Harnessing the AI revolution

Dr John Kasarda and Michael Chen discuss how accelerating advances in applications of artificial intelligence are transforming airports, airport cities, and the greater aerotropolis.

Artificial Intelligence (AI) is ushering in the Fourth Industrial Revolution (Industry 4.0) where digitisation, creativity, and innovation are transforming business processes worldwide.

The aviation sector is no exception. From machine learning algorithms optimising aeronautical operational efficiencies, and AI-driven predictive analytics streamlining cargo flows and creating new passenger experiences to adaptive design reshaping commercial development on and outward from airports, AI's impacts are vast and varied.

As AI is embraced and increasingly applied in airports, airport cities, and their spatially extended aerotropolises, the form and functions of all three are being enhanced.

Airports

Through AI applications, airports are unlocking new frontiers in efficiency and sustainability, evolving into smart, resilient, thriving aerodromes at the heart of national and global connectivity.

AI is bolstering airport security by augmenting human capabilities with intelligent surveillance systems and threat detection algorithms to create a safer and more secure environment for travellers and airport staff.

Anomaly and threat detection algorithms analyse huge amounts of data from CCTV cameras, passenger screenings, and baggage checks to identify and mitigate risks in real-time. Biometric authentication and AI-powered facial recognition software streamline security processes, expediting passenger flows.

In conjunction with other information technologies, AI is being applied to improve passenger experiences.

Unique traveller profiles crafted by AI from insights harvested from diverse data analytics, such as passenger demographics and retail transactions, allow airports to cater to the wants and needs of segments of one and deliver personalised services that boost non-aeronautical revenues and passenger satisfaction.

Robotic wayfinding assistants, conversant in multiple languages, autonomously guide passengers through terminals with accessibility technologies helping visually impaired passengers navigate using audio commands.

AI-powered predictive maintenance systems anticipate equipment failures before they occur, minimising downtime and often ensuring continuous operations by abating unforeseen disruptions.

Real-time analytics coupled with AI algorithms enable airports and their airlines to dynamically adjust staffing levels, security protocols, and sometimes flight schedules in response to changing conditions in forecasted passenger flows, weather, cargo and luggage volumes, or departing aircraft cancellations.

Industrial computer vision supports the automated dimensioning of shipments in logistics providers' warehouses, quality control in airline catering, and workplace safety and productivity applications in MROs.

AI-enhanced smart infrastructure is improving last-mile delivery through autonomous fleets and drone delivery systems.

Emerging IT applications are pivotal to promoting environmental stewardship within airport ecosystems. From energy-efficient terminals and carbon footprint monitoring to waste management, airports are incorporating AI-related green technologies to achieve sustainability goals; cutting energy costs and reducing waste translate directly to the bottom line.

Airport Cities

Major airports have evolved beyond simple transit nodes where flights take off and land; they have become multimodal,

Robotic wayfinding assistants at Incheon International Airport.

multifunctional central business districts of the broader aviation-integrated region (the aerotropolis).

An airport city, within the context of aerotropolis theory, is typically confined to airport property, sometimes spilling over to adjacent land.

In addition to passenger, cargo, and MRO terminals, the airport city encompasses time-critical manufacturing and distribution facilities and supporting logistics functions along with a range of commercial services that include, among others, catering, shopping and dining, hotels and hospitality, corporate offices and conference centres as well as leisure and entertainment.

This mixed-use business complex is highly leveraged by aviation and connecting surface transportation.

With AI fostering heightened synergies among aviation, ground transportation, and airport commercial development, dynamic investment environments are being created at and around the nexus of national and global flows of people, products, information, ideas, and capital.

Recent breakthroughs have produced an influx of investment in AI and AI-supporting industries, resulting in a global surge in demand for hardware to train, deploy, or interact with emerging AI practices.

Chip-makers are increasingly establishing light manufacturing and distribution operations on or near airports to speed access to distant suppliers and customers.

Indeed, Arizona (USA) municipal officials are studying the feasibility of a new cargo airport to transport the massive volumes of chips anticipated from the $65 billion Taiwan Semiconductor Manufacturing Company complex being built in the Phoenix area.

The same surge is catalysing the development of innovation clusters forming airport knowledge precincts that include AI firms alongside higher education facilities, sci-tech incubators, and more traditional software and R&D companies.

Innovative entities particularly benefit from clustered development, which affords flexible inter-enterprise relations and lowers business and other communication barriers to the transfer of uncodified tacit knowledge, for which face-to-face meetings are preferable.

Small-to-medium-sized enterprises, often considered the most dynamic innovators, are gravitating to airport cities as evidenced in the R&D zone at Beijing Daxing International Airport.

Likewise, Munich Airport, leveraging advances in AI, is developing LabCampus (see image on page 22), a 500,000-square-metre innovation hub dedicated to fostering automation, next-gen mobility technologies, and creative commercial ideas.

Among larger firms, Foxconn (Apple's primary assembler) has located its new AI-controlled iPhone assembly facilities near the runways at Zhengzhou (China) International Airport. Handling various operations from feeding parts and components assembly to intelligent correction and testing to packaging and storage, its 24/7 robotic assembly lines operate through the night, illuminated only by intermittent flashes of green lights.

Smart logistics operators extensively employing AI pervade the Zhengzhou Airport Economy Zone (ZAEZ), a world-leading platform for intelligent electronics production. Adjacent to the airport, the ZAEZ hosts the AI server production facilities of xFusion Digital Technologies Company and Wafer Works (pictured on page 23) dedicated to R&D and manufacturing of silicon wafers and related components. A cutting-edge medical sciences district with AI features is also under development.

Aerotropolis 4.0

Exemplifying the Fourth Industrial Revolution led by AI and its globally mobile talent, Aerotropolis 4.0 fuses the net age with the jet age.

This contemporary model builds on traditional aerotropolis concepts of aviation-linked regional development by incorporating advanced digitisation, innovation, lifestyle amenities, and sustainable residential, business, and infrastructure practices (see John Kasarda, Aerotropolis 4.0, *Airport World*, Issue 2, 2022).

The Aerotropolis 4.0 trend is powerful and pervasive. AI-focused enterprises are clustering around airports transforming outlying knowledge districts into global innovation centres.

At the Research Triangle Park near Raleigh–Durham International (USA), for example, Apple is creating 3,000 jobs in machine learning, AI, and software engineering. They will join other major digital innovators there such as Cisco, Cree, IBM, and Microsoft.

The Denver (Colorado) Aerotropolis, in partnership with Panasonic, established its CityNow initiative as a digitised lab for smart, sustainable urban innovations. This aerotropolis has likewise emerged as a leader in applying AI to advance its significant biosciences and aerospace clusters.

In Asia, Taipei's Taoyuan Aerotropolis and Thailand's Eastern Economic Corridor are both being planned and developed to lead each nation's Industry 4.0 policies, emphasising research, innovation and entrepreneurship along with smart, livable airport-linked cities.

Digital infrastructure, scientific knowledge, workforce skills, innovative capacity, sustainability, and quality of living are prioritised in Aerotropolis 4.0 firm site selection.

LabCampus, a 500,000sqm innovation hub being developed at Munich Airport.

The traditional aerotropolis development focus on improving transportation infrastructure and providing financial incentives to attract investments, must therefore be complemented by equal emphasis on providing digital, educational, R&D, lifestyle, and urban amenities desired by 4.0 economy firms and their tech-savvy, environmentally conscious employees.

To appeal to these firms, the Aerotropolis must be a place where talented professionals and highly skilled labour want to live, work, learn, create, be entertained, and raise and educate their families. This requires a paradigm shift in aerotropolis development strategies in which AI-enhanced quality of life and public services will play instrumental roles.

AI's Aerotropolis potential

AI has already demonstrated considerable promise to achieve Aerotropolis 4.0 priorities and potential by improving their operational efficiency, sustainability, and livability. Specific means include:

- **Intelligent Zoning and Land Use:** AI can help inform aerotropolis spatial planning to optimise land development that more effectively allocates residential, commercial, and industrial zones to create a better mix of uses that promotes their synergies and benefits from proximity to airports while mitigating adverse effects such as noise.
- **Transportation Networks:** AI can leverage simulations of transit conditions and route layouts to design more efficient and environmentally friendly transportation networks that reduce traffic congestion, pollution, and travel times on the ground and in the air.
- **Adaptive Buildings:** AI can contribute to the design of buildings that can change based on usage patterns, weather conditions, and other environmental variables.
- **Green Spaces and Public Areas:** AI can also be used to strategically plan the placement and size of parks and other public spaces to elevate the quality of life for residents.
- **Disaster Resilience:** By using AI to analyse historical data on natural disasters and ongoing climate data, new aerotropolises can be designed to be more resilient to climate change and natural disasters.
- **Enhanced Mobility:** Through autonomous vehicles and smart traffic management, AI can significantly improve mobility and traffic safety within an aerotropolis.
- **Environmental Monitoring and Sustainability:** By analysing data from sensors tracking air and water quality and other environmental factors, AI can help identify pollution sources and help to enforce regulations as well as optimise renewable energy integration for more efficient and sustainable resource use.
- **Smart Utilities:** Likewise, AI can optimise aerotropolis utilities through smart microgrids and by enhancing water, power, and waste management systems.
- **Responsive Public Safety:** AI can heighten aerotropolis security by analysing surveillance data to rapidly deploy resources to address emergencies.
- **Healthcare Services:** AI can improve proactive responses to disease detection and streamline resource allocation in medical actions and patient management systems to prevent contagion, reduce wait times, and raise the overall quality of healthcare in the aerotropolis.
- **Traveller Experience:** AI can be used to personalise the travel experience within an aerotropolis by offering customised recommendations for airport services, dining and retail options, lodging, tourist and leisure activities. Elevating the quality of public and commercial services through AI applications can boost aerotropolis livability, as well.
- **Economic Development:** By analysing market trends, consumer behaviour, new facility demand, and investment opportunities, AI can derive insights that help aerotropolis planners and developers make informed decisions and identify the best types of businesses to target to foster ROI and sustainable economic growth. The strategic application of AI will help an aerotropolis remain economically vibrant and adaptable to changing market conditions.

Robust ICT infrastructure and data management solutions will be required to digest and analyse the immense amounts of AI-relevant information generated by airports, airport cites, and their extended aerotropolises, and for applying AI to improve talent attraction, workforce skill development, and community engagement.

Such infrastructure, technological, and human resource management solutions include:

- **Ubiquitous Connectivity:** Ensure widespread, high-speed internet access via public Wi-Fi supported by extensive fibre optic and cloud networks alongside comprehensive mobile service coverage. Establish the necessary policies to promote competition among ICT service providers and avoid vendor lock-in.
- **Reliable Digital Infrastructure:** Attract data centres capable of efficiently managing and processing huge data volumes while ensuring information security and data availability crucial for advanced AI applications.

The Wafer Works facility at Zhengzhou Airport Economy Zone (ZAEZ) in China.

- **Smart Urban Technology:** Deploy smart city sensors and extensive CCTV networks to collect real-time data for traffic management, environmental monitoring, public safety, and improved security.
- **Environmental Sustainability:** Design infrastructure and constructed facility solutions that minimise energy consumption, emissions, materials waste, and environmental impacts of new developments. Aim for carbon-neutral or carbon-negative operational footprints.
- **Accessible AI:** Provide broad access to devices capable of running AI models or robust cloud connectivity that can support AI inference. Consider the geographic and demographic distribution of connectivity to avoid creating or perpetuating digital divides.
- **Talent Development and University Collaboration:** Foster partnerships with research universities and other educational institutions to drive innovation and talent development as well to produce a steady pipeline of technologically skilled labour that reinforces the aerotropolis's appeal to 4.0 businesses.
- **Workforce Reskilling:** Implement programmes to reskill the existing aerotropolis workforce to ensure that local labour can effectively support and benefit from modern digital infrastructure and businesses that rely on it. This should include aerotropolis vocational training institutions focusing on AI, computer and data science, cybersecurity, robotics, and other emerging technologies or educational curricula emphasising digital literacy along with STEM topics.
- **Community Engagement:** Leverage endogenous resident knowledge for more effective aerotropolis planning. Deploy AI-enabled information gathering systems that solicit and respond to feedback from local communities most impacted by airport and aerotropolis expansion to help obtain the social license to grow. Build trust and acceptance by fostering transparency and addressing resident concerns to preclude disenchantment and corresponding resistance that can delay or undermine aerotropolis development.

A comprehensive AI/ICT platform that attracts and supports innovative firms through upgrading operational efficiencies, security, and services along with contributing to aerotropolis environmental sustainability is necessary but not sufficient.

Lifestyle, institutional, and urban amenity planning in addition to community engagement (while protecting against 'big brother' data abuses) can and should be magnified through AI applications to meet Aerotropolis 4.0 human resources and social needs.

Data availability and accessibility are prerequisites to drive insights and applications within and across all aerotropolis planning domains, including the airport and its airport city. Aerotropolis collaboration with appropriate government agencies and business associations may be required to establish or adopt effective data policy and regulatory frameworks to handle data responsibly and align with ethical standards for data use.

Concluding remarks

Advances in AI are generating the greatest changes in business and services in economic history. Executives and stakeholders of smart airports and airport regions should expect AI-generated change to accelerate and embrace it to realise the full potential of AI for their aviation-centric ecosystems.

AI is elevating airports, airport cities, and aerotropolises to be more efficient, pleasant, sustainable, and adaptive entities. Its applications are optimising land use, multimodal surface transportation connectivity, and digital and commercial infrastructure to create dynamic, synergistic systems boosting livability along with business productivity and airport-area and metropolitan-wide prosperity.

AI's capabilities for improving the passenger experience, predictive maintenance, security enhancements, and environmental monitoring strengthen airport resiliency. Similarly, AI applications are spurring the advancement of airport cities and aerotropolises as global hubs for innovation and entrepreneurship.

Human resources development and talent attraction are vital since 4.0 business processes and technologies are only as effective as the knowledge and skills of those applying them.

AI will not move a box or transport a passenger. It can, however, make cargo shipments faster, cheaper, and greener and passenger journeys less stressful and more enjoyable.

Nor will advances in AI alter the fact that a successful airport city and aerotropolis requires a well-connected airport that efficiently handles growing volumes of air traffic.

As the digital internet of advanced ICT systems and the physical internet of airline networks become more interwoven and economically catalytic, the national and global importance of aviation, airports, airport cities, and aerotropolises will continue to rise. Rapid long-distance flows of people, products, information, ideas, and capital will only become more paramount during the AI-driven Fourth Industrial Revolution. AW

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