Research on the strategy of the architecture modeling of aviation ammunition system-of-systems based on mission and capability

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Abstract: The development of the aviation ammunition system has evolved from equipment-based capacity-based. The mapping relations of aviation ammunition mission-ability-weaponry and the capacity-need of different mission are analyzed in this paper. Foreign ammunition development trends and capacity-supported are discussed. Based on the advantages and disadvantages of foreign weapon system architecture, the DODAF (Department of Defense Architecture Framework) and Agent-based system construction strategy is used in the modeling process. This method can provide a certain reference for aviation ammunition architecture.

1. Introduction

Modern high-tech warfare is a confrontation between non-linear and asymmetric weapons and equipment systems, showing new features such as multi-dimensional space, real-time time, multiple objects, and diverse styles. The analysis of all weapons and equipment driven by the same combat mission cannot be performed separately, but should be considered as a weapon and equipment system. Affected by the transformation of warfare, the development of weapons and equipment has shifted from the emphasis on combat capabilities of equipment systems / equipment platforms to the overall combat capabilities of weapon systems [1]-[3].

At present, the airborne missile munitions of various countries in the world are developing in a trend of many types, high power and high accuracy. They have carried out networked and informationized research and practice of airborne weapons, and raised the system confrontation to a new level [4].

In response to this complex demand, how to scientifically plan the development of weapons and equipment is a huge challenge. It must be studied by a combination of quantitative and qualitative methodologies. This article sorts out the combat mission-capacity development of foreign aviation ammunition based on US military equipment. The advantages and disadvantages of the system framework, a scientific and feasible system construction ideas and modeling methods are proposed to
provide a reference for the construction of China's weapon equipment system, which has certain guiding significance.

2. Aviation ammunition operational mission and capability analysis

Aviation ammunition is an important component of precision guided weapons. It is used by fighter-bombers, attack aircraft and other air forces on ground (sea) structures, bridges, small and medium-sized command posts, airport runways, air defense radar positions, and surface ships. Important means of precision strike. Tactical applications are mainly positioned for supplementary bombardment by combat aircraft as a launching platform after a long-range, deep-precision strike weapon launched outside the defense area launches an attack. At present, airborne missile munitions have become one of the most widely used conventional weapons in modern high-tech local warfare and the most significant results have been obtained. The combat scenarios are also the most extensive. The following table briefly introduces and analyzes different combat scenarios. There are six main combat mission scenarios: Close air support; Deep penetration strike; Interruption in the air; Air defense suppression; Regional closure and control; Anti-intervention / area rejection.

Therefore, according to the type of mission performed by aviation ammunition and the characteristics of the strike target, the demand for aviation-made missile munitions is summarized as: Point and area target strike capability; Deep penetration ability; All-weather precision strike capability; Moving target strike capability; Launch capability outside the zone; Ability to spread; Identification of friend and foe; Electronic interference capability; Regional containment and control capabilities; Multi-bomb coordinated attack capability.

![Figure 1. The operational scenario of aviation ammunition.](image-url)
| No. | Operational scenario   | Mission connotation                                                                                           | Target                                                                                                                  | Capability requirement                                                                                                                                                                                                                                                                                                                                 | Ammunition type                                                                                       |
|-----|------------------------|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| 1   | Close air support      | Close air support is the process by which an aircraft strikes enemy targets near its friends to support ground tactical units. | Construction, armored vehicles, personnel, technical weapons, positions, and other                                      | Point target strike capabilities; face target strike capabilities; all-weather precise strike capabilities; moving target strike capabilities; enemy and friend identification capabilities                                                                                       | Rockets, small and medium-sized guided bombs, conventional bombs, air-to-ground missiles              |
| 2   | Aerial interruption    | Aerial interception is the act of disrupting, blocking or destroying enemy forces and supplies in the vicinity of the battlefield in the air.          | Roads and bridges, railway hubs, communication centers, military and material gathering places, etc.                          | Point and surface target strike capability; all-weather precise strike capability                                                                                                                                                                                                                                                   | Conventional / Guided Bombs, Spreaders, High-Power Bombs, Air-to-Surface Missiles                      |
| 3   | Deep Strike            | Depth strike is the use of airborne precision-guided weapons for deep penetration, which can not only effectively attack enemy ground targets, but also damage enemy air, sea and coastal targets. | Caves, bunkers, underground command posts, air defense command centers, command and communication centers, weapons of mass destruction storage rooms | Deep penetration capability; Out-of-zone launch capability                                                                                                                                                                                                                                                                                  | Penetration of guided bombs, long-range cruise missiles, medium-range air-to-surface missiles         |
| 4   | Air defense suppression| Air defense suppression is to suppress the enemy's surface-to-air missile                                      | Anti-aircraft artillery, battlefield radar positions,                                                                 | Electronic interference capability; Area target strike                                                                                                                                                                                                                                                                                              | Guided bombs, electromagnetic pulse bombs, communications                                          |
### 3. Capability support of foreign aviation ammunition

In recent years, military powers such as the United States, Russia, and Europe have launched a series of theoretical explorations and technological development practices for future wars. At the level of operational theory, due to changes in the strategic situation of the United States, Russia, and Europe, many countries have proposed a series of new operational theories adapted to high-intensity rejection environments; at the level of models and technologies, they benefit from new sensor technologies and microsystems The rapid maturity of technology, the miniaturization of various weapons, the expansion of capabilities, and the high cost-effectiveness have become possible, which has also promoted the

| No. | Operational scenario | Mission connotation                                                                 | Target                                      | Capability requirement          | Ammunition type                  |
|-----|----------------------|--------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------|----------------------------------|
| 5   | Zone containment     | Area containment and control operations are to limit the actions of the enemy within a certain range, making it impossible to carry out combat operations in accordance with its intentions. | Airport runways, bridges, highways, etc.   | Launch capability outside the zone; Ability to spread | Heavy guided bombs, spreaders    |
| 6   | Anti-access / area rejection | Anti-access capability refers to those capabilities that threaten the base and enter the theater's logistic line, block the access to the base or the theater; the purpose of the area rejection capability is to create an impenetrable "bubble" around the critical zone. Block its combat capabilities in the protected area. | Radar cars, missile launchers, personnel, various surface ships | Area containment and control capabilities; Out-of-zone launch capability; Multi-bomb coordinated attack capability | Swarm, networked ammunition     |
generation of new combat models. In the proposed multiple combat theory, model and technology development projects, diversified and cheap small arms are used to replace the original large and expensive weapons, and the functions of various links in the engagement process are distributed to different small arms. This has revolutionized the entire combat model.

Figure 2. The spectrum of aviation ammunition.

U.S. active guided bombs include 10 categories and about 130 models. With 250 kg, 500 kg, 1000 kg, and 2000 kg as the main body, the 10t-15t guided bombs represented by the "mother of bombs" and "giant ground bombs" have been developed, and the SDB has been developed downwards. The representative 125 kg small guided bomb is currently developing dozens of kilograms of small bombs, forming a perfect guided bomb system; equipped with warheads such as cloud explosions, temperature and pressure, electromagnetic pulses, and various types of combat. The ministry has effectively implemented blockades against surface targets such as airport runways and technical weapon positions; it has the ability to attack ground-based targets by installing seekers and data links for guided bombs; and by adopting a composite conductor system, it has full-time, precise weathering of all-weather and complex electromagnetic environments, and low-cost out-of-zone capabilities; in addition, it has developed a series of precision-hitting ammunition for small-scale urban targets with small damage. Comprehensively, we can see that the U.S. military’s aviation ammunition has a complete spectrum and basically meets its ability requirements. The US military’s modern wars have verified the rationality and credibility of its aviation ammunition planning.

4. Construction of aviation ammunition equipment system framework

At present, domestic and foreign researches on the framework of weapons and equipment systems are becoming more and more extensive. Among them, the US Department of Defense Architecture Framework (DoDAF) is the representative, extending the scope of application of the architecture modeling framework to the entire field of weapons and equipment systems. In the 1990s, the United States regarded architecture as an effective mechanism for responding to the capability transformation
of the Department of Defense in the information age, and thus developed a series of architectural frameworks, including C4ISR V1.0, V2.0, and DoDAF V1.0, V1.5, V2.0, V2.02. The DoDAF framework system has become a model for countries to study and refer to the military framework. A number of countries and organizations have also developed framework products, such as the British Department of Defense architecture framework MODAF, the NATO architecture framework NAF, and the Canadian Ministry of Defense architecture framework DNDAF.

However, DoDAF only proposes a number of guiding principles for designing in compliance with the framework. It does not provide methodologies and detailed processes for developing architecture products. This lacks additional design details for practical engineering problems, and the visual representation of DoDAF architecture products is schematically, there is no strict method system, which causes different modelers to understand and use models in a different meaning. Through the above analysis, it can be found that the US Department of Defense's Architecture Framework (DoDAF) mainly has the following defects [5-7]: ① lack of a description of the response to system capacity requirements; ② lack of analysis of the quantitative relationship within the system; ③ unable to be an architecture Construction and provide feedback and guidance; ④ architecture modeling data does not meet the consistency requirements, the data reuse rate is low.

In the above, based on the practical development of China's weaponry system construction, this article draws on the DoDAF multi-view and multi-angle framework construction ideas, and proposes an idea for the construction of the aviation ammunition equipment system framework based on the capability requirements of our army. That is, starting from the capability requirements of the weapon equipment system, the overall framework of the weapon equipment architecture is proposed, as shown in the following figure.

![Figure 3. The hierarchical relationship of mission-ability-weaponry.](image)

Figure 3 reflects the idea of building a weapon equipment system framework based on capability requirements. They mainly include two parts, as follows:

The modeling idea from requirements to architecture: this is a top-down decomposition and mapping process, mainly in a qualitative form, reflecting how to gradually build the architecture from the system capability requirements. First analyze the system capability requirements of the weapon and equipment system; then proceed from the system capability requirements and transform the system capability requirements into requirements for specific weapon equipment entities through step-by-step decomposition mapping. These requirements can be abstract expressions or contain Specific performance parameter values. Finally, according to the demand for weaponry and equipment
entities, select appropriate weaponry and equipment entities, build a weaponry and equipment architecture, and model and analyze the basic content of the weaponry and equipment architecture components and element relationships.

Modeling ideas from architecture to capabilities: this is a bottom-up analysis process, feedback from architecture to capability requirements, and further analysis based on the content of "from requirements to architecture" modeling, is a quantitative treatment of the results of qualitative modeling of "from requirements to architecture". The modeling idea from architecture to capability is mainly to analyze the contribution of the comprehensive system capabilities to the system capability requirements for the weapon equipment architecture constructed in the "from requirements to architecture" modeling process.

For the architecture of the weapon and equipment system to be built in the future, you can directly follow the architecture modeling ideas proposed above, analyze how to gradually build the weapon and equipment architecture from the system capability requirements, and then analyze the functions and capabilities of the weapon and equipment architecture. The degree of satisfaction of system capability requirements, so as to analyze the gap between system capabilities and system capability requirements and guide system construction.

For the architecture of existing weapons and equipment systems, you can also follow this modeling idea to analyze the weapon and equipment architecture gradually constructed from the system capability requirements put forward in practical applications, and compare and analyze the architecture of the existing system. The difference between the two is to adjust the existing architecture and analyze the contribution of the functions and capabilities of the existing architecture to the actual required system capabilities to provide feedback for system construction.

5. Suggestion

At present, the research of China's aviation ammunition weapon equipment architecture is still in the stage of reference and imitation. Based on the DoDAF equipment system framework as a reference model, China's weapon equipment system construction can be guided. Aiming at the advantages and disadvantages of the DoDAF equipment architecture modeling method, combined with the agent-based system confrontation simulation modeling method to construct the aviation ammunition weapon equipment system, this kind of "bottom-up, overall emergence” construction idea is used to build equipment behavior. The combination of the modular method and the complex network modeling method can scientifically evaluate the system contribution of aviation ammunition qualitatively and quantitatively, and has the advantages of knowledge mapping, continuity, and high robustness.

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