Aviation Data Analysis Seminar

Airport Industry Outlook: Past, Present, and Future

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ACI AIRPORTS COUNCIL INTERNATIONAL

Session objectives

During this session participants will gain an understanding of:

About ACI

Section 1. Air Transport Demand from an Airport Perspective

Section 2. AI in Airport

- Introduction to AI
- AI Use Cases in Airports
- AI Hype and Conclusion

THE VOICE OF THE WORLD'S AIRPORTS

ACI World contributes to the

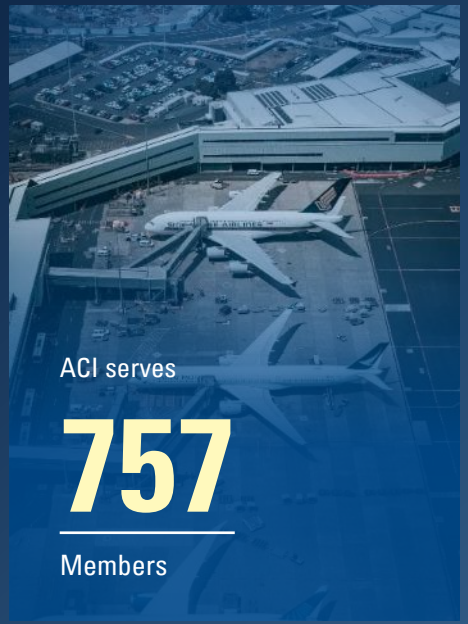
safety, security, and sustainability

of the global aviation industry by

Advancing the collective interests of airports and the communities they serve

Promoting excellence in airport management and operations

Who we serve



As of January 2024

ACI Federation

ACI World addresses

Global issues

International regulatory bodies
such as the International Civil Aviation Organization (ICAO)

Other organizations
with international interests

Each ACI Region addresses issues and regulatory bodies specific to that region.

Air Transport Demand from an airport perspective

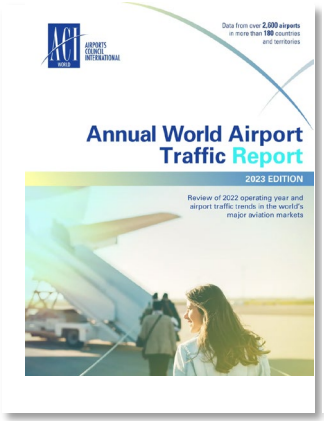
Presentation roadmap

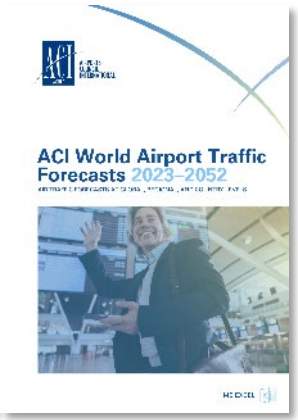
Air transport demand from an airport perspective

- Global passenger traffic past, present, and outlook
- Recovery, demand, seasonality and supply
- Business vs. leisure travel
- Selected micro and macro factors
- Traveler psychology
- Outlook

Airport Business

- Core fundamentals of the airport business pre-pandemic and beyond
- Impact of the pandemic on airport finance
- Financial health: Margins, returns and cost of capital



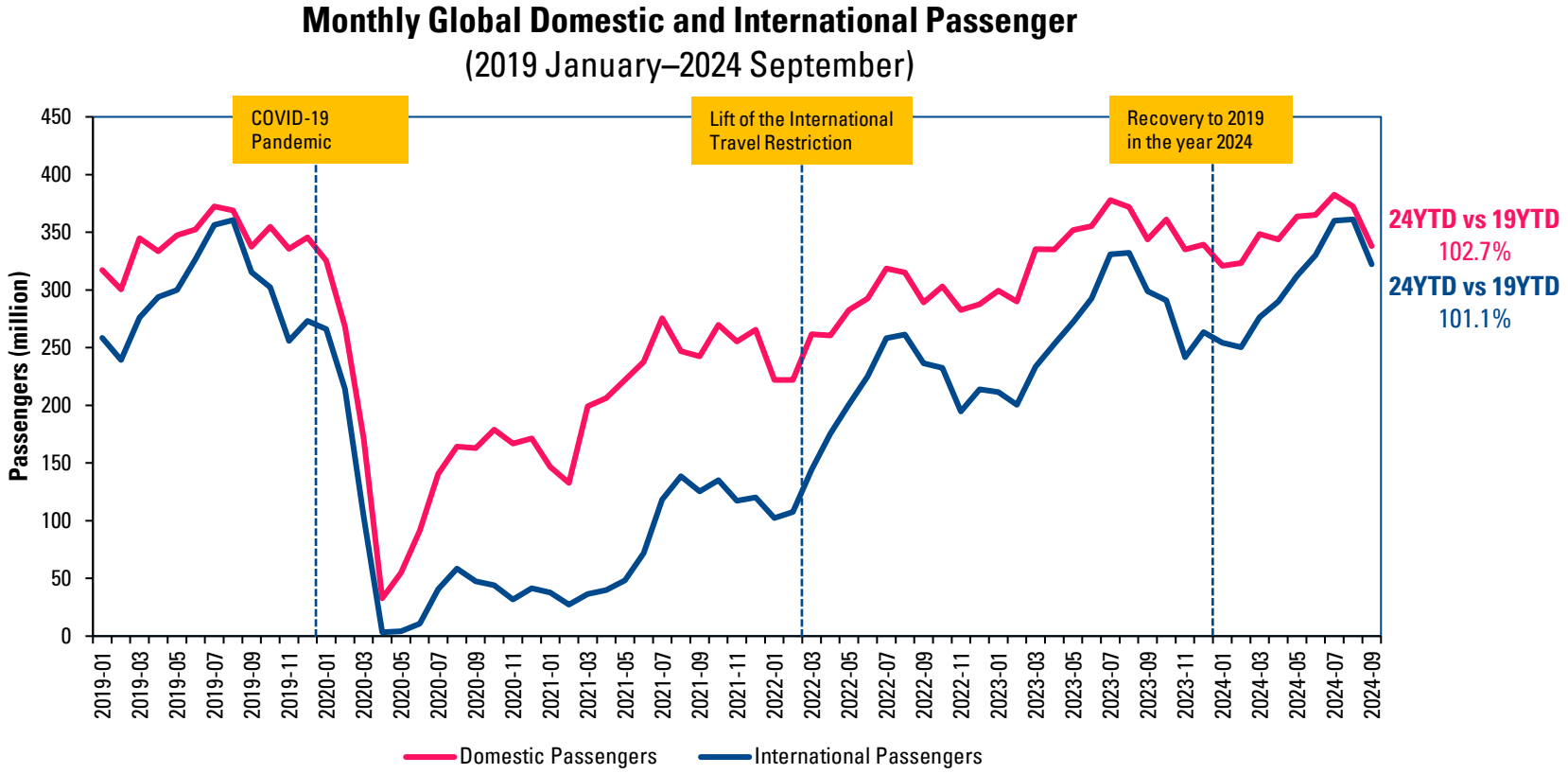


ACI airport traffic for over 2,600 airports across more than 180 countries and territories

ACI financial data from over 1,000 airports of all sizes and business models for the 2021 financial year, representing 82% of the world's pre-pandemic traffic.

Past

Global airport pax traffic – A tale of two markets

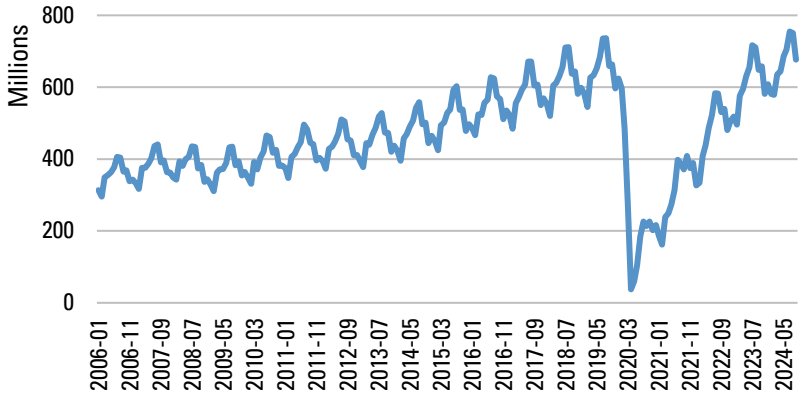


Source: ACI World Airport Traffic Database

Seasonality in passenger traffic –

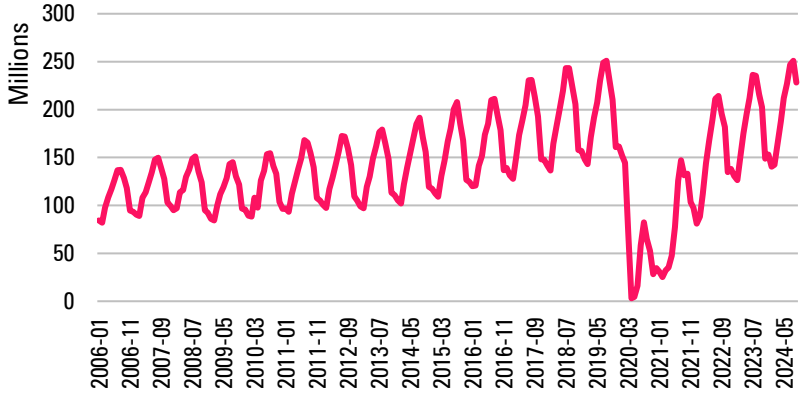
The Mediterranean effect

Total Passengers, World
2006 - 2024 Sep.



Peak months – Jul., Aug., Sep. % of annual traffic	
Pre-pandemic	Recovery period
28%	31% (+3%)

Total Passengers, Europe
2006 - 2024 Sep.

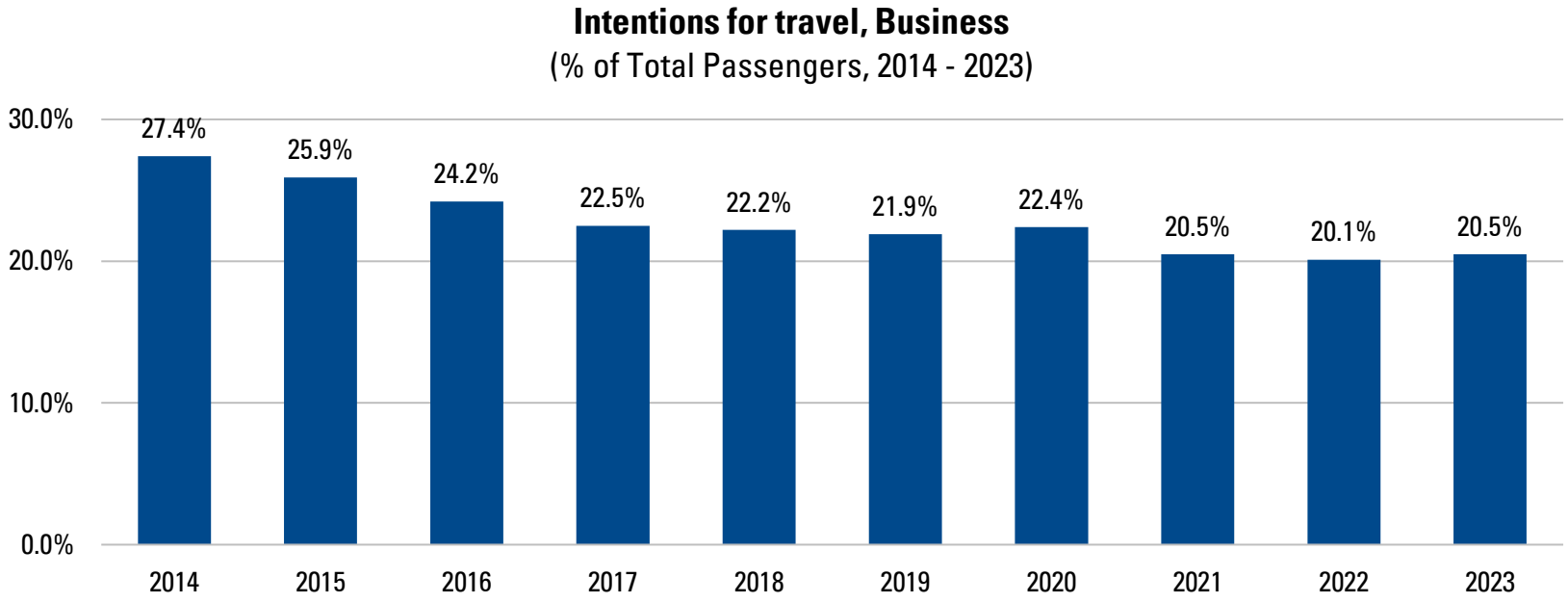


Peak months – Jul., Aug., Sep. % of annual traffic	
Pre-pandemic	Recovery period
30%	35% (+5%)

Source: ACI World Airport Traffic Database

Passenger mix – Intentions for travel

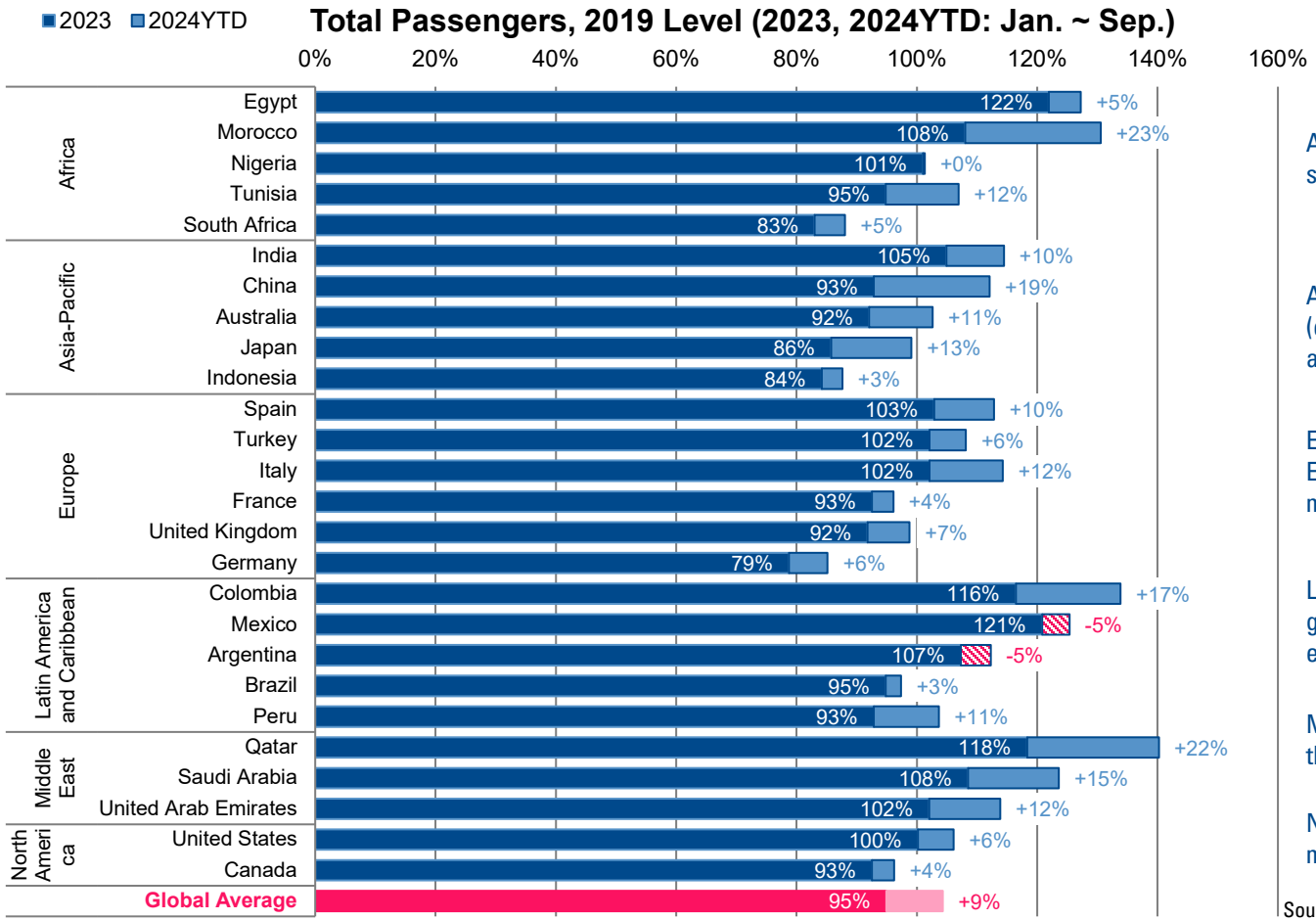
Traveling for business - % of total passengers



Source: ACI World, Airport Service Quality
n=149 airports

Present

Major Markets in 2023 and 2024 YTD



AFR – Northern African markets showing strong growth.

ASP – Major East Asian markets (e.g., China, Japan, Korea, etc.) are recovering in 2024.

EUR – Strong markets in Southern Europe, Western European markets falling behind.

LAC – Some markets had steep growths in 2022-2023 experiencing correction in 2024.

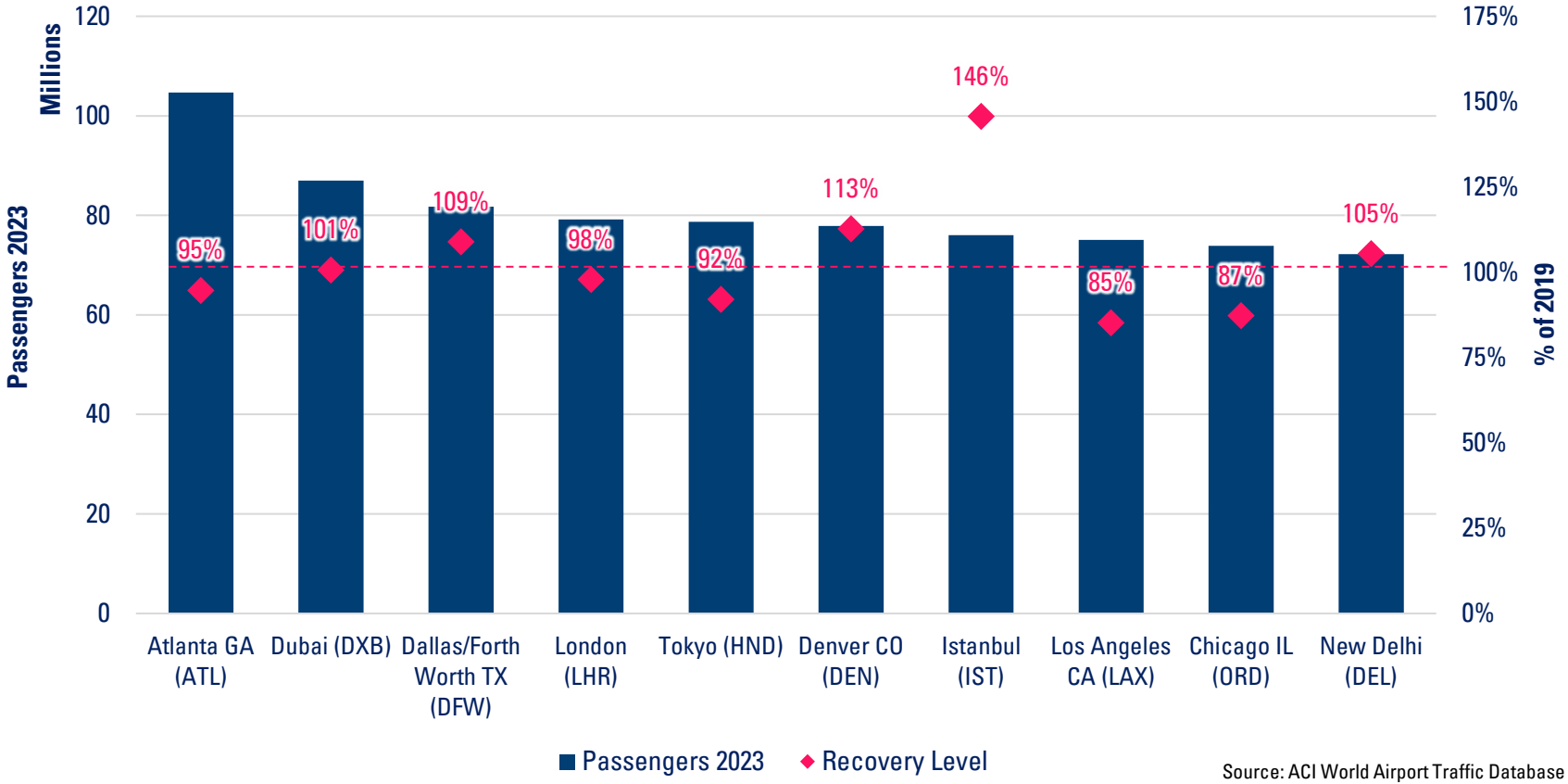
MEA – Major markets continuing their growth momentum in 2024.

NAM – Returning to pre-COVID market growth trend.

Source: ACI World Airport Traffic Database

Top 10 World Busiest airports (2023)

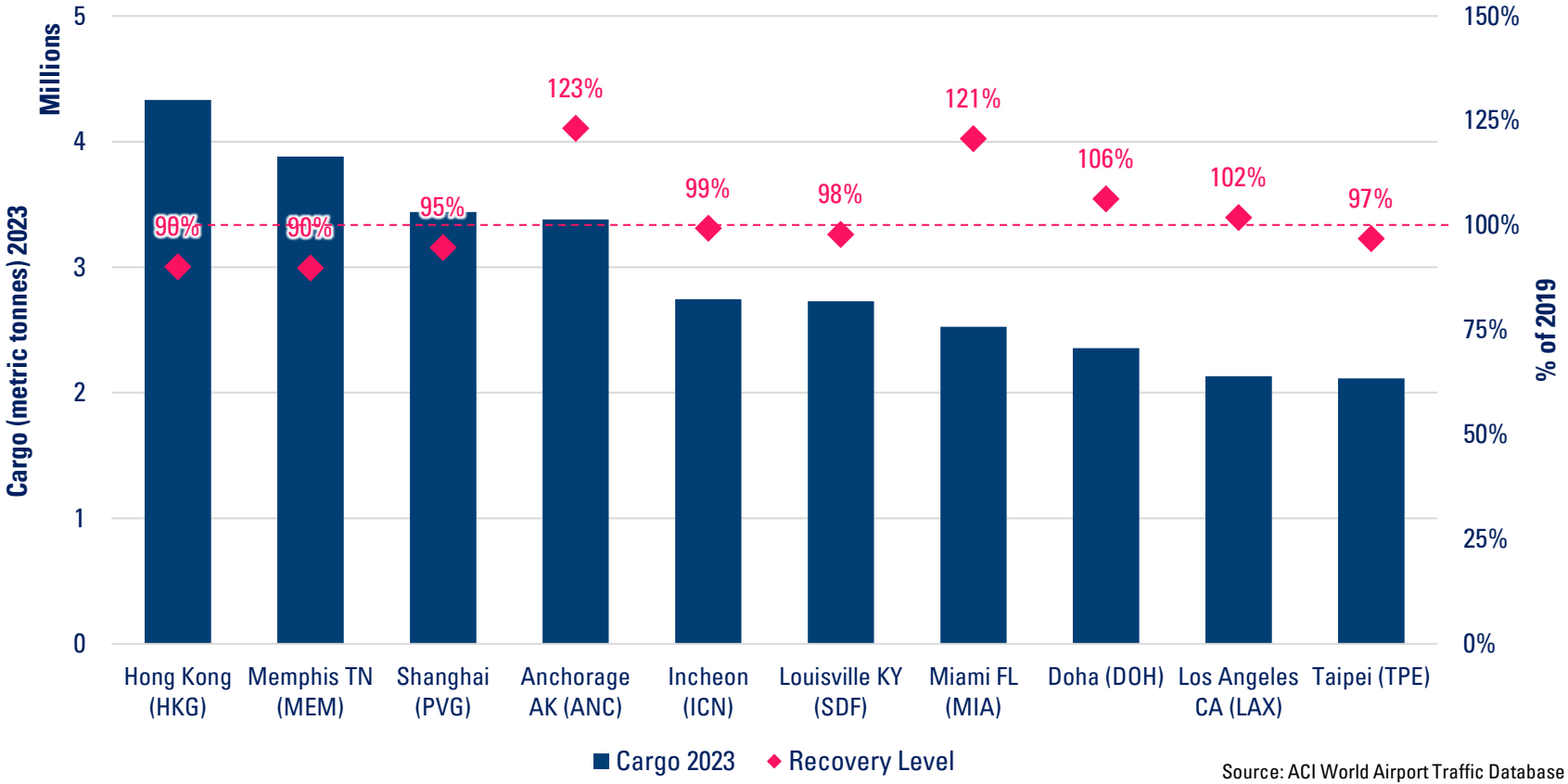
Total Passengers, Global Average: 95%



Source: ACI World Airport Traffic Database

Top 10 World Busiest airports (2023)

Total Air Cargo, Global Average: 96%

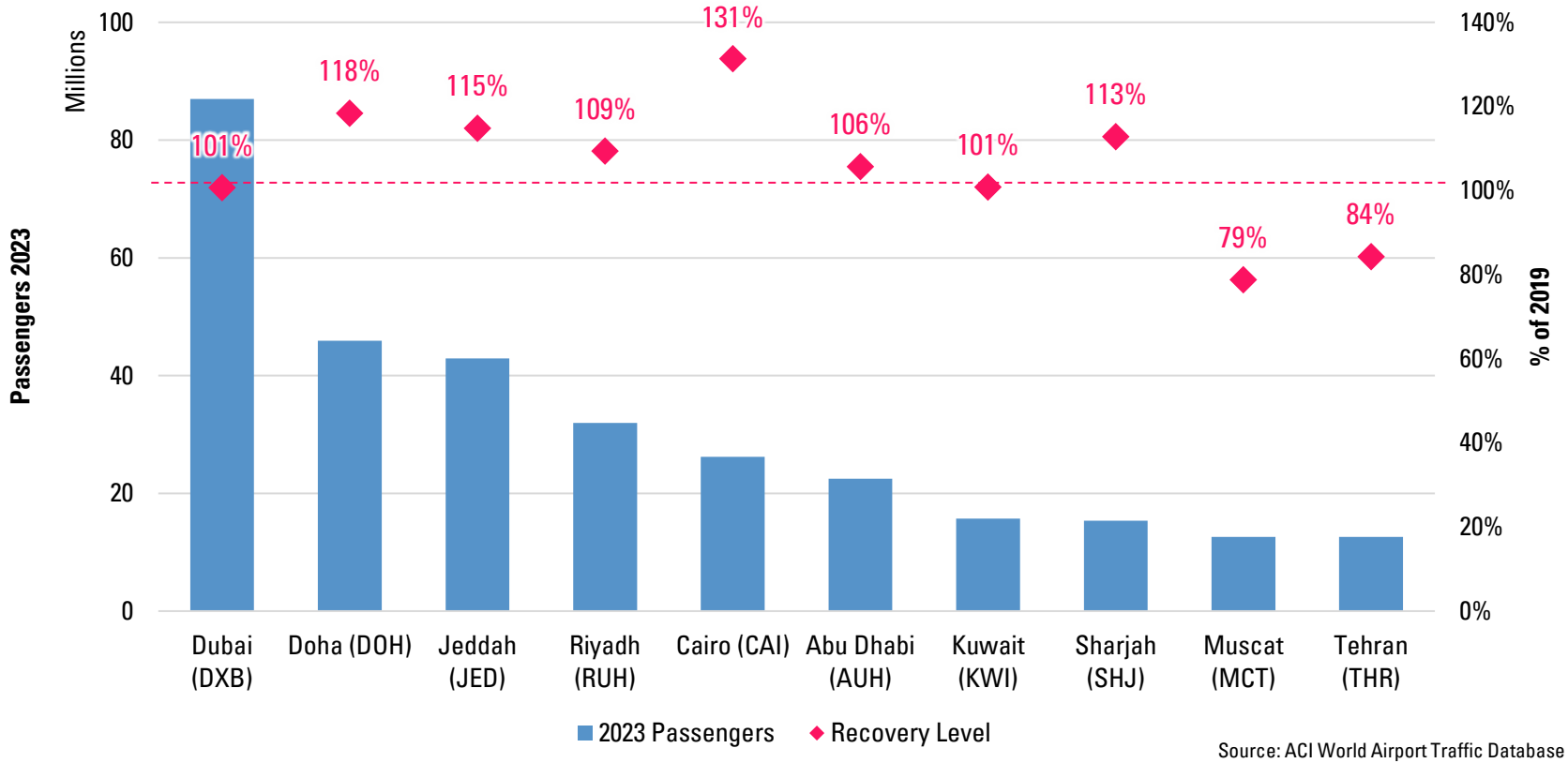


Source: ACI World Airport Traffic Database

Top 10 Middle East* Busiest airports (2023)

Total Passengers, Middle East Average: 102%

* ICAO Middle East Region

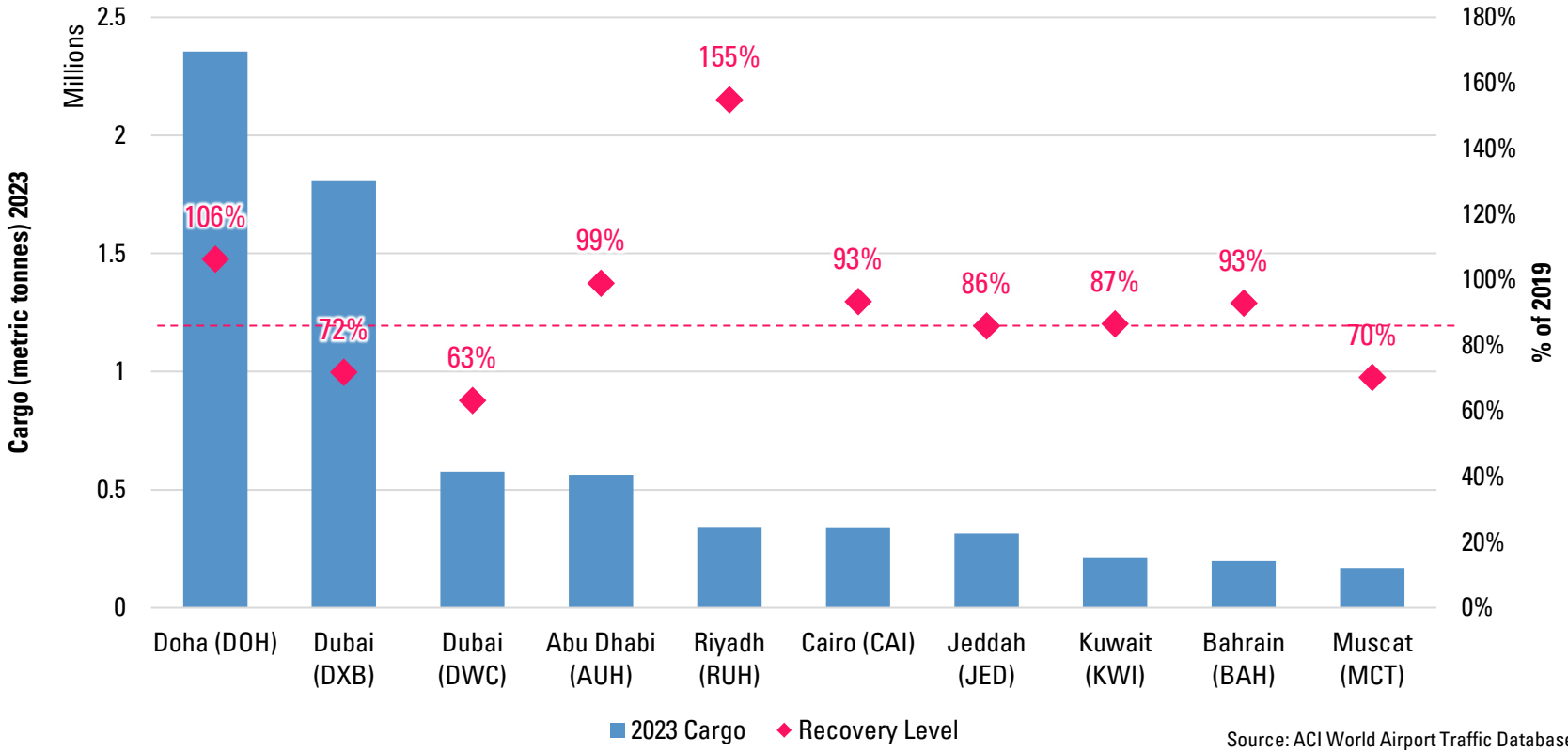


Source: ACI World Airport Traffic Database

Top 10 Middle East* Busiest airports (2023)

Total Air Cargo (metric tonnes), Middle East Average: 86%

* ICAO Middle East Region



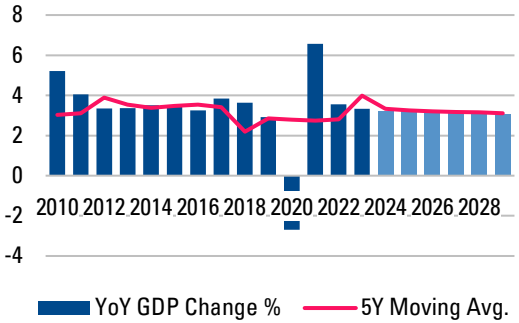
Source: ACI World Airport Traffic Database

Outlook

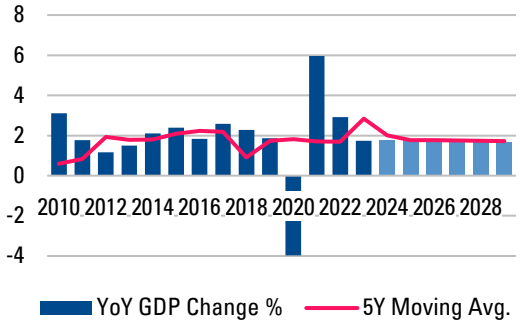
Macroeconomic factors impacting air transport demand

Lagging and coincident indicators

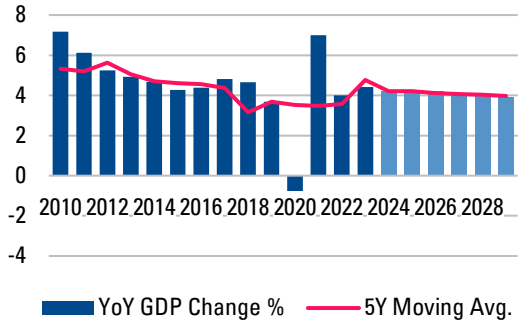
World, GDP Growth %
2000 – 2029 Forecasted



Advanced Economies, GDP Growth %
2000 – 2029 Forecasted



Emerging Markets and Developing Economies, GDP Growth %
2000 – 2029 Forecasted



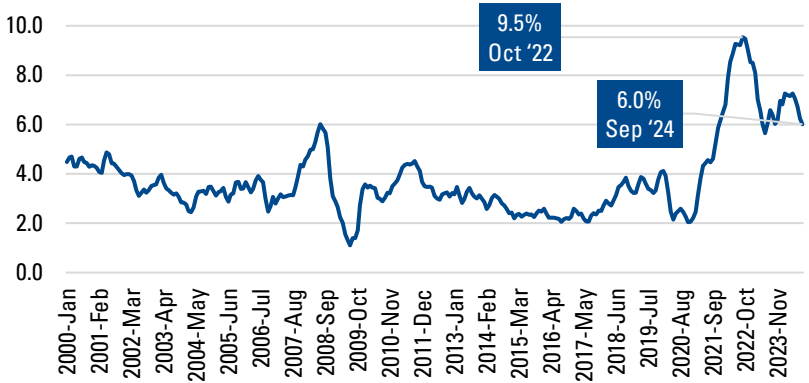
Source: IMF

The baseline IMF (International Monetary Fund) forecast predicts the world economy to grow at 3.2% in 2024 and 3.2% in 2025. Advanced economies are expected to see slight growth from 1.7% in 2023 to 1.8% in 2024 and 1.8% in 2025, while emerging markets will experience a slowdown from 4.4% in 2023 to 4.2% in 2024 and 2025. Global growth is projected to be 3.1% in five years, remains mediocre compared with the prepandemic average.

Macroeconomic factors impacting air transport demand

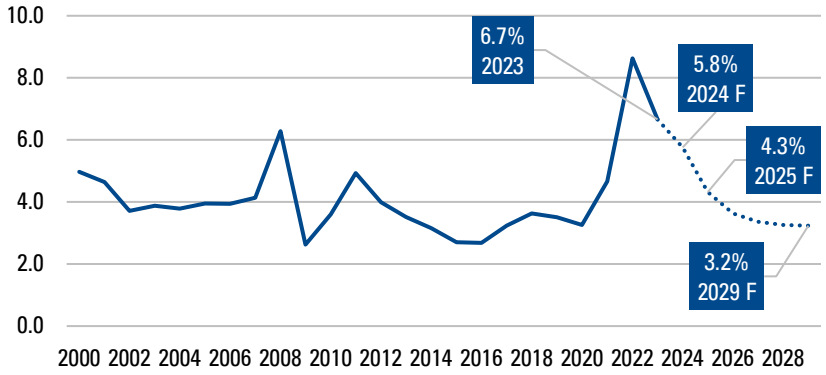
Lagging and coincident indicators

Inflation (% per annum), G20 Countries
2000 - 2024 Sep.



Source: OECD

Inflation (% per annum), World, Real + Forecasted
2000 – 2029 Forecasted



Source: IMF

Inflation soared at some of the highest levels in decades reaching over 9% in 2023 - Global tightening of monetary policy

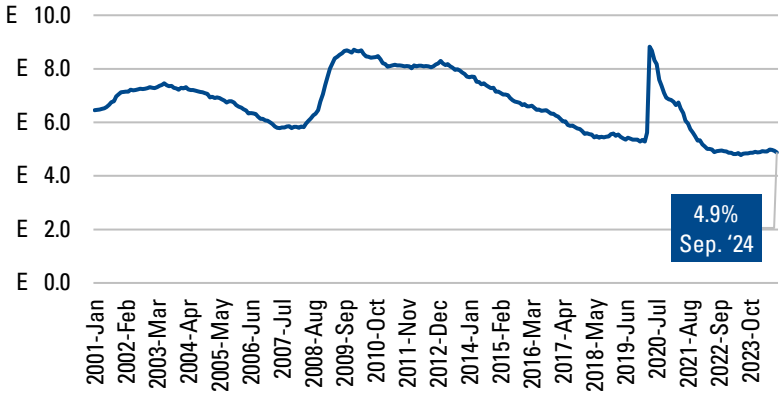
Global inflation is forecast to decline steadily, from 6.7 percent in 2023 to 5.8 percent in 2024 and 4.3 percent in 2025.

Macroeconomic factors impacting air transport demand

Lagging and coincident indicators

Unemployment Rate (%, Estimated) - OECD

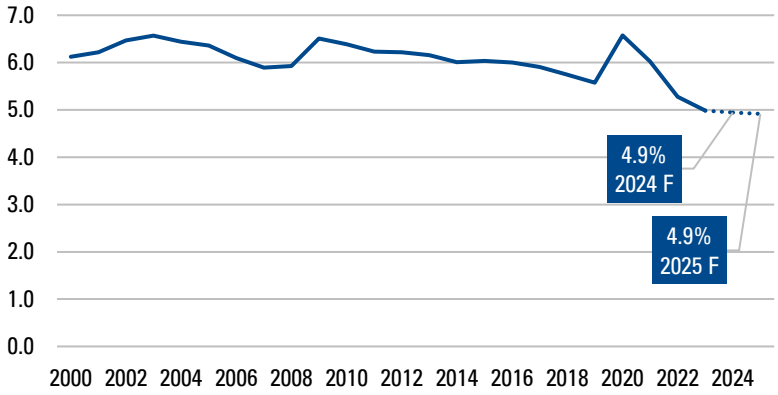
2005 - 2024 Sep.



Source: OECD

Unemployment Rate (%) – World

2000 – 2025 Forecasted



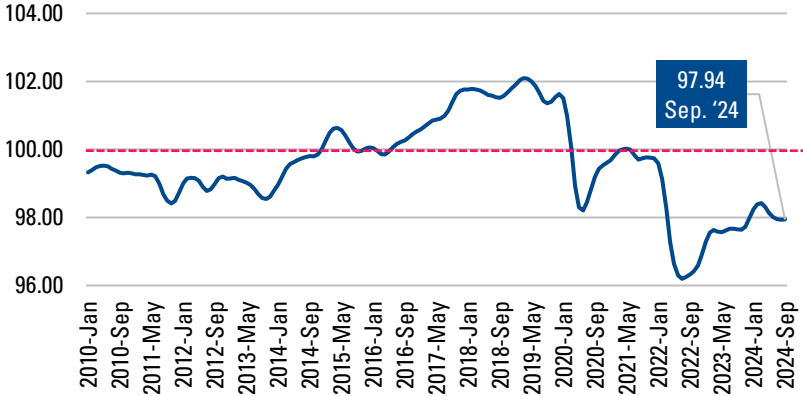
Source: ILO

The global unemployment rate is projected at 4.9 percent in 2024, slightly lower than in 2023 (5.0 percent). The lack of progress in further reducing labour underutilisation is worrying as employment deficits are still large. The latest ILO estimates of the jobs gap show that 402 million persons are without a job but wanting to work in 2024. This includes the 183 million who are counted as unemployed.

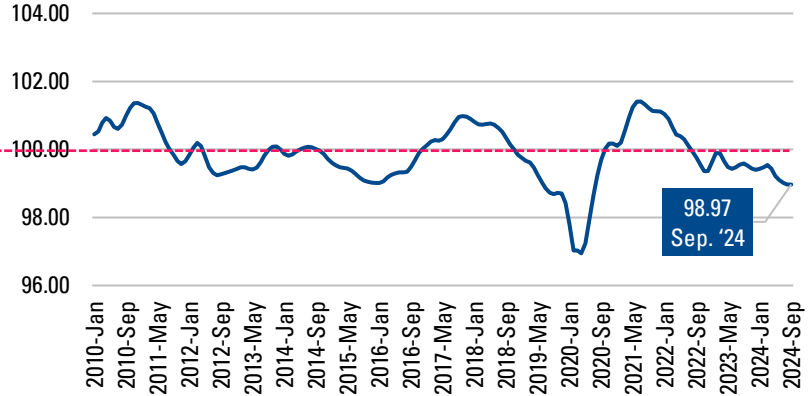
Macroeconomic factors impacting air transport demand

Leading indicators – confidence levels

Consumer Confidence Index – G20
2010 – 2024 Sep.



Business Confidence Index – G20
2010 – 2024 Sep.

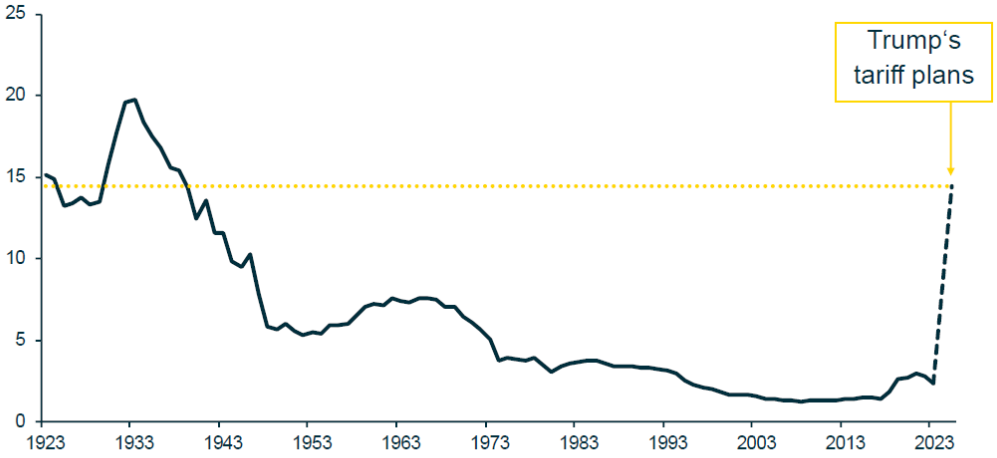


Source: OECD

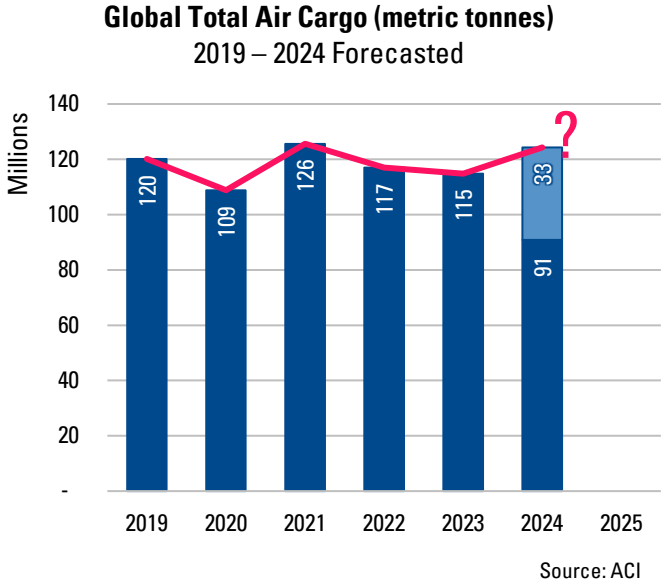
<100 signals a pessimistic attitude towards the economy and turning points.
Both Consumer Confidence Index, and Business Confidence Index below 100

Macroeconomic factors impacting air transport demand

Leading indicators – Global Trade



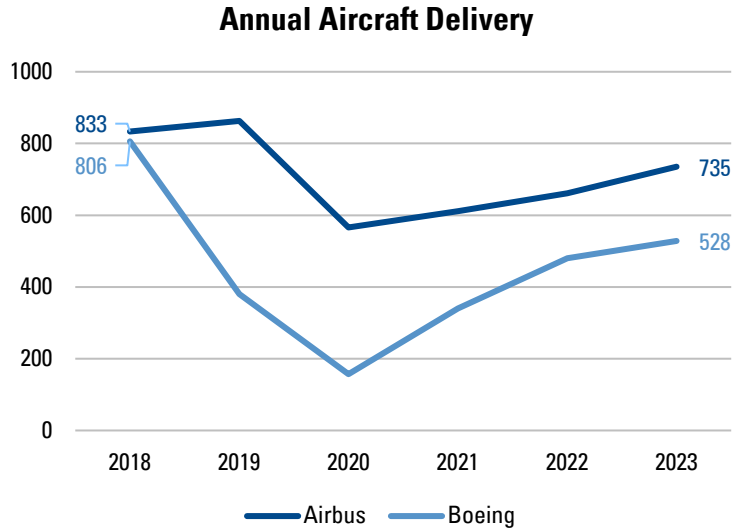
Sources: USTC, CBO, Commerzbank Research

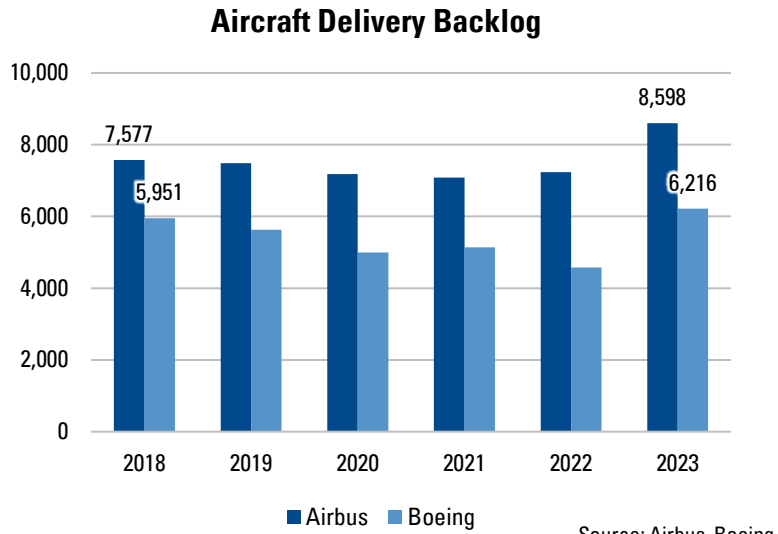


Source: ACI

Air cargo volumes expecting a slight bounce back in 2024 from a low base in 2023 but big uncertainty with weakened trade and economy.

Number of delivered commercial airplanes by manufacturers Airbus & Boeing

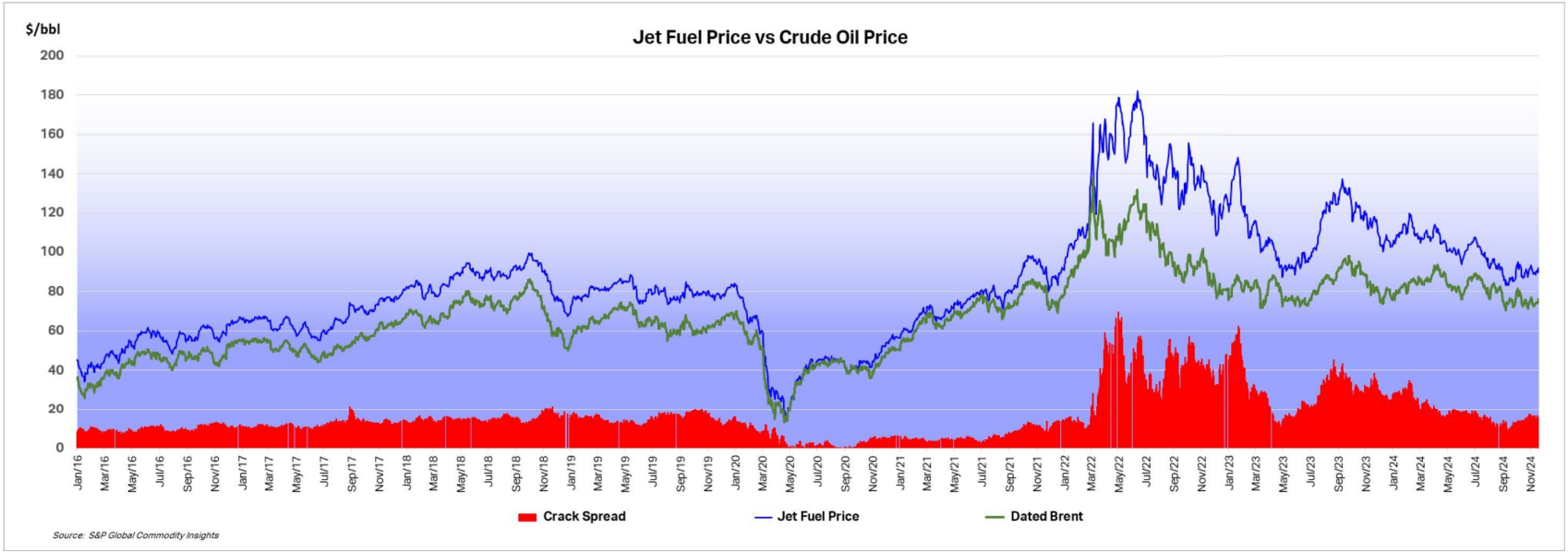




Source: Airbus, Boeing

Delivery of aircraft is below pre-pandemic level, while backlog reaches all-time high by the end of 2023. Aircraft production remains challenging to keep up with orders, facing global supply chain challenges.

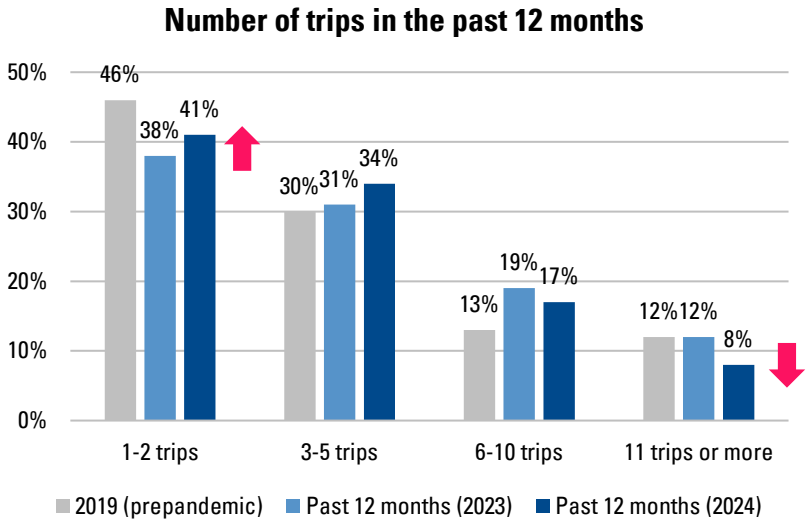
Jet Fuel Price Stabilizing



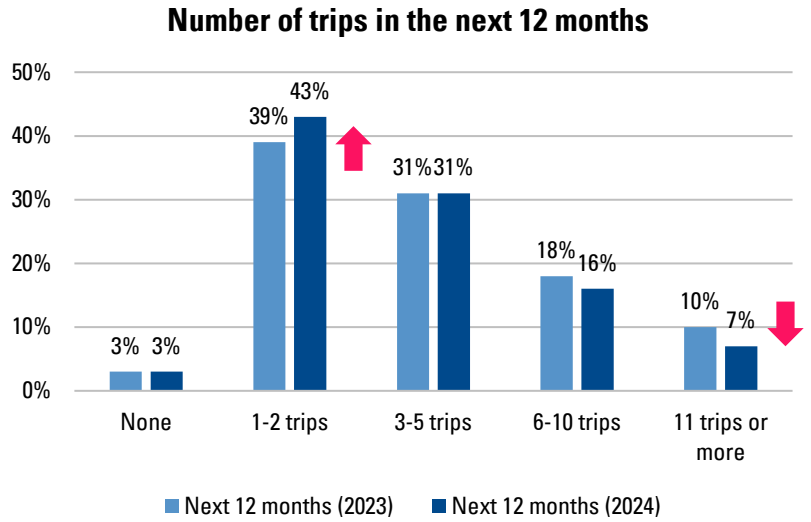
Source: IATA

Stabilization of jet fuel prices from 2023 Q4, gradually returning to pre-pandemic level.

Microeconomic factors – Consumer behavior



Q. How many trips by air have you made to any destination in 2019? / How many trips by air have you made in the past 12 months?



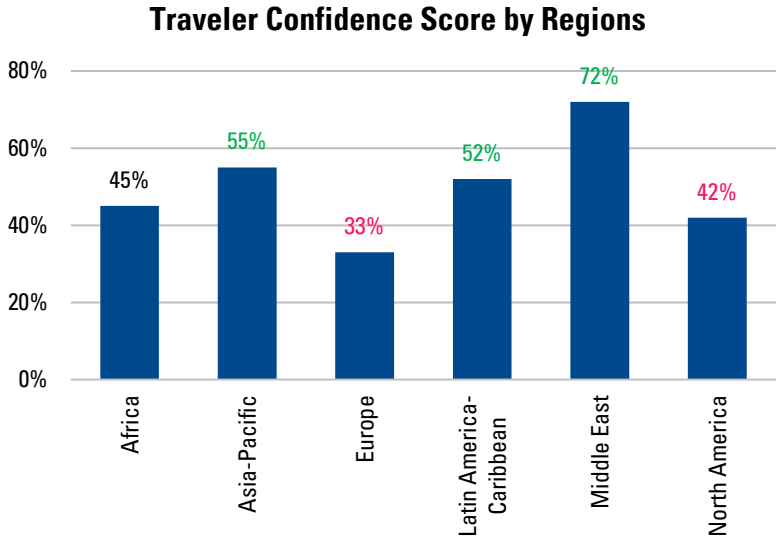
Q. Thinking about your intention to travel in the next 12 months, approximately how many trips by air would you say you expect to do?

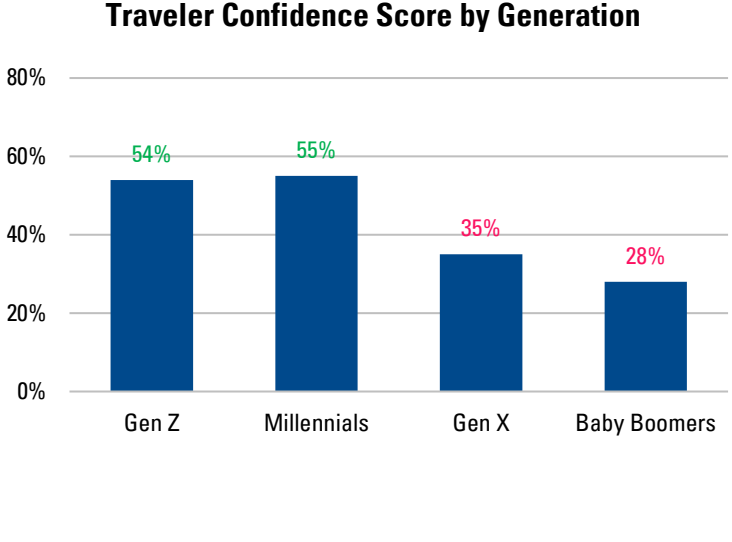
Base: All respondents (2020=4,100; 2023=4,125; 2024=4,125)

Source: ACI, ASQ 2024 Global Traveler Survey (November, 2024)

While results show that travel frequency remains generally higher than pre-pandemic levels, it appears that a slight decline is observed in 2024 in comparison to 2023, particularly within frequent flyers category (11 trips or more), while slight increase in occasional flyers, such as 1-2 trips or 3-5 trips – which can be explained by considering that the passenger growth in 2024 has been recovered to 2019 level, the air travel behaviour is reflecting this 'stabilization'.

Microeconomic factors – Consumer behavior



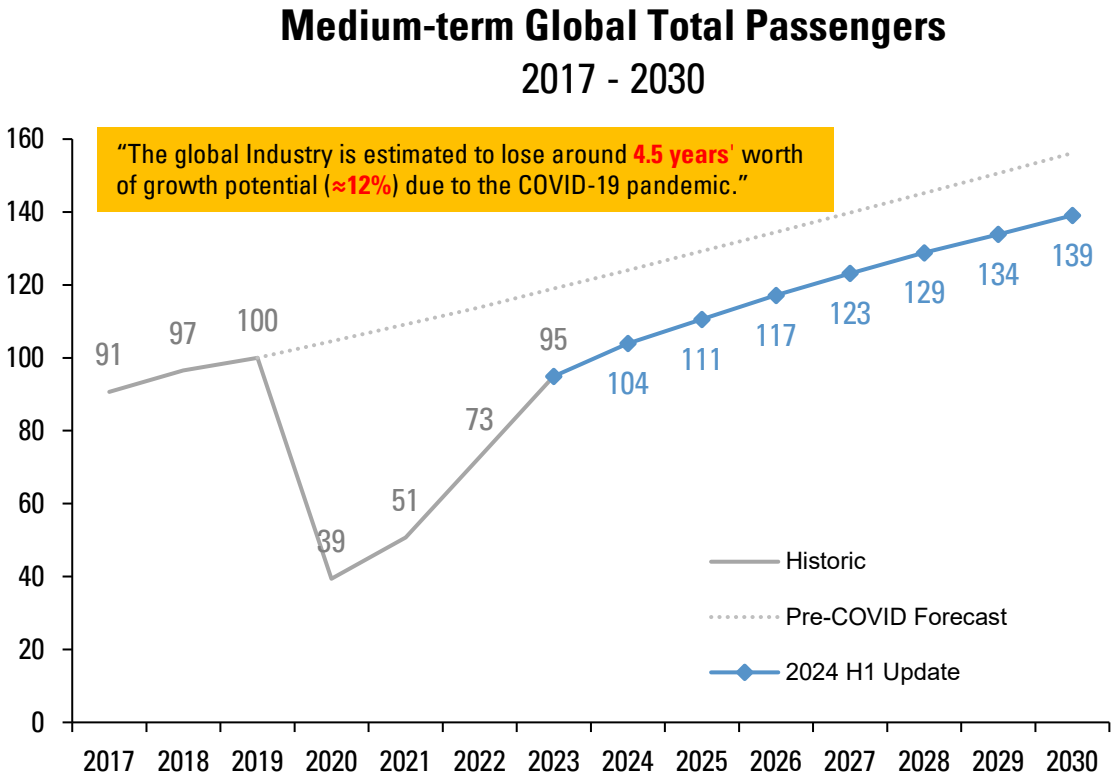


Base: All respondents, Q. Please indicate to what extent you agree or disagree with the following statements. 5-pt scale: Top 2 Boxes (strongly + somewhat agree). (n=4,125)

Source: ACI, ASQ 2024 Global Traveler Survey (November, 2024)

Travellers' overall confidence are mixed by regions and by generations. The confidence score marked lower in Europe and North America, and in older travellers, while higher in Asia-Pacific, Latin America-Caribbean, and Middle East, and younger travellers. The confidence score was generally higher in the segments that are growing faster, and therefore, positive in the medium-long term forecast.

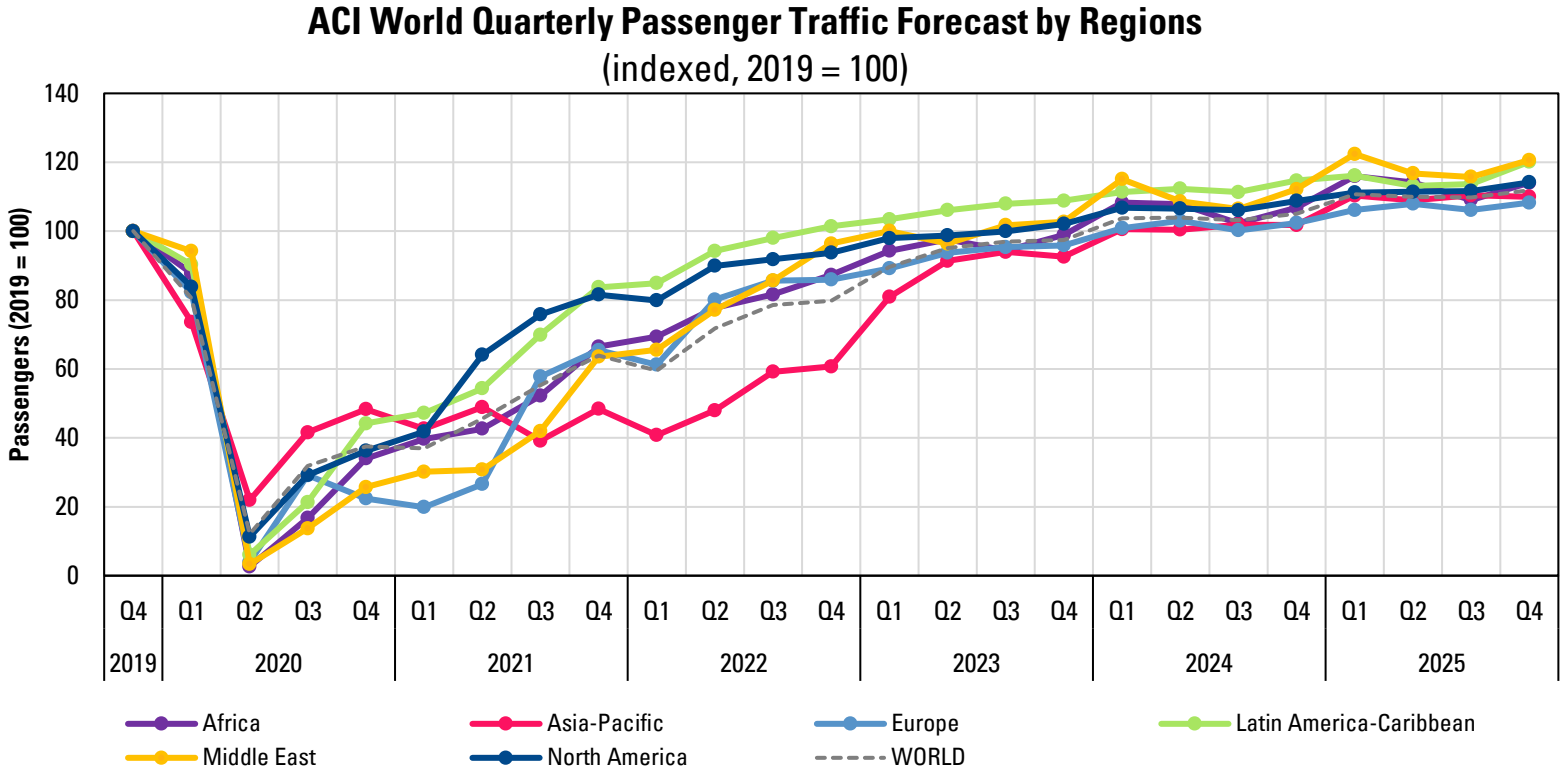
ACI Forecast Update (Sep. 2024)



- Escalating geopolitical conflicts
- Labor market bottlenecks
- Constraints on aircraft deliveries
- Travel costs remain elevated compared to pre-pandemic levels
- Uncertainty around global trade policies

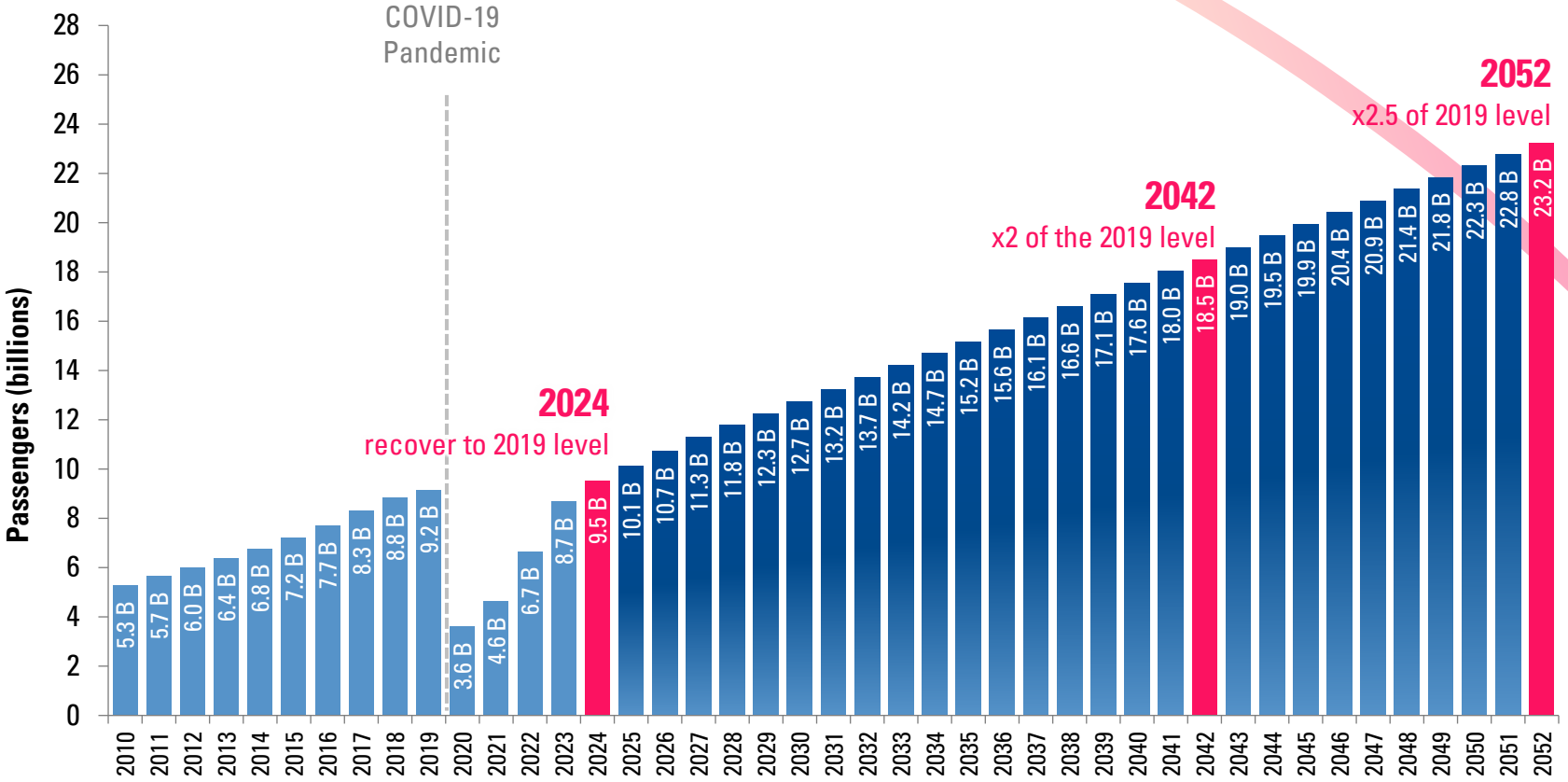
- Inflationary pressures easing
- Surge in international travel worldwide
- Stabilization of jet fuel prices
- Airline industry returning to profitability
- Gradual recovery of global connectivity

Medium-term Passenger Traffic Forecast by Regions



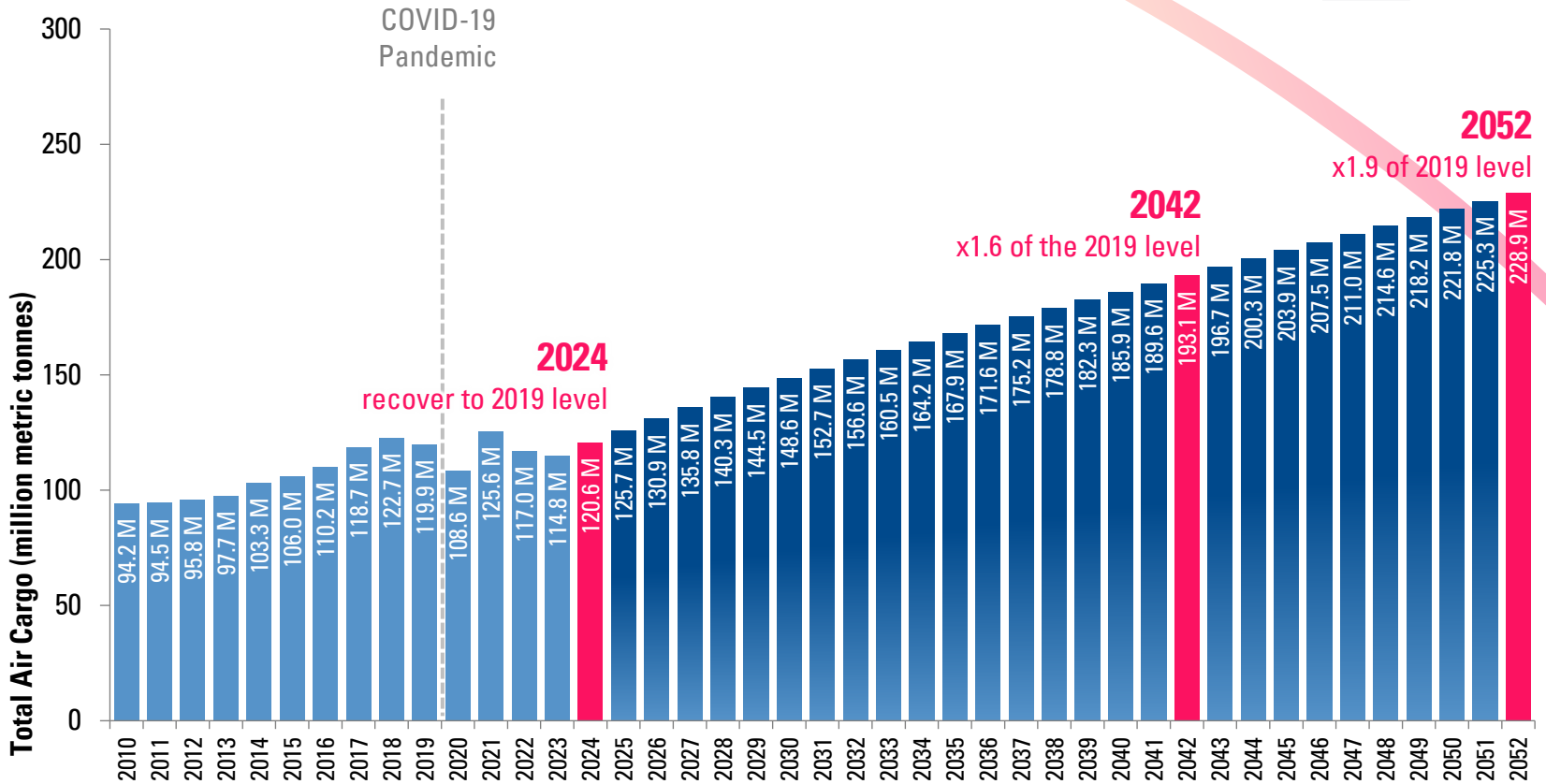
Source: ACI World, World Airport Traffic Forecast Update, September 2024

Long-term Passenger Traffic Growth



Source: ACI World, World Airport Traffic Forecast Update, September 2024

Long-term Cargo Traffic Growth



Source: ACI World, World Airport Traffic Forecast Update, September 2024

ACI WATF 2023-2052 Accuracy

ACI World Airport Traffic Forecast (WATF) 2023-2052 edition marked the highest total passenger forecast accuracy among past editions.

2023 Total Passengers	Forecasted February 2024	Actual July 2024	Difference % *
World 141 markets – 98.9% coverage	8,691,883,043	8,691,204,783	-0.01%
Africa 31 markets – 94.4% coverage	219,108,991	220,839,398	0.78%
Asia-Pacific 26 markets – 97.4% coverage	3,002,647,544	3,030,292,407	0.91%
Europe 44 markets – 99.9% ** coverage	2,289,090,026	2,278,243,050	-0.48%
Latin America-Caribbean 28 markets – 97.7% coverage	739,926,659	732,426,459	-1.02%
Middle East 10 markets – 99.4% coverage	421,965,384	407,769,455	-3.48%
North America 2 markets – 100.0% coverage	2,019,144,439	2,021,634,014	0.12%

The next ACI World Airport Traffic Forecast edition will be released in **February 2025**.

* Difference: (Actual – Forecasted) / Actual
** excluding Ukraine

Aviation Data Analysis Seminar

Artificial Intelligence in Airport Operations

Hyuntae Jung
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ACI World

ACI AIRPORTS COUNCIL INTERNATIONAL

Introduction to AI

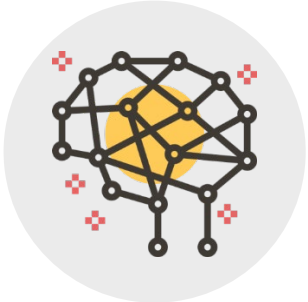
Starting from my personal story

Introduction to Artificial Intelligence

Starting from my personal story…

Air Traffic Management

Data Analytics Data Science



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Aviation Data Scientist

ATM → Safety → Economics

Why AI? Why did this aviation guy study AI?

Introduction to Artificial Intelligence

Starting from my personal story…

TOP 10 BUSIEST GLOBAL DOMESTIC FLIGHT ROUTES OF 2023
RANKED BY SEATS

2023 Ranking	Route	Route Name	Seats	2019 Ranking	2023 vs 2019
1	CJU-GMP	Jeju International - Seoul Gimpo	13,728,786	1	-21%
2	CTS-HND	Sapporo New Chitose - Tokyo Haneda	11,936,302	2	-4%
3	FUK-HND	Fukuoka - Tokyo Haneda	11,264,229	3	-1%
4	HAN-SGN	Hanoi - Ho Chi Minh City	10,883,555	4	6%
5	MEL-SYD	Melbourne - Sydney	9,342,312	5	-6%
6	PEK-SHA	Beijing - Shanghai Hongqiao	8,355,225	7	3%
7	HND-OKA	Tokyo Haneda - Okinawa Naha	7,982,218	9	4%
8	JED-RUH	Jeddah - Riyadh	7,902,142	8	-1%
9	BOM-DEL	Mumbai - Delhi	7,276,430	6	-12%
10	CGK-DPS	Jakarta - Denpasar-Bali	7,190,961		8%

OAG Schedules Analyser
Columns 2023 vs 2022 and 2023 vs 2019 show % variance in airline capacity between the two years.

Introduction to Artificial Intelligence

Starting from my personal story…

Student ATCo

Air Traffic Management

Global Air Navigation Plan

Aviation System Block Upgrade

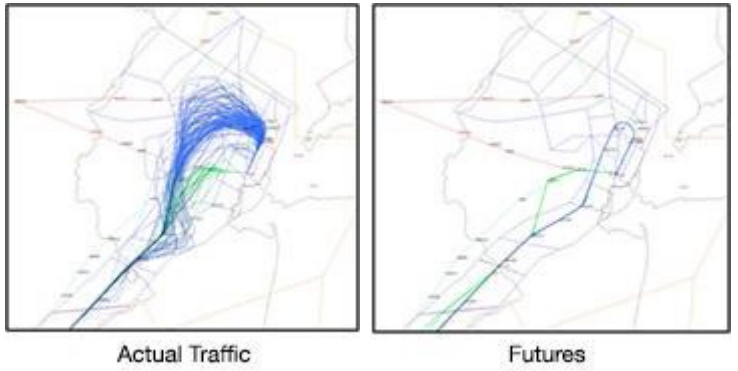
Introduction to Artificial Intelligence

Starting from my personal story…

Trajectory Based Operation

4-Dimension flight trajectories are shared and managed…

1. to all stakeholders based on data sharing
2. real-time data for Collaborative Decision Making
3. predictive analytics for planning, flexible to adapt

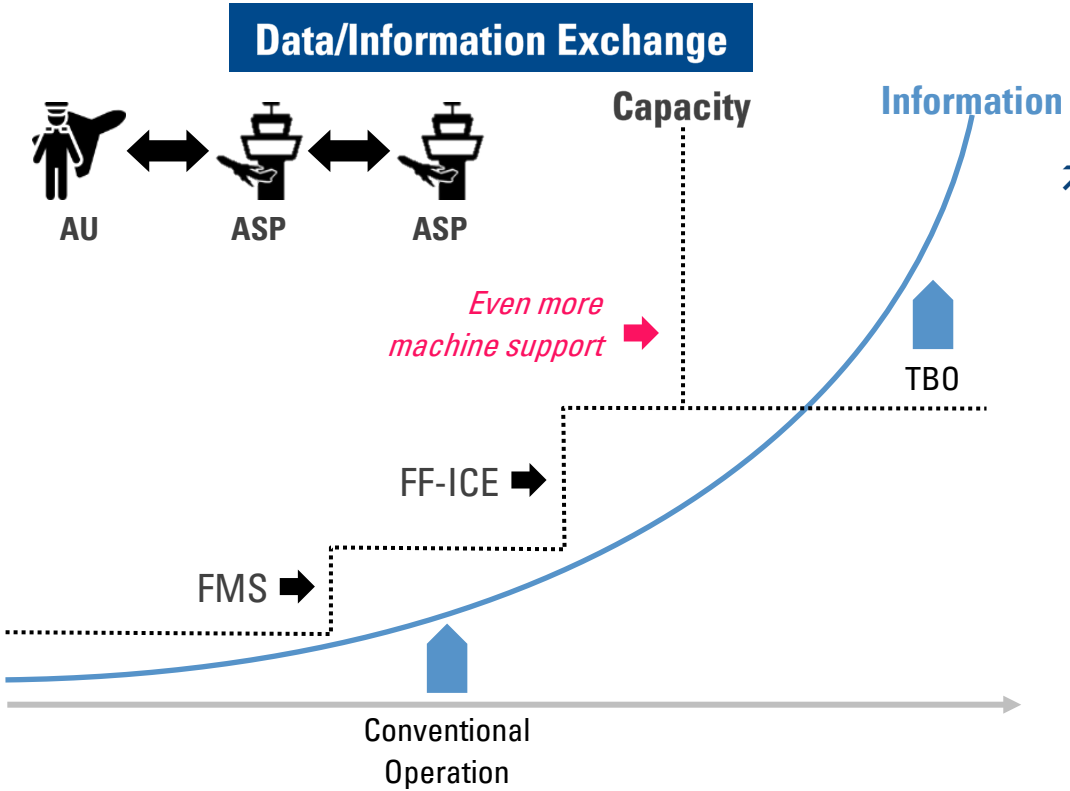


- ↗ Accurate future traffic flow prediction
- ↗ Efficient, predictable, and flexible operation
- ↗ System-wide performance optimization

Deployment planned in ASBU Block 3 (2031) & Block 4 (2037)

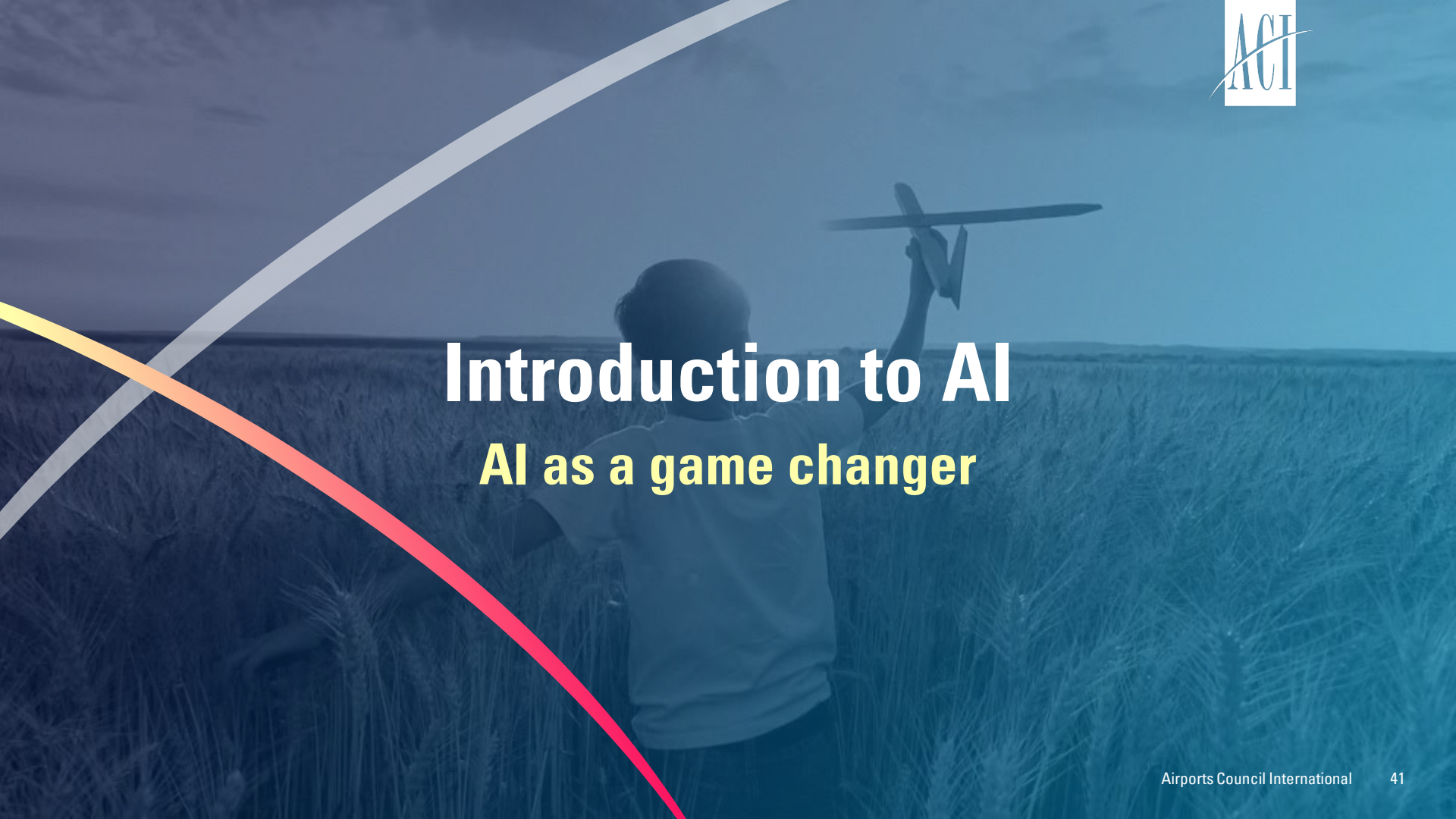
Introduction to Artificial Intelligence

Trajectory Based Operation



↗ **TBO can be achieved with automation technologies**

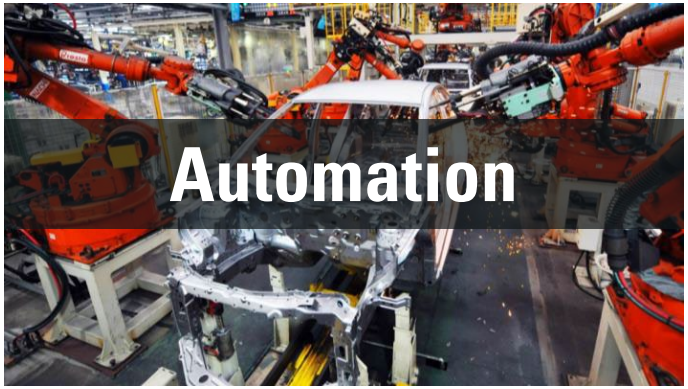
It is almost impossible for humans to identify, track, or manage every trajectory with low-level calculations.



Introduction to AI

AI as a game changer

Introduction to Artificial Intelligence

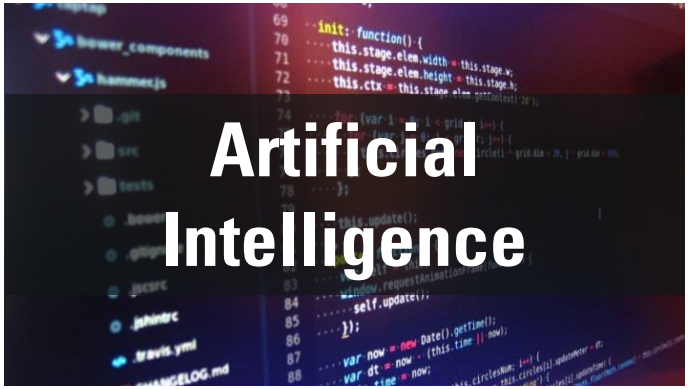


Mechanical Muscle

Performing tasks with minimal human intervention, following predefined rules and workflows.

Repetition of specific tasks efficiently and accurately.

Limited to the tasks it was programmed for; lacks flexibility.



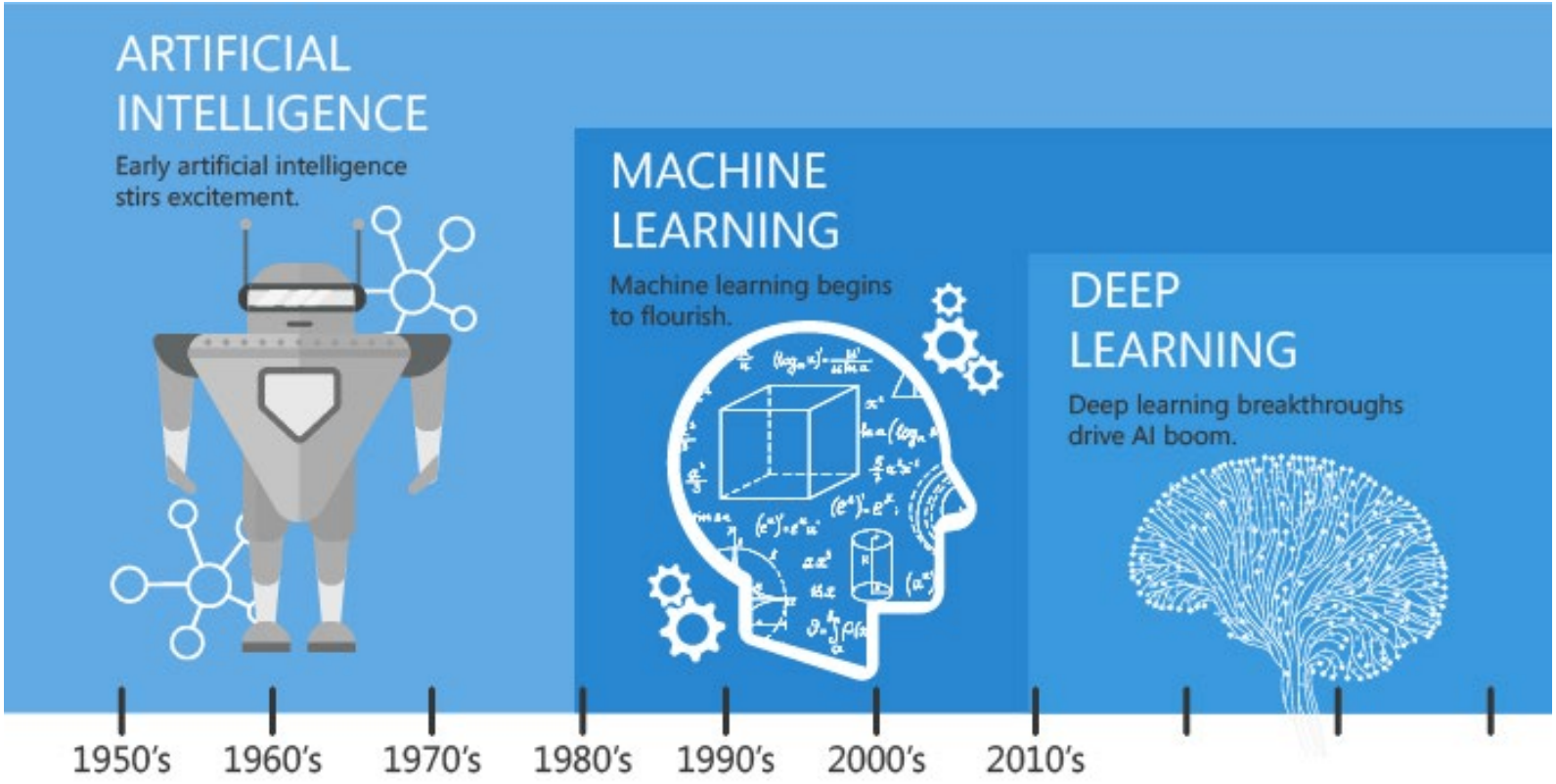
Mechanical Mind

Creating systems that can mimic human intelligence, learn from data, and make decisions.

Learning, reasoning, and adapting to new situations or data.

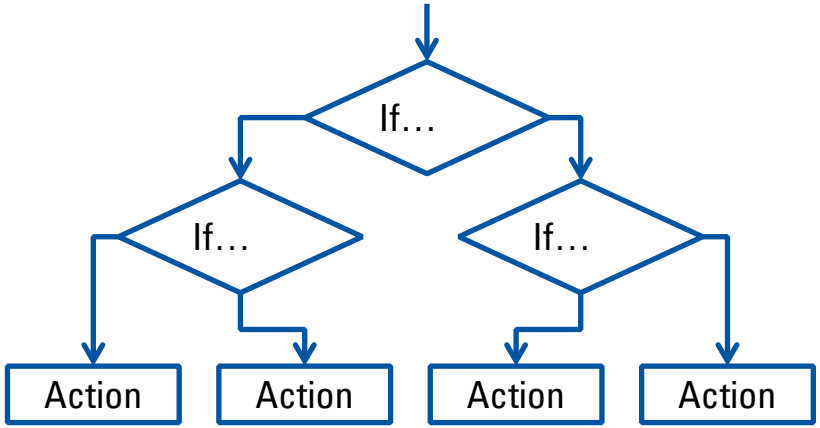
Flexible and capable of handling diverse and complex tasks by "thinking" through them.

Introduction to Artificial Intelligence



Introduction to Artificial Intelligence

Traditional Expert System (~1990s)

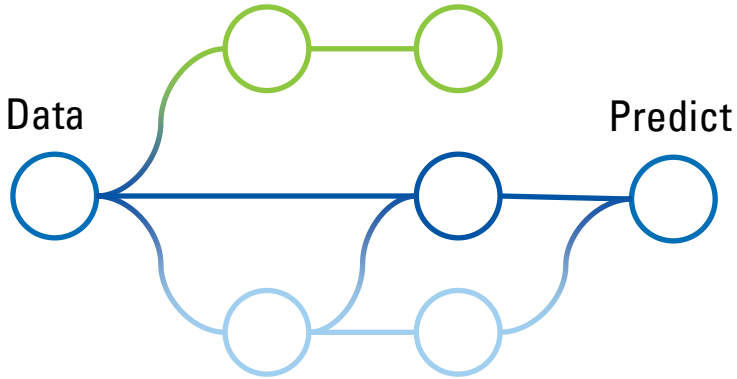


Architecture by human design, not from data

Built to **beat human performance**

> **Once built, cannot improve without changing the whole architecture**

Modern Machine Learning (2010s)



Machine learns itself from huge data

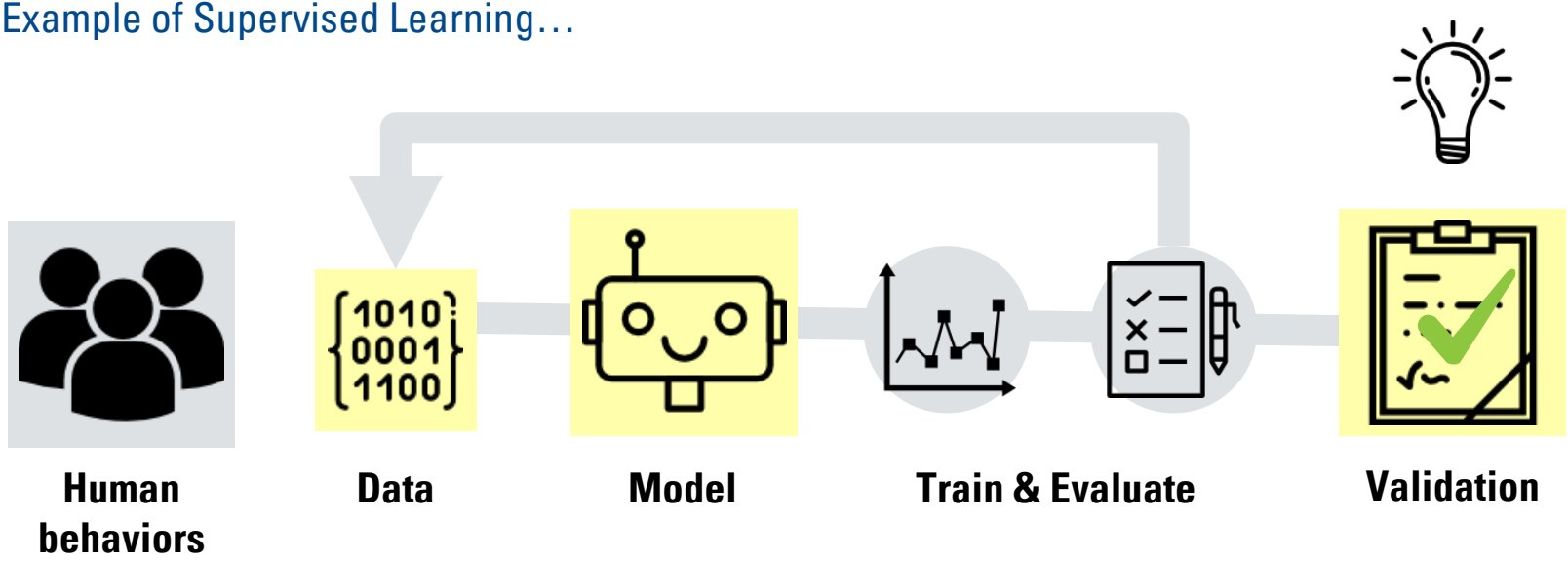
Built to **mimic human decision**

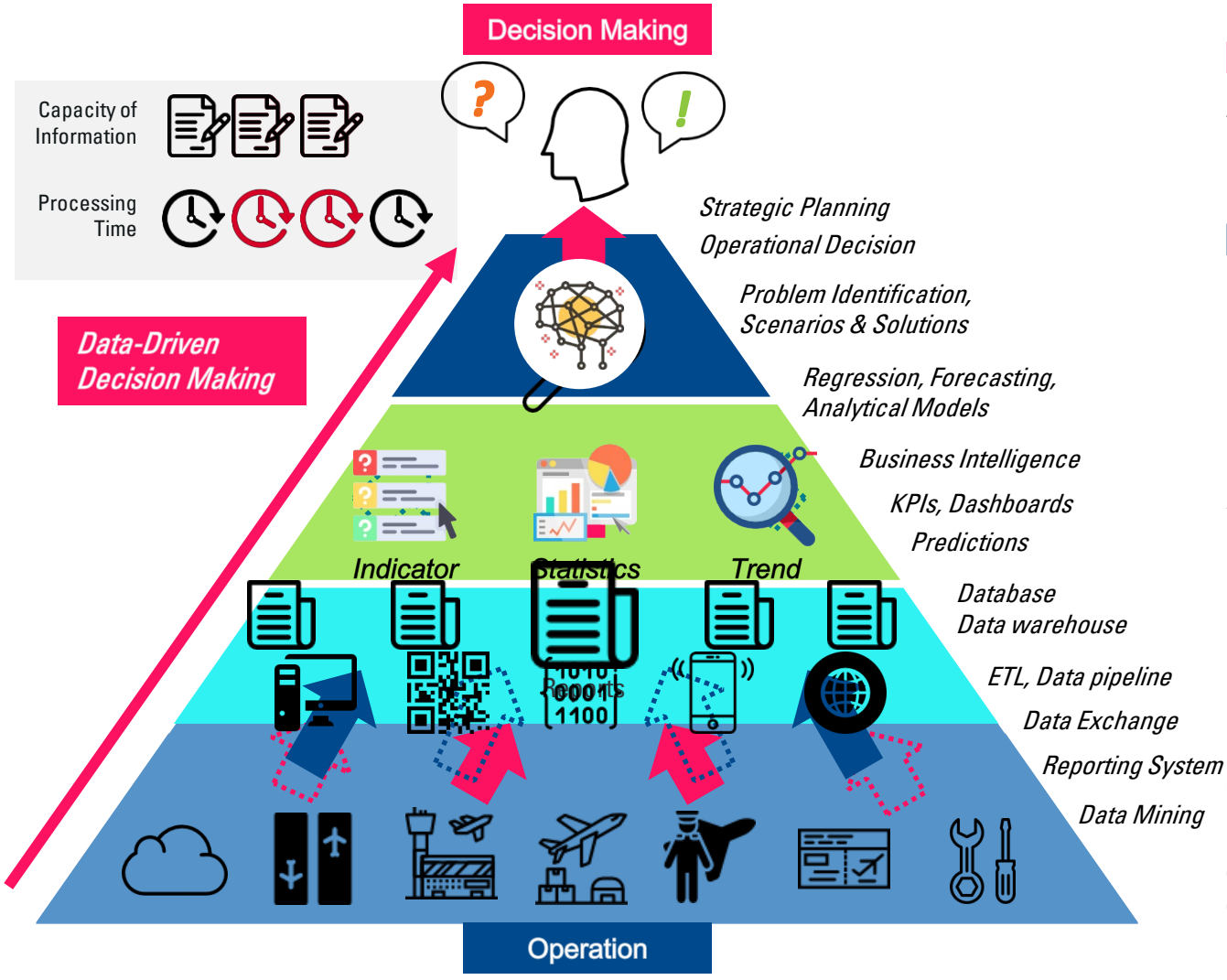
> **Continuously evolves by feedback cycle of training and prediction**

Introduction to Artificial Intelligence

Generating predictions close to actual result by capturing the pattern in data

Example of Supervised Learning…





Decision Level

Actionable intelligence is translated into strategic / operational decision.

Intelligence Level

Linking information to actionable insights. (e.g., Correlation, predictions, and recommendations)

Information Level

Analyzing data to extract meaningful patterns and trends. Contexts to enrich data.

Data Level

Organizing, structuring, and storing data into usable format.

Operation Level

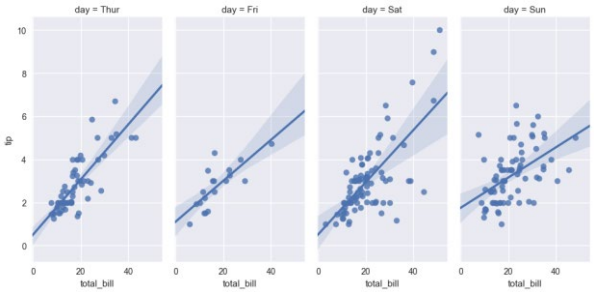
Raw data is collected from sensors, equipment, human inputs at operational environments.

Introduction to Artificial Intelligence

Solution: Prediction and Optimization

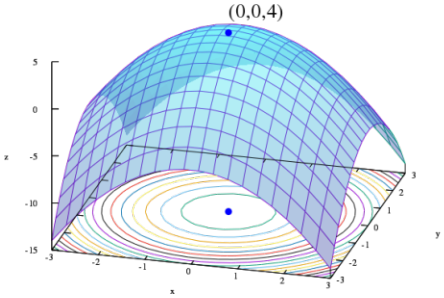
Regression & Prediction

Capture the best **link** that explains **correlation** between data.



Optimization

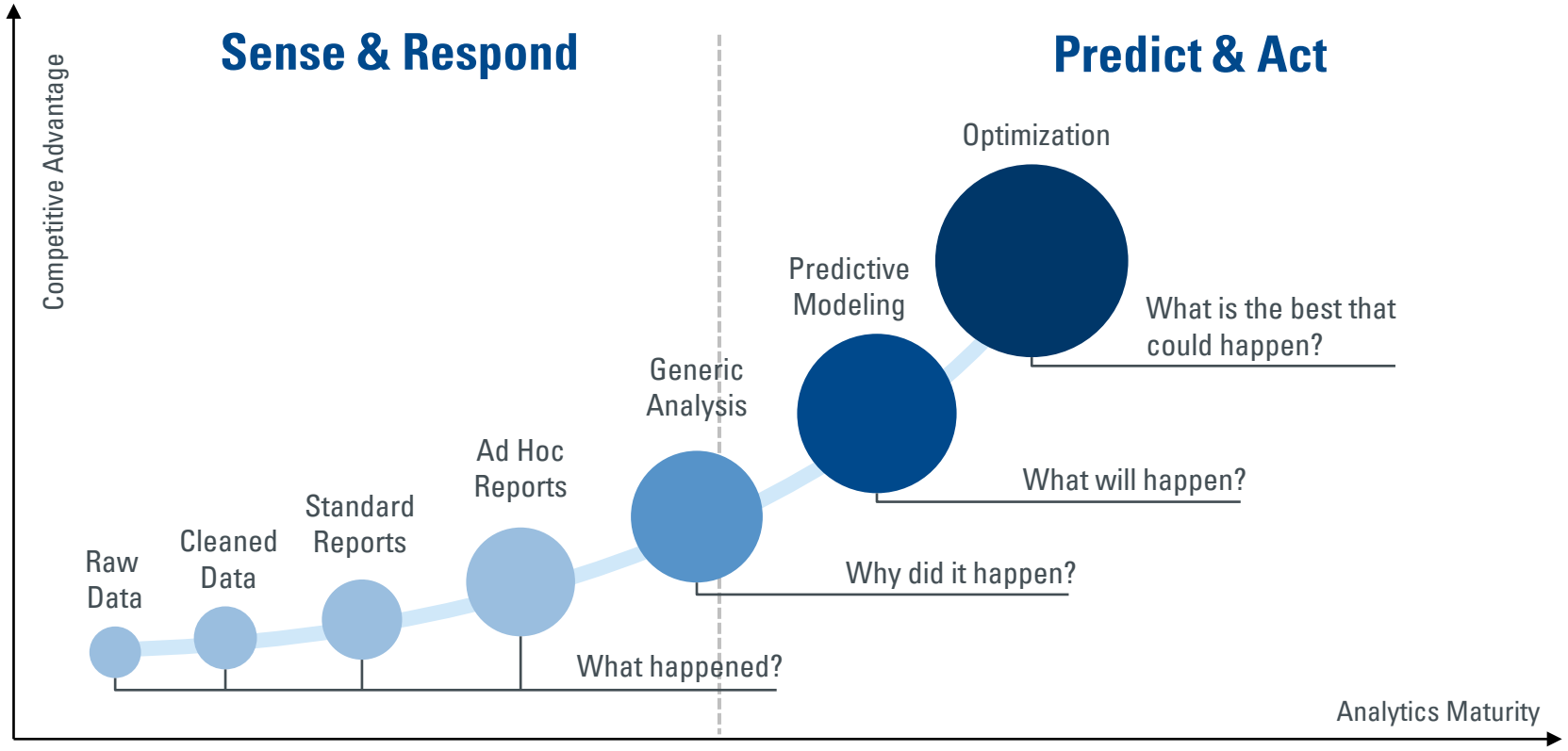
Find the best **solution** which fits the **objective**, with satisfying given **constraints**.



Machine Learning

- **Supervised Learning**
  - Classification
  - Regression
- **Unsupervised Learning**
  - Clustering
  - Feature Analytics
- **Reinforcement Learning**
  - React from Environment
- **Generative AI**

Introduction to Artificial Intelligence



Towards Predictive Era

Predictive Analysis in Aviation

Reactive, Proactive and Predictive

Reactive
Past

Proactive
Present

Predictive
Future

Responds to **past** events that have already happened.

Actively seeks the identification of **current** conditions.

Analyzes the system processes and environment to identify **future** problems.

Predictive Analytics in Aviation

Predictive Aircraft Maintenance

Sensors on aircraft components collect real-time performance data. Machine learning algorithms analyze this data to detect patterns indicating wear and tear or impending failures.

Flight Management and Air Traffic Management

Predictive models analyze factors like weather, air traffic, and operational data to forecast potential delays and disruptions. Optimizing fuel consumption and traffic flow.

Security Threat Detection

Systems analyze passenger data, behavior patterns, and other real-time inputs to flag unusual or suspicious activities. This includes monitoring airport surveillance systems, luggage scans, and access controls.

Passenger Demand Forecasting

Forecast passenger or cargo demand by analyzing historical booking data, macroeconomic trends, seasonality, and market competition to predict future demand and strategies.

Predictive Analytics in Aviation

Analysis and Prediction

Predictive Risk Management (Safety Management)

Predictive Maintenance (MRO)

Passenger Demand & Traffic Growth Prediction

Flight Delay & Disruption Prediction

Aviation and Flight Data Analysis

Risk Based Security and Facilitation

Optimization and Resource Allocation

ATM and ATFM Demand-Capacity Balancing

Network Optimization

Long-term Forecasting: Strategic and Tactical Planning

Airline Revenue Management

Dynamic Resource Allocation

Automation and Intelligence Augmentation

Drone and RPAS control (UAM)

Chat-bot for Customer Experience

Decision Support Tool for Flight Operation & ATC.

Validation of Potential Human Error

Training and Human Resource Management

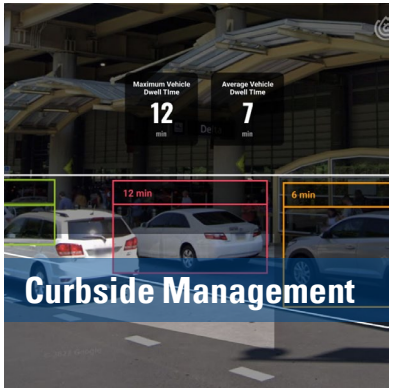
Data-Driven Decision Making

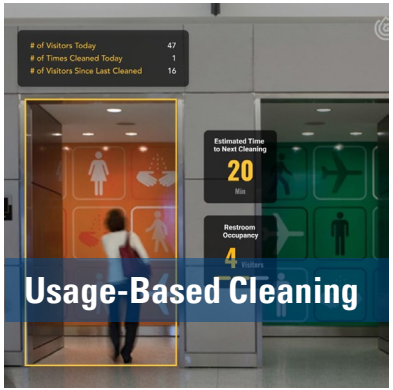
AI in Airport Operations

Passenger Flow Management

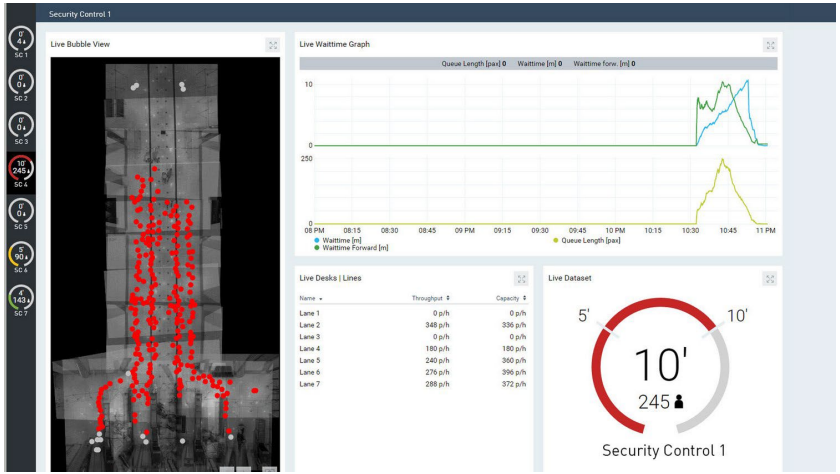
Real-time monitoring and predictive analytics to prevent congestion.

Case 1.
Airports Authority India – SITA
Manage congestions in curbside, parking, check-in, security, and boarding gates, to ensure smooth passenger flow.





Case 2.
YVR, JAX, DFW - Xovis AERO
Merging sensor data to track passenger flows to measure waiting time, queue, and congestion level.



Baggage Handling

AI + RFID powered tracking and rerouting of lost luggage

Case 1. Changi Airport (SIN)
Fully automated Terminal 2 Early Baggage Storage (EBS) system

Case 2. Denver Airport (DEN)
Denver International Airport upgraded its baggage handling capabilities with the introduction of the Checked Baggage Inspection System (CBIS) by TSA.

Case 3. Munich Airport (MUC)
Utilizing the original bag tag information, automatically suggests the most suitable alternative flight routing for these bags.

Case 4. North Kentucky Airport (CVG)
Experimenting with self-driving vehicles for luggage transportation between terminals and aircraft.

Security Checks

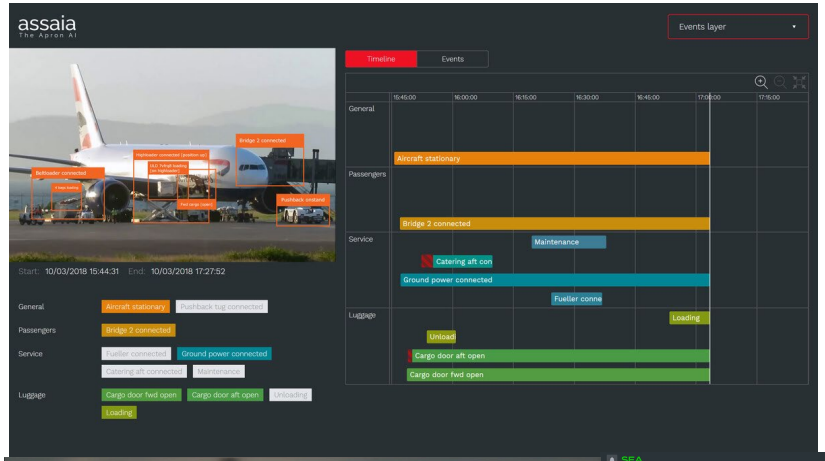
Computer vision technology + Predictive Analytics

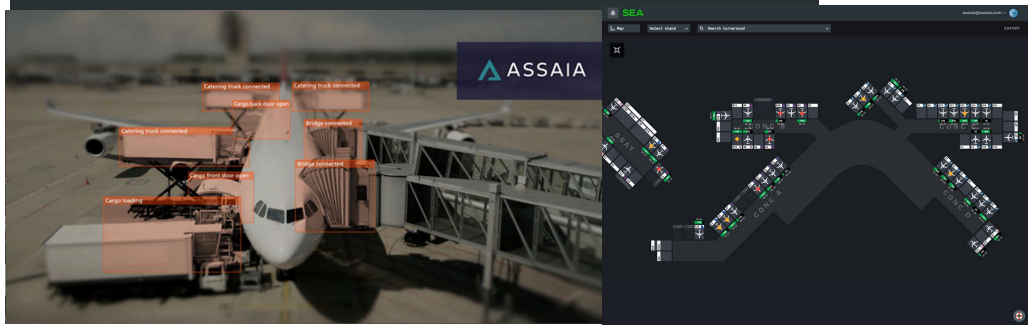
Case 1. Schiphol Airport (AMS)
Project DARTMOUTH is a persistent Computer Vision intelligence system designed to deliver enhanced security, operational efficiencies and a consistent passenger experience at security checkpoint.

Case 2. Incheon Airport (ICN)
Applied Computer Vision technology over X-ray Computed Tomography device to automatically detect prohibited items during the security check.

Airside Operation

AI powered turnaround operations





Case 1. Assaia – YYZ, SEA, JFK

Using camera placed in aircraft stands, aerobridges, and aprons, generate time-stamps of turnaround events by ML technologies.

In Toronto Pearson Airport (YYZ),

- Reduced taxi-time (8% increase)
- Reduced carbon emissions (120M kg of CO2)
- Increased capacity (gate, taxiway) utilization
- Improved on-time performance (7% reduction)

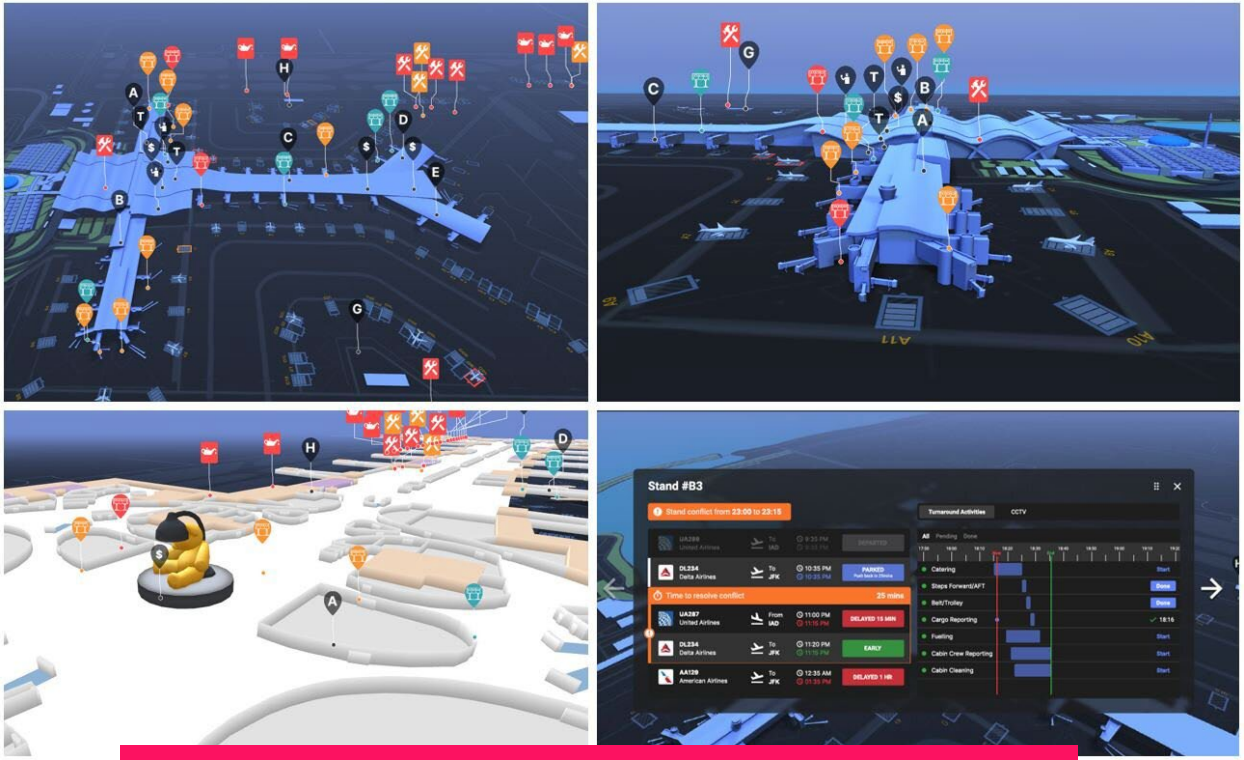
Terminal HVAC Operation

Energy consumption optimization in AI-driven HVAC system

Case 1. Brisbane Airport (BNE)
2% decrease in HVAC (heating, ventilation, and air conditioning) system energy usage, 17% reduction in building equipment run-time, and zero comfort-related customer complaints.

Case 2. Kansai Airport (KIX)
AI and sensor controlled energy-saving air conditioning system and air purification system at KIX's Terminal 2 Building in collaboration with Kobe University

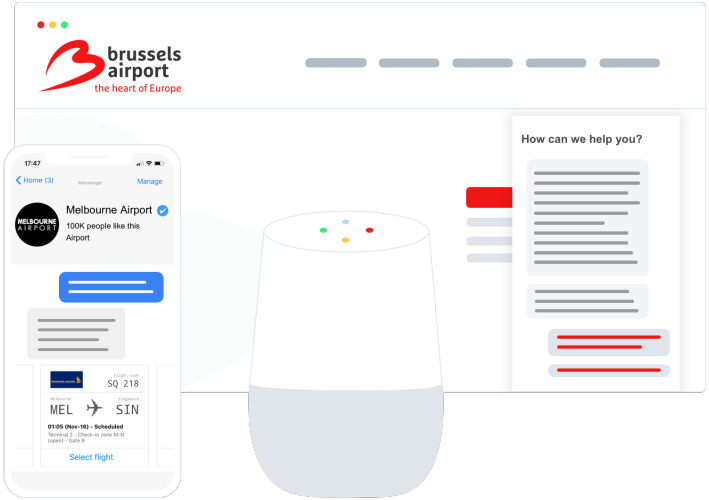
Digital Twin



Hamad International Airport (DOH) – SITA, Digital Twin platform

Enhancing Passenger Experience

Case 1. AI Assistance / Chatbot – Multiple airports



- **Personalized Travel Assistance:** AI travel assistants can tailor information and support to individual needs, offering a customized travel experience that enhances satisfaction. From booking flights to receiving recommendations on where to eat at the Airport, AI assistants are the ideal travel agents.
- **Real-time Information and Assistance:** With AI, passengers can receive instant updates on flight statuses, gate changes, and security wait times, enabling them to navigate the airport with ease.
- **Multilingual Support:** AI's ability to interact in multiple languages breaks down language barriers, ensuring all passengers receive the support they need.

Enhancing Passenger Experience

Case 2. Biometric Check-ins

Seamless travel using facial recognition technology. Collecting biometrics of passengers and using database to verify passengers passing checkpoints. Multiple airports going through pilot program (LAX, BCN, etc.)

Abu Dhabi Airport (AUH)
The Smart Travel Project at Zayed International Airport in Abu Dhabi will involve biometric sensors at every airport identification checkpoint by 2025.

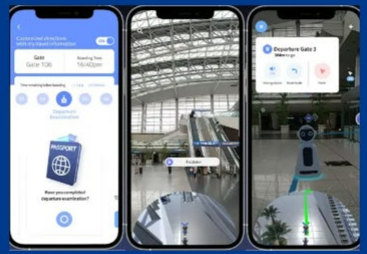
Enhancing Passenger Experience

Case 3. XR Metaverse Service

Best Innovation in Airport Passenger Related Processes

Incheon International Airport

Incheon Airport XR Metaverse Services, Connecting Virtuality and Reality



This project is a new and innovative metaverse-based service that allows passengers to enjoy Incheon Airport easily, smartly, and comfortably.

The Incheon Airport XR Metaverse consists of a 3D spatial metaverse environment providing an indoor wayfinding service of the actual passenger terminals (T1, T2 and Concourse), covering about 1.4 million square metres. It is based on 3D spatial data and augmented reality (AR) technology and offers a virtual experience of Incheon Airport using VR technology.

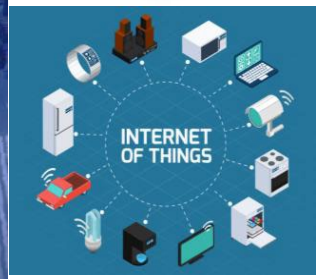
Furthermore, AR-based indoor wayfinding allows users to visit the digital version of the airport from home and get the necessary information by virtually experiencing various facilities and processes within the airport.

Incheon International Airport (ICN), XR Metaverse Service

Getting Ready for the AI Hype

Data, Data, and Data

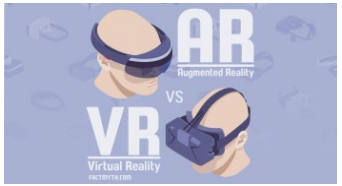
IoT



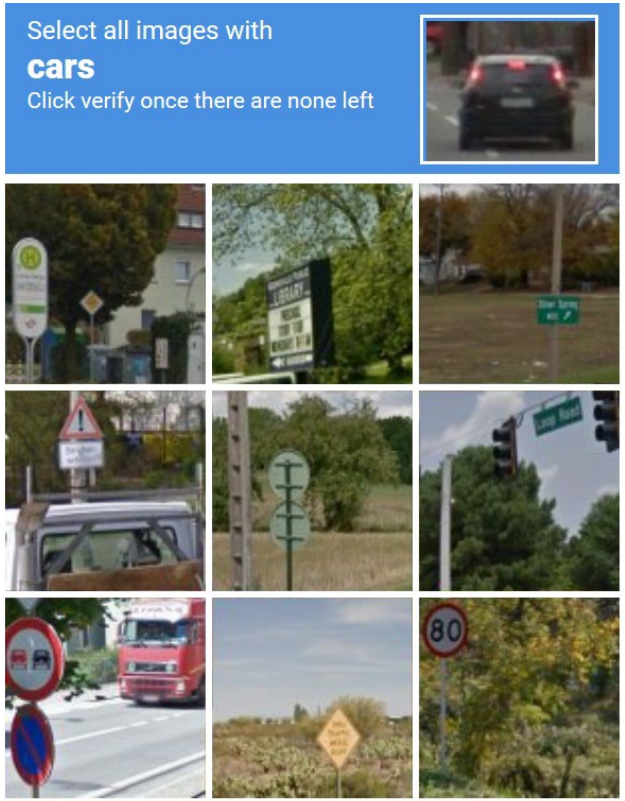
Big Data

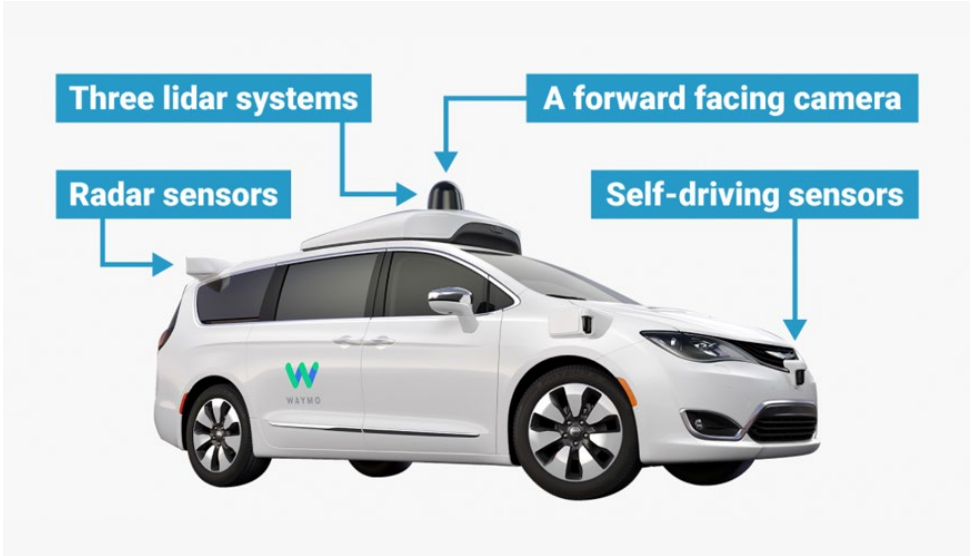
Artificial Intelligence

Human-Machine Interface

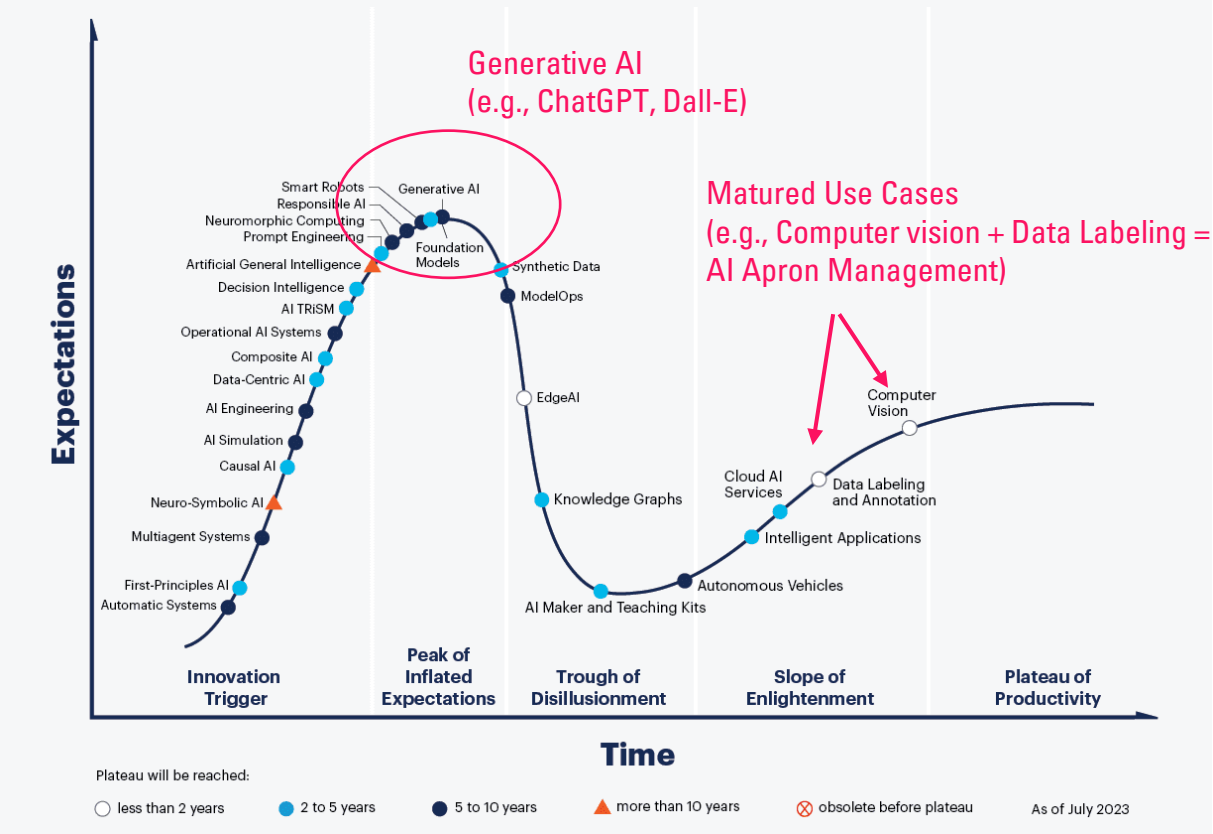


10 years ago, when self-driving cars were at the peak of hype…





Now AI at the Peak of Inflated Expectation



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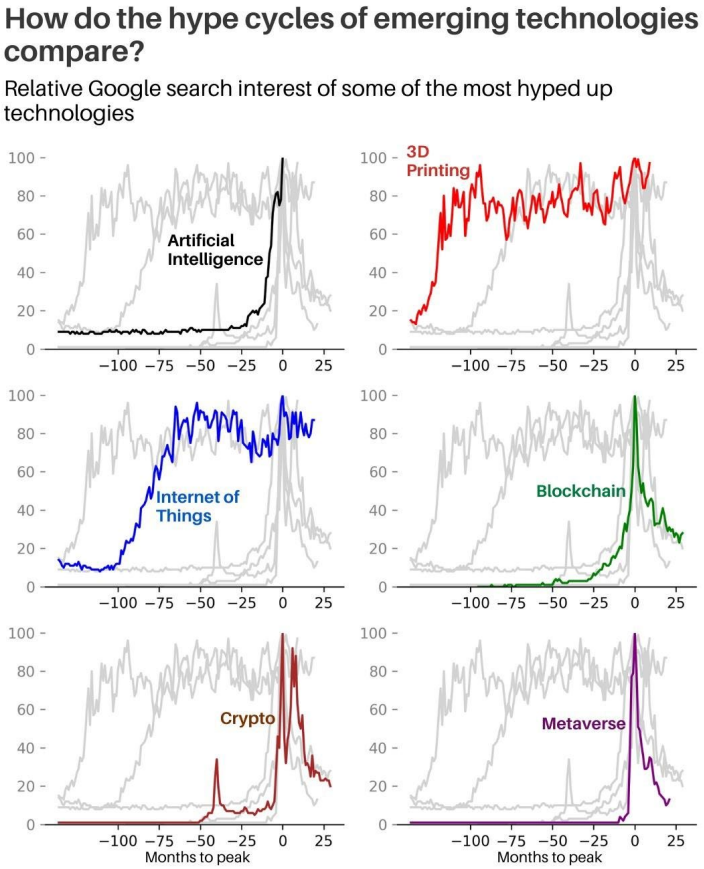

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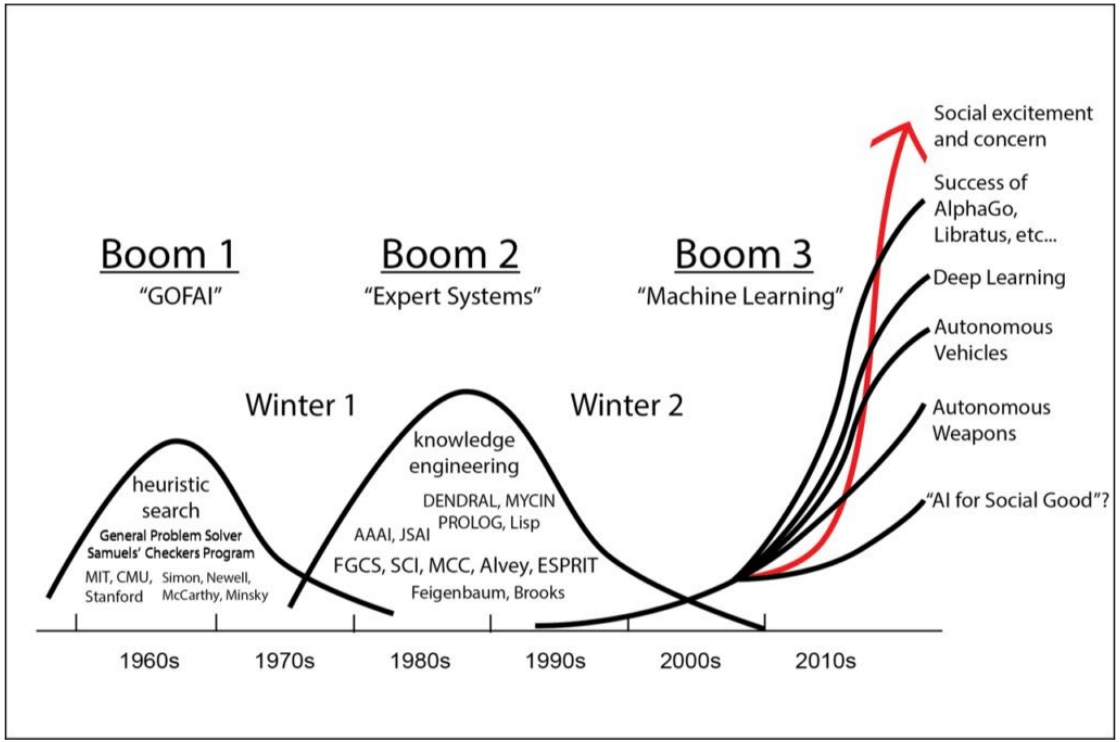

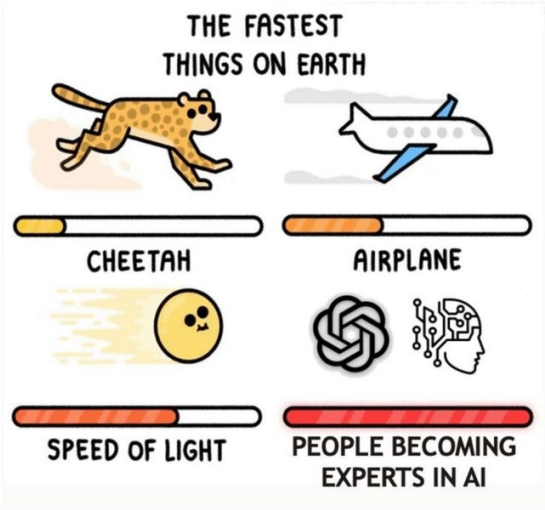

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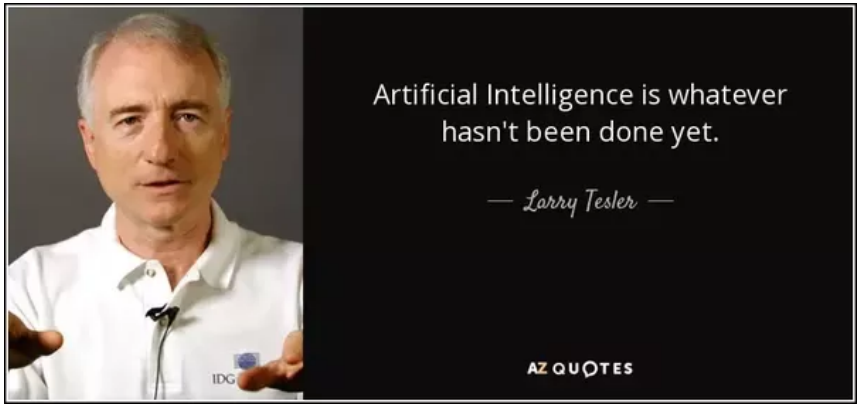

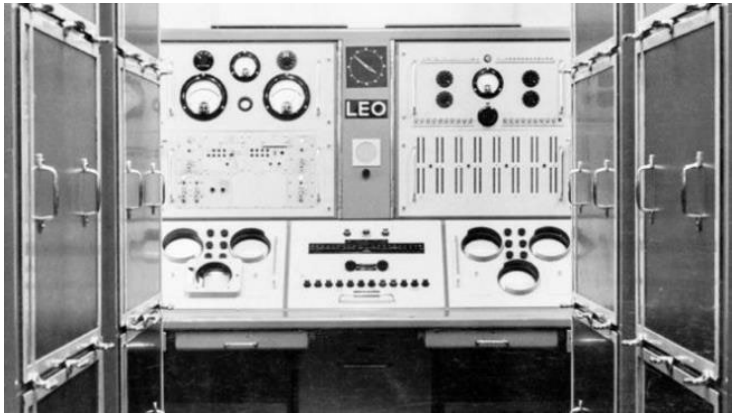

*"**Electronic brains**. Science fiction stuff?*
No. It's Britain's first computer exhibition at London's Olympia," 1960s

Conclusion

Conclusion: Innovative Mind

AI in Aviation – A Promising Tool That Requires Patience and Precision

Potential to transform the aviation industry by improving efficiency, safety, and passenger experiences.
From predictive maintenance and operational optimization to enhanced security and personalized services, AI offers a wealth of opportunities to address the challenges faced by modern airports.

AI is not a magic bullet. While the technology has made significant strides, many applications are still in the experimental stages.
As with any transformative technology, AI is currently navigating through the "hype" period, where expectations can sometimes outpace real-world capabilities. This often leads to overestimating short-term benefits while underestimating the time, research, and strategic effort needed to achieve long-term, sustainable impacts.

Conclusion: Innovative Mind

“A compass in the age of exploration”

- A revolutionary tool like the computer or the internet, transforms how we navigate complex landscapes. Just as the compass enabled explorers to venture into uncharted territories with greater precision and confidence, AI offers aviation stakeholders the ability to chart data-driven paths toward efficiency, safety, and innovation.

- However, much like the compass, AI is not the destination—it’s a tool. Its value lies not in its existence but in how well it is understood and utilized by its users. A compass in untrained hands can lead to confusion, and similarly, AI requires skilled guidance to ensure it points decision-makers in the right direction.

- AI is poised to reshape industries and societies, but its success depends on the knowledge, wisdom, and intent of those who wield it. By integrating AI thoughtfully into decision-making, the aviation industry can unlock its transformative potential while ensuring it remains a servant to strategy, not a master of it.

Conclusion: Innovative Mind

ACI AI Guidebook (Upcoming Release)

Embracing the AI Revolution

Best practices for airports to develop responsible AI governance guidebook

This guidebook was created as a result of increasing interest surrounding the topic from the aviation community. The World Information Technology Standing Committee (WAITSC) put together an AI task force to provide high-level guidance for all airports to implement responsible AI governance. It outlines key components of AI principles, data governance, workforce cultural adoption of AI usage, and considerations for risks, and it explores real-world airport AI use cases.

The guide's structure follows three key pillars—Defining AI, Approaching AI, and Using AI—to provide airports with an initial introduction to the topic from a high level, offering experience from airports focusing on setting up responsible AI for the benefit of their airport operations.