International Civil Aviation Organization

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Agenda Item 8: Airport Innovation and Technology

THE INTELLIGENT AND SUSTAINABLE DEVELOPMENT TRENDS OF AIRPORT PLANNING AND DESIGN

(Presented by China)

SUMMARY

In line with the global trend toward intelligent and sustainable airport development, airports worldwide are continuously embracing new concepts and leveraging advanced technologies to enhance their planning and design capabilities. In recent years, China has actively engaged in exploration and practice, widely adopting innovative approaches such as digital site selection, Building Information Modeling (BIM) technology, air-ground integrated design, remote air traffic control towers, "Zero-Carbon Airports", "Modification and Recycling of Waste Soil", and "Sponge City" design. This paper advocates for countries in the Asia-Pacific region to focus on emerging trends in airport planning and design by sharing relevant case studies, analyzing the achieved outcomes, and addressing the encountered challenges. It further encourages collaborative research efforts to advance the intelligent and sustainable development of airports across the Asia-Pacific.

1. INTRODUCTION

1.1 As global airport construction continues to evolve, the pursuit of smart and sustainable airport development has remained a key focus within the realm of airport planning and design. In China, significant efforts have been made in advancing research and innovation in smart and green airport planning and design. Furthermore, during the construction of airports in countries such as Pakistan, Nepal, Togo, Burundi, Tanzania, and Zambia—where China has been actively involved—new concepts and methodologies have been adopted, including digital site selection, BIM technology, air-ground integrated design, remote air traffic control towers, "Zero-Carbon Airports," "Modification and Recycling of Waste Soil," and "Sponge City" design.

2. DISCUSSION

2.1 *The Digital Site Selection.* traditional airport site selection predominantly depends on foundational materials such as topographic maps and satellite imagery. These approaches present challenges on interpretation of terrain and features, data omissions, manual efforts, and low efficiency. To overcome these limitations, China has developed advanced digital site selection technology that integrates GIS, BIM, big data analytics, and unmanned aerial vehicle (UAV) mapping technologies, along with multi-dimensional quantitative analysis of various control factors. This enables the

visualization and intelligent optimization of site selection plans. This technology significantly reduces the site selection cycle while enhancing the scientific rigor of planning processes. Its innovative significance lies in facilitating the transition from experience-based judgment to data-driven decision-making in site selection. It has been successfully implemented in complex terrain airport projects in Enshi, Foshan, and Pakistan, effectively improving site selection accuracy. For instance, at Enshi Airport in China, this technology was utilized during the site selection phase to simulate hundreds of potential site terrain configurations. Numerical simulations were also employed to analyze meteorological conditions post-construction for the proposed site, providing a robust basis for quantitatively assessing meteorological feasibility. Overall, digital site selection has markedly improved the efficiency and scientific validity of airport site selection processes.

2.2 *The BIM Technology.* The application of BIM technology in airport design has been extensively investigated in China to realize forward-oriented BIM-based design. By substituting conventional 2D drawings with dynamic and visually intuitive 3D models, the spatial arrangement and structural details of the airport can be conveyed more clearly. Furthermore, the technical handover during construction has evolved from "Drawing Interpretation" to "Model Walkthrough", markedly improving the efficiency of information dissemination. Additionally, automated design functionalities have been developed to address scenarios such as runway and taxiway segmentation, treatment of irregular pavements, reinforcement of drainage channels, runway and taxiway marking design, and computation of fill-and-cut zero lines. These functions are specifically tailored for repetitive and rule-bound design tasks, thereby freeing designers from labor-intensive manual calculations and drafting, and enhancing design efficiency by over 40%. This facilitates the intelligent and data-driven management of airport construction projects. Meanwhile, the digital model established through BIM technology provides a robust foundation for the subsequent smart operation of the airport.

2.3 *The Integrated Design Technology for Airport Airspace and Ground Operations.* An airport design scheme not only encompasses the visual design of ground facilities but also integrates navigation services, which constitute a critical component and potentially a pivotal aspect of airport construction. The increasing demand for collaborative design between airside and landside companies requires a holistic approach. By integrating airport ground design with navigation service schemes during the selection, consultation, and design phases, the comprehensiveness of the design and overall work efficiency can be significantly enhanced. In addition to traditional navigation service design, China has developed the "Airport Clear Zone Operation Management System Platform", enabling three-dimensional and intelligent evaluations of clear zone conditions. This innovation reduces assessment time by 70%, thereby markedly improving both the efficiency and precision of evaluations.

2.4 *The Remote Tower Technology.* Many small and linear airports, situated in remote locations far from urban centers, face challenges in recruiting sufficient air traffic controllers. Additionally, the construction of a conventional control tower incurs relatively high costs. Consequently, the establishment of remote air traffic control (ATC) towers enables air traffic controllers at large and medium-sized airports to remotely oversee and direct operations at smaller regional airports. This approach significantly enhances the overall utilization of regional air traffic control resources while reducing operational expenses for small and medium-sized airports. Remote towers enable long-distance monitoring, free from the constraints of physical construction requirements, and leverage advanced technologies such as wide dynamic range, high depth of field, and ultra-high resolution panoramic video to manage multiple airport towers from a centralized location. Furthermore, remote towers support continuous 24/7 operations, offering tangible benefits in terms of improved efficiency and reduced operational costs.

2.5 *The "Zero-Carbon Airports" Design.* In line with international carbon emission requirements, China has established the strategic goals of achieving "Carbon Peak" and "Carbon Neutrality", emphasizing the green and low-carbon transformation of airports to promote the application of renewable energy and enhance airport energy efficiency. Key technical challenges in integrating airport planning and design with renewable energy systems are addressed, taking into account the

geographical location and resource conditions of each airport. A comprehensive energy infrastructure is planned and constructed, fully leveraging renewable energy technologies such as ground source heat pump systems, photovoltaic power generation systems, solar hot water systems, and air source heat pump systems. This approach establishes a low-carbon or "zero-carbon", environmentally friendly, and safe solution for airports. For instance, Taiyuan Airport in China in the "zero-carbon" design, conducted critical technical research on photovoltaic installation. It includes assessments of the electromagnetic environment impact of photovoltaic panels on communication, navigation, and surveillance equipment, evaluations of glare pollution effects on airport operational safety, bird strike risk assessments, analyses of Foreign Object Debris (FOD) generation impacts, and studies on the influence of aircraft wake turbulence on photovoltaic systems. These evaluations ensure that the integration of renewable energy does not compromise airport operational safety.

2.6 *Rapid Modification and Recycling of Waste Soil.* During airport construction, narrow and elongated sections near drainage ditches and underground utility corridors often require backfilling. Currently, wet lean concrete or foam concrete are predominantly used as backfill materials, but these options are associated with high costs. At the planning and design stage, an innovative in-situ rapid solidification technology for surplus soil has been proposed. This technology enables the rapid modification of on-site surplus soil, significantly enhancing its strength and water stability. As a result, it improves the load-bearing capacity of the foundation while mitigating uneven settlement. By facilitating the reuse of surplus soil, this approach minimizes environmental impact during construction, aligns with the principles of sustainable development, effectively reduces ecological damage caused by construction projects, enhances green construction capabilities, and promotes innovation and advancement in airport engineering practices.

2.7 *The "Sponge Airports" Design.* In the airport design, it is essential to comprehensively incorporate Sponge City measures, such as water retention ponds, permeable grass pavers, and sunken green spaces. The Sponge City technologies including infiltration, detention, retention, treatment, utilization, and discharge, can effectively manage stormwater runoff, mitigate non-point source pollution, and reduce peak stormwater discharge. This approach not only achieves the various objectives of sponge cities but also establishes a systematic "Sponge Airport". It provides a critical foundation for transforming airports into environmentally sustainable, ecologically friendly, and green aviation hub ports.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) Fully recognize the trend that global airports are moving towards intelligence and green development;

b) Advocate States to jointly conduct research on relevant technologies for smart airports and green and low-carbon airports, launch multi-country cooperation projects, and promote the overall improvement of airport planning and design capabilities in the Asia-Pacific Region; and

c) Encourage states to actively share their achievements in technological innovation within airport planning and design, engage in mutual exchange of experiences, and promote the proactive adoption of new concepts and technologies in more countries, to improve the intelligence and sustainability of airports.

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