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Dynamic attack zone of air-to-air missile after being launched in random wind field

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Numerical calculation procedures;
Simulation analysis

Abstract A new concept is presented for air-to-air missile which is dynamic attack zone after being launched in random wind field. This new concept can be used to obtain the 4-dimensional (4-D) information regarding the dynamic envelope of an air-to-air missile at any flight time aimed at different flight targets considering influences of random wind, in the situation of flight fighters cooperated with missiles fighting against each other. Based on an air-to-air missile model, some typical cases of dynamic attack zone after being launched in random wind field were numerically simulated. Compared with the simulation results of traditional dynamic envelope, the properties of dynamic attack zone after being launched are as follows. The 4-D dynamic attack zone after being launched is inside traditional maximum dynamic envelope, but its forane boundary is usually not inside traditional no-escape dynamic envelope; Traditional dynamic attack zone can just be reliably used at launch time, while dynamic envelope after being launched can be reliably and accurately used during any flight antagonism time. Traditional envelope is a special case of dynamic envelope after being launched when the dynamic envelope is calculated at the launch time; the dynamic envelope after being launched can be influenced by the random wind field.

1. Introduction

The purpose of this paper is to present a new concept for air-to-air missile, dynamic attack zone after being launched in random wind field. This concept can be used in the air combats, because usually many flight fighters are attacked by a lot of air-to-air missiles when flight fighters fight against each other, and sometimes each fighter is attacked by hostile multiple missiles,[1–3] which are shown in Figs. 1 and 2, where h, x and z are respectively the altitude, longitude and latitude distance positions. To improve aggressive effectiveness of the air-to-air

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missiles in the capriccioso situation and unknown situation in near future of the air combat, there are too many problems to be solved, with the two problems listed as follows:

(1) The flight vehicles being attacked by missiles need to know the attack zones of each air-to-air missile at that moment in real time online. When cluster air-to-air missiles attack multitudinous coordinated aerial assault fighters, generally each air-to-air missile locks on and attacks a maneuvering flight target. In the anfractuous 4-dimensional (4-D) flight counter air, a target fighter maybe attacked by several air-to-air missiles. At this moment, this flight target vehicle can maneuver to break through interceptions and get rid of the assaults from all air-to-air missiles which can attack that target, as well as accomplish flight missions. Regarding all these air-to-air missiles, what is the attack zone information of each missile?

(2) Each air-to-air missile requires knowing the attack zones in allusion to different flight targets with their current flight statuses and some characteristics. In the situation of flight fighters fighting against each other, when two air-to-air missiles attack the same flight target, if the flight target has been destroyed by one of them, the other missile can attack the other maneuvering flight targets. Then, which maneuvering target should be attacked by this redundant air-to-air missile? This redundant missile can attack the flight targets which are inside the attack zone of the missile at this flight moment. So this redundant missile needs to know the attack zone regarding flight target statuses at this flight moment in real time online.

When cluster air-to-air missiles attack multitudinous flight targets, generally each missile locks on a maneuvering target and attacks the locked target until the missile gets or loses the target; but in the rough-and-tumble aerial warfare, the relative flight statuses including the relative positions and velocities between all missiles and each flight target are changing. Sometimes the attacked targets for all missiles should be redistributed, because this redistribution can make the missiles get better attack results.

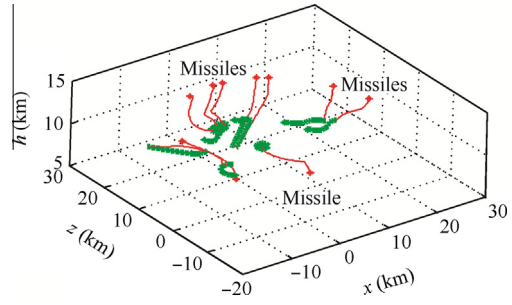

Fig. 1 A group of air-to-air missiles attack multitudinous flight targets.

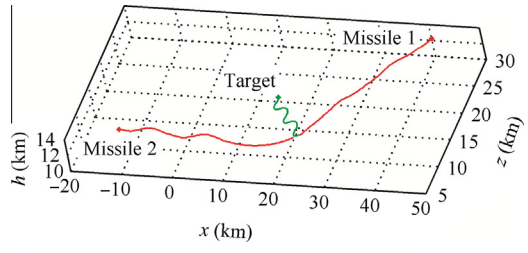

Fig. 2 Two missiles attacking one flight target at the same time.

Currently the dynamic envelope of air-to-air missiles or dynamic launch zone (DLZ) is just calculated at the launch time by the onboard computers in flight carrier of the missiles. According to the published papers, the attack zones of air-to-air missiles have been researched basically as the following aspects: (1) The high accuracy calculation regarding all kinds of dynamic attack zones for air-to-air missiles, such as the maximum envelope[4,5] and non-escape envelope,[6–8] as well as the launch envelopes for air-to-air missiles;[9,10] the envelope databases are obtained by this calculation for all possible initial conditions of missile and target at the launch time. (2) The approximated calculation of dynamic envelope or DLZ is in real time online, but the approximated DLZ is inside the acceptable error of curve fitting of air-to-air missile attack zones.[11–14] (3) The influences or sensitivity on attack zone boundaries or launch envelope because of all possible stochastic factors, such as the changes of air-to-air missiles launching conditions,[15] random wind field,[16] the errors of missile model,[17,18] etc. But currently there is not any paper in related to the dynamic attack zone of air-to-air missiles after being launched in random wind field. If the concept and flight numerical simulation are researched regarding the dynamic attack zone in random wind of air-to-air missiles after being launched, it is very important for aerial warfare based on flight fighters and missiles. The dynamic attack zones of air-to-air missiles after being launched in random wind are researched and analyzed in detail.

2. Problem formulation on dynamic attack zone after being launched in random wind field

Generally, the traditional dynamic attack zone of air-to-air missile is calculated according to the reference point when the aircraft is launching this missile. Based on the flight states including different entry angles of the flight target, the attack zone boundary can be calculated.

For the air-to-air missiles which can attack flight targets in omnidirectional directions, the attack zone is a continuous envelope which includes the reference point;[4] for the frontal attack air-to-air missile, the attack zone envelope is made up of inner, lateral and outer boundaries. To make a difference between the traditional dynamic attack zone and dynamic attack zone after being launched, the traditional dynamic attack zone is also called dynamic attack zone at launch time.

Definition 1. Dynamic attack zone of air-to-air missile after being launched in random wind field: an air-to-air missile was launched and flied along a trajectory to intercept a flight target, at the flight time t_s in this intercept process, based on the missile flight states including flight velocity and position vector, dynamic attack zone for this missile to attack the other flight targets. The reference point of this dynamic attack zone is the missile flight position at the flight time t_s. The dynamic attack zone after being launched in random wind field is described as