AIRPORT RESILIENCE AND EFFICIENCY THROUGH DIGITAL TWIN

Agenda

Air Traffic Growth in India

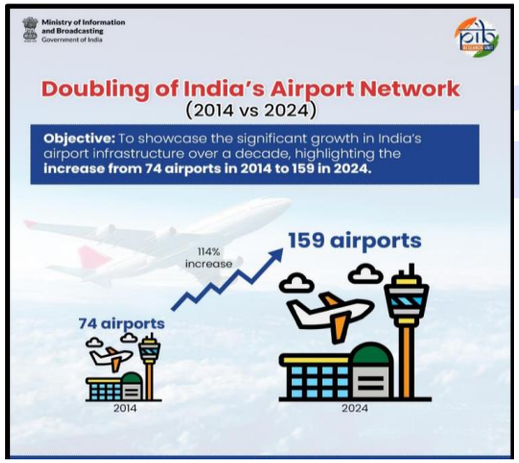
Operational Demands

Airport Systems and Stakeholders?-siloed data

Digital Twins (DTs):five key points

Competencies of Aviation Professionals & Regulatory Updates for Digital Twin Technology

Air Traffic Growth in India



Forecast by 2040

Region	2040 Passenger Forecast	Annual Growth Rate	Share of Global Traffic (2040)
India	1.1 billion	6.20%	~13%
Asia Pacific	Over 4 billion	4.50%	~50%
Global	Just over 8 billion	3.40%	100%

- Air passenger traffic in India to grow 80% by 2028-29.
- Commercial aircraft fleet to expand to 1,300 by 2028.
- 21 new Greenfield airports approved across India.

Source(Airbus)

- New aircraft needs: 1,770 small, 440 medium and large
- 6.2% annual growth in passenger traffic (global average 3.9%)
- New pilot needs: 34,000; New technician needs: 45,000

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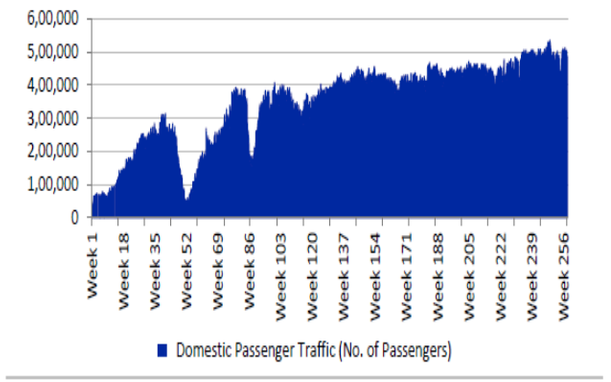
Key facts

EXHIBIT 4: Daily Domestic Passenger Traffic since May 25, 2020

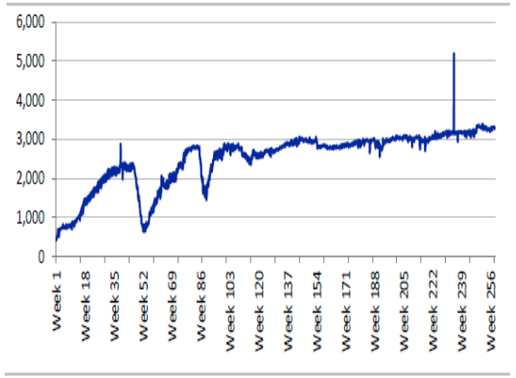


Source: MoCA, DGCA, ICRA Research

- For April 2025, the domestic air passenger traffic stood at 145.5 lakh against around 132.0 lakh in April 2024, implying a YoY growth of 10.2%.
- For FY2025 (April 2024–March 2025), the domestic air passenger traffic was around 1,653.8 lakh, a YoY growth of 7.6%, in line with ICRA's estimate.
- The highest single-day traffic of 5,35,343 was recorded on February 23, 2025, surpassing the previous historic highs as passenger travel was upbeat with the Maha Kumbh event held in Prayagraj
- The report said international passenger traffic for Indian carriers reached 338.6 lakh in FY25, reflecting a strong YoY growth of 14.1 per cent.

Source(ICRA)

EXHIBIT 3: Domestic Daily Flight Departures since May 25, 2020



Source: MoCA, DGCA, ICRA Research

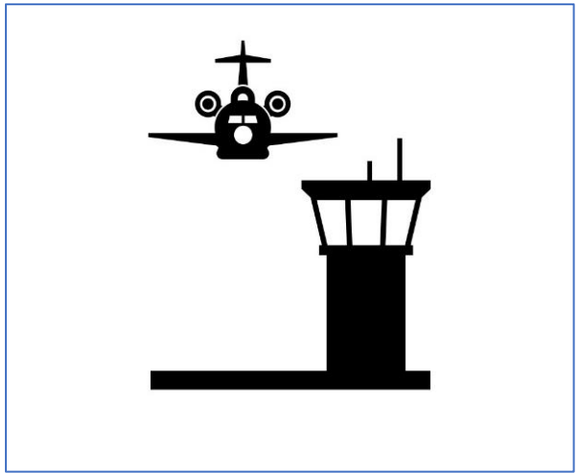
- For April 2025, the average daily departures were around 3,268, higher than the average daily departures of around 3,058 in April 2024
- Airline capacity deployment in April 2025 was 6.9 per cent higher than in the same month last year in April 2024
- At 148, the average number of passengers per flight in April 2025 was higher than 144 in April 2024
- It is estimated that the domestic aviation industry operated at a Passenger Load Factor (PLF) of 89.5% in April 2025, against 86.8% in April 2024, and 86.0% in FY2025, against 88.0% in FY2024.

Source(ICRA)

Operational Demands

Airline

- ✈ Safe
- ✈ Simple to fly
- ✈ Shortest Possible Track
- ✈ Noise abatement
- ✈ Fuel Saving



ATCO

- ✈ Safe
- ✈ Simple to use
- ✈ High efficiency

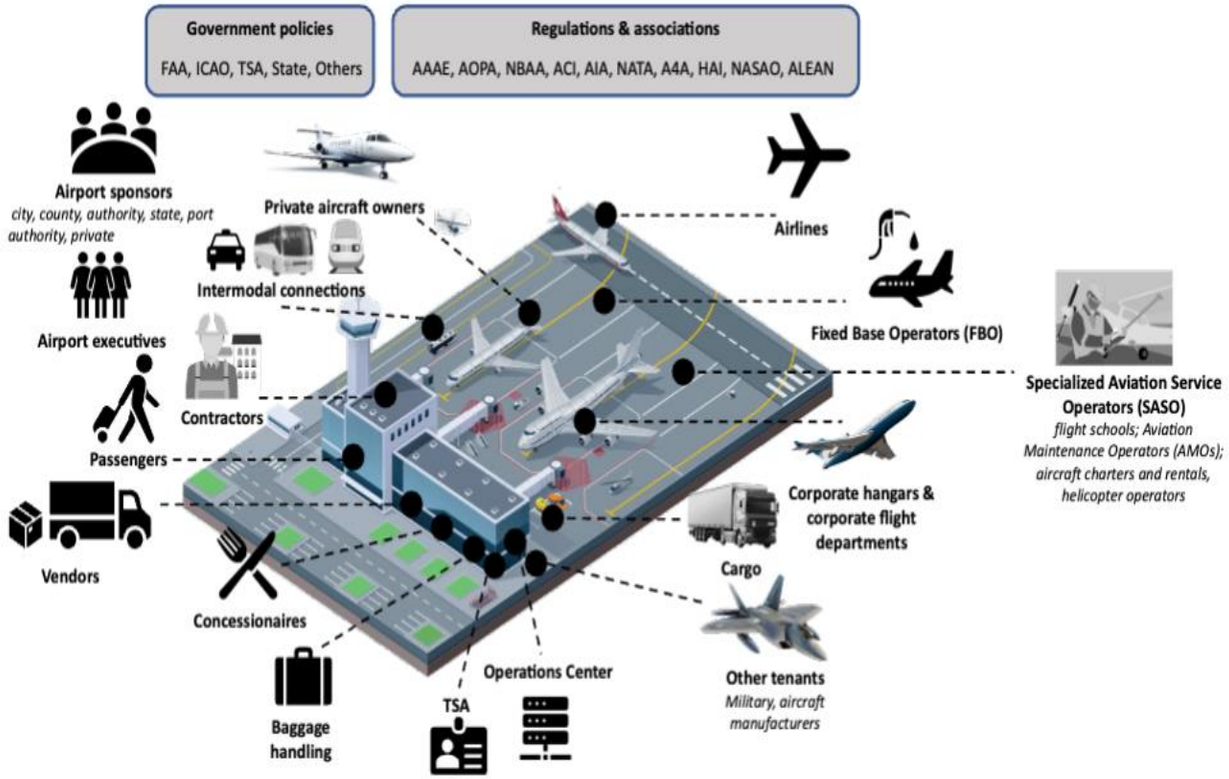
Airport Operator

- ✈ Efficiency
- ✈ Capacity
- ✈ Safety

Critical Parameters ANSP

- ✈ Required Navigation Parameters(RNP)
- ✈ Required Communication Parameters (RCP)
- ✈ Required Surveillance Parameters(RSP)

Airport Systems and Stakeholders?-siloed data

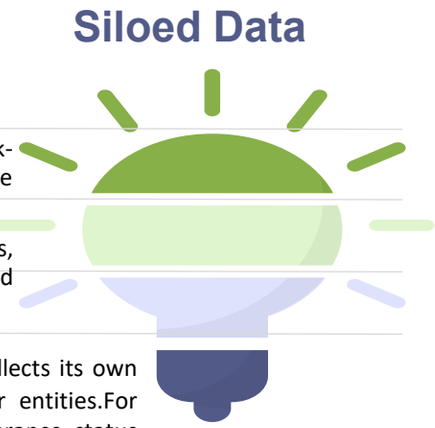


Challenges

City Side: Vehicle traffic congestion affecting passenger movement

Terminal: Bottlenecks at access control, check-in islands, counters, trolley availability, baggage belts, and delivery delays.

Airside: Inefficiencies in slot allocations, aircraft turnaround times, runway usage, ground handling, and ground vehicle control.

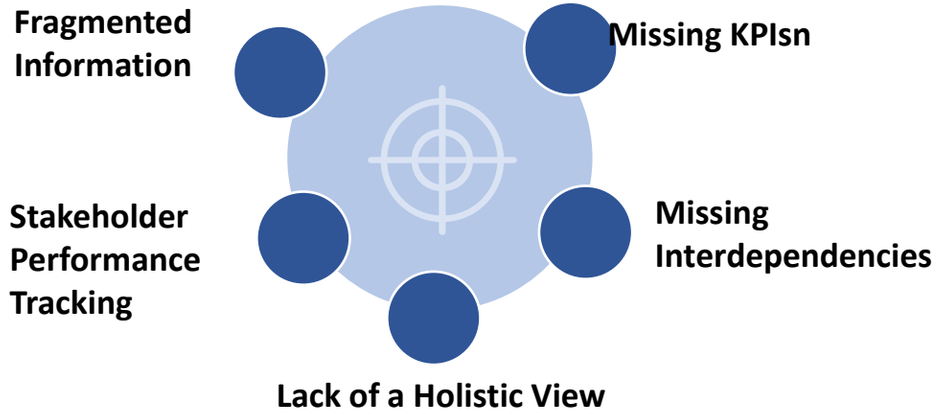


Siloed Data :- Uses separate IT systems, Collects its own data, Rarely shares real-time data with other entities.For example: TSA might not share passenger clearance status with airlines in real time.

Working with other ATM stakeholders

- Flight Schedules and Status
- Passenger Data
- Baggage Handling System (BHS) Data
- Ground Support Equipment (GSE) Data
- Runway and Airfield Data, Terminal and Facilities Data
- Staff and Resource Management
- External/Environmental Data, Security and Safety Data

Potential issues



✈Digital Twins (DTs):five key points

DIGITAL TWINS (DTS): A FOUNDATION FOR MODERN AIRPORTS

- ✈ Digital Twins (DTs) are real-time, interactive 3D models of physical systems, serving as virtual replicas of airports
- ✈ They consolidate all operational and infrastructure data streams from stakeholders into a centralized data lake, **providing a single, transparent source of truth for airport operations.**
- ✈ Enabled by **IoT, cloud computing, and advanced analytics,** DTs unlock predictive insights, simulations, and automated decisions, enhancing operational efficiency and the passenger experience.

OPTIMIZING OPERATIONS THROUGH REAL-TIME INSIGHTS

- ✈ Airport operators use DTs to model, analyze, and improve complex operations such as passenger flows and staff deployment, and to simulate 'what-if' scenarios
- ✈ This technology can continuously measure and optimize aircraft turnaround times, **accurately predict aircraft touchdown timings**, and **precisely measure runway occupancy duration.**

ENHANCING SAFETY & PROACTIVE CYBERSECURITY

- ✈ DTs enable **continuous surveillance of airside space utilization** to proactively identify and rectify deviations, thereby ensuring higher safety levels
- ✈ For cybersecurity, DTs combined with Generative AI allow for virtual modeling of complex cyber threats such as ransomware, insider breaches, and supply chain attacks, helping security teams to proactively identify and mitigate risks..

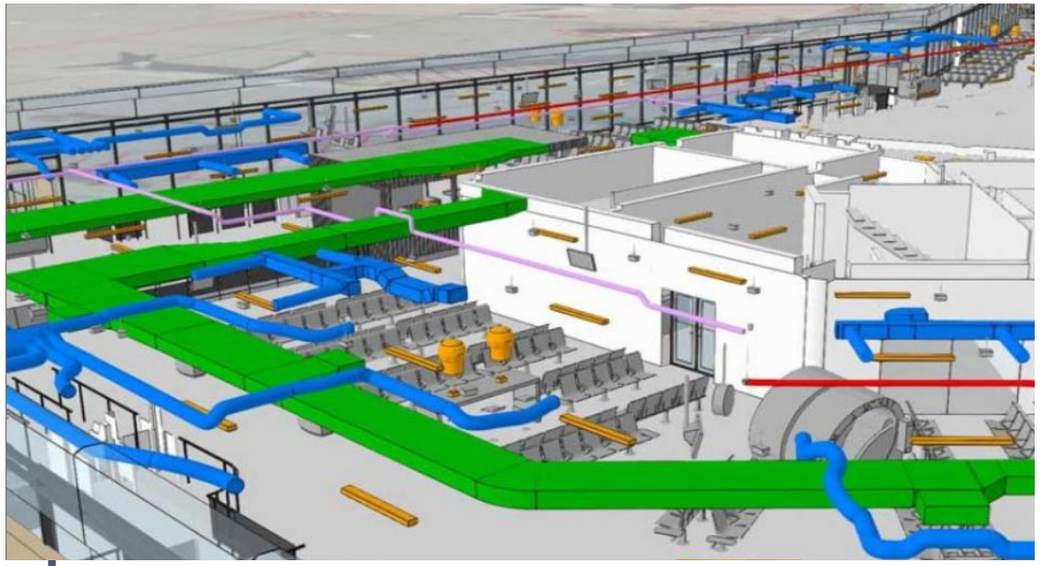
REVOLUTIONIZING TRAINING & WORKFORCE DEVELOPMENT

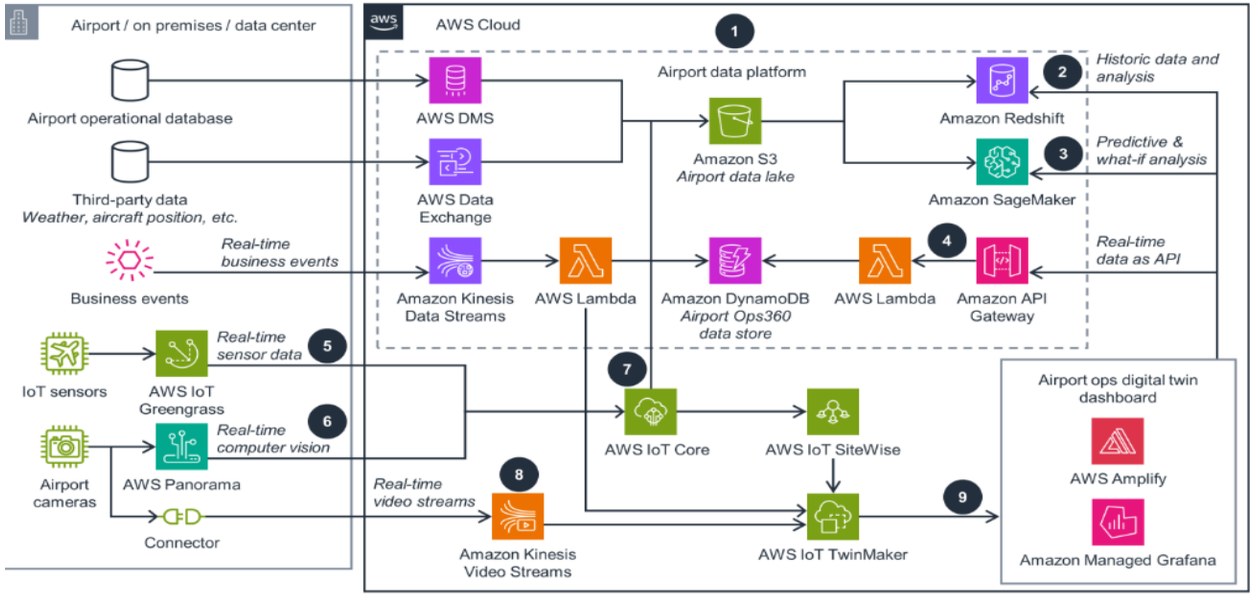
- ✈ DTs provide immersive training environments that replicate real airport conditions (e.g., lighting, crowds, weather) using AR/VR, allowing safe practice of real scenarios and adaptive response development.
- ✈ They support Competency-Based Training and Assessment (CBTA)

KEY ENABLERS: DATA SHARING, STANDARDS, & COLLABORATION

- ✈ update relevant Standards and Recommended Practices (SARPs)
- ✈ Open standards are essential to ensure seamless data compatibility, and secure protocols
- ✈ Promote open, secure, and standardized data-sharing frameworks

Digital Twins (DTs)- A Foundation for Modern Airports





Competencies of Aviation Professionals

Adapt to advanced simulations

Professionals must master digital twins providing real-time flight and systems simulations.

Strong data literacy required

Ability to analyze and interpret complex aviation data is essential across roles.

Systems thinking proficiency

Understanding interconnected aviation systems ensures safer and efficient operations.

Digital communication skills

Expertise in digital tools fosters collaboration among pilots, controllers, and engineers.

Familiarity with AI and IoT

Knowledge of AI, machine learning, IoT enhances decision-making and predictive maintenance.

Cybersecurity awareness

Protecting aviation infrastructure from cyber threats is a critical emerging skill.

Airport Cyber Resilience Challenges

Airports face high cyber threat exposure

Critical vulnerabilities amplify risks

Major cyber threats targeting airports

Digital Twins enable safe threat modeling

Generative AI simulates complex cyber events

ICAO

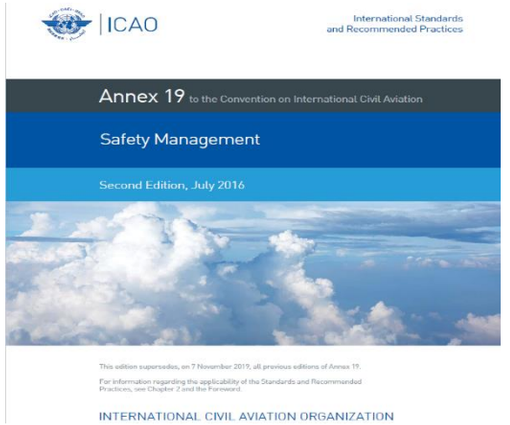
Regulatory Updates for Digital Twin Technology

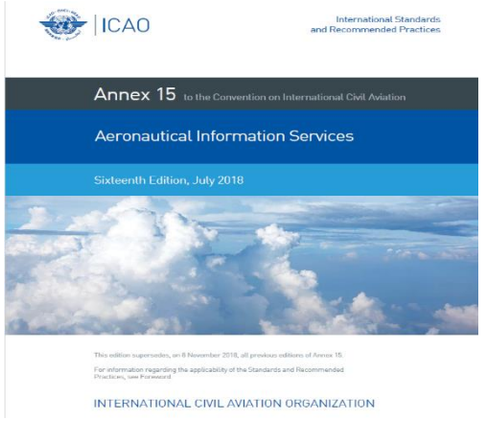
3) Revise Annex-11 Guidelines

Support predictive airspace modeling with AI-driven air traffic control tools to optimize traffic flow.

4) Incorporate Digital Twins in Annex-19

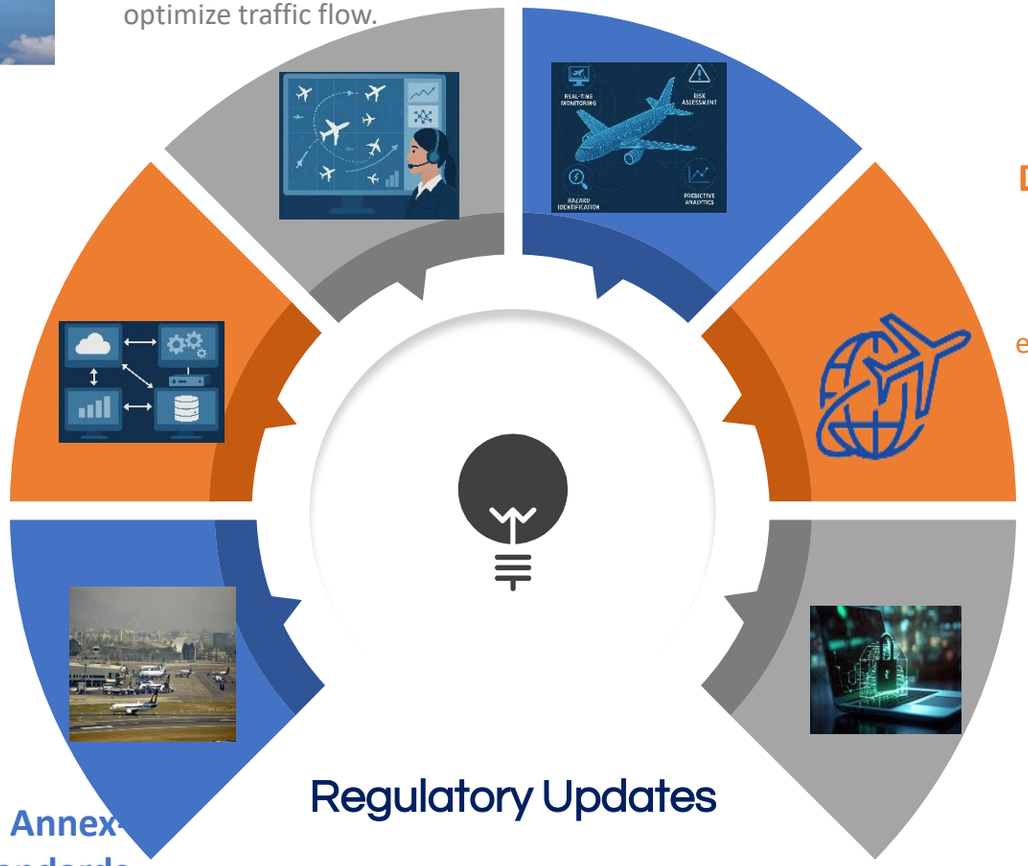
Integrate Digital Twins for proactive safety and risk management in aviation operations.





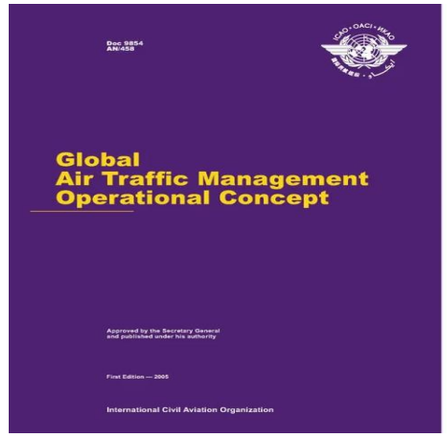
2) Enhance Annex-15 Protocols

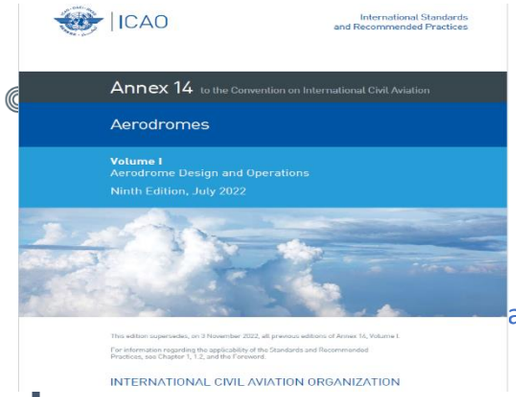
Ensure real-time, high-quality data sharing among systems to improve interoperability.



5. Integrate Digital Twins in Doc 9854

Position Digital Twins as a core element of future air traffic management systems for enhanced efficiency.





1) Update Annex-14 Standards

Define standards for digital modeling of airport infrastructure for better safety.

6. Update Cybersecurity Protocols

Address risks and ensure system integrity through enhanced protocols and governance frameworks.

THANK YOU