International Civil Aviation Organization

The Seventh Meeting of the Asia/Pacific Aerodrome Design and Operations Task Force (AP-ADO/TF/7)

(Bangkok, Thailand, 17 to 20 February 2026)

Agenda Item 6: Airport Innovation

DIGITAL APPLICATIONS FOR AIRPORT WHOLE LIFE CYCLE BASED ON DATA AND SIMULATION

(Presented by CHINA)

SUMMARY

This paper presents the digitalization level of traditional airport construction is relatively low, which result in high labor costs and low operational efficiency from site selection to construction of airport. The Civil Aviation Administration of China (CAAC) focus on the whole-life-cycle airports, introducing the digital twin, artificial intelligence, and simulation technologies into application scenarios across the site selection, planning, design, construction, and operation. Based on the digital twin foundation, full-process simulation, and data-driven intelligence, CAAC demonstrates that digital technology would contribute a lot in improving decision-making and optimizing resource allocation.

1. INTRODUCTION

1.1 Traditional airport construction commonly exhibits the following challenges:

a) As for the Decision-Making: The data compatibility of various systems is poor, and airport employees usually only understand the content they are responsible for, with little knowledge of other areas, making it difficult to coordinate various data and make scientific decisions.

b) As for the Construction: During the site selection, the conventional "expert survey+analogy analysis" model results in a longer site selection cycle. During the planning and design, the design scheme was determined based on experience with similar airports, and it was not possible to accurately evaluate the situation of this airport. During the construction, based on experience, the level of refinement is relatively low, resulting in redundant and wasteful materials.

c) As for the Data Utilization: The data between different systems is incompatible, and the data between different airports is not shared. The knowledge and experience of operation are relatively scattered, which cannot effectively guide the design and construction of subsequent airports.

1.2 To further enhance airport construction and operational quality, mitigate safety risks and optimize passenger experience, the Civil Aviation Administration of China (CAAC) proposed a digital application system for airport whole-life-cycle management. The system based on digital twin foundation, full-process simulation and data-driven intelligence. By leveraging cutting-edge technologies including digital twins, simulation, and artificial intelligence, this system could achieve functions including intelligent site selection with unified data sources, parametric design methodologies, and digital construction processes.

1.3 To advance whole-process management of airport planning, design, construction, and operations, CAAC advocates conducting simulation studies for airports using digital technologies. This

approach requires designing and constructing airports from the operational standpoints of Air Traffic Control (ATC), Airlines, Ground Handling Agents, and Pilots. This approach enables operational efficiency and user accessibility.

2. DISCUSSION

2.1 CAAC proposes a 'Consistent Model, Unified Data Source' whole-life-cycle digital foundation. This framework creates an integrated airport data-flow and business-process transmission system, enabling end-to-end model continuity from site selection through operational handover.

a) By leveraging the airport construction and operations macro-database (which including construction databases, standards repositories, and operational databases), a bidirectional mapping system bridging physical infrastructure and digital twins is established.

b) An innovative 'AI + Digital Twin' framework is developed: Industry-specific vertical AI large models are built using the macro-database, integrated with knowledge graph-based memory for airport construction/operations and vector databases of regulatory standards, elemental dependency chains are constructed via simulation. This achieves the transformation from parametric BIM design to intelligent construction.

c) Through the digital foundation and simulation technologies, demonstrate the rationality of airport facilities and operation processes from the perspective of usage and operation, and try to avoid design errors caused by experience.

2.2 For the site selection, CAAC proposes a strategic shift from digitalization to intelligentization in airport location decision-making. This involves constructing an Airport Site Selection Agent with four core components: 1) Memory Module. Integrates industry big data including: standards, airport macro-datasets, physical environment inputs, surrounding infrastructure and/or transportation and/or population. 2) Planning Module. Performs domain-specific fine-tuning to generate Chain-of-Thought processes encompassing: Reflection, Critical analysis, Strategic planning. 3) Tool Module. Connects via MCP (Model-Content-Process) protocol to: Digital site selection platforms, Parametric BIM design tools, Enabling multi-modal output generation. 4) Action Module. Leverages industry-grade intelligent computing infrastructure to: Transition scale parameter forecasting from traditional analogy methods to big-data simulation prediction, enhance site screening metrics through intelligent automation.

2.3 For the planning and design, CAAC proposes a simulation-driven parametric BIM forward design and validation system. Leveraging the airport construction and operations macro-database, this framework could rapidly generate mathematical topology configurations of airports categorized by functional targets. Performs end-to-end geometric configuration simulations through modular scenario assembly. Enables multi-disciplinary parametric generative design to produce 3D airport scenes. Based on Tabletop exercises, Operational simulations, this framework conducts solution optimization and delivers final BIM+GIS design deliverable.

2.4 For evaluating planning and design deliverable, CAAC mandates stakeholder-perspective simulation assessments during review phases. This involves: Conducting tactical simulation platform evaluations based on 3D airport models through the perspective of pilot, air traffic controller, ground service crew, passenger. Optimizing airport designs from user/operator viewpoints, Performing specialized validations via simulation for: Airfield layout rationality (runway-taxiway configuration), Apron gate allocation efficiency, Complex taxiway intersections, Visual aid navigation system effectiveness to ensure operational integrity and safety upon commissioning.

2.5 To address simulation tooling gaps, CAAC recommends enhancing conventional end-to-end airport simulation by integrating AI-agent technologies. This approach resolves limitations of traditional methods, overcomes static/idealized assumptions and incorporates operational complexity. Besides, another Technical Approach is implementing AI-enhanced simulation which includes aircraft, ground vehicles, personnel, and equipment, leveraging parametric BIM forward design outputs, generating immersive 3D operational sandboxes, and enabling visual/immersive tabletop exercises.

2.6 For the construction, CAAC recommends implementing digital construction methodologies to enhance automation, mechanization, and intelligence throughout airport development. This integrates BIM+GIS convergence, IoT & spatial positioning technologies, AI-driven information management, to enable precision control over critical project dimensions on quality assurance, safety compliance, schedule optimization and cost management.

2.7 During operation, leveraging the BIM+GIS digital foundation, the system could integrate facility and sensor IoT networks to establish an 'Air-Space-Ground Integrated' multi-source perception framework. Deploys AI-agents to assimilate real-time, including passenger flow status, meteorological data, ATC coordination feeds and Flight operation metrics and facility/equipment diagnostics. And then, executes operational plan simulations and populates the Airport Construction & Operations Macro-Database. This could contribute to the National Airport Cluster Macro-Database and enables knowledge feedback loops for future airport planning.

2.8 CAAC is systematically consolidating best practices and technical requirements for digital construction. We welcome aviation authorities and stakeholders from relevant countries and regions to actively share expertise in airport digital development, jointly advancing the safe, environmentally compliant, and sustainable growth of global high-altitude airports.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) encourage other APAC States to share their experience in the digital applications for airport design, construction and operation; and

c) discuss any relevant matters as appropriate.

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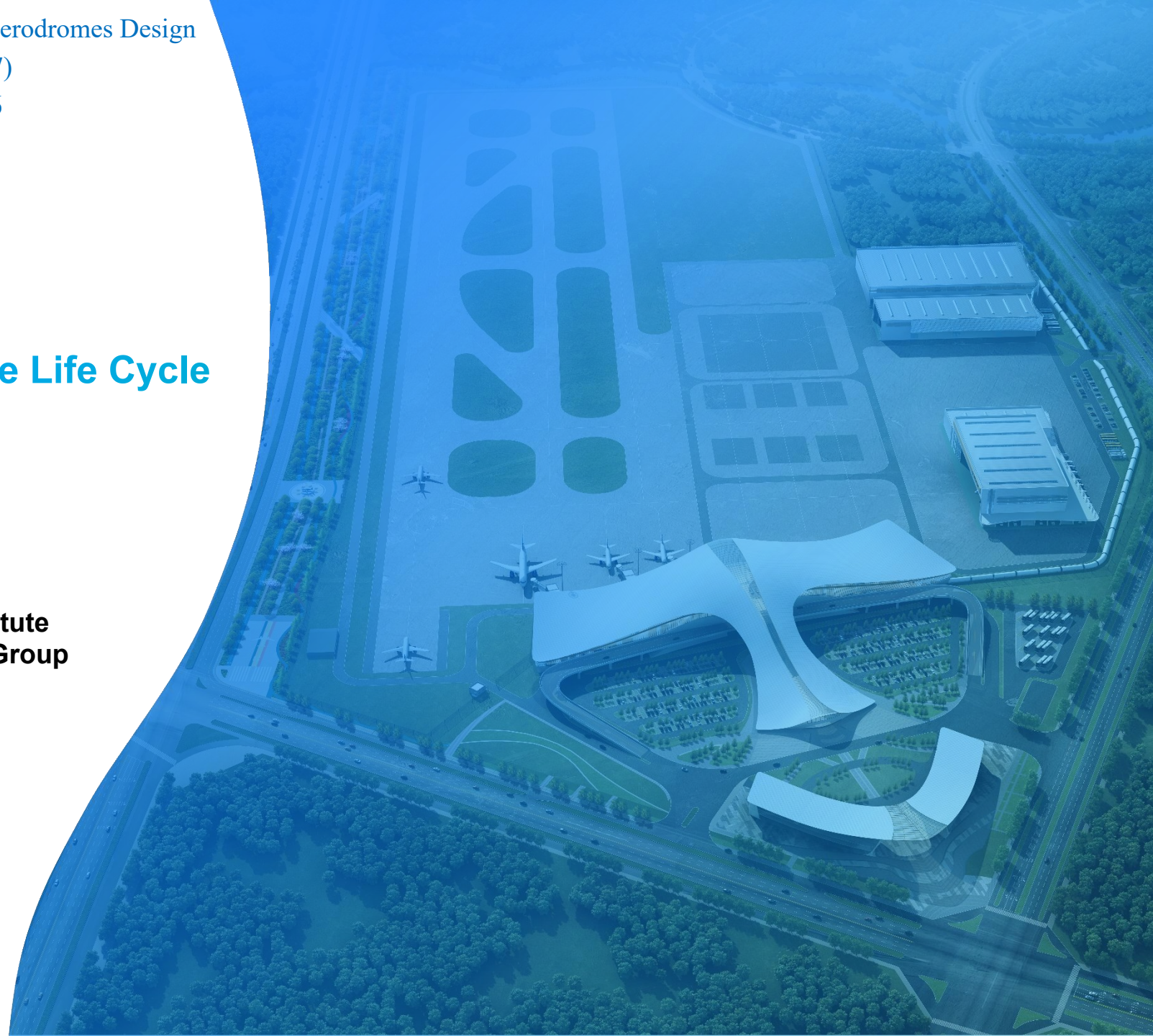
Digital Applications for Airport Whole Life Cycle

Data, Simulation, Digital Twin

Civil Aviation Administration of China

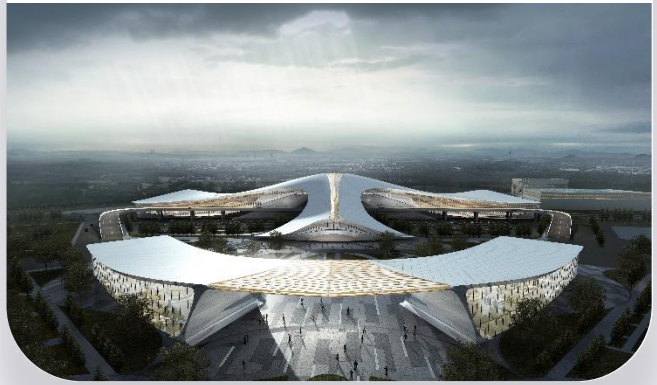
Southwest Design and Research Institute Co. Ltd., China Airport Construction Group



Content

1

Implementation Routes



2

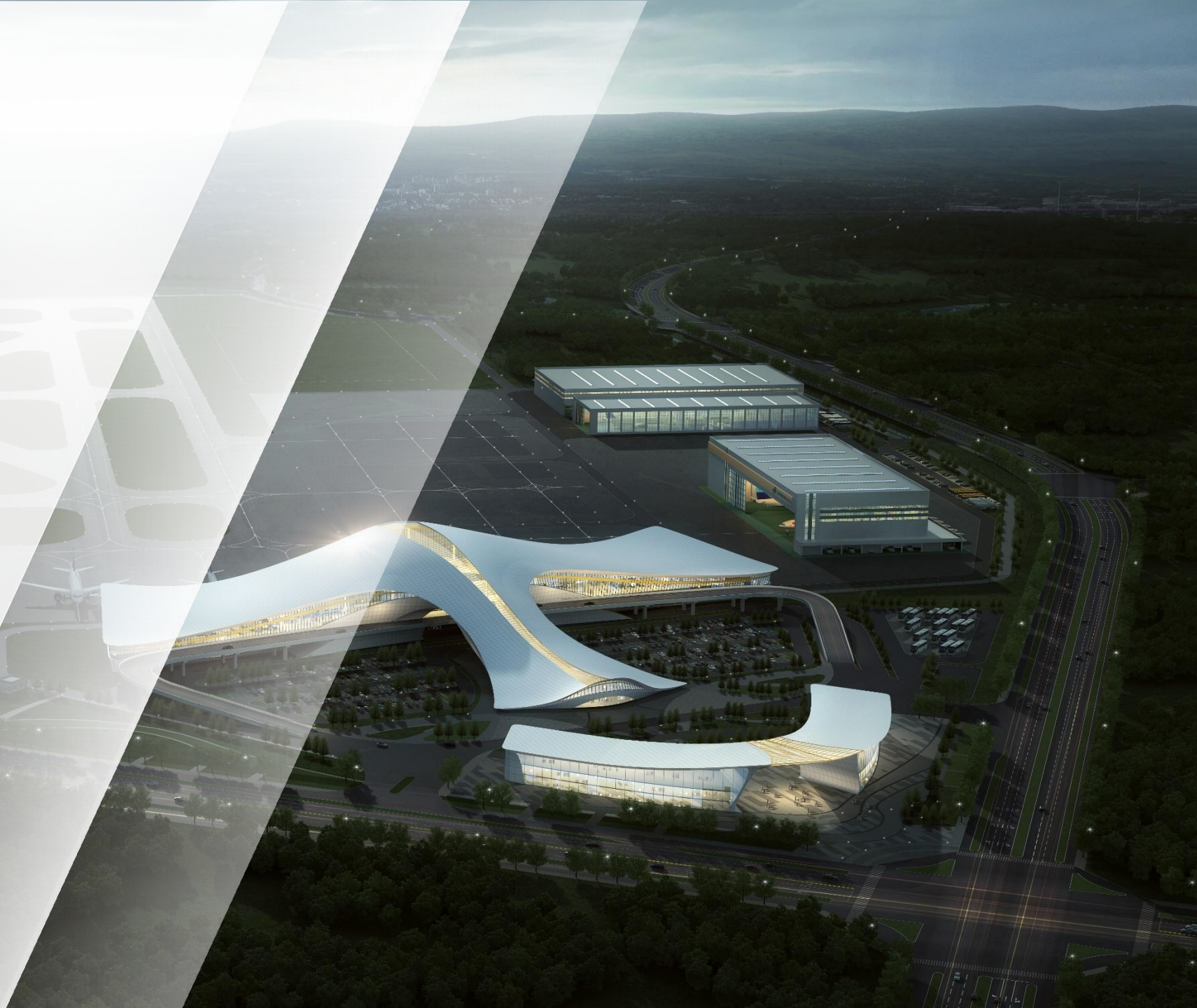
Digital Applications

3

Action

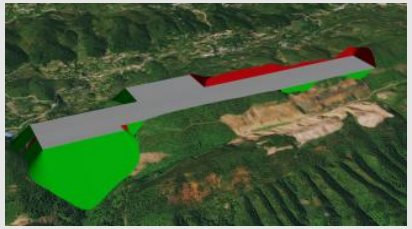
01

Implementation Routes



Airport Design, Construction & Operations Macro-Database

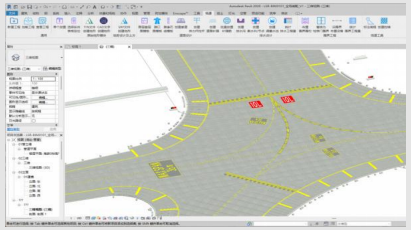
Site selection



Digital site selection → Intelligent site selection
Expert review → Expert + AI review

simulation and verification by AI

Planning & Designing



Parametric design → Generative design
Expert review → Expert + AI + simulation review

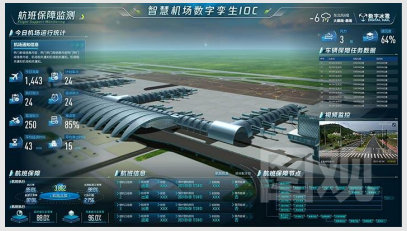
Data accumulation → Knowledge repository integration

Model based on BIM and GIS

BIM: Building Information Modeling

GIS: Geographic Information System

Operation



Legacy encoding → knowledge graph & vector embeddings
Multi-source runtime system integration with AI control
Basic integration → situational awareness & AI operations

Completion of physical airport & digital twin

Construction

Knowledge repository platform
Robotic & prefabrication intelligence construction
AI schedule management
Simulation & verification in construction

Blue parts are still under developing

02

Digital Applications

Site selection

Planning

Designing

Construction

Operation

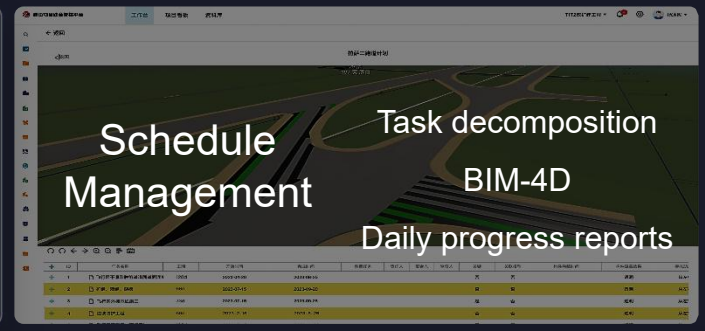
Digital Management System

Design Management

Drawing/model

Version update

Online change



Schedule Management

Task decomposition

BIM-4D

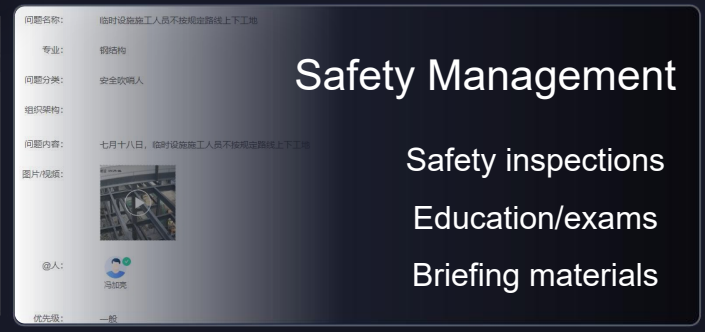
Daily progress reports

Quality Management

Quality Assessment

Quality Inspection Patrol

BIM-AR



Safety Management

Safety inspections

Education/exams

Briefing materials

Resource Management

Online reporting

E-signature

Auto-archiving

Material Management

Subdivision acceptance

QR code in/out

Underground pipeline tage

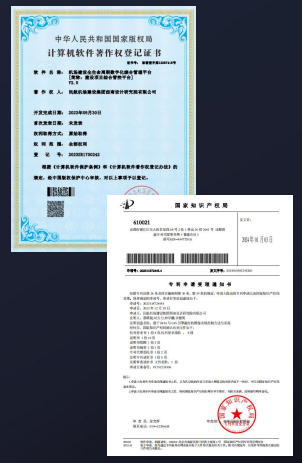
Cost Management

Quantity verification

Auto-BOQ

Daily progress reports

BIM+GIS Engine



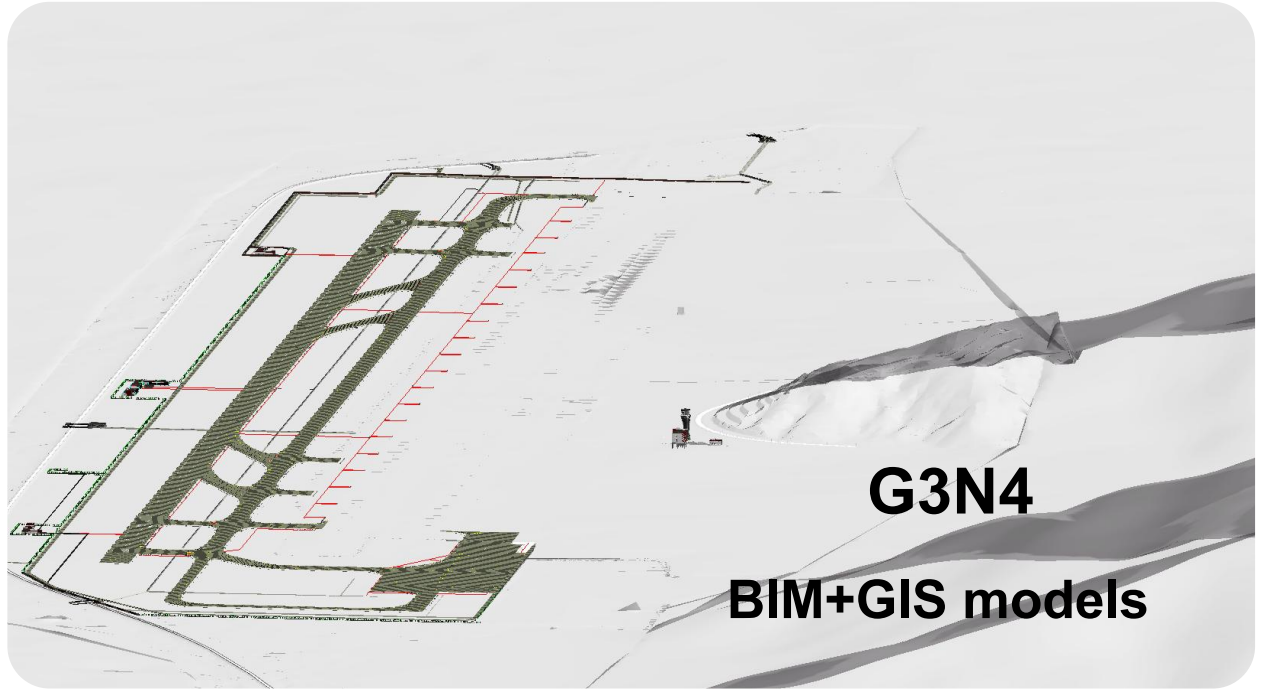
Patents & Software

Copyrights

AR construction briefing

Non-stop Construction Management

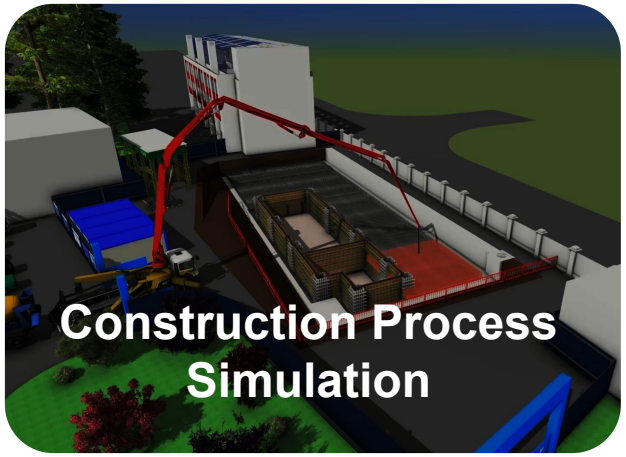
Paperless Management



Digital twin airport info library

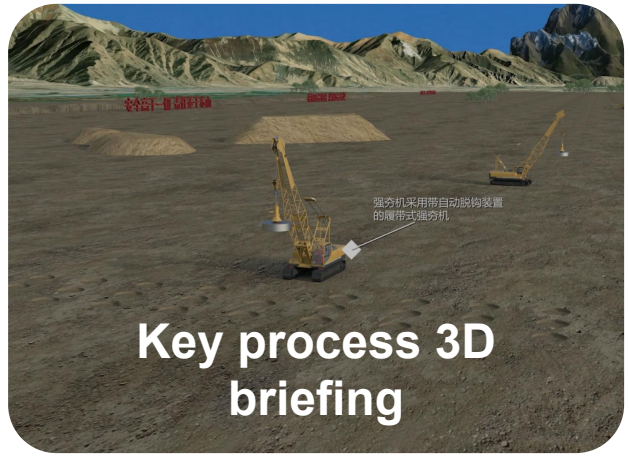
QR code tags

3D joint drawing review



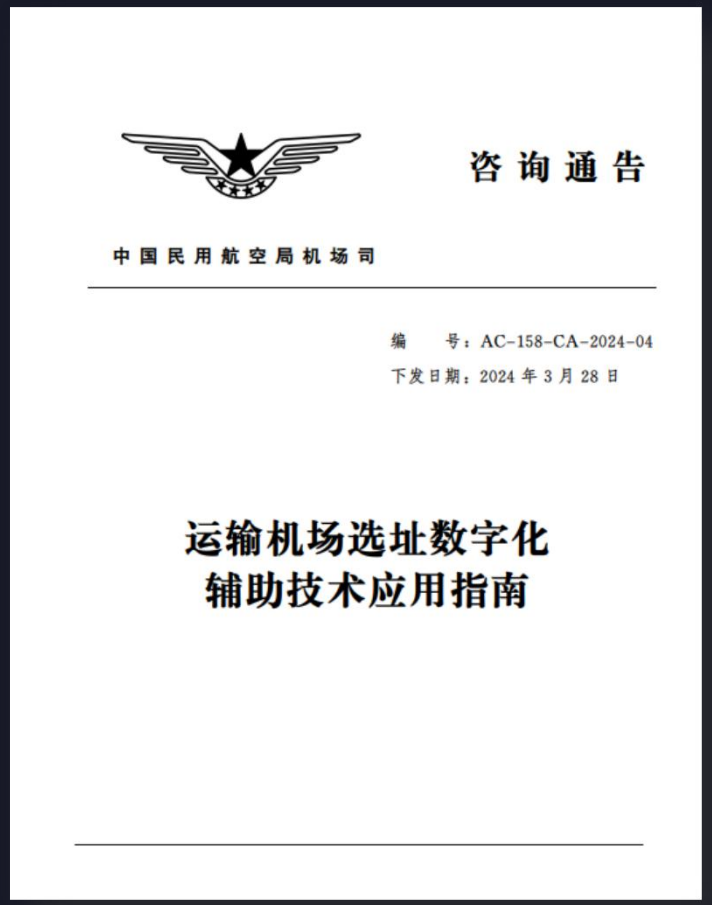
Quality, safety and cost

Model coding application



Site selection

Airport Site Selection via Multi-Physics Simulation



咨 询 通 告

中 国 民 用 航 空 局 机 场 司

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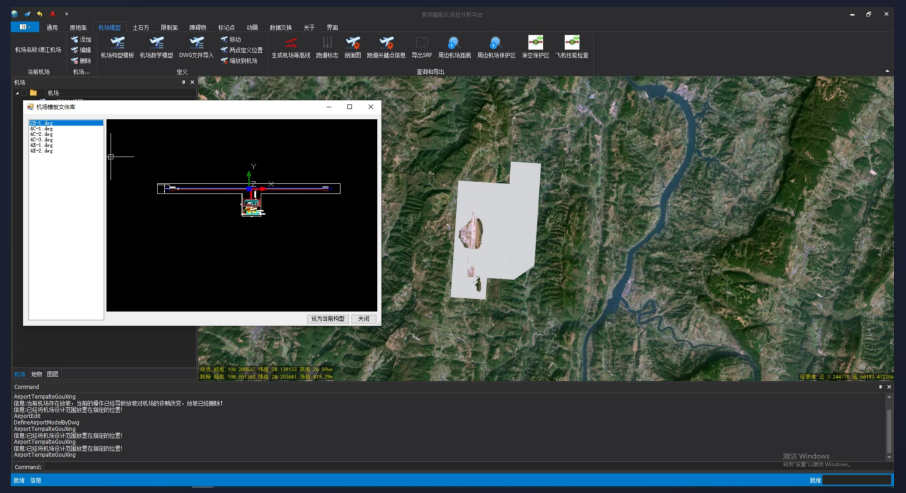
下发日期：2024 年 3 月 28 日

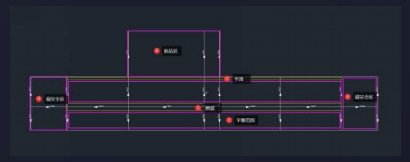
运输机场选址数字化
辅助技术应用指南

Guidelines of the application of digital auxiliary technology in site selection

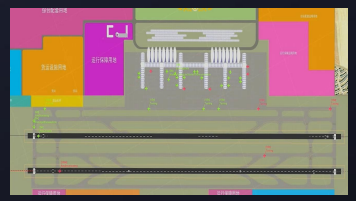
Optimal Solution Intelligent Siting Iteration



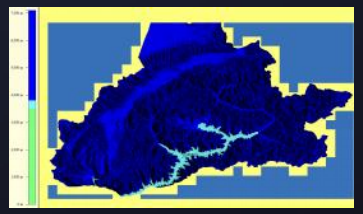
Airport configuration module library



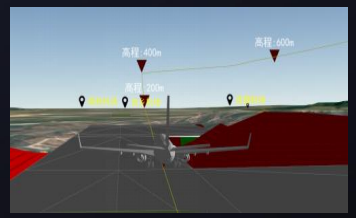
Mathematical topology model



Operation Simulation

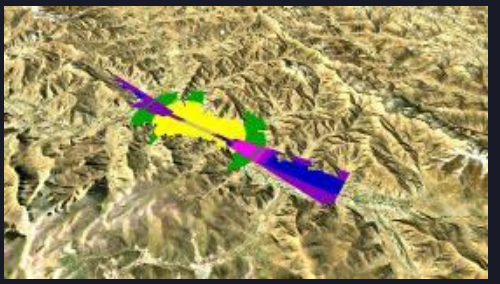


GIS multi-factor analysis



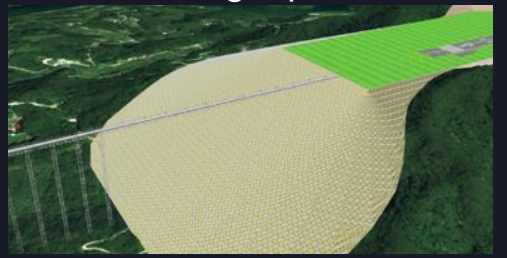
Flight roaming simulation

Airport Ground Model



Automatic airspace

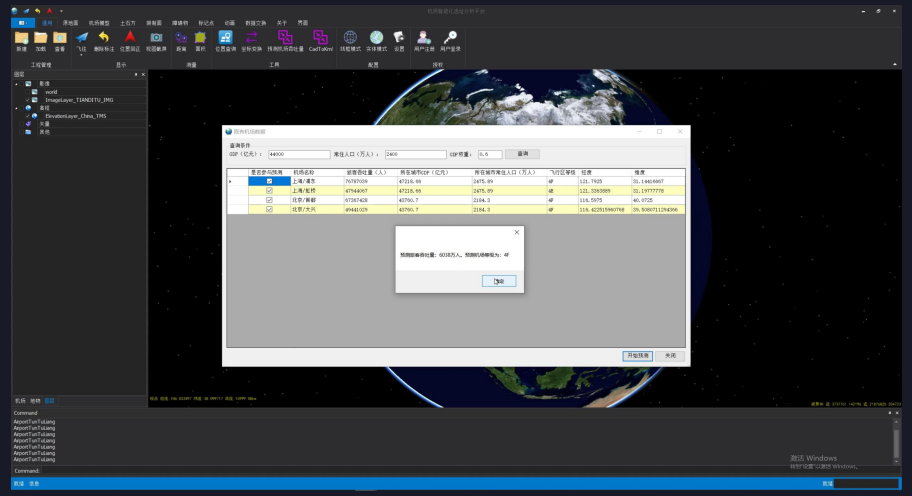
Automatic flight procedure



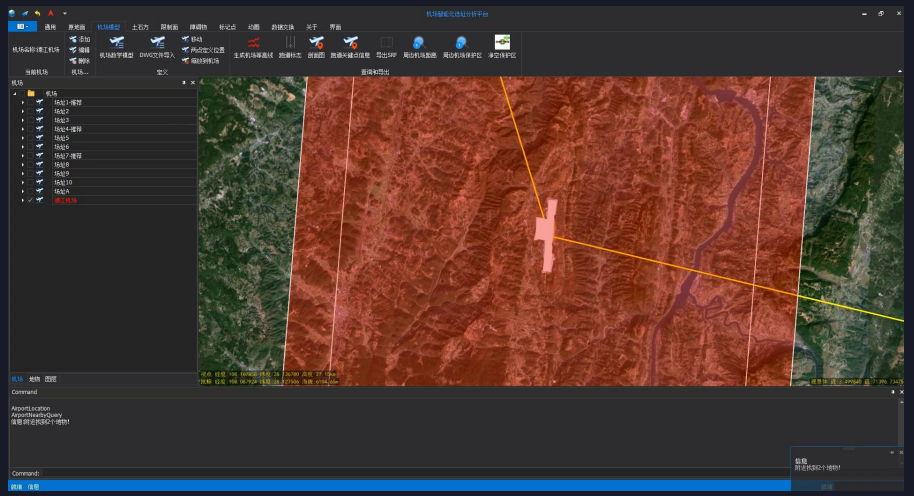
Site visualization

Planning

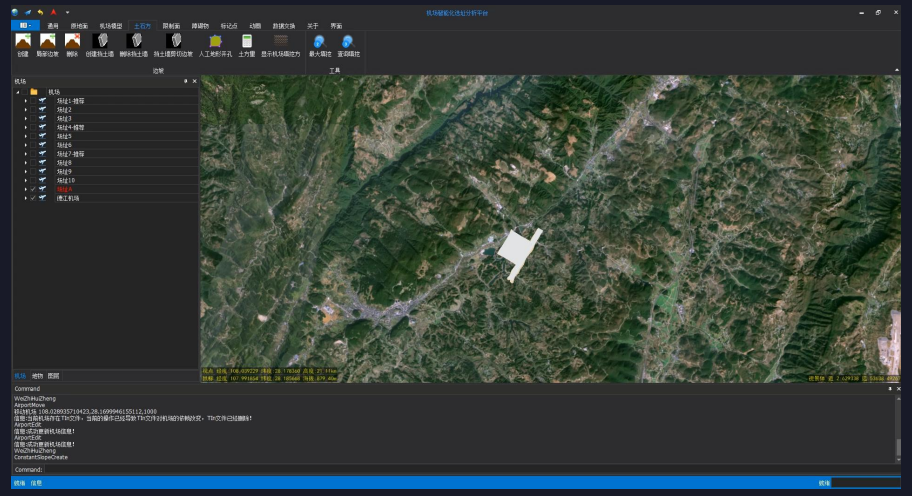
Parametric Simulation



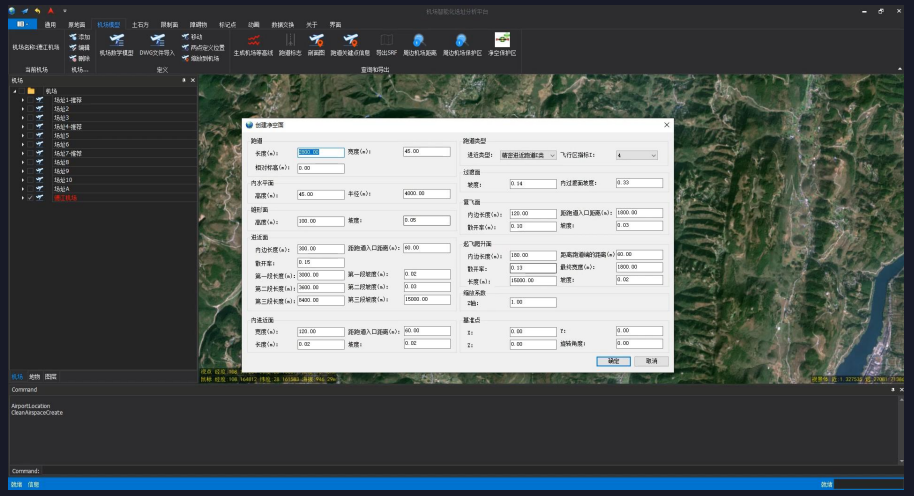
Capacity Indicator Big Data Prediction



Automatic Analysis of Surrounding Airports



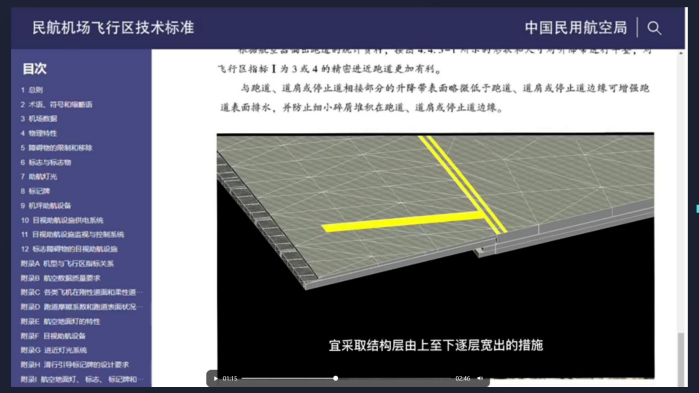
Automatic Terrain Calculation



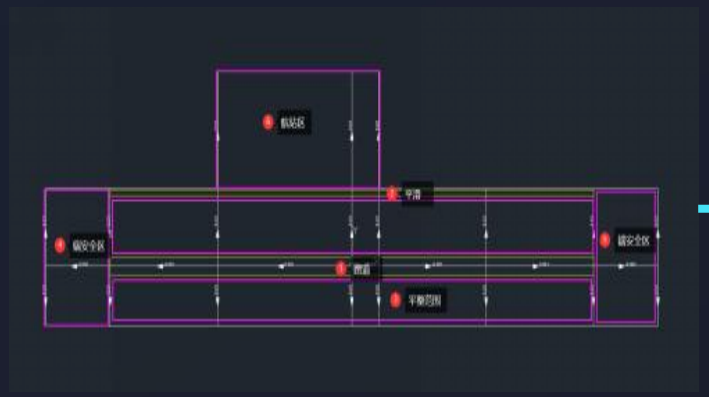
Automatic Obstacle Limiting Surface

Design

Combine AI and BIM 3D Forward Design: Integrated Simulation→Generation→Self-check AI Design

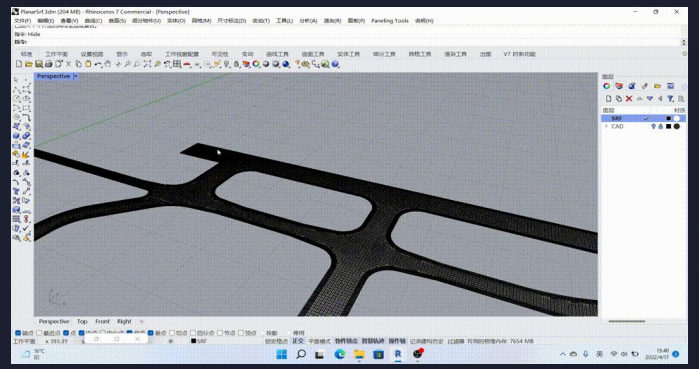


Self-checking Standards



Digital Airport Configuration

Modular Scenario Assembly



Generative Parametric Design

Simulation Verification & Optimization

序号	产业分类		一级分类		二级分类		三级分类	四级分类	编码	构件库编码
	代码	类别名称	代码	类别名称	代码	类别名称	类别名称	类别名称		
1							跑道		10-10.10.10.00	D-A-A01-10-10.10.10.00-001
2					A01	跑道设施	升降带		10-10.10.20.00	D-A-A01-10-10.10.20.00-001
3							跑道安全区		10-10.10.30.00	D-A-A01-10-10.10.30.00-001
4							净空道		10-10.10.40.00	D-A-A01-10-10.10.40.00-001
5							停止道		10-10.10.50.00	D-A-A01-10-10.10.50.00-001
6							无线电高度表操作场地		10-10.10.60.00	D-A-A01-10-10.10.60.00-001
7					A02	滑行道设施	滑行道(桥)		10-10.20.10.00	D-A-A02-10-10.20.10.00-001
8							滑行带		10-10.20.20.00	D-A-A02-10-10.20.20.00-001
9					A03	机坪(不含航站区、货运区、机务维修区机坪)设施	机位滑行通道		10-10.30.10.00	D-A-A03-10-10.30.10.00-001
10							机位		10-10.30.20.00	D-A-A03-10-10.30.20.00-001
11							载人/引出区		10-10.30.30.00	D-A-A03-10-10.30.30.00-001
12							机坪上的车道		10-10.30.40.00	D-A-A03-10-10.30.40.00-001
13							机坪设施	机坪监控	10-10.30.50.01	D-A-A03-10-10.30.50.01-001
14								配电箱(电源井)	10-10.30.50.02	D-A-A03-10-10.30.50.02-001
15								飞机地面电源装置	10-10.30.50.03	D-A-A03-10-10.30.50.03-001
16								飞机地面空调	10-10.30.50.04	D-A-A03-10-10.30.50.04-001
17								空调地井	10-10.30.50.05	D-A-A03-10-10.30.50.05-001
18								地锚	10-10.30.50.06	D-A-A03-10-10.30.50.06-001
19							机位附近规划的停车位或地面障碍设施停放区		10-10.30.60.00	D-A-A03-10-10.30.60.00-001
20					A04	飞行区交通设施	围场路		10-10.40.10.00	D-A-A04-10-10.40.10.00-001
21							空侧服务车道(桥、隧)		10-10.40.20.00	D-A-A04-10-10.40.20.00-001
22							车辆停放区		10-10.40.30.00	D-A-A04-10-10.40.30.00-001
23							充电设施		10-10.40.40.00	D-A-A04-10-10.40.40.00-001
24							层双重		10-10.50.01.00	D-A-A05-10-10.50.01.00-001

Structured component coding

Design

Integrated Simulation→Generation→Self-check Design

principle

Data Platform Drives Parametric Modeling

Airport Skeleton Mathematical Model

3D collaborative platform

Enterprise-encrypted model library
Real-time model assembly

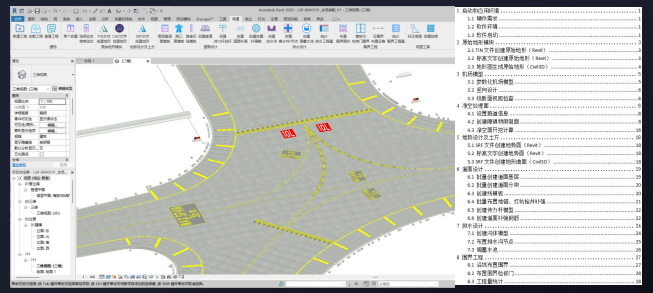
Forward Design Platform

Airport standards built-in and updates
Cross-disciplinary data sharing

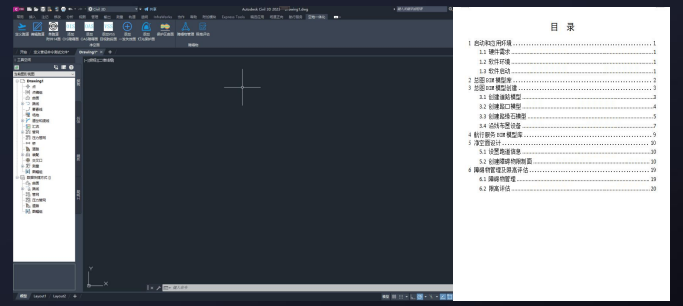
Simulation Optimization

End-to-end simulation
AI-NPC visual simulation
Multi-agent simulation

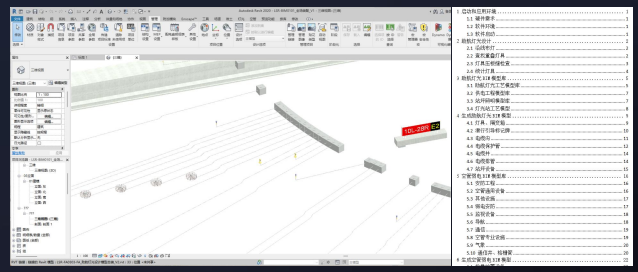
BIM Civil Aviation Modules 1



Air-Ground Integration Modules 2



Underground Pipeline Modules 3

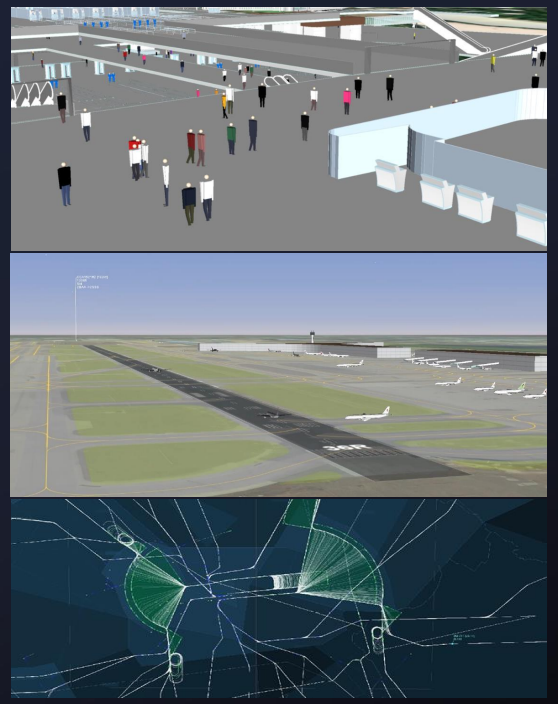


Outcomes 4

Airport Planning-Design-Multidimensional Simulation Verification System

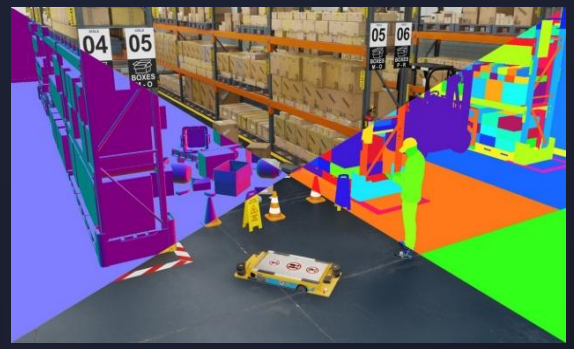
Critical Technical Route

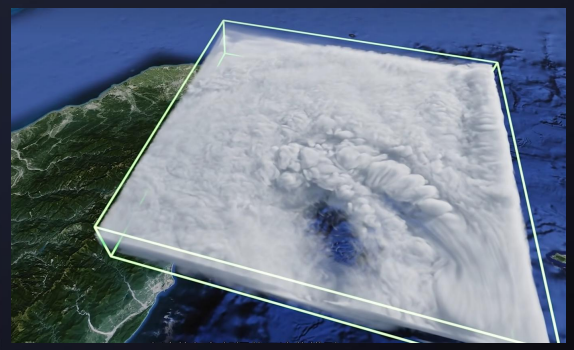
BIM + GIS



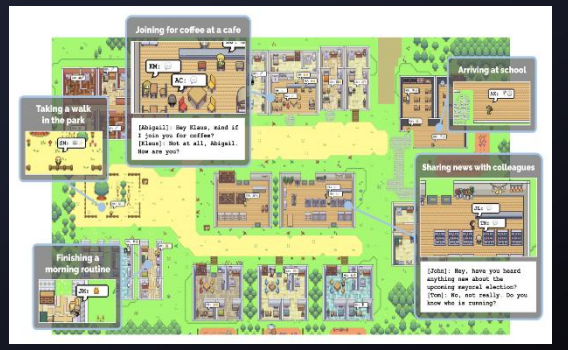
Digital Twin

Simulation





Multi-agent



Hybrid Simulation Architecture: Combine traditional end-to-end simulation with multi-agent behavioral simulation using AI, balancing stability, comprehensiveness, and flexibility

Digital Twin Base: Combines digital twin scenarios with agent models to build a bidirectional "physical-virtual" interaction system supporting MLP strategy iteration.

Cross-stage Data Integration: Embeds agent rules in planning/design stages | Synchronously optimizes physical space & virtual behavior logic during construction | Trains agent decision models with historical data during operation

Simulation during designing

Forward design - End-to-end simulation linkage

Airport Mathematical Skeleton

↓

BIM Forward Design
Parametric Auto-modeling

↓

Scenario Auto-generation

↓

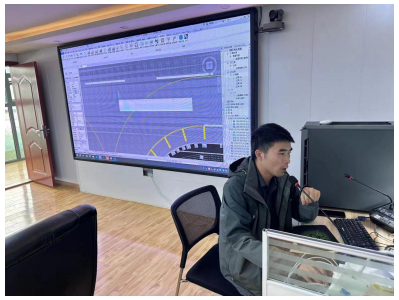
Operation process
simulation

Simulation during designing

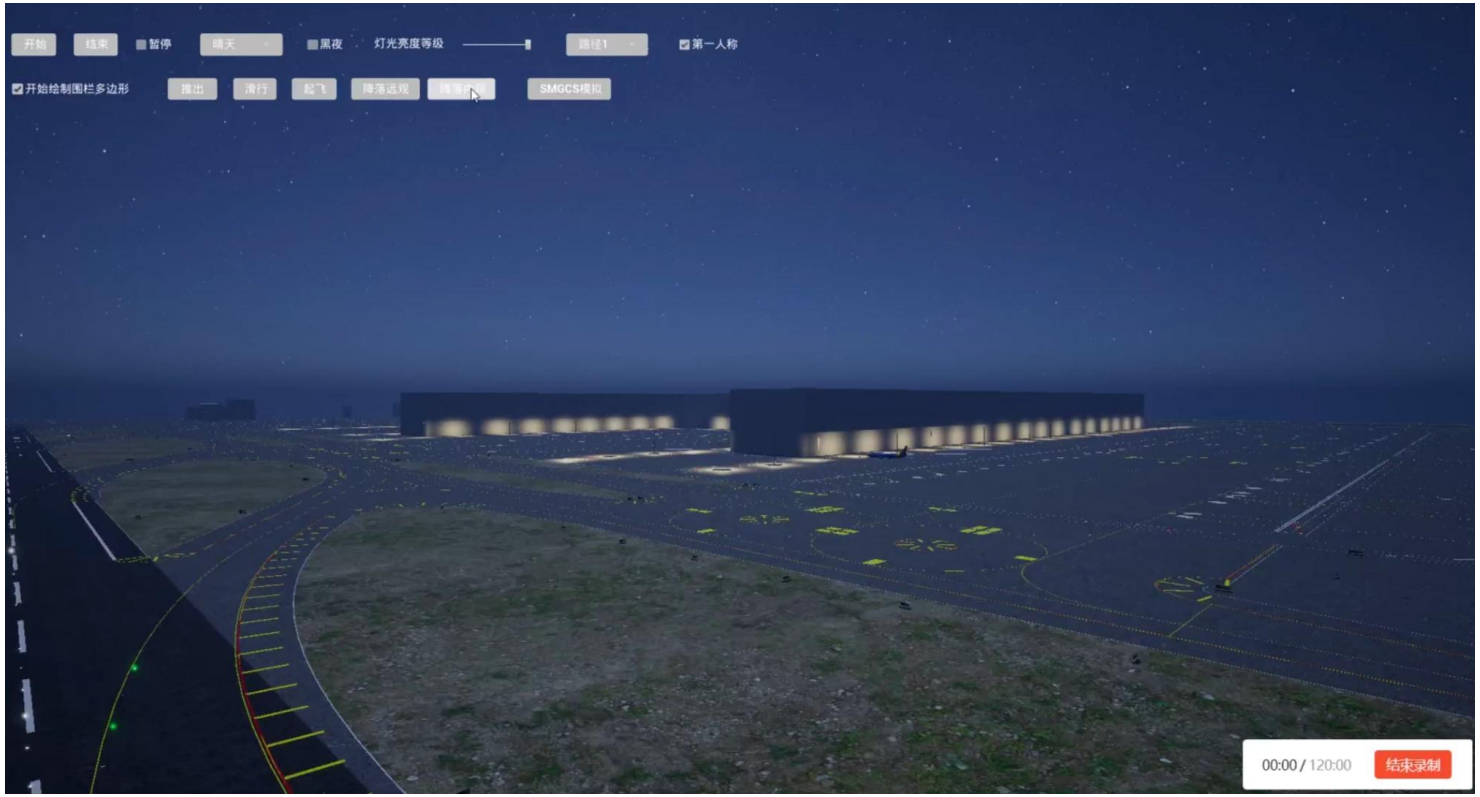
Visual Aids Simulation Based on Pilot Perspective

Visual Aids Facility Simulation






VR construction briefing with design company, command center, flight management, experts, and pilots.



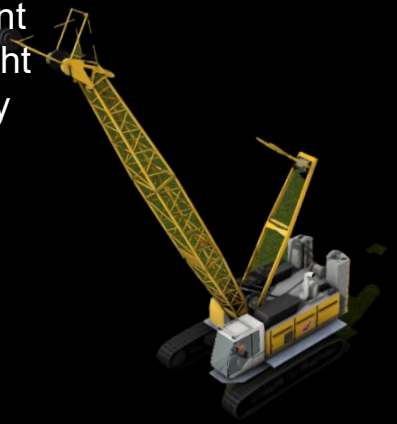
During preliminary design review, conducts simulation from pilot's perspective.

Digital Construction

IoT-enabled construction

Dynamic Compaction

Compaction count
Compaction height
Potential energy
Time per blow



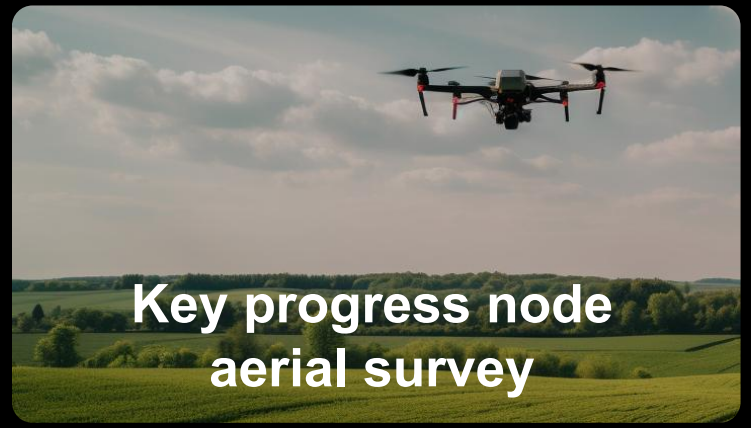
Roller Compaction

Trajectory
Pass count
Coverage statistics

Environmental monitoring

Non-stop Construction
Personnel positioning

Video surveillance
AI computing

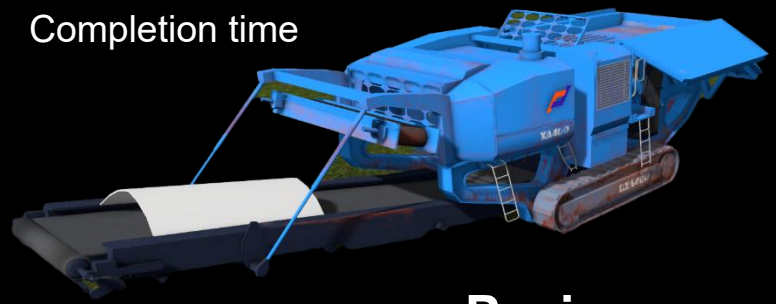


Key progress node aerial survey

Vehicle positioning

Batching plant Detection systems

Trajectory
Elevation
Completion time



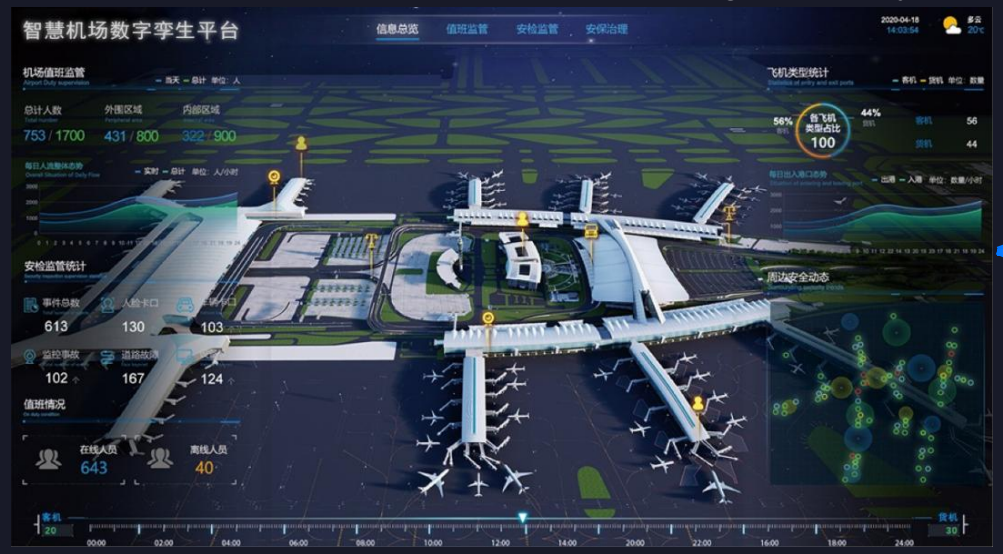
Paving

Operation

AI-Integrated Airport-wide Security Situational Awareness

Digital Twin Platform for Smart Airport

Critical content: Data hub & intelligent analysis



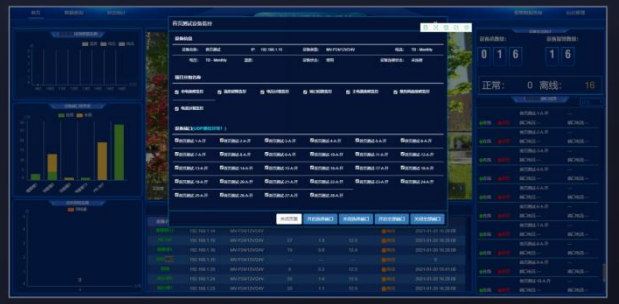
- "Air-Space-Ground Integrated" Multi-source perception network
- Integrates facility & sensor-class devices
- Applies to digital twin scenarios
- AI diagnoses infrastructure security status & predicts threats
- Builds monitoring backend connecting airport data

Integrated Systems

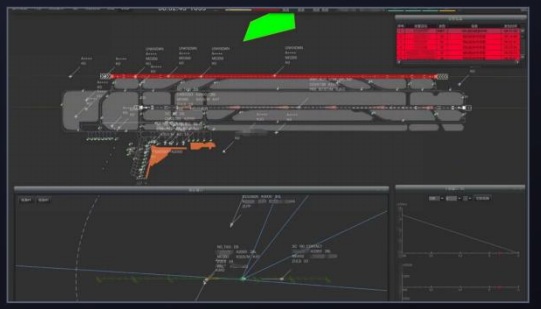
Smart lighting system

Smart runway system

Multilateration system



Smart bird deterrence system



Airplane guidance system

- Millimeter-level intrusion prevention | Slope stability | Bridge structural safety | Full-area settlement | Pavement structural defects
- Runway incursion | FOD risk | Bird strike prevention | "Rogue" drones | Baggage anomalies

03

Action

Action

Note the information in the WP and presentation.

We encourage other APAC states to share the experience of digital applications in the aerodrome design and operation.

Thanks for your attention

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