The Convergence of AI and Low-Altitude Economy

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***Abstract*—The low-altitude economy, as a national strategic emerging industry utilizing airspace below 1,000 meters (extendable to 3,000 meters in specific scenarios) as its operational platform, is rapidly developing and projected to reach a market size of 2 trillion yuan by 2030. Artificial intelligence (AI) technology, as a key enabling technology, is driving the transformation of the low-altitude economy from traditional applications to intelligent and autonomous operations. This paper systematically analyzes the current state and development trends of the integration of AI and the low-altitude economy from three aspects: technical framework, application scenarios, and challenges. First, we propose a four-layer technical architecture comprising perception, cognition, decision-making, and execution layers, and elaborate on core technologies such as multi-agent collaborative control, knowledge graphs and semantic compression, and airspace intelligent management. Then, we analyze the implementation effects of AI technologies in typical application scenarios such as logistics and distribution, urban governance, emergency rescue, and cultural tourism and education. Finally, we discuss challenges including safety risks, regulatory policies, and technical bottlenecks, and propose corresponding development recommendations. Through analysis of existing literature and practical cases, this paper provides theoretical reference and practical guidance for the deep integration of the low-altitude economy and AI.**

Keywords*—*Low-altitude economy, artificial intelligence, multi-agent collaboration, unmanned systems, airspace management

I. Introduction

The low-altitude economy refers to an entire industrial chain economic form that relies on airspace below 1,000 meters (extendable to 3,000 meters in specific scenarios), utilizes aircraft such as drones and electric vertical take-off and landing (eVTOL) vehicles as carriers, and encompasses R&D manufacturing, operation management, and service support. In 2023, China's low-altitude economy market scale exceeded 500 billion yuan and is expected to surpass 2 trillion yuan by 2030, becoming a new engine for national economic growth [1]. The low-altitude economy has been listed as a national strategic emerging industry and was included in the government work report for the first time in 2024. Various regions are actively conducting pilot demonstrations.

AI technology plays a crucial role in the development of the low-altitude economy. From intelligent perception and autonomous decision-making to multi-machine collaboration, AI technologies are comprehensively enhancing the intelligence level and operational efficiency of low-altitude aircraft [2]. Research shows that the development of the low-altitude economy can not only significantly promote new types of consumption but also empower economic transformation by fostering the development of new quality productive forces. In regions with high population density, the impact of low-altitude economic development on new consumption is more pronounced.

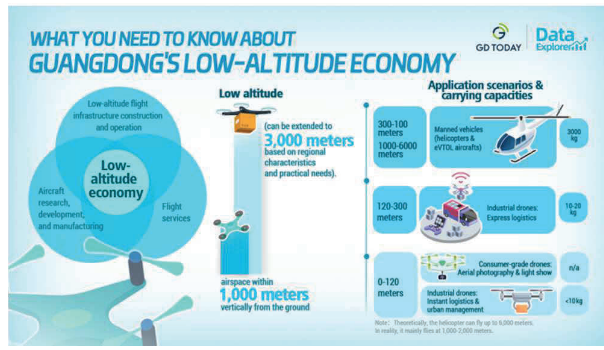

Fig. 1. Role of Low-altitude Economy [3]

Currently, low-altitude economy applications have expanded from traditional surveying and mapping and inspection to emerging fields such as urban governance, emergency disaster relief, transportation, cultural tourism, and education [4]. However, the development of the low-altitude economy still faces five major constraints: lagging airspace management reforms, infrastructure shortages, core technology bottlenecks, ambiguous business models, and imperfect regulatory systems [5].

Based on existing literature and practical application cases, this paper systematically analyzes the integration framework, application scenarios, and development challenges of AI technology and the low-altitude economy. Section 2 introduces the technical framework of the low-altitude economy and AI; Section 3 details key technologies for multi-agent collaboration; Section 4 explores typical application scenarios and implementation effects; Section 5 discusses technical challenges and countermeasures; and finally, Section 6 summarizes the paper and outlines future development directions.

II. Technical Framework of Low-Altitude Economy and AI

The technical framework of the low-altitude economy can be divided into four layers: infrastructure layer, core layer, application layer, and support layer. AI technology primarily penetrates the core and application layers, providing intelligent support for the low-altitude economy.

TABLE I. TECHNICAL FRAMEWORK OF LOW-ALTITUDE ECONOMY AND AI EMPOWERMENT DIRECTIONS

Layer	Components	AI Empowerment Directions	Typical Technologies
Infrastructure Layer	Airport facilities, communication networks, navigation systems	Intelligent infrastructure management	IoT, 5G-A, BeiDou positioning
Core Layer	Aircraft manufacturing, power systems, flight control systems	Intelligent perception, autonomous control	Computer vision, deep learning, reinforcement learning
Application Layer	Logistics distribution, urban transportation, agricultural plant protection	Intelligent decision-making, task optimization	Multi-agent collaboration, path planning
Support Layer	Airspace management, airworthiness certification, insurance finance	Intelligent supervision, risk control	Digital twin, intelligent prediction

A. Perception and Control Systems

Perception and control systems form the foundation of low-altitude aircraft intelligence. Through data collection and fusion from various sensors (visual, LiDAR, infrared, etc.), environmental perception capabilities are constructed. Advanced deep learning algorithms, such as convolutional neural networks (CNN) and recurrent neural networks (RNN), enable drones to achieve target detection, tracking, and recognition [6,7]. For example, Songshan Lake's AI "aerial police" equipped with AI algorithms can identify traffic accidents in real time and automatically collect evidence, with a response time of only 90 seconds.

B. Decision-Making and Planning Systems

Decision-making and planning systems are responsible for task allocation, path planning, and behavioral decision-making. Algorithms based on reinforcement learning and multi-agent collaboration enable drone swarms to make autonomous decisions and adapt to dynamic environments [8, 9]. Chengdu Aircraft Industrial Group developed an integrated solution of "Unmanned duty system + Zongheng Cloud + AI", which can achieve multi-drone collaborative operations and intelligent airspace management.

C. Communication and Network Systems

The low-altitude economy requires reliable communication networks to support information exchange between drones and ground stations, and among drones. 5G-A, satellite communication, and ad-hoc network technologies provide drones with high-speed, low-latency communication capabilities [10, 11]. The multi-agent collaborative control method proposed by Inspur Communications requires efficient communication networks for the construction and sharing of knowledge graphs.

D. Data and Intelligent Platforms

Data is the foundation of AI applications. The massive amount of data generated by the low-altitude economy requires efficient processing and analysis. Zhongke Star Map's "Star Map Cloud 2025" combines large model technology with low-altitude vertical domain knowledge to launch low-altitude intelligent agents, constructing a complete intelligent closed loop of "perception-cognition-decision-execution". The meteorological data products listed on Jiangsu Province Data Exchange provide precise meteorological services for the low-altitude economy, enhancing flight safety. Additionally, edge-cloud collaboration and federated learning technologies also play important roles in data processing and sharing for low-altitude aircraft networks [12, 13].

III. KEY TECHNOLOGIES FOR MULTI-AGENT COLLABORATION

Multi-agent collaboration is the core of low-altitude economy intelligence, enabling multiple drones to collaboratively complete complex tasks. Inspur Communications Information System Co., Ltd. applied for a patent for "low-altitude multi-agent collaborative control method and system", proposing a knowledge graph-based multi-agent collaboration framework.

A. Knowledge Graph and Semantic Compression

On each agent, data collected by multiple sensors is fused to form a fused feature vector. Semantic encoding is performed on the fused feature vector to construct a local knowledge graph. Then, semantic compression is applied to the local knowledge graph to generate compressed shared knowledge, which is transmitted to other agents. This method reduces communication overhead and improves system efficiency.

B. Distributed Decision-Making and Control

Each agent updates its local knowledge graph based on the received compressed shared knowledge from other agents, forming a global perspective. Based on the updated knowledge graph, agents can make more reasonable decisions. This distributed decision-making mechanism improves the robustness and flexibility of the system.

TABLE II. COMPARISON OF MULTI-AGENT COLLABORATION TECHNOLOGIES

Technology Type	Advantages	Disadvantages	Application Scenarios
Centralized Control	Global optimum, easy management	Single point of failure, large communication overhead	Small-scale collaboration, simple environments
Distributed Control	Strong robustness, good scalability	Local optimum, complex coordination	Large-scale clusters, dynamic environments
Hybrid Control	Balanced global and local performance	Complex design, high interface requirements	Medium scale, complex tasks

C. Collaboration and Competition Among Agents

Multi-agent reinforcement learning (MARL) enables agents to find a balance between collaboration and competition [14]. Through the design of reward functions, agents learn to cooperate with other agents to complete tasks. The airspace management platform developed by Chengdu Aircraft Industrial Group can achieve intelligent supervision of low-altitude airspace and multi-drone collaborative operations, providing technical support for the safety and efficiency of low-altitude flights [15].

IV. APPLICATION SCENARIOS AND PRACTICAL CASES

The integration of AI and the low-altitude economy has demonstrated great potential in multiple fields. The following are several typical application scenarios and practical cases.

A. Logistics and Distribution

Drone logistics distribution is an important application scenario of the low-altitude economy [16]. JD.com uses drones for logistics distribution in the Qinghai-Tibet Plateau region, solving distribution challenges in remote areas. However, urban drone logistics distribution faces safety risks, including regulatory policies, social public, equipment technology, and other factors. Through complex network analysis, 13 key risk factors such as illegal flights, poor equipment status, and equipment failures can be identified, and corresponding control measures can be formulated.

B. Urban Governance

In the field of urban governance, drones are widely used in traffic management, security patrols, and other areas [4]. Dongguan Songshan Lake's deployed AI "aerial police" can respond to traffic accidents within 90 seconds, conducting on-site evidence collection and traffic guidance. Through recognition models and computing power support, the system achieves an "air-ground integrated" intelligent patrol mode, effectively compensating for the deficiencies of traditional traffic management methods. As of the first half of 2025, Songshan Lake's AI "aerial police" have accumulated 840 flights, assisting in handling more than 1,900 road traffic accidents and security incidents, reducing the average congestion duration of traffic accidents by 70% and increasing accident handling efficiency by 30%.

C. Emergency Rescue

In the field of emergency rescue, drones can quickly reach areas that are difficult for personnel to enter, performing tasks such as search and rescue, and monitoring [17, 18]. The western Sichuan earthquake zone uses tethered drones to provide emergency communication services, solving the problem of communication interruptions in disaster areas. Drones also play an important role in disaster assessment and material delivery.

D. Cultural Tourism and Education

In the field of cultural tourism and education, drones provide new possibilities for experiential education and tourism. Chengdu Aircraft Industrial Group explores new growth points of "technology + education + cultural tourism", and through collaboratively building industry-education integration platforms with multiple universities, strengthens the foundation of industrial drones in the cultivation of applied talents. Applications such as drone light shows and aerial photography also enrich tourism experiences.

V. CHALLENGES AND COUNTERMEASURES

The integrated development of the low-altitude economy and AI faces multiple challenges, requiring effective countermeasures.

A. Safety Risks and Management

Safety is the primary issue in the development of the low-altitude economy. Urban drone logistics distribution faces risk factors in regulations and policies, social public, external supervision, enterprise management, personnel operation, equipment technology, and field environment. Through complex network analysis, key risk factors and key paths can be identified, and targeted control measures can be formulated [19, 20].

B. Regulations, Policies, and Standards

Regulations and policies are important guarantees for the development of the low-altitude economy [5]. Currently, lagging airspace management reforms and imperfect regulatory systems are the main constraints on the development of the low-altitude economy. The 2023 Central Economic Work Conference first positioned the low-altitude economy as a "strategic emerging industry", and the 2024 "General Aviation Equipment Innovation Application Implementation Plan (2024-2030)" further detailed key tasks such as technological innovation, industrial chain collaboration, and scenario application demonstration. The regulatory standard system needs to be further improved to provide institutional guarantees for the development of the low-altitude economy.Internationally, the International Civil Aviation Organization (ICAO) has also released relevant frameworks for unmanned traffic management (UTM) to guide the development of the industry [21].

C. Technical Bottlenecks and Innovation

The development of the low-altitude economy faces technical bottlenecks such as endurance, payload capacity, and anti-interference ability [22]. It is necessary to increase R&D investment and break through core technologies such as high-performance materials, intelligent flight control, airspace management, and safety assurance. In the first half of 2025, Chengdu Aircraft Industrial Group invested 50.0597 million yuan in R&D, accounting for 37.18% of its revenue, focusing on the R&D of vertical take-off and landing fixed-wing drones, multi-rotor drones, unmanned duty systems, and other directions. Moreover, the application of digital twin technology in air mobility also provides new ideas for solving technical problems in the low-altitude economy [23,24].

D. Talent Cultivation and Education

The development of the low-altitude economy requires a large number of professionals. It is necessary to cultivate applied talents through industry-education integration. Universities and enterprises can cooperate to co-build laboratories and training bases, providing students with practical opportunities. At the same time, it is necessary to strengthen the training of on the job personnel to improve professional skills and qualities.

TABLE III. CHALLENGES AND COUNTERMEASURES FOR THE DEVELOPMENT OF AI IN THE LOW-ALTITUDE ECONOMY

Challenge Type	**Specific Manifestations**	**Countermeasures**	**Participants**
Technical Challenges	Perception accuracy, decision-making intelligence, endurance	Increase R&D investment, break through key technologies	Enterprises, universities, research institutions
Regulatory Challenges	Airspace management, airworthiness certification, operational supervision	Improve regulations and standards, innovate regulatory mechanisms	Government, industry associations, enterprises

Challenge Type	Specific Manifestations	Countermeasures	Participants
Safety Challenges	Mid-air collisions, communication interruptions, cyber attacks	Build safety systems, strengthen risk management	Operating enterprises, regulatory agencies
Talent Challenges	Shortage of professionals, skills mismatch	Industry-education integration, on-the-job training	Universities, enterprises, training institutions

VI. International Comparison and Best Practices

The development of low-altitude economy varies significantly across countries, reflecting different regulatory approaches, technological capabilities, and market environments. Comparative analysis of international experiences provides valuable insights for China's low-altitude economy development [25].

A. *United States: Regulatory Framework and Innovation Ecosystem*

The United States has established a comprehensive regulatory framework for unmanned aircraft systems through the Federal Aviation Administration (FAA). The Part 107 regulations for small unmanned aircraft systems provide clear guidelines for commercial operations [26]. Additionally, the FAA's Integration Pilot Program (IPP) and subsequent Beyond program have facilitated the safe testing and integration of drones into national airspace [27]. American companies like Amazon Prime Air and Wing (Alphabet subsidiary) have pioneered drone delivery services, demonstrating the potential of large-scale commercial operations [28].

The U.S. approach emphasizes public-private partnership, with regulatory sandboxes allowing companies to test innovative applications in controlled environments. This balanced approach between safety regulation and innovation promotion offers valuable lessons for other countries developing their low-altitude economies [29].

B. *European Union: Harmonized Standards and Cross-border Cooperation*

The European Union Aviation Safety Agency (EASA) has developed a harmonized regulatory framework across member states, facilitating cross-border drone operations [30]. The U-series regulations establish categorized rules based on operational risk, enabling scalable implementation of drone technologies [31].

Notably, the EU has invested significantly in U-space, the European framework for managing drone traffic at low altitudes. Projects like SESAR JU have advanced the development of automated systems for drone registration, identification, and airspace management [32]. This coordinated approach across multiple countries demonstrates the importance of standardized protocols for regional integration of low-altitude operations.

C. *Singapore: Urban Integration and Smart Nation Initiative*

Singapore has emerged as a leader in urban drone integration, aligning its low-altitude economy development with its Smart Nation initiative [33]. The country has implemented a progressive regulatory framework that supports drone operations in urban environments while addressing privacy and security concerns [34].

Singapore's approach includes dedicated drone ports, automated traffic management systems, and integration with existing urban infrastructure [35]. The collaboration between government agencies, research institutions, and private companies has created a thriving ecosystem for drone innovation, particularly in areas such as urban mobility, infrastructure inspection, and emergency response [36].

D. *Comparative Insights for China's Development*

These international experiences highlight several best practices relevant to China's context:

Phased Implementation: Successful countries have adopted gradual approaches, starting with restricted operations and progressively expanding based on demonstrated safety and reliability [37].

Stakeholder Engagement: Regulatory frameworks developed through consultation with industry stakeholders tend to be more practical and effective [38].

Technology-Neutral Regulations: Flexible regulations that accommodate technological advancements while maintaining safety standards have proven more sustainable [39].

International Collaboration: Participation in global standard-setting bodies helps align national regulations with international best practices [40].

China can leverage these insights while developing its distinctive approach to low-altitude economy, considering its unique urban density, manufacturing capabilities, and governance structure [41].

VII. Conclusion and Outlook

This paper systematically analyzes the current state and development trends of the integration of the low-altitude economy and AI. As a national strategic emerging industry, the low-altitude economy is moving from pilot exploration to large-scale development. AI technology provides strong momentum for the development of the low-altitude economy through innovations in perception control, decision planning, communication networks, and data intelligence.

Multi-agent collaboration is the core direction of low-altitude economy intelligence. The multi-agent collaborative control method based on knowledge graphs and semantic compression can improve system efficiency and robustness. In scenarios such as logistics distribution, urban governance, emergency rescue, and cultural tourism and education, the integration of AI and the low-altitude economy has already demonstrated significant effects.

However, the development of the low-altitude economy still faces challenges such as safety risks, regulatory policies, technical bottlenecks, and talent shortages. It requires the collaboration of multiple parties including government, enterprises, universities, and research institutions to jointly promote the high-quality development of the low-altitude economy.

In the future, with the deepening of airspace management reforms, breakthroughs in technological innovation, and the expansion of application scenarios, the low-altitude economy will achieve greater development. New technologies such as digital twins, blockchain, and quantum communication may further integrate with the low-altitude economy, creating new possibilities. We need to strengthen international cooperation, jointly formulate standards and rules, and promote the healthy development of the global low-altitude economy.

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