# BEARING-CORRECTED GUIDANCE WITH INCOMPLETE TARGET INFORMATION FOR OVER THE SHOULDER

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## Abstract

*A new guidance scheme, called bearing-corrected guidance with incomplete target information, or shortly bearing-corrected guidance, is proposed for Over the Shoulder (OTS) control procedure. The OTS here is designed for a typical compound guidance, which consists of the programmed guidance phase, inertial and data link guidance phase, and homing phase. The bearing-corrected guidance is introduced to the first two phases that are essential for a successful OTS. Lots of comparative simulation experiments and related analyses have been conducted. It has been shown that the bearing-corrected guidance offers a new promise for the OTS.*

## 1 Introduction

Over the Shoulder (OTS) control technology is an efficient strategy available for a fighter to attack targets, appearing from its rear area, by using missiles guided according to the fighter's on-board control and information processing system. For an OTS control process, the missiles are usually assumed to be launched forwards and then, based on a predetermined guidance rule, turn back towards the rear targets. The OTS is designed for a typical compound guidance, which usually consists of the programmed guidance phase, inertial and data link guidance phase, and homing phase.

Most fighters in existence are unable to detect rear target with on-board radar systems; even the so-called on-board warning systems may be used, the only information available is the target azimuth within a certain accuracy. However, traditional compound guidance requires the carrier fighter to offer complete information about the target status, such as distance and azimuth, etc.

Due to the difficulty of employing the traditional guidance scheme, we focus our attention on exploring the function, though limited, of the on-board warning systems. In this paper, a new guidance scheme, called the bearing-corrected guidance with incomplete target information, or shortly bearing-corrected guidance, is introduced to the first two phases. The motivation of the study on the bearing-corrected guidance is for finding a new way to control a missile to maneuver towards a rear target, based on the limited information available.

## 2 The Bearing-Corrected Guidance with Incomplete Target Information

For the problem under consideration, the available information includes the azimuth of the target, and the positions and velocities of the fighter and the missile. We define the attack plane as the plane determined by two vectors, the velocity vector of the fighter and the bearing line vector of the target, if these two vectors are not on the same straight line; otherwise, wingspan plane is regarded as the attack plane. The bearing-corrected guidance aims at keeping the position and velocity of the missile on the attack plane and controlling the missile to turn to the bearing line of the target.

Before launching, the carrier fighter bind the missile with the following data concerning:

- azimuth of the target;
- position of the fighter; and
- velocity of the fighter.

The attack plane is then set up by the on-board computer of the missile, and the missile is controlled according to the bearing-corrected

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guidance to complete the programmed phase in a prearranged time. During the inertial guidance phase, the fighter sends out the above data periodically as commands to the missile. The missile's on-board computer calculates a new attack plane when commands received. The following angles are used as errors to keep the missile flying in the attack plane:

- the angle between the attack plane and the vector pointing to the missile from the fighter, and
- the angle between the attack plane and velocity vector of the missile.

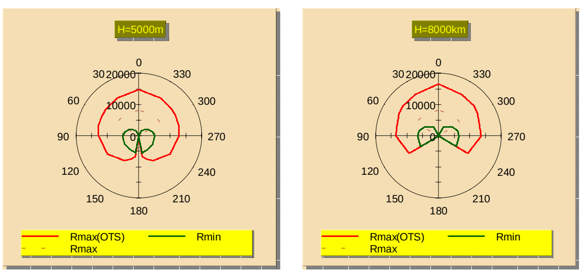
Also, the angle between the vector pointing to the missile from the fighter and the vector pointing to target from the fighter is used as an error to drive the missile to turn to the target.

## 3 Simulation Experiments

In order to verify the effectiveness of the new guidance scheme proposed above, a simulation modeling has been established and capture areas are obtained as simulation results.

Fig.1 shows the capture areas at altitudes of 5000m and 8000m, respectively. It should be noticed that all the capture areas are obtained under the hypothesis that the target pursues the carrier throughout the whole simulation process.

In the figures, the center of a circle




(a) H=5000m (c) H=8000m

Fig.1 Capture areas

represents the initial position of the carrier fighter. The numbers indicated along the circle represent different azimuths of the target. Directions 0 degree or 360 degree mean that the two fighters are head-on to each other, while direction 180 degree means that the target fighter tags after the carrier. Rmax (OTS) and Rmin denote the maximum and minimum distances, respectively. The sector enclosed by dotted line (Rmax) is the capture area out of which targets cannot be hit, if an OTS control procedure is not introduced.

From the figure it can be seen that, the OTS with the bearing-corrected guidance can extend the sector area to the new capture area enclosed by red line. Also, the OTS can make the carrier in capable of attacking the target successfully, provided that the target is flying within the capture area and is pursuing the carrier.

It is also clear that the available capture area varies significantly with the change of the altitude condition: the higher the altitude, the harder for the carrier to attack the rear targets.

## 4 Conclusions

In this paper, the bearing-corrected guidance with incomplete target information is addressed to perform an OTS control procedure. The performance of the proposed guidance scheme has been demonstrated and evaluated. Based on our experimental results and analysis, the following conclusions can be drawn:

1. The capture areas under different altitude conditions show that the presented guidance scheme can successfully accomplish the crucial mission in the OTS process, that is, to make a missile to maneuver towards a rear target fighter and then enter the homing guidance phase.
2. The effectiveness of the OTS depends strongly on the fighting altitude and the azimuth of the target fighter. Basically, the higher the altitude, or the larger the bearing, the lower the effectiveness that the OTS can achieve.
3. This guidance scheme can be employed to attack not only rear targets but also front targets, which offers more opportunities for a carrier fighter to attack targets.

## References

[1] F. Cai and X. Gao, Bearing-Corrected Guidance for over the Shoulder. *Journal of Flight Dynamics*, Vol. 18, No. 1, pp. 10-14, 2000.