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Current Status, Challenges, and Development Pathways of Civil Aviation Apron Control

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Abstract: With the continuous expansion of China's civil aviation transportation industry, airport ground operations have become increasingly dense. As a core component of safe ground operations and efficient flight scheduling, apron control serves as a critical hub connecting air traffic control, airports, airlines, and ground service providers. Currently, reforms regarding the transfer of apron control responsibilities are being fully implemented across the country. Major airports are gradually establishing independent apron control systems, with initial success in informatization of facilities and standardization of personnel. These efforts have effectively improved ground operation order and reduced safety conflict risks on the apron. However, the industry still faces challenges such as unclear responsibility boundaries, significant barriers to multi-party collaboration, uneven development of intelligent systems, incomplete safety management frameworks, and insufficient professional talent reserves—factors that severely hinder improvements in ground operational efficiency. Based on an analysis of the current state and issues within the civil aviation apron control sector, this paper proposes targeted development pathways from five dimensions—systems, coordination, intelligence, safety, and human resources—to provide theoretical guidance and practical support for high-quality development in apron control.

Keywords: Civil aviation apron control; Current status; Challenges; Development pathways

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1. Introduction

Against the backdrop of ongoing advancements in smart civil aviation, domestic airport capacity continues to expand, leading to increasingly intensive aircraft taxiing, pushback, and ground handling operations [1]. As the central role in ground safety management and operational dispatch, the quality of apron control directly affects flight punctuality and overall airport efficiency [2]. With the full implementation of apron control transfer reforms, airports have progressively taken over ground control functions, transforming the traditional model of centralized air traffic control [3]. However, in practice, airports at various levels still face shortcomings in control standards, coordination mechanisms, intelligent applications, safety management,

and talent development, resulting in significant imbalances in industry growth. This paper analyzes the current state, challenges, and root causes of civil aviation apron control, and proposes scientifically sound and feasible development pathways to guide standardized, refined, and intelligent advancement in apron control.

2. Current state of civil aviation apron control development

2.1. Full implementation of control transfer reform and formation of operational framework

Under unified directives from the Civil Aviation Administration of China (CAAC), major hub and trunkline airports have largely completed the transfer of apron control responsibilities, while reform is steadily progressing at smaller airports. This has fundamentally broken the traditional model where air traffic control towers exclusively managed all ground operations. The industry now features a clear division of labor: air traffic control manages runway takeoffs and landings, while airports assume primary responsibility for apron operations. Core apron control duties include aircraft pushback, engine start-up, taxiing to gates, apron towing, and ground traffic management. Since the reform, airports have significantly enhanced their autonomy in ground control, effectively addressing previous limitations such as obstructed visibility and delayed remote dispatch, making them better suited to high-density operations at large airports. Overall, the standardization of apron control transfer continues to improve, and the benefits of reform are gradually emerging, becoming a key measure to optimize airport ground operations and strengthen airports' primary responsibility for safety.

2.2. Adoption of differentiated operational models tailored to airport levels

Currently, Chinese airports have developed three differentiated operational models—self-managed, joint-managed, and outsourced—based on passenger volume, apron size, and flight density. Major hub airports such as Beijing, Shanghai, Guangzhou, and Shenzhen have fully adopted self-managed models, establishing dedicated apron control teams and building independent operational dispatch systems to meet complex, high-frequency ground operations. Most trunkline airports employ a joint-control model, strengthening coordination between airports and air traffic control to ensure operational stability. Smaller airports with lower traffic volumes typically use outsourced models, streamlining operations by leveraging existing resources. The widespread adoption of differentiated operational models has effectively balanced the operational capacities and development needs of airports of various levels, avoiding resource waste and capacity shortages. This approach enables apron control operations at airports across all tiers to better align with their actual conditions, significantly enhancing overall industry operational adaptability.

2.3. Continuous infrastructure iteration and steady improvement in informationization

With the advancement of smart civil aviation initiatives, domestic airports have continuously upgraded hardware facilities and information systems for apron control. Hub airports generally equip professional equipment such as surface surveillance radar, high-definition panoramic monitoring, and electronic flight progress strips, enabling real-time monitoring of apron operations and precise traceability of flight information. Some major airports have introduced digital technologies like remote towers and intelligent monitoring systems, overcoming the visual limitations of traditional physical control towers and expanding

coverage areas. Meanwhile, airports are progressively establishing basic operational dispatch platforms to enable online circulation of flight plans, ground support, and control instructions, replacing the traditional manual point-to-point communication model. Although smaller and medium-sized airports have relatively basic equipment configurations, the overall trend toward informatization and intelligent transformation remains clear, resulting in a significant improvement in foundational operational capabilities compared to the era of manual control.

2.4. Gradual refinement of management systems and initial establishment of safety operations framework

Guided by civil aviation regulatory standards and local oversight requirements, China's apron control industry has established an initial standardized management system. The Civil Aviation Administration has issued specialized regulations on apron control training, safe operations, and control handovers, clearly defining operational standards, qualification requirements, and safety red lines. Airports have developed detailed apron operation procedures, emergency response plans, and safety inspection systems tailored to their specific operational environments, standardizing processes including aircraft taxiing, ground handling, and operations under special weather conditions. At the same time, the industry has established routine safety supervision mechanisms, with regulators conducting regular on-site inspections and targeted audits to strictly address safety hazards such as runway incursions and apron collisions. The implementation of these standardized systems has effectively regulated controllers' operational behaviors, strengthened the safety baseline for ground operations, and maintained stable safety performance across the sector [4].

3. Major challenges facing civil aviation apron control and their causes

3.1. Ambiguous authority boundaries and inconsistent industry standards

Currently, overlapping responsibilities and unclear boundaries remain prominent issues in apron control operations, primarily due to insufficient refinement of top-level institutional frameworks. The coordination between apron control, tower control, and airport operations control centers lacks precise definition, leading to role overlap and regulatory gaps in critical areas such as control handover, flight release, and ground scheduling. During peak traffic periods, poor interdepartmental coordination often results in delayed dispatches and miscommunication of instructions. Additionally, a unified industry-wide operational standard has yet to be established in China, with significant differences existing among hub, trunk, and smaller airports in terms of control procedures, operational norms, and handover criteria. Some smaller airports continue using simplified operational systems, which lack sufficient standardization. The slow pace of updating top-level regulations relative to industry growth, coupled with the absence of detailed guidance for differentiated operations, has hindered standardized and uniform development, resulting in inconsistent operational quality across the sector.

3.2. Pronounced barriers to multi-party collaboration and severe information silos

Fragmented information and poor coordination among air traffic control, airports, airlines, ground handling services, and maintenance personnel represent core constraints on apron operational efficiency. The root cause lies in the lack of an integrated collaborative governance framework. Currently, each party operates its own independent information management system, with incompatible data interfaces and non-uniform

information standards, preventing real-time sharing of key data such as flight schedules, support progress, control instructions, and gate status. Daily operations still heavily rely on traditional point-to-point communication methods like phone calls and WeChat, resulting in delayed information transmission and high error rates, which can easily lead to scheduling discrepancies. Meanwhile, the industry has yet to establish a regular inter-departmental coordination mechanism, resulting in fragmented daily communication and scheduling. During emergencies such as extreme weather or widespread delays, response coordination among parties is slow, and collaborative handling is inefficient, easily exacerbating operational chaos at airports.

3.3. Uneven smart development and insufficient overall empowerment

The development of intelligent airside control systems across Chinese airports remains highly uneven, primarily due to imbalanced resource allocation and lack of unified technical standards. Hub airports, with ample funding and technological resources, have already implemented smart applications such as intelligent dispatching, conflict warnings, and automated sequencing, achieving significant digital empowerment. In contrast, most small and medium-sized airports face limited investment, outdated control equipment, and lagging information systems, enabling only basic monitoring and manual dispatching, with slow progress in intelligent upgrades. Additionally, the absence of standardized equipment and data protocols leads to poor system compatibility and data incompatibility across airports, making regional coordinated smart operations difficult to achieve. Current intelligent technologies are applied in limited scenarios, lacking adaptability for complex conditions such as adverse weather or flight traffic peaks. The data governance system remains underdeveloped, preventing full realization of the potential of smart technologies in enhancing operational safety and efficiency.

3.4. Complex operational risks and gaps in safety management

The complex environment on the apron—characterized by mixed movement of aircraft, vehicles, and personnel, along with overlapping operations—poses significant safety management challenges. These issues stem mainly from incomplete control regulations and inadequate risk prevention mechanisms. Currently, aircraft, service vehicles, and staff operate densely and chaotically within the apron area, leading to frequent safety hazards such as scratches, collisions, and runway incursions. The industry lacks specialized control guidelines for complex situations like extreme weather, special flights, or large-scale delays, and there is no clear framework for differentiated responses. Moreover, safety risk assessments often occur only after incidents, while preventive warnings and real-time controls remain poorly developed, leaving a gap in establishing a routine risk prevention system. Additionally, air traffic controllers face extremely high workloads during peak hours; prolonged intense operations increase risks of fatigue and judgment errors, highlighting critical shortcomings in human factor safety management and creating ongoing threats to apron safety.

3.5. Shortage of skilled personnel and poor alignment in training systems

There is a shortage of multidisciplinary talent in apron control, and team development lags behind, driven primarily by traditional training models and inadequate incentive mechanisms. As apron control becomes increasingly sophisticated and digitized, the industry urgently needs professionals combining expertise in air traffic control, digital operations, and emergency response. However, current training still focuses heavily on

theoretical instruction, with insufficient emphasis on practical training, operation of intelligent equipment, and simulation exercises in complex scenarios. Training programs across airports are highly homogenized, lacking targeted and personalized development. Furthermore, the industry's evaluation, promotion, and incentive systems are inadequate, with compensation not matching workload intensity, leading to low motivation among frontline controllers and frequent talent turnover. Small and medium-sized airports struggle to attract qualified personnel, resulting in persistent talent gaps that hinder the development of smart, standardized air traffic control.

4. High-quality development pathways for civil aviation apron control

4.1. Improve top-level institutional design and standardize industry operations

To address the problems of incomplete institutional frameworks and inconsistent standards, continuous optimization of top-level design is required to build a dual system combining standardization and differentiation. Civil aviation authorities should clarify the responsibilities and boundaries between apron control, tower control, and airport operations control, clearly defining the core duties of each position and department in handoffs, flight scheduling, and emergency response to eliminate overlapping responsibilities and regulatory gaps. National standards for fundamental apron operations should be unified, standardizing procedures for control handovers, operational practices, and safety red lines to ensure baseline operational consistency across the industry. At the same time, tailored operational management guidelines should be developed based on the characteristics of different airport levels, meeting the distinct development needs of hub, trunk, and small/medium-sized airports. Establish a dynamic mechanism for updating industry standards, and promptly revise and improve industry regulations based on the application of intelligent technologies and the implementation of new operational models, continuously addressing institutional shortcomings.

4.2. Build an integrated collaborative platform to break down information barriers within the industry

To address challenges such as poor multi-party coordination and information silos, it is essential to establish a unified, multi-stakeholder collaborative operational system. Leveraging the framework of smart civil aviation development, build a centralized apron operations coordination and decision-making platform that standardizes data interfaces and information protocols across all parties—air traffic control, airports, airlines, and ground handling services—ensuring seamless connectivity. This will enable real-time sharing and synchronized updates of flight schedules, gate status, support progress, and air traffic control instructions. Optimize daily dispatch communication mechanisms to replace fragmented traditional practices, enabling unified instruction distribution and online process closure. Establish regular cross-departmental coordination meetings to systematically identify operational pain points and refine collaboration processes. Simultaneously, enhance emergency response plans by clearly defining responsibilities and procedures in extreme scenarios, improving multi-party coordination efficiency and comprehensively advancing integrated ground operations.

4.3. Coordinate intelligent upgrades to balance overall industry development

Addressing uneven progress in industry-wide digitalization and intelligence, promote coordinated upgrades across the entire sector. Increase financial and technical support for smaller and medium-sized airports, drive

modernization of outdated air traffic control equipment and monitoring systems, and standardize hardware and information system specifications to elevate foundational digital capabilities at grassroots airports. Deepen innovation in smart applications at hub airports, expanding use cases such as AI-based intelligent scheduling, automated surface conflict warnings, automatic flight sequencing, and remote tower operations to adapt to complex operational conditions. Strengthen the industry's data governance framework by standardizing data collection, sharing, application, and security management processes to ensure secure and compliant data usage. Develop regional smart collaborative operation systems to enable data interoperability and resource coordination among airports and between government and enterprises, reducing development disparities and promoting balanced, high-quality intelligent growth in apron air traffic control.

4.4. Strengthen comprehensive risk prevention and control systems to safeguard ground operation safety

Focusing on complex risks in apron operations, establish a full-chain safety management system encompassing pre-event early warning, in-process control, and post-event review. Refine operational guidelines for complex scenarios such as adverse weather, special flights, large-scale delays, and peak traffic periods, clearly defining pedestrian and vehicle movement routes, dispatch standards, and response procedures to standardize apron operations. Implement routine safety risk inspection mechanisms, focusing on core risks like runway incursions, apron collisions, and fatigue-related operations, maintaining hazard registries and ensuring closed-loop rectification. Optimize air traffic controller shift scheduling to scientifically allocate working hours, alleviate pressure during peak periods, and eliminate fatigue-related risks. Enhance safety education and hands-on training for all personnel to strengthen controllers' risk identification and emergency response capabilities. Improve safety supervision and evaluation mechanisms to reinforce accountability across all positions, building a robust defense for ground operation safety.

4.5. Optimize talent development systems to strengthen the industry's human capital foundation

To address talent shortages, establish a comprehensive talent development and management system aligned with smart civil aviation. Innovate talent cultivation models by creating a tripartite training platform integrating theoretical instruction, simulation exercises, and on-site practice, emphasizing core competencies such as intelligent equipment operation, complex scenario dispatching, and emergency response. Strictly enforce training duration and assessment standards for air traffic controllers. Improve recruitment mechanisms to attract multidisciplinary professionals and strengthen frontline workforce capacity. Enhance performance evaluation, promotion, and incentive systems by linking job performance and professional competence to compensation, boosting employee motivation and reducing turnover. Establish industry-wide exchange and training platforms to facilitate the sharing of air traffic control experience and technological applications across airports, continuously enhancing the professional expertise and overall capability of the industry's control teams [5].

5. Conclusion

In summary, apron control is a core guarantee for the safe and efficient operation of civil aviation airports on the ground, and an essential component of the smart civil aviation system. Currently, China's civil aviation

apron control reform has achieved phased results, with an operational framework largely established, infrastructure continuously improved, and management systems steadily optimized, providing strong support for the stable development of the civil aviation transportation industry. However, the sector still faces multiple challenges, including an incomplete rights-and-responsibilities system and significant barriers to multi-party collaboration, which hinder standardized, intelligent, and integrated development. Based on actual industry operations, this paper analyzes the root causes of various issues and proposes a comprehensive, actionable development pathway from five dimensions: institutional mechanisms, coordination, technology, safety, and talent. Going forward, as the construction of smart civil aviation continues to deepen, the apron control industry must further advance reforms, address existing shortcomings, and continuously promote standardization, intelligence, and collaborative upgrades to comprehensively enhance the safety and efficiency of airport ground operations.

Disclosure statement

The author declares no conflict of interest.

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