivity of the missile echo receiver and the missile tracking distance.

c. Double aircraft distance test on the ground
To make clear the interference of the multipath effect when the illuminating source is separated from the missile

d. Three aircraft joint test in the air and on the ground
Check the possibility of searching and capturing the target when the radars on both missile-carrying aircraft and illuminating aircraft are switched on.

e. Double aircraft joint test in the air
The flight of changing the altitude and the lateral distance is used to find out the locations of the aircraft to avoid the interference on the missile scanning produced by the multipath effect and the main wave beam leakage and get prepared for the three aircraft joint test.

f. Three aircraft joint test in the air
Verify the correctness of the radio frequency interface to get the evaluation result of the radio frequency interface.

2 The plan and procedures of the three aircraft joint test

2.1 The missile ground scanning test

There are three problems to be solved to make the missile scanning the sky properly. The first problem is the multipath effect interference. A V-shaped-groove vehicle of variable

wave-absorbing material is employed to make a good electromagnetic environment for the missile, which can not only shield the interference of the ground objects but also shield the scatter interference of the wings and fuselage. The second one is the realization of the coordinate conformity between the missile and the missile-carrying aircraft, which can be implemented by adjustment of the missile's relative position to the aircraft on the basis that the missile can receive the filed electric interface signal from the carrier normally. The third one is the carrier's capability that transmits the filed target echo signal to the missile, which makes the missile scanning properly and, after the simulated missile launching, lays the foundation for the grounding-to-air tracking test later.

2.2 The ground-to-air tracking test

The ground-to-air tracking test, in the process of establishing the normal scanning after the launch of the simulated missile, provides a target aircraft, which makes the missile guiding head change to tracking mode from the searching mode, and the alternative ground power equipment that can let the missile function properly. Fig. 1 is the ground-to-air tracking test.

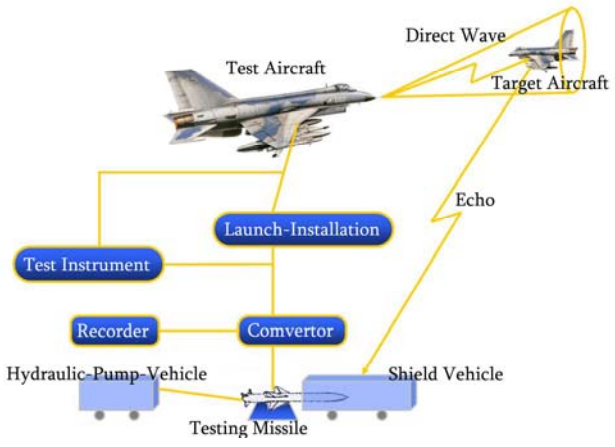

Fig. 1 The Ground-to-air Tracking Test

2.3 Ground distance test

To keep a certain distance between two aircraft is to avoid the direct wave affection on the missile receiver. While the missile-carrying aircraft is shot with continuous wave, the following inspections should be implemented: whether the test missile and the matching missile can coordinate normally; whether the missile can tune normally and establish the normal scanning after the launch; whether the telemetry system of the missile functions.

The purpose of the test is to make sure that the missile has a good tuning under the circumstance of the separation of the missile-carrying aircraft and the carrier and that the missile of the missile-carrying aircraft can search independently on the foundation of the reception of the filed information from the carrier under the condition that the illuminating aircraft carries out a continuous-wave shooting after the launch of the simulated missile from the missile-carrying aircraft.

2.4 The ground three-aircraft-joint test

The purpose of the test is to realize the active tracking of the target in the air after the simulated missile launching on the basis of the ground distance test and to check that if there is a frequency and asynchronous interference when the radars of both aircraft on the ground are switched on, which is a preparation for the layout of the three-aircraft-joint test in the air.

2.5 Double-aircraft-joint test in the air

Double-aircraft-joint test in the air should be completed to deal with the problem that the ground double-aircraft-joint distance test is able to make the missile tune and that it scans on the basis of the filed information after meeting the requirements of the simulated missile launching and that check the affection on the missile's scanning ability caused by the direct wave leakage, which is produced by the illuminating aircraft's shooting on the missile-carrying aircraft, and multipath effect, probing the real technical situation for the location layout of the three-aircraft-joint test in the air in the future.

2.6 Three-aircraft-joint test in the air

The test aim of the three-aircraft-joint test in the air is to carry out a through inspection on the direct wave of the radio frequency interface and

the quality of the echo signal of the wholly-weapon and fire control system. Fig. 2 is the diagram of the flight plan:

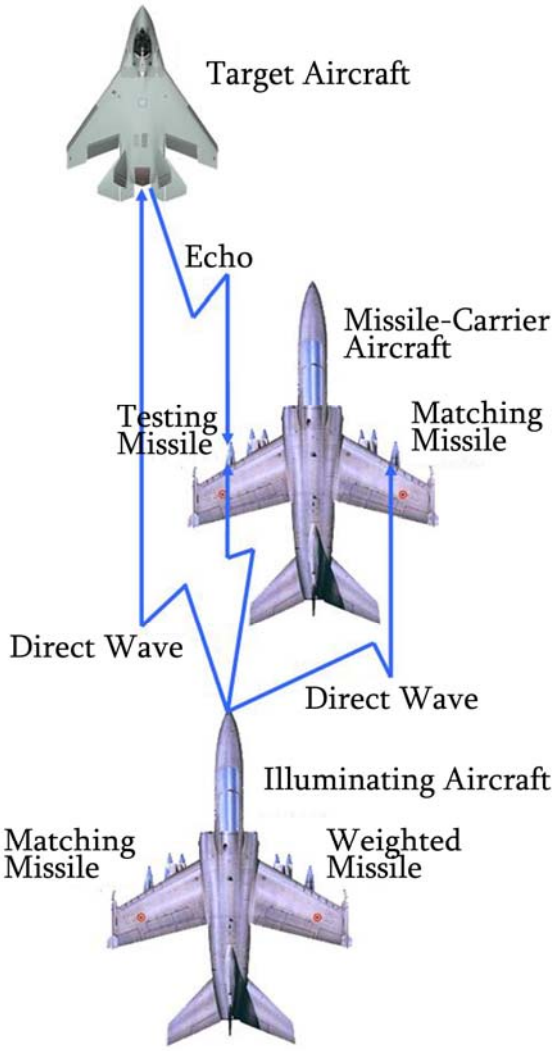

Fig.2 Diagram Of The Flight Plan Of Three-aircraft-joint Test

a) D is the distance between the missile-carrying aircraft and the target aircraft, Dzd is the distance between the illuminating aircraft and the missile-carrying aircraft, L is the lateral distance. The radars on both aircraft track the target steadily.
b) Three aircraft accelerate simultaneously when they finish the formation in the designated after take off. The velocity of the target is Vt0→Vt1 while the velocity of the missile-carrying aircraft and the illuminating aircraft is V0→V1. T stands for time.
c) The target aircraft decelerates, but the illuminating aircraft and the missile-carrying aircraft accelerate. The target aircraft begins to decelerate (Vt1→Vt0) when the missile-carrying aircraft reaches V1. The radio frequency system should be switched on and be kept under a stable working condition when the illuminating aircraft reaches V1. The missile-carrying aircraft and illuminating aircraft continue to accelerate (V1→V2) in the specific time period when the above velocities have been achieved.
d) When the illuminating aircraft reaches V2 and the distance between the missile-carrying aircraft and target aircraft is R, the pilot control the aircraft on displays and the system to meet the launching condition to simulate the missile launching and make the missile search the target automatically. Moreover, the data should be recorded.
e) In the process of chasing the target aircraft by the missile-carrying aircraft and illuminating aircraft and when the distance between the missile-carrying aircraft and the target aircraft is about ΔR, the relocation should be carried out till the conclusion of the whole test. Fig. 3 is the flight path.

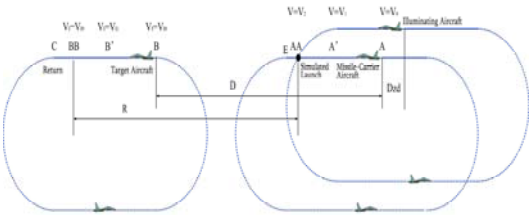

Fig. 3 The Flight Path Of Three-aircraft-joint Test

3 The Test Results Analysis

The integrated evaluation of correctness, efficiency and coordination of the radio frequency interface between the airborne fire control system and the missile can be implemented by analyzing the testing record and telemetry data (e.g. location of three aircraft, missile tracking distance, echo scanning and locking and establishment of relativity), and comparing the relative information one by one, such as the missile control command, with the corresponding requirements.

4 Conclusions

The three-aircraft-joint test results demonstrate that series test of the ground test, ground-to-air test, double-aircraft-joint test in the air and three-aircraft-joint test in the air is an efficient method to check the radio frequency interface of the missile fire control system, which can not only certificate the radio frequency interface but also provides the test data for a successful target practice. It can be used as a viable tool to check the radio frequency interface of the missile fire control system similar to the semi-active radar guided system.

Reference

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[2]Lu Yan and Zhu Peishen. *The Principles of the Aviation Fire Control*. 1st edition，1989.10

Author: Yuan Huixin, female, from Yu County, Researcher, M.s degree in Electrical Engineering, involved in Avionics and the Flight Test of the Weapon Fire Control System.