

# Differences in large aircraft design between military and civil perspectives

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**Abstract.** Military transport aircrafts and civil aircrafts are important parts of the aviation field. With the development of aviation technology and the specificity of aircraft functions, the design of military transport aircraft and civil aircraft gradually differs according to application scenarios. However, in the aircraft design, military transport aircrafts and civil aircrafts still have a lot of mutual references. Analyzing the differences between them and the reasons for the differences may contribute to the design and development of military transport aircraft and civil aircraft in the future, and provide reference suggestions for the design of civil aircraft in the context of the civil-military integration. In this article, the application scenarios and functions of military transport aircraft and civil aircraft are analyzed, as well as the special situation of civil aircraft research and development. This article may offer a reference for the future research and development of military transport aircraft and civil aircraft.

**Keywords:** Military Transport Aircraft , Civil Aircraft, Large Aircraft Design.

## 1. Introduction

In the early design and development of aircraft, there was no distinction between military and civilian use. Until the World War, there was no clear distinction between military and civilian transport aircraft. The same type of aircraft was used under different conditions to carry out tasks like transportation [1]. After World War II, due to the development of aviation technology and the specific requirements for transport aircraft, the transport aircraft was gradually divided into many types of aircraft with the specified mission objective. With the development of aviation technology and the specificity of aircraft functions, the design of military transport aircraft and civil aircraft gradually differed according to application scenarios and the aircraft design gradually divided into two systems: military aviation aircraft design and civil aviation aircraft design. As the technical performance requirements for military aircraft continue to improve, military aircraft are gradually developed to meet different combat missions, while civil aircraft are developed economically under the choice of the market. As the difference between them gradually increases, military aircraft and civil aircraft have gradually developed two sets of design and development systems.

In this article, by comparing the design and development system of military transport aircraft and civil aircraft, in-depth analysis of the reasons for the difference between the two designs has been made. In this paper, the application scenarios and functions of military transport aircraft and civil aircraft are analyzed, as well as the special situation of civil aircraft research and development, in

order to explore the specific differences between military transport aircraft and civil aircraft. In addition, the future development trend and the significance of mutual reference under the background of the era of civil-military integration are discussed. This article may offer a reference for the development of transport aircraft.

## **2. Military and civil aircraft design**

### *2.1. Difference of application scenarios*

Military transport aircrafts require the ability to take off from and land to rudimentary airfields while keeping the takeoff and landing distances as short as possible. As a result, most military transport aircraft are designed with an upper monoplane multi-engine structure and a more efficient lift system while civil airliners continue to use the traditional lower monoplane structure with a relatively simple lift system. The upper monoplane layout allows the aircraft's engine system to be raised, which enhances the ability of military transport aircraft to operate on simpler runways. With the development of engine technology, the size of the aircraft engine is getting larger, and the distance between engine and ground is getting closer for civil airliners adopting the lower monoplane. The impact of ground debris is also getting more significant, so the construction and maintenance standards of airports are also getting higher. The military transport aircraft adopting upper monoplane has a higher engine distance from the ground. The military transport aircraft is less attractive to ground debris and thus has lower requirements for airports, enlarging the deployment range and adapting to its military nature. However, the layout of the upper monoplane requires the reinforcement of the aircraft's fuselage structure, resulting in the complication of the collective structure and adversely affecting the aerodynamic performance of the aircraft [2]. In order to ensure the comfort of passengers, civil aircrafts often pursue stable flight conditions. On the other hand, in order to carry out military missions, military aircrafts sometimes take extreme manoeuvre flight mode, which requires a more robust airframe structure.

### *2.2. Difference of functions*

Military transport aircrafts tend to carry larger and heavier than civil transport aircrafts. Many large military transport aircraft are designed with full-size hatches to facilitate the loading of large equipment, while the monoplane structure of military transport aircraft also provides superior space for hatches [3]. Military aircrafts of the same size tend to have lower floors than civilian aircraft to allow for easier loading and unloading of equipment and personnel. This design also increases the height of the cargo hold, allowing for the transport of larger equipment. In terms of shape, civil aircraft tend to have a rounded fuselage cross-section to reduce aerodynamic drag in flight while military transports tend to have a rectangular shape that shrinks upwards to increase the width of the cabin. The vast majority of modern civilian aircraft have a cylindrical fuselage, and the overall shape of the fuselage is a streamlined spinning body with two pointed ends and a large centre. The weight distribution of the cargo carried by military transport aircraft, such as tanks, tends to be more concentrated, so compared with civil aircraft, military transport aircrafts tend to have more extreme aspect ratios to adapt to the characteristics of its heavy load concentration to avoid the aircraft losing balance during heavy transport [2].

Cargo and baggage loading on civil aircraft mostly requires specialised baggage carriers, and the transport of cargo is dependent on the facilities of civil airports [3]. In contrast, heavy vehicles transported by military aircraft can be directly accessed through the rear hatch at the tail end of the aircraft into the cargo compartment with a lower floor height [4]. At the same time military aircraft can open the compartments for the task of airdropping supplies during military operations, while the cargo compartments of civilian aircraft cannot be opened in flight and is lack of capability to drop supplies without landing.

### *2.3. Specificity of civil large aircraft design*

In the design and development of civil aircraft, economy is an important consideration. China's early development of the Y-10 aircraft did not consider the economy during the development and considered too much about its design as a specialised aircraft, resulting in the failure of its subsequent development [5,6]. In contrast to military aircraft, which often seek better maneuverability, civil aircrafts need to combine flight speed with fuel consumption. In the last century, the Concorde achieved supersonic flight, but was eventually retired in 2002 due to its huge fuel consumption and noise. In order to ensure economic efficiency, the cruising speed of modern large passenger aircraft is generally maintained at 800-970km/h. Within this speed range, the aircraft can achieve the unity of speed and efficiency.

At the same time, compared with military aircraft, civil aircraft need to give more consideration to the comfort and environmental impact of their aircraft, such as the environmental impact of noise and environmental treatment of engine exhaust. Civilian aircrafts are often required to undergo a rigorous noise assessment and validation process before entering service, whereas military aircraft do not have such requirements [7].

As a civil aircraft needs to compete in the market, the passenger comfort is also a factor that needs to be taken into account in the design and manufacture. The design of the seats, the space for passengers to move around in the cabin, and the noise level in the cabin are all factors that affect the comfort of civil aircraft. On the other hand, military aircraft are often designed to pursue better military performance at the expense of the sensory experience of the aircraft occupants.

After the continuous selection and elimination of the market, the airworthiness certification of civil aircraft follows a unified international certification standard. The development of transport aircraft needs to meet the different needs of each country as different countries have different technical standards. China's military aircraft technical standards originated from the Soviet Union and later combined with China's national conditions for localization [8]. For the development of civil aircraft, the acquisition of airworthiness certificate is as important as the design. For the sake of greater sales profits after the development of civilian aircraft, it is often necessary to obtain international market approval. After a long period of development in the field of civil aviation, two world-class civil aircraft manufacturing groups have been formed, namely, the Boeing from the United States and the Airbus from Europe. As the official representatives of civil aviation in the two regions, the US Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) control the global discourse in the field of airworthiness regulations [9]. The Russian Il-96 passenger aircraft, with its performance not inferior to Western passenger aircraft, was refused airworthiness certification because of the west countries' monopoly, which prevented it from entering the international market completely [6]. Military aircraft, in contrast, do not need to consider the issue of internationalization.

Civilian aircraft tend to place a greater emphasis on safety than military aircraft. When a safety accident occurs, compared with military aircraft, civil aircraft will often have a greater impact on public opinion in society, resulting in the reputation of the aircraft belonging to the airline and the aircraft manufacturer suffers a heavy blow, which in turn causes huge economic losses [10]. Therefore, compared with military aircraft, civil aircraft have a more standardized flight safety and security system and accident investigation system, and has a lot of global regulations.

### **3. Civilian large aircraft design of civil-military integration era**

The aviation industry plays an increasingly important role in today's national defence construction. As an important achievement of the aerospace industry, large civil aircrafts should be designed with the possibility of militaristic modification in mind. There are two ways of converting civil aircraft into military aircraft: one is to directly modify the factory aircraft, using the aircraft only as a delivery platform, and adding military equipment of different functions to the aircraft without changing the performance of the aircraft itself. The other is to modify the production line of civil aircraft, so that a set of production lines can simultaneously produce civil aircraft and modified military aircraft. In the

latter way, the modified aircraft can be structured during the manufacturing process, which can better meet the requirements of the military [11].

Nowadays, more and more military aircraft, such as early warning aircraft and anti-submarine aircraft, adopt civil passenger aircraft as platforms, which are modified to meet the needs of military use [8]. The design life of civilian aircraft is often longer than that of military aircraft. As the market continues to improve the comfort, economy and safety of aircraft, many civil aircraft are replaced by a new generation of aircraft before they reach the end of their service life. These civil aircrafts eliminated from the market are still of considerable value in the military field. For example, the US Army's E-3/8 aircraft was modified from the outdated and sealed Boeing 707 as a platform [2]. A mature civil aircraft has often been used for a long period of time with stable performance. The use of civil aircraft modifications can save the military from separately re-developing or redesigning a new aircraft [11]. This not only solves the problem of a large number of retired civilian airliners, but also saves money for the military [12].

With the gradual expansion of the size of our civil aviation fleet, it has become an air transport force that cannot be ignored. As early as 1952, the United States established a civil aviation reserve and built a complete system to convert civil aircraft to military use in wartime. Under the background of the era of military-civilian integration, China's commercial aviation system should pay enough attention to the use of civil aircraft in wartime. The possibility of military use should be taken into account in the development and construction of civil aircraft, and the possibility of conversion for transporting military materials should be taken into account in the design of airliners [13]. However, it should not be so over-invested in this direction that it affects the function of the civil aircraft itself, leading to the deviation of its design and development from the initial goal.

The militarized value of the design and development system of civil aircraft is explored, while the construction of the army is integrated into the economic and social development system. This will make full use of the country's comprehensive national strength to achieve the overall enhancement of the military construction capacity, so that the country's economic, scientific and technological and other areas of advantage and resources can be maximised [11].

#### **4. Conclusion**

According to the utility, aircrafts can be divided into two categories, military and civil. There are differences in the structure of military transport aircraft and civil aircraft due to their different application scenarios and types of cargoes to be transported. The structure of military aircraft is more suitable for transporting large and heavy equipment to meet the needs of military missions, while civil aircraft pay more attention to economy, comfort and safety to meet the needs of the market. Civil aircrafts are more global in nature than military aircraft, with globally recognized regulations and technical guidelines.

In the context of civil-military integration and the integration of peace and war, the design of civil aircraft can give more consideration to the potential capacity for military conversion, while the structural design of military aircraft can also take advantage of the experience from civil aircraft. Civil aircrafts can also be used as a backup for military aircraft when necessary, and the relevant departments should pay more attention and prepare a plan for the emergency requisitioning and militarized conversion of civilian aircraft in special circumstances.

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