

Research on the Construction of a Civil-Aviation Skilled-Talent Training System in the Context of a Low-Altitude Economy

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Abstract: The rapid development of the low-altitude economy has put forward compound, practical and innovative requirements for the knowledge structure, professional competence and professional literacy of civil-aviation talents. Aiming at the existing problems in civil-aviation talent training for the low-altitude field, such as insufficient curriculum-content coverage, insufficient in-depth interdisciplinary integration, disconnection between practical teaching and industrial operation, and outdated teachers' knowledge structure, this paper combines talent demands for operation-management and safety-assurance links in the low-altitude-economy industrial chain. Taking the training foundation of air-traffic-management-related majors in Civil Aviation University of China as the research object, it analyzes the training objectives and core requirements for civil-aviation skilled talents under the background of the low-altitude economy. On this basis, a three-dimensional training-requirement framework composed of knowledge structure, competence system and professional literacy is constructed. This paper puts forward a modular curriculum system of "core modules + orientation modules + interdisciplinary modules", designs a progressive four-in-one practical-teaching system consisting of professional cognition, professional foundation, engineering practice and engineering design, and proposes implementation paths from the aspects of curriculum optimization, teaching-mode innovation, practical-platform construction, industry-education-research integration and quality evaluation. The research provides references for civil-aviation transportation and air-traffic-management-related majors to adapt to the development demands of the low-altitude economy and promote the reform of talent-training systems.

Keywords: Low-altitude economy; Civil-aviation skilled talents; Air traffic management; Talent-training system; Industry-education integration

Online publication: October 27, 2026

1. Introduction

At present, a new round of scientific-technological revolution and industrial transformation is developing in depth, and China's economy is shifting toward a high-quality-development stage. As a comprehensive economic form integrating resources from multiple fields, including aviation manufacturing, information-communication, and transportation, the low-altitude economy has become an important position

for fostering new-quality productive forces and building a modern industrial system^[1]. The strategic status of the low-altitude economy in China has continuously risen from planning guidance and industrial cultivation to the construction of pillar industries^[2-3].

Nevertheless, the contradiction between rapid industrial development and insufficient talent supply has become increasingly prominent. During investigations in Shenzhen, Hunan, Anhui and other regions, the author finds that local governments and enterprises generally report insufficient support from professional talents. There is a severe shortage of civil-aviation skilled talents who can grasp the operational rules of the low-altitude economy, carry out systematic planning and design, and solve complex operation-organization problems. Meanwhile, society holds cognitive bias toward low-altitude-talent training, simply equating it with “drone pilot” training. At present, talent training oriented toward the low-altitude economy within the higher-education system lacks systematic design, and the training system is disconnected from industrial demands. Therefore, clarifying specific requirements of the low-altitude economy for civil-aviation skilled talents and improving the talent-training system has become an important subject to be solved urgently.

2. Development trend of low-altitude economy and analysis of talent demands

Relying on low-altitude airspace, the low-altitude economy takes manned and unmanned aerial vehicles as transport carriers to carry out manned transportation, cargo transportation and operational flight activities, driving the integrated development of relevant fields. Its industrial-chain upstream covers R&D and manufacturing; the midstream includes flight operation and infrastructure; the downstream consists of comprehensive services and derivative business forms. The School of Air Traffic Management of Civil Aviation University of China shall focus on the midstream-and-downstream links of “operation management” and “safety assurance”, and give play to the traditional advantages of air-traffic-management disciplines in efficient and safe utilization of airspace resources.

Talent demands of the low-altitude economy for civil-aviation skilled talents are reflected in three dimensions. The literacy dimension requires extreme safety-culture literacy, systematic planning and innovative thinking, as well as rigorous awareness of laws and regulations. The knowledge dimension calls for an interdisciplinary knowledge structure of “mastering management, understanding operation, knowing aircraft, and being familiar with application scenarios”, covering airspace management, UTM systems, transportation economics, aircraft performance, application scenarios and so on. The competence dimension requires practical-application and technology-integration capabilities, operation-management and risk-assessment capabilities, as well as policy-research and standard-application capabilities.

3. Current situation and challenges of civil-aviation skilled-talent training

Relying on the transportation major, the School of Air Traffic Management of Civil Aviation University of China has formed a mature talent-training system. Its core courses include *Air Traffic Flow Management*, *Theory and Methods of Airspace Planning*, *Air-Traffic-Control Equipment and Systems*, etc. Practical sessions rely on key laboratories and practice bases of air-traffic-control bureaus, delivering a large number of professional backbones for the civil-aviation industry^[4].

However, facing the low-altitude economy, the existing system has obvious deficiencies. First, the curriculum system lags. It lacks cutting-edge content such as UAM and AAM, and rarely involves

drone-operation regulations and UTM principles. Most technical courses center on large-scale centralized air-traffic-control systems, with insufficient coverage of distributed network-based UTM technologies. Second, interdisciplinary integration is shallow. The low-altitude economy involves the intersection of aircraft manufacturing, traffic management, digital technology and other fields, yet existing training is still dominated by engineering disciplines, with insufficient intersection with management science, law and other disciplines. There is a lack of comprehensive courses integrating “technology, management, regulations and scenarios”. Third, practical teaching is disconnected. Existing laboratories mainly serve transportation-aviation scenarios, lacking simulation environments for mixed operation of high-density heterogeneous aircraft. Cooperation with low-altitude-technology enterprises is insufficient, and students can hardly get access to the most cutting-edge commercial-operation practices. Fourth, teachers’ knowledge structure needs updating. Most teachers lack systematic research and front-line practical experience in the field of the low-altitude economy.

4. Construction of the requirement framework for civil-aviation skilled-talent training

4.1. Construction principles

Combine forward-looking nature with adaptability: benchmark international cutting-edge science and technology of the low-altitude economy while adapting to the reality of China’s low-altitude-airspace-management reform. Unify theoretical nature and practical orientation: adhere to in-depth theories and strengthen practical orientation at the same time. Coordinate universality and featured orientation: highlight the features of “low-altitude-airspace management” and “low-altitude-traffic-operation safety”. Promote interdisciplinary intersection and industry-education integration: break disciplinary barriers and deeply integrate industrial resources.

4.2. Training objectives

Based on national development strategies for the low-altitude economy and oriented toward demands for safe and efficient operation assurance of low-altitude airspace, cultivate high-quality compound civil-aviation skilled talents who develop morally, intellectually, physically, aesthetically, and labor-wise. Such talents shall possess solid basic theories of transportation engineering, systematic knowledge of low-altitude economy and air traffic management, good interdisciplinary vision, be familiar with low-altitude-operation rules and safety standards, and be competent for jobs including low-altitude-airspace planning, unmanned-aircraft traffic management, low-altitude-flight service, safety-risk assessment, operation organization and technical assurance.

4.3. Core literacy and competence requirements

At the knowledge-structure level, build a compound system of “in-depth development + horizontal expansion + extended development”. The in-depth-development part refers to basic theories of air transportation, including fundamentals of air traffic management, airspace-planning principles, aircraft performance and flight principles, principles of communication-navigation-surveillance, and aviation-safety theories. The horizontal-expansion part denotes specialized knowledge of low-altitude economy, including low-altitude-operation rules and regulations, UTM/U-space system architecture and service functions, low-altitude-airspace planning and assessment methods, and low-altitude-flight-service-and-assurance systems.

The extended-development part consists of interdisciplinary knowledge, including artificial intelligence and machine learning, big-data analysis, Internet-of-Things and communication technologies, business-model innovation of the low-altitude economy, project management, and fundamentals of aviation-law and policy-making^[5].

At the competence-system level, focus on five core competencies: competence in operation management and optimization of low-altitude-flight activities, capable of organizing, scheduling and optimizing low-altitude-flight activities in specific regions by adopting system-modeling and simulation technologies; competence in low-altitude-airspace planning and assessment, capable of participating in classified demarcation of low-altitude airspace and design of air-route-network schemes, and conducting safety and efficiency assessment; competence in drone-system application and data analysis, capable of applying drone platforms to scenarios such as logistics and inspection, and analyzing operation data; competence in identification, assessment and control of low-altitude-safety risks, proficient in safety-risk-assessment tools such as SORA; competence in continuous learning and technological innovation, capable of discovering practical problems in low-altitude-economy operation and putting forward improvement schemes.

At the professional-literacy level, consolidate three cornerstones: profound civil-aviation-safety-cultural heritage, internalizing the core value of “safety first”; strong sense of social responsibility and awareness of laws and regulations, deeply understanding the impacts of low-altitude-flight activities on the public and urban environment; good teamwork and communication capabilities, capable of effective communication with technical personnel, managers, regulators and the public from diverse professional backgrounds.

5. Design of talent-training system for air-traffic-management majors

5.1. Modular curriculum system

Adopt the structure of “core modules + orientation modules + interdisciplinary modules”. General-education and basic modules strengthen foundations of mathematics, physics, computer science and engineering, and add *Python Programming* to improve capabilities in data-analysis and algorithm application. Professional-basic modules include core courses such as *Air-Traffic-Engineering*, *Operations Research*, *Principles of Management*, *Flight Principles*, *Fundamentals of Communication-Navigation-Surveillance*, as well as featured courses such as *Introduction to Low-Altitude Economy*. Compulsory-professional and orientation modules fall into three categories. The operation-management category includes *Air-Traffic-Control and Management*, *Low-Altitude-Airspace and Air-Route Design*, *Control Rules and Procedures*, *Drone Operation Management*, etc. The technical-assurance category includes *Air-Traffic-Simulation Technology*, *Low-Altitude-Safety Management and Assessment*, *Low-Altitude Communication-Navigation-Surveillance Technology*, *Digital Platform for Low-Altitude Operation*, etc. The comprehensive-application category includes *Introduction to Low-Altitude-Traffic Management*, *Low-Altitude-Flight Service and Assurance*, *Unmanned-Aircraft Air-Traffic Management*, etc. Interdisciplinary and featured elective modules offer cutting-edge courses such as *Business-Model Innovation of Low-Altitude Economy*, *Aviation Law and Low-Altitude-Supervision Policies*, *Application of Big-Data and Artificial Intelligence in Low-Altitude Operation*, forming a dynamically expandable thematic-course library^[6].

5.2. Four-in-one practical-teaching system

Construct a progressive practical chain ranging from “professional cognition” to “comprehensive design”.

The first level is professional-cognition practice (1.0 credit): organize cognitive internships and inspect low-altitude-logistics bases and general-aviation airports to build intuitive industrial impressions. The second level is professional-basic practice: cultivate basic data-processing capabilities relying on *In-Class Experiments for Operations Research, Statistics and Analysis of Air-Traffic Data*. The third level is engineering-practice practice: it includes air-traffic-control-simulation practice (15 class hours), conducting command-and-control training for mixed operation of manned and unmanned aircraft in simulation scenarios such as control towers and terminal areas; low-altitude-operation-management practice, carrying out full-process simulation for tasks such as logistics distribution, inspection and emergency rescue; radar and digital-surveillance practice (8 class hours), training situational-identification and conflict-judgment capabilities under complex environments. The fourth level is engineering-design practice: it includes course design (2 weeks), requiring students to design low-altitude-operation-assurance schemes for cities or specific regions; graduation design (12 weeks), encouraging students to select cutting-edge topics of low-altitude economy and produce verifiable engineering-design or management schemes.

5.3. Guarantee path of industry-education-research integration

Implement the dual-tutor system. Invite experts from low-altitude-operation enterprises, air-traffic-control units and industrial-management departments to serve as industrial tutors and participate in curriculum construction, practical guidance and training evaluation. Upgrade simulation-training platforms: build simulation environments for low-altitude mixed-operation based on existing laboratories, and adopt digital-twin technology to restore real-world low-altitude-operation scenarios. Establish a closed-loop quality-evaluation system: conduct evaluation based on achievement degrees of training objectives and graduation requirements, and dynamically adjust course syllabi according to industrial technical standards and operation practices.

6. Paths and countermeasures for realizing training requirements

6.1. Optimize curriculum-system design

Construct a new curriculum system characterized by “modularization, interdisciplinarity and forward-looking nature”. Core modules consolidate foundations, offering courses including *Introduction to Low-Altitude-Economy Systems*, *Low-Altitude-Airspace Planning and Management*, *Drone-Operation Rules and Risk Assessment*. Orientation modules deepen featured content, setting the low-altitude-traffic-management orientation (*Urban Air-Traffic Management*, *UTM Theory and Technology*), the low-altitude-operation-service orientation (*Low-Altitude-Flight-Service and Assurance System*), and the low-altitude-safety-and-technology orientation (*Low-Altitude-Surveillance and Communication Technology*, *Intelligent Perception and Avoidance Technology*). Interdisciplinary modules expand horizons: cooperate with schools of economics-management, law and computer science to offer micro-majors^[7].

6.2. Innovate teaching modes and methods

Fully promote case-based teaching and build a library of typical Chinese low-altitude-economy cases, collecting airspace-reform schemes, operation-management cases of typical application scenarios, and major-safety-incident analyses from pilot regions such as Shenzhen, Hainan, and Hunan. Thoroughly implement project-based learning, closely integrating course assessment with project practice. For instance,

in the course *Low-Altitude-Airspace Planning and Management*, assign group tasks for students to complete low-altitude-airspace-planning schemes; in *Drone-Operation Rules and Risk Assessment*, require students to write SORA assessment reports targeting specific logistics-drone air routes. Actively carry out joint teaching by universities and enterprises, inviting experts from relevant departments of the Civil Aviation Administration of China, technical executives and operation directors of leading low-altitude-economy enterprises to give lectures^[8]. Vigorously build simulation-training platforms, adopting digital-twin technology to construct urban low-altitude environments and simulate high-density operation of aircraft such as drones and eVTOLs.

6.3. Strengthen practical-teaching sessions

Co-build high-level practical platforms. Cooperate with the Air-Traffic-Control Bureau of the Civil Aviation Administration of China and leading low-altitude-economy-operation enterprises to establish a “Low-Altitude-Economy Industrial College” or “Smart IIII.Low-Altitude Joint-Innovation Laboratory”, which serves as a physical platform for joint technology R&D, standard formulation, and talent training. Set up special innovation projects for “low-altitude economy”, encouraging students to form interdisciplinary teams focusing on real-world industrial problems, with both on-campus and off-campus dual tutors. Excellent achievements can be further transformed into practical applications. Organize students to participate in industrial competitions and standard seminars. Encourage students to take part in competitions such as “Internet+” and “Challenge Cup”, and outstanding students are encouraged to participate in seminars on low-altitude-economy technical standards and management norms organized by the Civil Aviation Administration of China and industrial associations^[9].

7. Conclusion

Against the grand background that the low-altitude economy has risen as a national strategic emerging industry, this paper systematically discusses talent-training requirements and system-reform directions targeting the core bottleneck of insufficient supply of civil-aviation skilled talents^[10]. The research draws the following conclusions. First, talents demanded by the low-altitude economy feature compound, practical and innovative attributes, so systematic reshaping must be carried out. Second, there exist structural contradictions between existing training systems and low-altitude-economy demands, mainly reflected in insufficient response of training objectives, incomplete curriculum-system coverage, weak interdisciplinary integration, disconnected practical teaching and outdated teachers’ knowledge. Third, the three-dimensional training-requirement framework of “knowledge-competence-literacy” provides clear guidance for low-altitude-talent training, embodying the organic integration of traditional advantages of air-traffic-management disciplines and new demands of the low-altitude economy.

For the low-altitude economy, the training of civil-aviation skilled talents must realize the strategic expansion from “serving traditional transportation aviation” to “serving the low-altitude economy simultaneously”. Through systematic education-and-teaching reform, build a new paradigm for professional talent training with distinct features, close connection with industries and emphasis on practice. It will provide solid talent support and intellectual guarantee for China’s transformation from a major civil-aviation country to a powerful civil-aviation country and for the high-quality development of the strategic emerging industry of the low-altitude economy.

Funding

2024–2026 Educational Science Research Program of the China Association for Transportation Education (Project No.: JT2024YB032)

Disclosure statement

The authors declare no conflict of interest.

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