International Legal Comparison and Cross-regional Coordinated Development of Greater Bay Area's Low-altitude Economic Development

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Abstract: By comparing the legal framework of low-altitude economy in the United States, the European Union, Japan and Singapore, this paper analyzes its characteristics and advantages in terms of regulatory flexibility, airspace coordination and privacy protection, and points out the gaps in the legal framework, airspace management and industrial chain coordination of the Greater Bay Area (GBA). On this basis, some suggestions are put forward, such as constructing dynamic laws and regulations system, improving airspace coordination mechanism, strengthening supporting capacity of industrial chain, and formulating rules for cross-border flow of low-altitude data, so as to promote the high-quality development of GBA low-altitude economy. At the same time, this paper discusses the path of cross-regional coordinated development of GBA low-altitude economy from four aspects: top-level design, mechanism construction, collaborative management and safe development, and puts forward some measures, such as establishing coordinated development planning, breaking through institutional barriers, innovating governance model and strengthening technical support, in order to provide useful reference for low-altitude economic development in other regions.

1. Introduction

Low-altitude economy, that is, new economic activities such as UAV logistics, smart city management, emergency rescue, sightseeing and so on, not only expand the spatial scope of traditional economic activities, but also provide new impetus for improving social efficiency and promoting industrial upgrading. Especially in the Greater Bay Area (GBA), the core area of the country's major strategic layout, the development of low-altitude economy is regarded as an important engine to promote regional high-quality development, promote scientific and technological innovation and deepen reform and opening up [1].

However, the opening and development of low-altitude economy is not smooth sailing. With the gradual opening of low-altitude airspace and the increasing low-altitude economic activities, a series of legal risks and challenges have followed. How to ensure the safe and orderly conduct of low-altitude economic activities and how to balance the relationship between low-altitude economic development and airspace management and privacy protection has become an urgent problem [2].

Therefore, this paper thoroughly analyzes the present situation and challenges of GBA's low-altitude economic development, draws lessons from international advanced experience, improves the legal framework of GBA's low-altitude economy, and explores the promotion path of high-quality development of low-altitude economy. At the same time, this paper also hopes to provide new ideas and directions for the development of low-altitude economy in other regions by studying the cross-regional coordinated development of GBA low-altitude economy.

2. International legal comparison of low-altitude economic development

2.1. Overview of international legal framework for low-altitude economy

The comparison of international low-altitude economic legal framework is shown in Table 1.

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Table 1 Comparison of international legal frameworks for low-altitude economy

region	Legal framework	characteristic	superiority
United States of America	Federal Aviation Regulations (FAR) as the core, Small UAV Rules (Part 107)	Market orientation and dynamic supervision	Flexible revision of laws and regulations to support commercialization pilot projects.
	The FAA monitors the airspace through B4UFLY application, and implements the UAV registration system.	Class E low-altitude airspace is divided into general aviation and UAV activity areas, and the dynamic release mechanism.	California and other places restrict the intrusion of drones into the private sector.
EU	EASA led, Authorization RegulationNo. 2019/945 and Implementation RegulationNo. 2019/947.	Unified supervision and risk classification	Unify rules across member countries to promote the large-scale application of low-altitude economy
		Airspace management: "U-space" system, integrating manned and unmanned aircraft airspace, and piloting urban air traffic.	UAV is required to be equipped with electronic identification and geo-fence technology to restrict flying in densely populated areas.
Japan	AAM Development Roadmap	Enterprise-led technology research and development (Honda and Toyota participate in eVTOL manufacturing)	Clarify commercialization goals (such as deploying flying cars at the 2025 Osaka World Expo)
Singapore	Divide the no-fly zone, commercial zone and residential zone, and the third-party management entity coordinates the flight conflicts between enterprises.	Pilot UAV tubular route	-

The UAV management system in the United States is market-oriented and implements dynamic supervision. The core legal framework includes the Federal Aviation Regulations (FAR) and the Small UAV Rules (Part 107) specially formulated for UAVs, which clearly stipulates the flying altitude and the operation within the line of sight. The Federal Aviation Administration carries out real-time airspace monitoring through B4UFLY application, and implements the registration system of unmanned aerial vehicles [3]. In its low-altitude airspace management, Class E airspace is set as a general aviation and UAV activity area, and a dynamic release mechanism is adopted. In terms of privacy protection, California and other places have passed legislation to restrict drones from invading the private sector. The advantage of this system lies in the flexible revision of laws and regulations, such as the release of "Advanced Air Traffic Strategic Blueprint", while supporting commercial pilot projects, such as Amazon's UAV logistics service [4]. On the whole, this system not only ensures safety but also promotes innovation.

The European Union implements unified supervision and risk classification management through the European Aviation Safety Agency (EASA). According to the Authorization RegulationNo. 2019/945 and the Implementation RegulationNo. 2019/947 issued in 2019, UAV operations are classified into "open", "privileged" and "authorized" [5]. Its characteristics include the construction of a "U-space" airspace management system integrating manned aircraft and unmanned aircraft,

such as its application in the Volocopter project in Germany; The UAV is required to be equipped with electronic identification and geo-fence technology to ensure flight safety and limit flight in densely populated areas [6]. The advantage of this system lies in providing unified rules for all member countries and promoting the development of low-altitude economy.

Japan and Singapore have their own characteristics in UAV management. Japan has set clear commercialization goals through AAM Development Roadmap, such as planning to deploy flying cars at the Osaka World Expo in 2025, and Honda, Toyota and other enterprises will lead the technical research and development of electric vertical takeoff and landing aircraft (eVTOL) [7]. Singapore manages the airspace by carefully dividing the no-fly zone, commercial area and residential area, and coordinates the flight conflicts among enterprises with the help of third-party entities, and at the same time, pilots the tubular route of unmanned aerial vehicles to optimize air traffic management [8]. The practices of these two countries reflect the efforts to actively promote technological innovation and commercial application while ensuring safety.

2.2. Present situation of GBA low-altitude economic law

On the legal basis, China mainly relies on the Civil Aviation Law and the Provisional Regulations on Flight Management of Unmanned Aerial Vehicles for UAV management, but the special legislation is still insufficient. Locally, Shenzhen took the lead in implementing the Regulations on the Promotion of Low-altitude Economy and Industry in 2024, and Zhuhai, Guangzhou and other places also successively introduced local regulations, focusing on the improvement of infrastructure construction and safety management [9].

In terms of characteristics and problems, Shenzhen, as a pioneer, is exploring low-altitude air route network and intelligent take-off and landing points, and piloting application scenarios such as cross-border logistics. Guangdong province put forward the management mode of "negative list+dynamic release", which promoted the decentralization of airspace examination and approval authority. However, there are still some challenges: rigid airspace management, insufficient cross-regional coordination ability, and difficulties in coordination caused by differences in rules between Hong Kong, Macao (China) and the mainland; The regulations are lagging behind, especially the approval process of light drones is cumbersome, and there are no clear rules for cross-border data flow; The industrial chain is scattered, and the downstream applications such as insurance and maintenance are insufficient. Enterprises often need to build their own operation teams to make up for these shortcomings.

2.3. Comparison and enlightenment of international laws

There is a certain gap between GBA and the international advanced management model in terms of regulatory flexibility, airspace coordination and privacy protection. The FAA of the United States can dynamically revise the Part 107 rules, while the local regulations of GBA are relatively slow to update; The EU has realized the effective integration of transnational airspace through "U-space". In contrast, the data sharing platforms in Guangdong, Hong Kong and Macao (China) have not been opened. California's privacy legislation provides clear guidance, while GBA still needs further improvement in cross-border data security rules.

In order to narrow these gaps, the following suggestions are put forward: First, establish a bay area coordination mechanism, refer to the EU's "U-space", integrate the air traffic control data of Guangdong, Hong Kong and Macao (China), and pilot the logistics route of Guangzhou-Shenzhen-Hong Kong UAV to promote the coordinated management of airspace between regions. Secondly, build a dynamic regulatory system, learn from the experience of FAA in the United States, set up a "sandbox supervision" mechanism, simplify the approval process of light drones, and enhance the adaptability and flexibility of regulations. In addition, third-party low-altitude operating companies are introduced to provide one-stop services including flight registration and insurance, and strengthen the supporting capacity of the industrial chain. Finally, we should formulate specific rules for cross-border flow of low-altitude data, clarify the boundaries of geographic information collection, and strengthen privacy and data security protection.

3. Study on the coordinated development of GBA low-altitude economy across regions

The coordinated development of GBA low-altitude economy needs to be guided by "breaking the wall of the system", supported by "hard power of science and technology" and "safety and toughness" as the bottom line. This paper puts forward the framework of cross-regional coordinated development of GBA low-altitude economy, as shown in Figure 1.

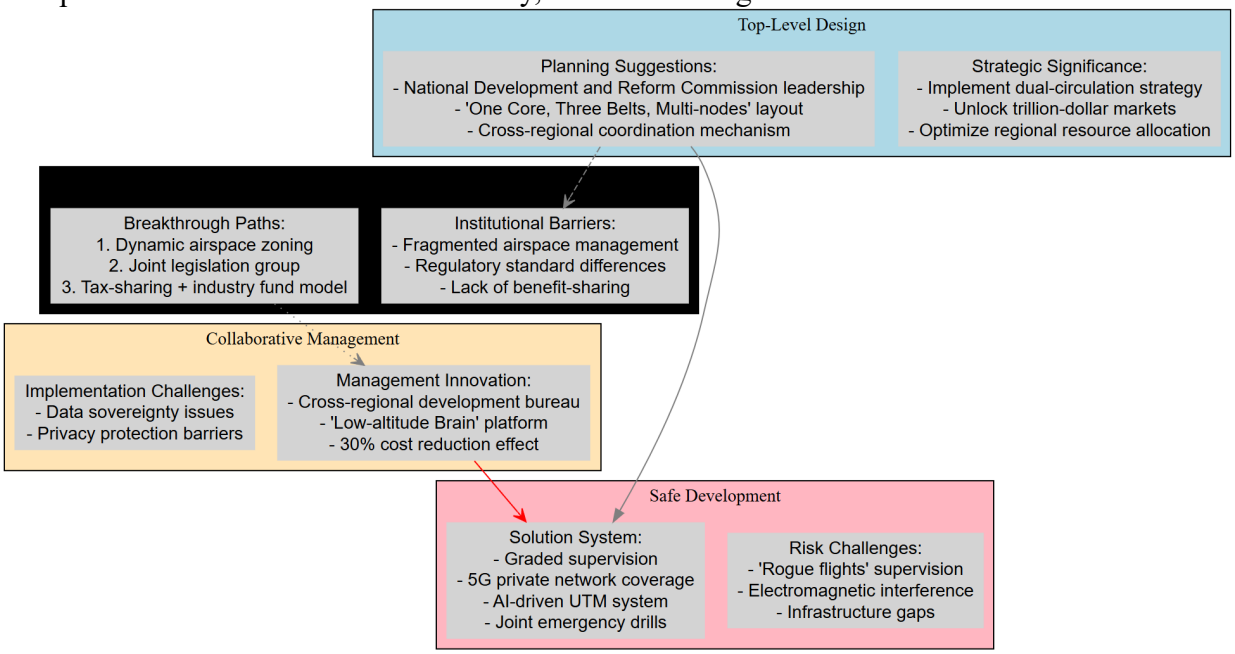

Figure 1 Framework of cross-regional coordinated development of GBA low-altitude economy

3.1. Top-level design: strategic guidance and overall planning

The cross-regional coordinated development of GBA low-altitude economy is an important starting point for implementing the national "double-cycle" strategy and promoting the deep cooperation between Guangdong, Hong Kong and Macao (China). It can release the trillion-dollar market potential of emerging industries such as drone logistics, low-altitude tourism and emergency rescue, and promote the optimal allocation of regional resources and the flow of innovative elements. It is suggested that the National Development and Reform Commission should take the lead and work with the governments of Guangdong, Hong Kong and Macao (China) to formulate the GBA Low-altitude Economic Collaborative Development Plan, clarify the spatial layout of "one core, three belts and multiple nodes", establish a cross-regional division of labor and cooperation mechanism, and coordinate the allocation of airspace resources, industrial division of labor and infrastructure interconnection.

3.2. Mechanism construction: breaking through barriers and innovative governance

At present, the development of low-altitude economy faces the problems of compartmentalization of airspace management, insufficient coordination between military and civil aviation, differences in laws and standards among the three places and lack of benefit sharing mechanism, which limits the large-scale development. In order to break through these obstacles, it is suggested to promote airspace reform, implement "dynamic airspace designation" through central and local cooperation, and pilot "low-altitude flight corridor" and "temporary airspace release" mechanisms to realize flexible allocation of airspace resources; Strengthen policy coordination, establish a joint legislative group for low-altitude economy in Guangdong, Hong Kong and Macao (China), promote mutual recognition of rules such as airworthiness certification and cross-border data flow, and explore the "negative list of low-altitude economy in the Bay Area"; Build a benefit-sharing mechanism and adopt the model of "tax sharing+industrial fund" to promote cross-regional industrial chain cooperation, such as Shenzhen R&D, Zhuhai manufacturing and Hong Kong financial empowerment, so as to jointly promote the development of low-altitude

economy.

3.3. Collaborative management: platform empowerment and efficiency improvement

In order to promote the development of GBA low-altitude economy, an innovative management model of "GBA low-altitude economic cooperative development bureau" can be established, with special committees for airspace management, emergency response and industrial promotion, and a rotating chairman system can be implemented to enhance organizational coordination. At the same time, the digital governance platform of "Bay Area Low-altitude Wisdom Brain" will be built, and the data of civil aviation, public security, meteorology and other departments will be integrated to realize one-line flight planning and real-time visual monitoring of airspace state.

3.4. Security development: risk prevention and control and technical escort

GBA, as the area with the highest density of low-altitude flight in China, is facing the problems of "black flight" supervision, frequent electromagnetic interference and insufficient infrastructure. In order to solve these problems, we should build a hierarchical supervision system, adopt "electronic fence+risk rating" for logistics drones, and implement the mandatory standard of "double backup safety redundancy" for manned aircraft; By establishing comprehensive low-altitude 5G private networks, developing AI-driven low-altitude traffic management systems (UTM), and deploying anti-drone laser interception devices among other technical safety measures, the safety is significantly enhanced. At the same time, the joint emergency command center of Guangdong, Hong Kong and Macao (China) will be established, plans for cross-border rescue and airspace emergency requisition will be formulated, and the "Bay Area Low-altitude Security Shield" cross-regional exercise will be held every year to strengthen the emergency linkage capability.

4. The promotion path of high-quality development of low-altitude economy

4.1. Policy support

At present, many places have issued relevant policies, such as Beijing, Shanghai, Guangdong and other places have formulated low-altitude economic development action plans, and defined development goals and safeguard measures. In the future, we should further improve the industrial policy of low-altitude economy, increase financial subsidies and tax incentives, and guide the rational flow of social resources to the low-altitude economy. For example, financial subsidies are used to support the settlement of major low-altitude economic projects, infrastructure construction, and the formulation of standards and norms. Meanwhile, streamlining the flight plan submission process, optimizing airspace usage management, and providing a more efficient and flexible policy environment **are essential** to facilitating the development of the low-altitude economy.

4.2. Technical innovation

Technological innovation is the core driving force of low-altitude economic development. Low-altitude economy involves a wide variety of aircraft, rich application scenarios, and technological breakthroughs are crucial. It is suggested that enterprises, scientific research institutions and universities should be encouraged to increase R&D investment to promote low-altitude economic and technological innovation. For instance, establishing technology incubation platforms based on local research institutions and enterprises can accelerate the transformation of scientific and technological achievements into productive forces. Universities, scientific research institutions and enterprises should be supported to cooperate and participate in the research and formulation of domestic and international standards, and an industrial standard system should be built throughout the whole life cycle of low-altitude equipment research and development design, manufacturing, test verification and operation support.

4.3. Infrastructure construction

Infrastructure construction is the support of high-quality development of low-altitude economy. At present, many places have accelerated the construction of low-altitude infrastructure, such as the

layout of general airports, landing points and other facilities. In the future, we should further build a safe, efficient and interconnected infrastructure system to meet the needs of low-altitude economic and industrial development. To meet the takeoff and landing requirements of new aircraft, it is essential to standardize the construction standards of related facilities and accelerate the improvement of the infrastructure support system. Additionally, efforts should be made to promote the development of low-altitude communication, navigation, and surveillance networks; enhance the management of airspace navigation, communication, and surveillance; and provide safer and more efficient support for low-altitude flights.

4.4. Coordinated development of industrial chain

The industrial chain of GBA low-altitude economy has begun to take shape, but it still faces problems such as insufficient industrial chain coordination. It is suggested that policy guidance and market mechanism should be adopted to promote the coordinated development of enterprises in the middle and lower reaches of the industrial chain. For instance, support various regions in cultivating key enterprises within the low-altitude economy chain based on their resource advantages and in constructing specialized industrial parks to promote the integrated development of upstream and downstream enterprises. It is essential to strengthen cooperation between industry, academia, and research institutions, promoting deep integration across all segments of the low-altitude economy chain, thereby forming a united force for industrial development.

5. Enlightenment to the development of low-altitude economy in other regions

5.1. Learn from GBA experience

GBA has established a three-dimensional support system, including national strategic support, local legislative guarantee and industrial fund investment, through the promulgation of special policies such as "Guangdong Province Action Plan for Promoting High-quality Development of Low-altitude Economy" and "Shenzhen Special Economic Zone Regulations for Promoting Low-altitude Economy Industry". It is suggested that other areas can learn from the following measures: setting up a special fund for low-altitude economy and simplifying the approval process by adopting the management model of "negative list+dynamic airspace release"; Formulate local regulations for emerging areas such as drones and eVTOL, and clarify relevant rules such as airworthiness certification and cross-border data flow.

In terms of industry consolidation and scene innovation, GBA has built a complete industrial chain from R&D to manufacturing to operation with the differentiated division of labor among Shenzhen, Guangzhou and Zhuhai. This provides inspiration for other regions, and we should focus on local characteristic areas to develop low-altitude economy. For example, mountainous areas are suitable for low-altitude logistics and emergency rescue, and tourist cities can develop aerial sightseeing projects. At the same time, by opening specific scenes as pilots, such as agricultural plant protection, urban inspection, medical emergency, etc., the business model is verified and promoted by demonstration projects, and the wide application of the "low altitude+"model is realized.

GBA took the lead in establishing small and micro service stations, low-altitude route networks and intelligent landing points for low-altitude economic public infrastructure in China, which provided valuable experience for other regions. It is suggested that other areas should promote the construction of "three networks", including improving the facilities network (such as landing points and energy stations), air network (communication and navigation system) and service network (flight supervision platform), especially in logistics hubs and densely populated areas. At the same time, the digital twin technology is used to build a low-altitude traffic management platform, integrate flight data and urban management system, and realize dynamic airspace allocation.

In terms of regional coordination and cross-border cooperation, GBA has piloted cross-border logistics routes through the policy linkage of Guangdong, Hong Kong and Macao (China), and established a low-altitude economic and industrial alliance. This enlightens other regions to

establish cross-administrative coordination mechanism, create airspace sharing database, unify flight rules and supervision standards, and avoid inefficiency caused by individual actions in each region. In addition, we should actively explore international cooperation, connect with the international airworthiness certification system, and promote mutual recognition of technology export and standards in order to enhance our competitiveness in the global low-altitude economy.

5.2. Avoid legal risks and challenges

In the aspect of legal risk identification, the main challenges faced by GBA include frequent "black flying" incidents caused by decentralized cross-regional airspace approval authority and insufficient coordination between military and civilian airspace, data collected by drones may violate the Data Security Law and the Personal Information Protection Law, and the ambiguity of responsibility identification among manufacturers, operators and users in flight accidents. These problems urgently need to be solved through a sound legal framework to promote the healthy development of low-altitude economy.

In view of the above risks, it is suggested to take the following series of countermeasures: First, formulate the Law on the Promotion of Low-altitude Economy on the legal framework, clarify the airspace classification, flight safety responsibilities and data use boundaries, and introduce a "supervision sandbox" mechanism to allow enterprises to try out new technologies in limited areas. Secondly, strengthen collaborative supervision, establish a multi-department joint law enforcement platform, integrate the functions of civil aviation, public security, industry and information and other departments, crack down on illegal flight behavior, and promote electronic fence and UAV real-name registration system technology to ensure the traceability of flight activities. Finally, build an insurance and relief system, promote the popularization of low-altitude flight liability insurance to cover all kinds of losses, and set up a low-altitude economic dispute arbitration center to provide a quick way to resolve disputes.

6. Conclusion

As a new field, GBA low-altitude economy plays an important role in promoting regional high-quality development. Through the comparison of international laws, this paper finds that the United States, the European Union and other regions have advantages in terms of regulatory flexibility, airspace coordination and privacy protection. Although GBA has local laws and regulations, it still faces problems such as rigid airspace management, lagging laws and regulations and scattered industrial chain. In order to narrow the gap with the international advanced level, it is suggested to establish a bay area coordination mechanism, build a dynamic legal system, introduce third-party operating companies, and formulate rules for cross-border flow of low-altitude data. Cross-regional collaborative development needs to be guided by "breaking the wall of the system" and strengthen top-level design, mechanism construction, collaborative management and safe development. Policy support, technological innovation, infrastructure construction and industrial chain coordination are the key paths to improve the high-quality development of low-altitude economy. For other regions, we can learn from GBA experience, set up special funds, simplify the examination and approval process, integrate the industrial chain, promote the construction of "three networks", strengthen regional coordination and cross-border cooperation, and avoid legal risks.

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