The differentiated generations of air bomb base on landmark technology

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Abstract: The development of air bomb was closed to 100 years from World War I. In this study, the typical technologies applied in air bomb were analyzed, and the characteristics of air bomb using various technologies were summarized. The differentiated generations based on landmark technology were developed to describe air bomb, and the various types of air bomb were illustrated on corresponding.

1. Introduction
Air bombs first appeared in the early 20th century. In 1911, Italian army dropped 2.04 kilograms of explosives which was modified by 4 grenades from the plane into the Turkish army, this is the earliest air bomb, and it created a history of bombing by aircraft.

In World War II, bombs growing category with the improvement of aircraft performance, especially in the latter part of World War II, guided bombs appeared. In order to deal with enemy ships, Germans developed two radio-guided "Lufthansa 293" and "Frieze X" guided bombs.

After World War II, the development of guided bombs has been highly valued by countries around the world. The United States has successively developed a series of guided bombs such as the "PAVE WAY" series, the JDAM series, and the SDB series. Russia developed the КАБ series of guided bombs, France developed the AASM series of guided bombs, and other countries such as Israel and South Africa have also developed their own guided bombs.

In this study, the development of air bombs is classified as generations I, II, III, and IV based on the landmark technology in the development of air bombs.

2. The first generation of air bombs
The first generation of air bombs were mainly unguided air bombs. Most of this generation of products do not use guidance technology, and the attack accuracy is relatively poor. It is suitable for hitting opposing targets, and, its ability to deal with hard targets is poor.

The first generation of air bombs began to be buried in aircraft bomb bays. It is basically a medium-to-high-resistance bomb with poor performance and a single mechanism of action. Most of
them are blast-killing types, and their power is relatively small. These bombs are short and thick in shape. There was a demand for aircraft external bombs with the aircraft performance improves and low-altitude penetration strikes, a series of low-altitude, low-resistance bombs had been developed.

The characteristics of the first generation of air bombs are unguided, low hit accuracy, and low comprehensive destruction efficiency.

3. The second generation of air bombs

The second generation of air bombs is characterized by the comprehensive guidance of air bombs. The accuracy of air bombs has been greatly improved by adding guidance and control systems based on analog circuits. Its representative products are American “White Eye Star” TV guided bombs, “PAVE WAY” I / II / III laser guided bombs, Russia’s KAB series guided bombs, etc.

(1) “White Eye Star” TV Guided Bomb

After World War II, the United States developed the White Eye Star (AGM-62A) TV guided bomb. However, the missile initially adopted a pre-launch lockout and “hit whatever” guidance scheme, which limited its range of action. In order to solve this problem, White Eye Star II and Extended Range White Eye Star II were developed. White Eye Star II added two-way data transmission, commanded guidance, and locked after launch. It increased the missile wing, reduced the seeker, and realized long-range delivery, medium-range program guidance or command guidance, manual locking of the terminal segment, automatic or passive guidance.

(2) “PAVE WAY” series of laser guided bombs

The “PAVE WAY” program in the United States began in 1965 with the main purpose of improving the accuracy of conventional air bombs [1]. It converted MK82, MK84, and MKll8 universal bombs into laser navigation bombs. The PAVE WAY I laser navigation air bomb had a relatively high hit accuracy. It used a duck-type pneumatic layout, and in the design of laser guidance and control, the selection of the guidance law and the realization of components were simple and practical. It full used mature and existing components, therefore, it greatly improved the cost-effectiveness ratio of weapons.

The Gemstone II laser-guided bomb started in 1975. The main purpose was to improve the weapon's mobile overload, increased the gliding distance, and expanded the carrier's loading compatibility and loading density. Therefore, Gemstone II adopted a folding tail design.
Figure 1. "PAVE WAY" series of laser guided bombs.

The Gemstone road III laser guided bomb adopted a new design solution. It used proportional guidance and high lift folding tails. The Gemstone III laser-guided bomb was particularly suitable for low-altitude bombers. It could be used to hit moving targets and hard targets.

(3) КАБ series of guided bombs
Russia successfully developed a КАБ-500Л laser-guided bomb in 1976. Subsequently, two laser-guided bombs КАБ-500Л-Ф and КАБ-1500Л-ПР were developed and put into production in 1982. These bombs used a semi-active laser weathervane seeker, and they had certain ability to hit hard targets. In the 1980s, Russia successively developed and commissioned КАБ-500Кр and КАБ-1500Кр TV-guided bombs.

The second generation of air bombs is characterized by guidance based on analog circuits, and they have high hit accuracy. Its comprehensive damage efficiency has also greatly improved with the improvement of hit accuracy.

4. The third generation of air bombs
The third generation of air bombs is characterized by the digitization and integration of navigation bomb control systems. They have realized a dual-mode guidance method of medium guidance + terminal guidance by adding inertial / satellite guidance methods. Its representative products include the United States enhanced "PAVE WAY" II / III guided bombs, JDAM series guided bombs, SDBI, JSOW series, and French AASM series guided bombs.

(1) Enhanced "PAVE WAY" Guided Bomb
The enhanced "PAVE WAY" guided bomb was a branch of the "PAVE WAY" laser-guided bomb that incorporated the GPS / INS guidance system. Therefore, the enhanced "PAVE WAY" had become a third-generation advanced air bomb with all-weather, multi-target attack capabilities and high hit accuracy.
(2) Joint Direct Attack Bomb (JDAM)

In 1992, the US Navy / Air Force developed JDAM (Joint Direct Attack bomb) \[2\] with all-weather, out-of-zone, post-launch, and multi-target attack capabilities, it was the first successful third-generation guided bomb.

JDAM development was divided into three stages: the first stage was to install JDAM guidance components on MK84 / BLU-109 and MK83 / BLU-110. The second stage was to install JDAM guidance components on laser-guided bombs, GBU-15 TV / infrared guided bombs and AGM-130 long-range air-to-surface missiles. The third stage was the installation of autonomous terminal guidance devices. JDAM guided bombs were tested in 1999 and full production began in 2001. Subsequently, the U.S. military developed LJDAM, a laser sensor was installed on the head of JDAM to implement laser terminal guidance of the bomb.

(3) Small Diameter Guided Bomb I (SDB I)

After the Gulf War, the United States began to develop small diameter bombs (SDB) \[3\]. The development of SDB was divided into two phases. In the first stage, the basic SDB I (GBU-39 / B) was developed, which was mainly used to hit ground-based targets.

SDB I was small in size and light in weight. It was suitable for mounting on various attack platforms. SDB I used a foldable "diamond back" wing with a large lift-to-drag ratio, which had a long gliding distance. It adopted the "strapdown inertial navigation + wide-area differential GPS" composite guidance method with high hit accuracy. It adopted a modular design and was equipped with a large aspect ratio to penetrate the blast warhead, which greatly improved the damage ability. It used a multiple suspension device, which increased the number of bombs carried by the aircraft and improved the aircraft's combat effectiveness on the ground.

(4) AASM Series Guided Bomb

France's AASM (Modular Air-to-Ground Weapon) was a precision-guided weapon developed by
France itself. The bomb was on the body of existing ordinary bombs, and it was equipped with guidance and range extension components to form 125 kg, 250 kg and 1000 kg guided bombs. This modification could greatly reduce costs. The AASM basic type used GPS/INS guidance, and the follow-up type added an infrared imaging seeker and a power range extender.

![AASM series guided bomb.](image)

The third-generation air bomb is characterized by a multi-mode, high-precision guidance based on digitalization, and a highly integrated modular design of the system. It achieves high hit accuracy and high comprehensive damage effectiveness of guided bombs.

5. The fourth generation of air bombs

Multi-mode guidance, intelligence, information, networking and multi-cooperation are the development direction of the fourth generation of air bombs. Air bomb will become an important link in the information chain, undertaking combat tasks such as reconnaissance, detection, communication relay, precision damage and assessment of targets.

(1) Small Diameter Guided Bomb II (SDB II)

In 2006, the US military initiated the development of the SDB II project. SDB II was equipped with a low-cost multi-mode composite seeker (Lidar + IR imaging + Millimeter wave radar) and a two-way data link on the basic SDB I. It further improved hit accuracy, and realizes automatic target attack and moving target strike.

![SDB II small diameter guided bomb.](image)

(2) Low-Cost Autonomous Attack System (LOCAAS)

A low-cost autonomous attack system (LOCAAS) powered by Lockheed Martin. LOCAAS is
equipped with GPS guidance components and a small data link [4]. It used data link information to achieve target identification, location, and attack. The information was transmitted between the carrier, the bomb and the bomb, therefore, it could avoid repeated attacks on the target. This small bomb had the function of networked and informational bomb.

The fourth-generation air bomb is characterized by a networked and intelligent coordinated combat guided bomb strike system. A single bomb achieves multi-mode guidance, autonomous target recognition, and has the ability to strike gray areas.

6. Conclusion
Since 1911, air bombs have experienced nearly 100 years of development, and their development history has gone from high resistance to low resistance, low speed to high speed, unguided to guidance, multi-component to high integration, and independent to networking. Networking, collaboration and intelligence will become the development of air bomb.

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