Research on the Guidance Technology of Air-To-Ship Missile Attacking Nearshore Ship

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Abstract. In the complex nearshore context, attacking warship has been one of the important combat tasks to air-to-ship missile. Due to the island environment and anti-air facilities, hitting effect significantly decreases which calls for higher requirements for guidance technology. This paper hatches the development of air-to-ship missile used to attack nearshore warship, expounds vital guidance technology like the TV guidance technique, the man-in-loop infrared imaging guidance technology, multi-mode compound guidance, etc., and analyzes the trend of the guidance technology of anti-aircraft missile for nearshore combat, which can provide valuable technical reference for study of new type of air-to-ship missile and the nearshore combat.

Keywords: Air-to-ship Missile, Nearshore Battle, TV Guidance; Infrared Imaging Guidance, Multi-mode Compound Guidance

1 Introduction

In the modern war, the possibility of local high-intensity offensive and defensive operations relying on the background of the island is greatly enhanced [1]. The attack of nearshore targets has become an important combat task for anti-ship missiles, among which the air-to-ship missile with long range, great power and high precision is an important weapon to attack the nearshore ships.

The inshore combat environment is complex, with islands and reefs of different sizes, various artificial structures, dense forests and dense interlaced military and civilian vessels. Compared with the target attack in open sea area, the strike effect of air-ship missile is obviously reduced when attacking the target nearshore [2]. Therefore, guidance technology is vital for using air-to-ship missile to attack nearshore ship.

Main guidance technologies to ensure that the air-to-ship missile can accurately hit the ship are TV imaging guidance [3], infrared imaging guidance controlled by human in loop[4-5], multi-mode composite guidance [6-7] and synthetic aperture radar guidance[8-9]. This paper summarizes the development of foreign air-to-ship missiles for nearshore combat, and mainly introduces the principles, advantages and disadvantages of related guidance technology and the development trend. The typical regulation schemes can be exemplified as follows:
2 Nearshore Applications of Air-to-ship Missile

2.1 The United States
JAGM developed by Lockheed Ma in 2018[10] has initial operational capability. Dual-mode JAGM has all-weather combat capability after adding low-frequency millimeter wave radar. Passive infrared imaging guidance is added to form a three-mode seeker missile with laser semi-active/millimeter wave radar/infrared imaging. [11] The combination of these three modes enhances the anti-jamming and searching ability of the missile in the nearshore operation.

The LRASM adopts radar/photoelectric/infrared three-mode composite guidance technology, which can achieve high precision detection and tracking of the target, with a range up to 900 kilometers, as shown in Fig.1.

![Fig. 1 B-1B bomber dropping LRASM](image)

When sensing the electromagnetic signal of the enemy air alarm radar boot, the missile adopts sensors similar to passive RF devices, and classifies the electromagnetic signal based on the target identification algorithm. In the case of sensor and network interruption, LRASM missile can still achieve autonomous navigation and guidance.

Currently developed BLOCK3 [2] adds a new type of bi-directional onboard data link, and improves the target selection capability in the nearshore environment and the target positioning correction capability in the mid-course guidance process. The seeker’s newly added photoelectric imaging technology makes it suitable for the nearshore attack and target precision attack.

2.2 Other Countries
Russian Sandfly air-to-ship missile use radar seeker guidance technology interminal phase, and radio altimeter is used to measure flightitude in real time. The seeker uses passive mode first. When the active mode is disturbed, it changes into the passive mode. The seeker has strong anti-interference performance.

Japan’s supersonic air-to-ship missile XASM-3 with operational capability in 2016 adopts inertial/GPS intermediate stage guidance and active and passive radar terminal guidance. At the end of the trajectory, XASM-3 can effectively reduce the probability of being intercepted by sea skimming and flying.

Norway successfully developed JSM in 2018 adopting midcourse internal navigation and GPS/terrain matching auxiliary navigation, infrared imaging guidance and bi-directional data link in the last stage. It has advantages such as long detection range, accurate and stable wide field of view, strong anti-interference ability, etc.

3 Key Guidance Technology

3.1 Television Imaging Guidance Technology
The television imaging guidance technology uses the television seeker to search, capture, identify, locate and track the missile during the braking stage, and sends out the guidance signal to control the missile to aim at the target in real time until it destroys the target, The TV seeker is composed of
optical imaging system, platform servo control system, seeker structure, TV tracker, etc. The guidance process is shown in Figure 2.

Fig. 2 Process of TV guidance

Due to the successful development of infrared CCD, the wave length range of TV imaging guidance is extended to visible light and near infrared wavelength, which makes the TV imaging guidance not only have good guidance ability in the island area, but also have good effect in hitting the land target. The US AGM-65B and AGM-142 series air-to-ground missiles, Russian KH-59 series air-to-ground missiles and the Bristol RP8 air-to-ground missiles all adopt the TV guidance system.

Advantages: anti-electromagnetic interference, small size and mass of TV seeker, high guidance precision, no active outward radiation signal, good concealment.

Difficulty: It is extremely vulnerable to the influence of the weather, external photoelectric interference environment and other factors.

3.2 Infrared Imaging Guidance Technology Controlled by Man in Loop

The infrared imaging terminal guidance seeker is turned on to capture and search the target, and the complex background image of the nearshore is obtained. After selecting the target manually, the guidance signal of the seeker drives the missile control system to make the missile fly to the target. When the target is identified and tracked automatically by image matching, the operator will continue to observe the returned infrared image, change the attack point if necessary, and recapture the new target.

Fig. 3 The man-in-loop infrared imaging guidance

Take the use of SLAM missiles hitting ships in the US Navy as an example. The missile performs automatic flight under the control of GPS/INS integrated navigation equipment. When the missile has a range of about 1min from the target, the missile operator activates the infrared seeker of the missile and begins to search, identify and select the target. At about 20s before the missile hits the target, the missile control personnel uses the target locking procedure, selects the target point, and finally locks the target about 10s before the missile hits the target. After that, the missile will guide the target autonomously and carry out precise strike on the target.

Advantages: The missile is equipped with the ability to accurately identify and precisely attack the designated target under the complex background conditions near the shore and has good concealment.

Difficulty: The professional quality of the controller of the weapon system is highly required, and the detection range of the infrared imaging seeker is greatly affected by meteorological conditions.

3.3 Multimode Composite Guidance Technology

The multi-mode composite guidance technology uses one main guidance mode, combines two or more detection sensors, and gives play to the advantages of different frequency bands, different detection
mechanisms and different detection systems through the information interaction between sensors. The nearshore combat environment is complex, and when the air-to-ship missile attacks the ship, it meets the multilayer confrontation of the land, ship and air, and the nearshore ships have better concealing in the island environment.

Advantages: Compared with the traditional single-mode guidance weapon, the multi-mode composite homing guidance weapon integrates the advantages of single-mode guidance mode and significantly improves its combat capability.

Difficulty: The information of multiple modes with different characteristics should be compared and fused to determine which mode is the effective guidance mode and the mode switching technology in case of interference.

3.4 Synthetic Aperture Radar Guidance Technology

The synthetic aperture radar guidance technology is essentially the digital image matching region related guidance technology, which is an important method to improve the precision to hit the nearshore target [6]. Missile SAR terminal guidance principle is shown in figure 4.

Compared with traditional point and surface imaging radar, synthetic aperture radar has the advantage that it can image targets in complex large scenes and can output dozens or even millions of pixels of image information, which is convenient to distinguish ships from islands.

![Fig.4 Principle of SAR guidance](image)

Advantages: It is capable of all-weather detection throughout the day, with high range and azimuth resolution, providing the location, distance and azimuth information of the target, and imaging under various adverse weather conditions.

Difficulty: Based on the relative motion between target and radar, it is difficult to form high-frame-frequency gaze forward imaging due to the need of certain aperture and sampling time.

4 Further Development

4.1 Frontier Imaging Guidance

Under the offshore environment, islands are dotted which provide natural shelter for ships. Military and civilian ships confounding makes the target recognition more difficult. The current imaging guidance image resolution and the ability of gazing should be promoted and terahertz technology, quantum and metamaterials frontier disruptive technology are in urgent need to adapt to the nearshore complex operational environment, and improve the guidance precision, thus realize the "accurate targeted" attack.

4.2 Multi-missile Cooperative Guidance

Multi-bomb collaborative guidance technology refers to launching multiple missiles with different functions on different aircraft platforms, communicating with each other through the on-board two-way data link, sending back battlefield situation in real time, realizing information sharing, and achieving coordinated attack on the designated target in time, space, function and tactics. The situation of the island shore ships can be acquired by launching the forward guided missile and then transmitted back to the missile for guidance correction, so as to improve the ability of real-time detection and correction of the target and improve the accuracy of hitting.

4.3 Intelligent Composite Guidance
The intelligentization of intelligent composite guidance technology is reflected in the fusion of traditional guidance technology and new guidance mechanism and intelligent technology, as well as the free switch of various guidance modes according to the needs of combat. For example, Israel remote spike a new type of multi-band II missile seeker blending in artificial intelligence technology guidance technology integrates thermal and high-definition (HD) color image, and assembly of uncooled infrared sensor target tracking in artificial intelligence [6].

5 Conclusion
To sum up, since the 1980s, air-ship missile, as an important weapon for nearshore ships, has developed with the development of precision guidance technology and gradually acquired the ability to strike nearshore targets. The technology of television imaging guidance, infrared imaging guidance of man in loop control and synthetic aperture radar guidance have been relatively mature, and the development of multi-mode composite guidance technology still needs to be further improved. In the future, the air ship missile precision guidance technology will be developed into intelligent composite guidance, forward imaging guidance, and multi-bomb collaborative guidance, which can effectively improve the air ship missile's ability to strike targets near the island shore, improve the hunting accuracy of the predetermined targets.

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