Analysis of the operational characteristics of the US Aircraft Carrier Battle Group

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Abstract. According to the operational requirements of attacking the US Aircraft Carrier Battle Group, its defense capabilities are analyzed in this paper. Furtherly, the disadvantages of the defense capabilities are studied, and the effective means of defensive counterattack against the US Aircraft Carrier Battle Group are raised, which can be utilized to guide the operational applications of airborne weapons.

1. Introduction
On October 27, 2015, the U.S. missile destroyer “Larsen” broke into the 12 nautical waters of Zhubi reef in Nansha, China and carried out “freedom of navigation”, which opened a new stage for the U.S. challenge China’s maritime rights and interests in the South China Sea [1].

On November 21, 2019, the U.S. missile destroyer "Wayne Meyer" broke into the territorial waters of China's Xisha Islands for navigation, which became the 21st batch of U.S. warships to break into the 12 nautical miles waters of China's South China Sea Islands and reefs without the permission of the Chinese government in four years.

During the Spring Festival and novel coronavirus released in China in January 25, 2020, U.S. Navy “Montgomerie” battleship still entered the adjacent waters of Nansha island in China.

The U.S. Navy's unauthorized entry into China's territorial waters has been normalized. In addition, the defense system of the U.S. aircraft carrier battle group is nearly perfect, which makes it difficult to break the defense. It is necessary to take precautions to carry out the analysis of the operational characteristics of the U.S. Navy's aircraft carrier battle group in advance, so as to "know the other, and never lose a hundred battles".

2. Deployment and mission of US aircraft carrier strike brigade
After the Iraq war in 2003, the U.S. Navy reduced the composition of aircraft carrier strike group, renamed the aircraft carrier strike group, and took the aircraft carrier which is the primary protection target of air defense operations as the core combat [2]. The current standard carrier strike group mainly includes six ships: one aircraft carrier and its aviation coalition, one cruiser, two destroyers, one attack nuclear submarine and one combat support ship. The positions of each ship are shown in figure 1.
In air defense operations, the ships in the U.S. carrier strike brigade will be fan-shaped to semi-circular and circular along the "threat axis", and the escort forces will protect the carrier and combat support ship in the centre of the formation. One Ticonderoga cruiser as forward, usually 150-200km in front of the aircraft carrier, two Arley Burke class destroyers for protection, one Saramento class supply ship for combat support, and one Los Angeles class strategic nuclear submarine for anti-submarine and long-range strike missions. The E-2C airborne warning aircraft is usually 250-300km in front of the aircraft carrier (inside the anti-aircraft fire circle of the forward picket ship), flying at a height of 7.5km-9.15km, performing the detection and warning task. The typical carrier-based fighters F-35C and A/F-18 patrol at a height of 15km, 250-350km in front of the aircraft carrier, protecting the airborne warning aircraft and attacking the incoming fighters.

In the air defense battle position of the carrier strike group, the E-2C airborne warning aircraft is the air combat command centre, which is responsible for the forward and out operations and air-to-air interception operations of the carrier aircraft. The Ticonderoga cruiser is the command center of the carrier strike group, which is responsible for the overall defense and attack operations. The Alec Burke destroyer is mainly engaged in air defense, anti-missile and anti-submarine operations. The aircraft carrier is the core of the main strike force, it is responsible for the task of external strike.

3. An analysis of the defense forces of the U.S. aircraft carrier strike brigade
The core of ground attack of carrier strike brigade is aircraft carrier, and the core of air combat is carrier based airborne warning aircraft [3], and the core of air defense is formation picket ship [4,5]. Generally, the carrier is at the core of the formation, protected by air plane, surface ship and underwater submarine in multi-dimensional and Stereoscopic way, and has strong anti-destruction ability, so it will not be the first round of attack target.

Airborne warning aircraft of aircraft carrier is in the defense range of several fighter escorts and surface ships such as picket ship. It needs to use advanced long-range high-speed air-to-air missiles to attack and perform air defense tasks.

In order to increase the depth of defense, the picket ship is at the forefront of the formation, with the closest attack distance, and the joint defense strength of other ships is relatively low, which is the preferred target of the first round of attack. In the air defense operations of the carrier strike brigade, the Ticonderoga class cruiser is used as the forward picket ship. If the sentry ship is destroyed, the command center of the carrier strike brigade and the surface air defense protection capability of the airborne warning aircraft will be destroyed.
4. **Analysis of the combat capability of the Alec Burke class destroyer[picket ship][ airborne warning aircraft]**

With the service of the new generation of Alec Burke destroyer, its battle command system also has the war zone command capability of the Ticonderoga class cruiser. Therefore, according to the U.S. Navy plan, since 2020, the Alec Burke class destroyer will be gradually used to replace the Ticonderoga class cruiser. Before 2035, all the Ticonderoga class cruisers will be decommissioned.

According to the position distribution of the aircraft carrier members, the detection distance of the ship borne radar of the picket ship is 460km, and the E-2C airborne warning aircraft is 100-150km from the picket ship [6]. It can detect 350-450km of low-altitude fighters in front and 600km of high-altitude bombers.

Weapon penetration process: F-35C and A/F-18 fighters perform air defense tasks, intercept 750km and 600km enemy fighters in front of the picket ship, and do not have the anti-missile ability to intercept cruise missiles flying at ultra-low altitude. Therefore, the main intercepted threat faced by the weapons penetration process is anti-missile weapons of Alec Burke destroyer defense system as shown in figure 2. The main weapons on board the Burke destroyer includes: SM-6 interceptor, SM-2 interceptor, RIM-7 sea sparrow missile, RIM-116 ram missile and phalanx close-in weapon system. The detailed intercepting capability is shown in table 1.

![Alec Burke class destroyer defense zone](image)

**Figure 2. Basic capability of destroyer weapon.**
Table 1. Interception capability.

| Weapon          | Range (km) | Speed (Ma) | Warhead                |
|-----------------|------------|------------|------------------------|
| SM-6 missile    | 230        | 3          | Mk-125                 |
| SM-2 missile    | 150        | 3          | Mk-125                 |
| Sea sparrow     | 15         | 2.5        | High energy focusing   |
| missile         |            |            |                        |
| Rahm missile    | 9          | 2.5        | WDU-17B                |
| Phalanx         | 1.5        | 4500 per minute, initial speed 1100m/s | Shell piercing projectile |

It can be seen that in the process of approaching the target, when the weapon is within 230km from the target, it will be intercepted by a SM-6 missile. When it is within 150km, it will be intercepted by SM-6 and SM-2 missiles. When it is within 15km, it will be intercepted by a Sea Sparrow missile; when it is within 9km, it will be intercepted by a Hiram missile. When it is within 1.5km, it will be intercepted and threatened by the Phalanx close-in weapon system.

5. Analysis of the combat capability of the Alec Burke class destroyer

Although the Burke class destroyer has constructed a multi-level missile interception system including SM-6 missile, SM-2 missile, sea sparrow missile, Rahm missile and phalanx close-in weapon system, as well as a wide area detection system with advanced shipborne radar and airborne warning aircraft, it still has its defense weaknesses.

Detection blind area: the height of shipborne radar is limited to 18m. Although the detection distance can reach 450km, the distance between the detection line of sight and the sea level tangent point is only 15km due to the influence of the earth curvature. When the distance exceeds 15km, curvature occlusion begins to occur. The height of curvature occlusion at the distance of 450km can reach 15km. Therefore, the target shipborne radar can hardly find the other aircraft within this range. Although the airborne warning aircraft can effectively reduce the earth's curvature occlusion through forward and middle and high altitude down detection, there is still a detection blind area affected by forward out distance and flight height factors. According to the battle positions of the airborne warning aircraft and the picket ship, the detection distance of the airborne warning aircraft to the sentry ship is 350km-450km (for missiles), 550km-750km (for aircraft), and the flight height of the airborne warning aircraft is 9km, the curvature shielding height at 350km, 450km, 550km and 800km from the sentry ship is 11m, 980m, 3.5km and 17km respectively, and the opposite fighter cannot be found beyond 800km.

Interception blind area: sm-6 missiles, SM-2 missiles, sea sparrow missiles, Rahm missiles and phalanx close-in weapon system constitute a tight missile defense network, but each system has a strike range and clearance, beyond which interception cannot be achieved. The range boundary is shown in table 2.
Table 2. Interception capability.

| Weapon         | Far bound /km | Near bound /km | High bound /km | Low bound /km |
|----------------|---------------|----------------|----------------|---------------|
| SM-6 missiles  | 230           | 15             | 33             | 15            |
| SM-2 missiles  | 150           | 15             | 24             | 15            |
| sea sparrow    | 15            | 1              | 3              | 10            |
| Rahm missile   | 9             | 0.1            | 5              | 5             |
| Phalanx        | 1.5           | -              | -              | -             |

It can be seen that in the distance of more than 230km, all shipborne weapons cannot achieve interception and strike. SM-6 can intercept at a distance of 230km-15km and a height of 33km-15m, but cannot intercept at a height of less than 15m. SM-6 and SM-2 can intercept at a distance of 150km-15km and a height of 24km-15m, but cannot intercept at a height of less than 15m. Sea sparrow can intercept at a distance of 15km-1km and a height of 3km-10m, but cannot intercept at a height of less than 10m. Rahm can intercept at a distance of 9km-0.1km and a height of 5km-5m, and cannot intercept at a height of less than 5m. The low interception boundary of these defense weapons constitutes a blind area corridor from the outside to the inside (230km → 0.1km) and from the high to the low (15m → 5m). The attack weapons can guarantee the security in this area, as shown in figure 3.

Figure 3. Defense capability and weak points sketch map of aircraft carrier battle brigade.

It can be seen that there are detection blind area and interception blind area in target defense. In the detection blind area, combat aircraft or offensive weapons cannot be found, with high security. But in the detection area and interception blind area, weapons with high security. When attacking the target, the trajectory of attack weapon is in the detection blind area and interception blind area, which will greatly improve the penetration probability.

6. Conclusion
This paper makes a detailed analysis of the composition, position, attacking and intercepting ability of the US Navy's carrier battle brigade, and gives suggestions on the priority of attacking targets. Based on the combat ability of the Arley Burke class destroyer, it puts forward suggestions on the weak
points of the defense of the carrier battle brigade, which can provide some guidance and help for the airborne weapons to fight against the carrier battle brigade.

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