

# **Introduction to Aviation System and Air Transport Regulation (AAE2004)**

## **Lecture 01 – Aviation system**

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B.Eng. (hons) Scheme in Aviation Engineering (48403)

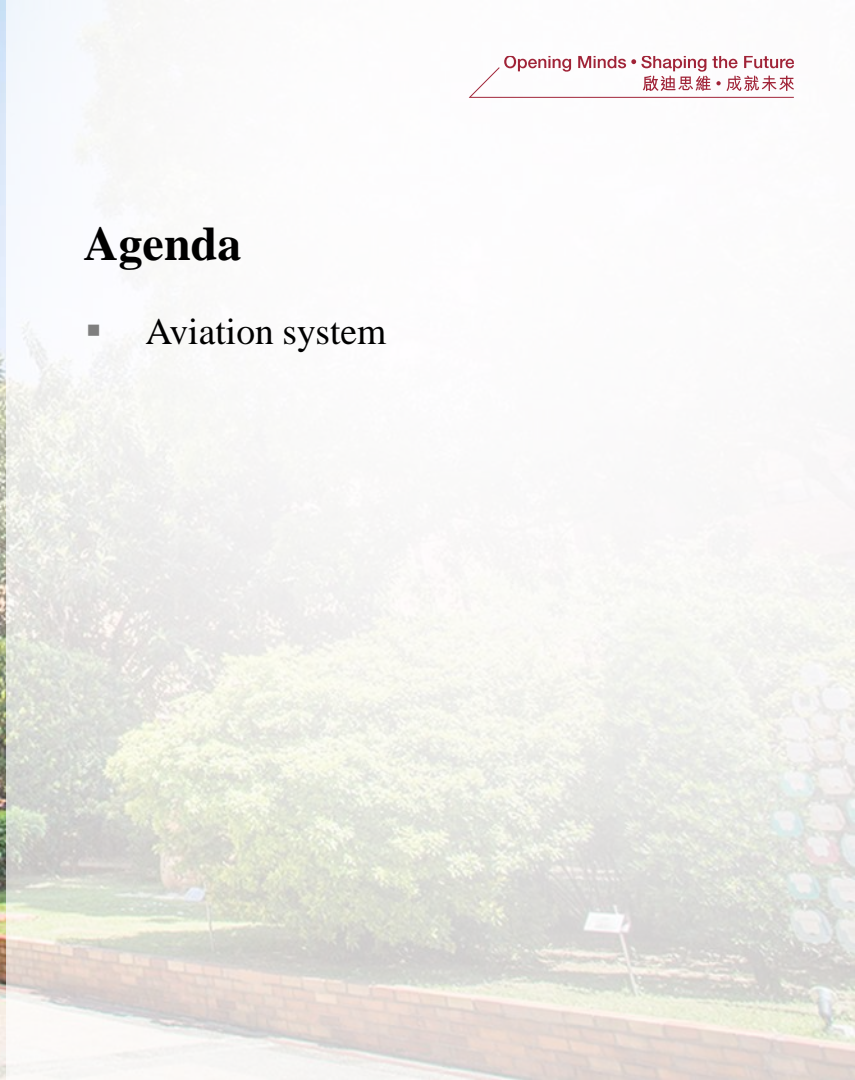
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## Agenda

- Aviation system





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# Aviation system

Opening Minds • Shaping the Future  
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- Trade is facilitated by transportation systems.
  - No nation is self-sufficient.
  - Each is involved at different levels in trade to sell what it produces and to acquire what it lacks.
- The modern day transportation industry:
  - Many modes of transportation: trucking, railroad, shipping, pipeline, by air, etc.
- Air transport has become an essential economic and social instrument throughout the world.
  - The fastest mode of connecting people and business, and delivering goods and services.





By definition, aviation is everything related to atmospheric flight. It includes the practical aspects of flying, the operation or simply the use and handling of aircraft, and also the design, development, production of air vehicles.

The aviation industry is all the business activities related to aviation:

1. Aviation and aerospace manufacturing (manufacturing of aviation and space related items for the civil, military and space related segments of the industry).
2. The airlines: major, national, regional and all cargo.
3. General Aviation: All flying except that done by the military and by the scheduled airlines.
4. Government aviation including the military and non-military segments. Non-military aviation in the government sector would include the operation of airports or the regulation of civil aviation.
5. Airports and infrastructures.

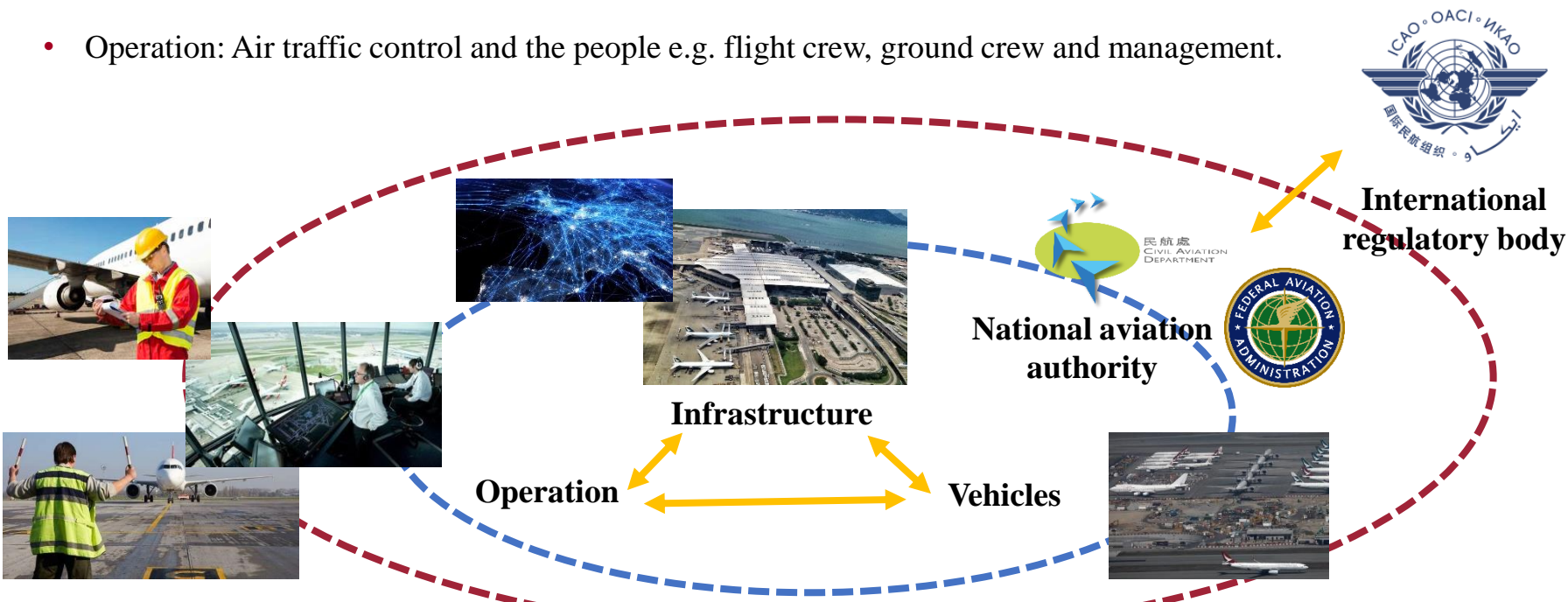
# The air transport system



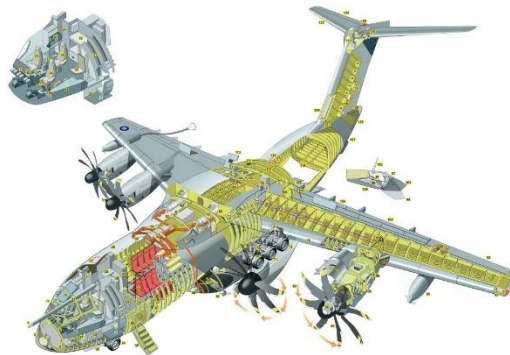
At a national level, the country's air transport system is governed and regulated by the national aviation authority.

The air transport system is made by three key elements:

- Infrastructure: Airports, flight routes and networks
- Vehicles: Airlines and aircraft
- Operation: Air traffic control and the people e.g. flight crew, ground crew and management.



- Aeronautical engineering is a subset of the aviation industry.
  - Normally, aerospace engineers are employed in the aviation and aerospace design, manufacturing and research segments of the industry.
  - Aerospace engineers learn more about the design, manufacture and in-service engineering support.
  - Aviation engineers focus more on aircraft operation and air traffic management.
- Air transport operation is about aircraft operation and the systems that are in place, in particularly in the civil transportation sector to guarantee safe operations.



- From the operations' perspective, there are two categories of air transports:

## Civil

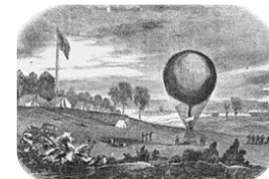
**Civil aviation** includes all non-military flying, both general aviation and scheduled air transport aircraft, and private and commercial.



## Military

**Military aviation** is the use of air vehicles for the purpose of conducting and enabling warfare.

- Military aircraft includes bombers, fighters, transports, trainers, and reconnaissance aircraft.
- Even simple balloons were used as military surveillance air vehicles, in as early as the 18<sup>th</sup> century.
- The variety allows for the completion of a wide variety of military objectives.





# Aircraft category and purpose

## Civil

### General aviation

- Business jets
- Trainers
- Homebuilt
- Aerobatic
- Gliders
- Firefighters
- Medical transports



### Transport

- Airliners
- Cargo aircraft
- Mail planes



### Other civil aviation aircraft

- Sea plane
- Special purpose aircraft
- Rotorcraft
- UAV



## Military

### Combat aircraft

- Fighter, Bomber
- Electronic warfare aircraft
- Maritime patrol aircraft
- Multirole combat aircraft

### Non-combat aircraft

- Military transport aircraft
- Reconnaissance, surveillance aircraft and UAV
- Experimental Aircraft



Electronic warfare aircraft



Multirole combat aircraft



Military transport aircraft



Experimental Aircraft



Civil aviation is one of two major categories of flying, representing all non-military aviation, both private and commercial.

Civil aviation aircraft are distinguished by two categories:

- **Non-scheduled general aviation:** including all non-scheduled civil flights, private or commercial.
- **Scheduled air transport:** including all passenger and cargo flights operating on regularly schedules and routes.
- Scheduled air transport is the larger operation in terms of passenger numbers, however, general aviation is larger in the number of flights.



# Scheduled air transport

- Including all passenger and cargo flights operating on regularly published schedules and routes.
  - Services and flights are open to use by the public for a service fee.
  - All airlines are in the scheduled air transport category.
- Aircraft operating in this category:
  - Less flexibility with respect to choice of airports, hours of operation, load factors and similar operational characteristics than non-scheduled category.
  - Scheduled air transports must operate flights even if partially loaded, e.g. low load factor.
- The common use of scheduled air transport includes:
  - Scheduled air cargo and freight carriers
  - Scheduled air passenger carriers
  - Transport of passengers by air over regular routes and on regular schedules
  - Renting of air-transport equipment with operator for the purpose of scheduled passenger transportation



- Non-scheduled air transport is also commonly referred to as general aviation (GA) includes:
  - Private and recreation air transportation
  - Ambulance Services
  - Non-scheduled Chartered Passenger and Freight Air Transportation
  - Scenic and Sightseeing Transportation, and Air taxi services



**Air ambulance** provides the fastest method of transporting critically ill patients from one facility to another, medical rescue services for people in urgent and dangerous situations, or to bring critically ill patients closer to loved ones in the quickest possible way.



**Air taxi services companies** provided short-haul, on-demand transportation. Air taxi are usually small airplanes or helicopters. Most air taxi service providers also utilised their fleets for sightseeing trips, or commutes between airports, chartered emergency medical transportation, and the delivery of workers and equipment to offshore oil well sites.

**Charter air transportations** are hired air transportations, similar to car rental. Most chartered air service are on ad-hoc basis, however, it is not uncommon for airline companies to hire chartered airplanes on short term basis.







To measure the transportation efficiency of an airline (or many other forms of transportation), here are a couple of widely adopted performance indicators.

- Distance travelled or length of journey
- Payload quantity: Number of passengers and weight of freight
- Passenger kilometre (PKM)
- Revenue passenger kilometre (RPK)
- Freight tons kilometre (FTK)
- Available seat kilometre (ASK)
- Passenger load factor (PLF)
- Yield



## PKM

- Passenger kilometre (PKM) is a measure of the volume of passengers carried by an airline. It is calculated as:

$$\text{PKM} = \text{TPC} \times \text{TDC}$$

Where,

TPC is total passengers carried (number of passengers)

TDC is the total distance travelled measured in kilometres



An airplane flies a distance of 4767 kilometres. There are 130 passengers in the flight. What is the PKM?

$$\text{TPC} = 130$$

$$\text{TDC} = 4767$$

$$\text{PKM} = 130 * 4767 = 619,710$$

In this example, the airline has 619,710 passenger kilometres.

An airplane flies a distance of 380 miles. There are 150 passengers in the flight. What is the PKM?

$$\text{TPC} = 150$$

$$\text{TDC} = 380 * 1.6093 = 612$$

$$\text{PKM} = 150 * 612 = 91,800$$

In this example, the airline has 91,800 passenger kilometres.



- For Airlines, revenue is generated by transporting passenger and cargo.

## Revenue passengers

(Passengers who paid for their flights)

- Passengers travelling on published fares
- Passengers using publicly available promotional offers
- Passenger flying on frequent flyer redemption tickets
- Passenger travelling on corporate discounts
- Passenger using preferential fares like government, seamen, military, youth, concessions etc.

## Non revenue passengers

(Passengers who did not pay for their flight)

- Passengers travelling free
- Passengers using fares or discounts only available to airline employees or their agents
- Passenger travelling on business for the airline
- Children who do not occupy seats

- A revenue passenger-kilometre is flown when a revenue passenger is carried one kilometre. It is a measure of sales volume of passenger traffic. The RPK of an airline is:

$$\text{RPKM} = \text{TRPC} \times \text{TDC}$$

It is the total number of kilometres travelled by all paying passengers.

Where,

- TRPC is total revenue passenger carried (number of revenue passengers)
- TDC is the total distance travelled measured in kilometres

An airplane flies a distance of 4767 kilometres. There are 130 passengers in the flight, where 4 were non-revenue passengers.

What is the RPK?

$$\text{TRPC} = 130 - 4 = 126$$

$$\text{TDC} = 4767$$

$$\text{RPK} = 126 * 4767 = 600,642$$

In this example, the airline has 600,642 revenue passenger kilometres

- Tonnes kilometre (TKM) is equivalent to PKM for freight. a measure of the volume of freight business carried by an airline. It is calculated as:

$$\text{TKM} = \text{TFC} \times \text{TDC}$$

Where,

TFC is total freight carried (number of tonnes)

TDC is the total distance travelled measured in kilometres

A freight carrier flies a distance of 4767 kilometres. There are 20 tonnes of cargo in the flight. What is the TKM?

$\text{TFC} = 20$

$\text{TDC} = 4767$

$\text{TKM} = 20 * 4767 = 95,340$

In this example, the carrier has 95,340 freight tonne-kilometres



- Available seat kilometres (ASK) is a measure of an airline flight's passenger carrying capacity or potential. It is equal to the number of seats available multiplied by the number of kilometres flown.

$$\text{ASK} = \text{TSA} \times \text{TDC}$$

Where,

TSA is total seats available

TDC is the total distance travelled measured in kilometres

- The passenger load factor (PLF) of an airline is a measure of how much of an airline's passenger carrying capacity is used. It is an important efficiency indicator of a flight, and of the airline. It is calculated as:

$$\text{PLF} = \text{PKM} / \text{ASK}$$

Where,

PKM is passenger kilometre

ASK is the available seat kilometres

Efficient and effective use and management of aircraft capacity is critical.



An airplane flies a distance of 4767 kilometres. The aircraft has 150 available seats and there are 130 passengers in the flight. What is the ASK and PLF?

$$\text{TSA} = 150$$

$$\text{TPC} = 130$$

$$\text{TDC} = 4767$$

$$\text{ASK} = 150 * 4767 = 715,050$$

$$\text{PKM} = 130 * 4767 = 619,710$$

$$\text{PLF} = 619,710 / 715,050 = 0.867$$

In this example, the airline has 715,050 available seat kilometres.  
For this particular flight, the passenger load factor was 0.867.

- Yield measures the average earnings made by an airline by transporting revenue passengers or cargo per kilometre flown, given in cents per kilometre.

Passenger yield is defined as:

$$\text{Passenger yield} = \text{PR} / \text{RPK}$$

Where,

PR is the passenger revenue

RPK is the revenue passenger kilometre

Cargo yield is defined as:

$$\text{Cargo yield} = \text{CR} / \text{TKM}$$

Where,

CR is the cargo revenue

TKM is the freight tonne kilometre





A passenger flight generated revenue of £36,400 with 126 revenue passenger onboard. The flight flew a distance of 2200 kilometres. Calculate the passenger yield.

$$PR = £36,400$$

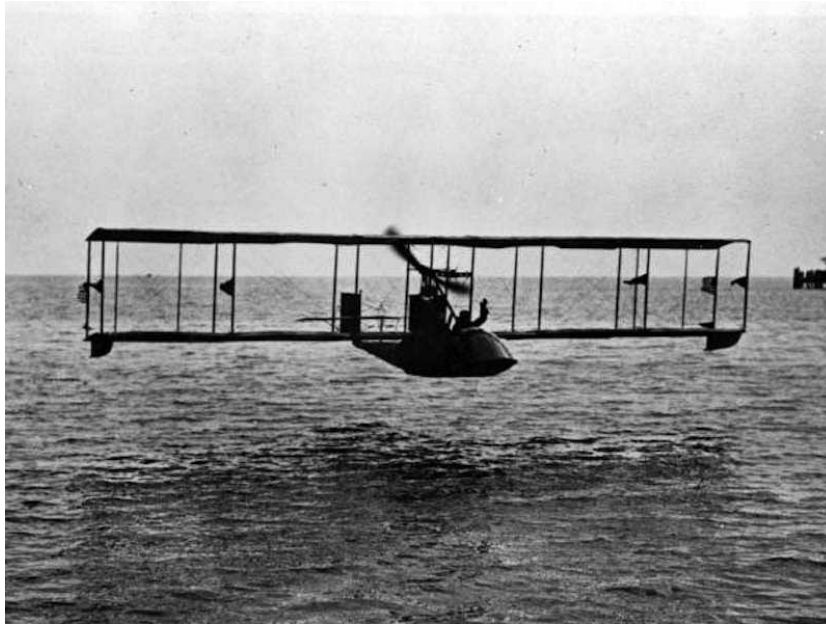
$$TRPC = 126$$

$$TDC = 2200$$

$$RPK = 126 * 2200 = 277,200$$

$$\text{Passenger yield} = £36,400 / 277,200 = £ 0.13$$

In this example, this flight earns the airline £ 0.13 per passenger per kilometre.



- The first commercial flight in history occurred in the U.S. on January 1<sup>st</sup> 1914.
- The passenger was Mr. Abram Pheil.

- After 100 years since the world's first commercial flight, the aviation industry has evolved into a truly safe, boundary-free way of travel around the world. The aviation industry is a truly global industry.
- The global air transport system connects the world physically through:
  - A network of aircraft routes
  - Aircraft that serve these routes
  - Airports
  - Air traffic control
- Air transport is the only rapid worldwide transportation network available today, whether it is for global business travel, tourism or for connecting people.





A major contributor to global economic prosperity both directly and as a catalyst.

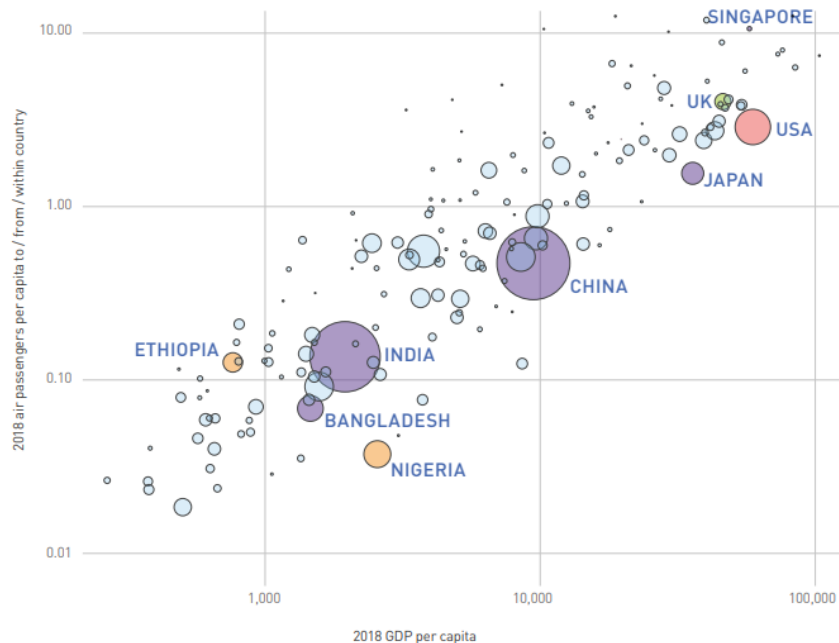
Before Covid-19 hit:

- Supported 87.7 million jobs worldwide
- Contributed \$3.5 trillion (4.1%) of global GDP

In 2019:

- Transported 4.5 billion passengers to 3,780 commercial airports all over the globe
- 46.8 million scheduled commercial flights worldwide
- 61 million tonnes of freight were carried by air

- The relationship between GDP per capita and trips (air travel) per capita.
- The GDP per capita measures the average economic output per person of a country.

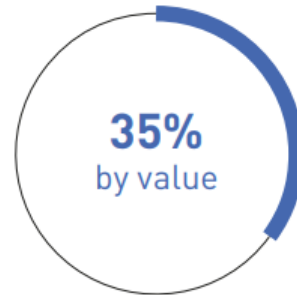
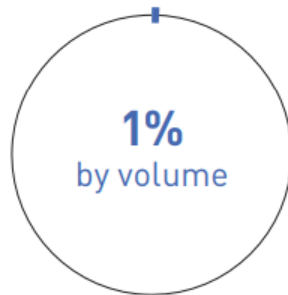




- In today's consumer society, the 'time-to-market' is a key competitive factor of most new product.
- Air transport plays a vital role in realising globalisation, making globalisation efficient, improving the 'time-to-market' to help companies stay competitive.

In 2019:

- 61 million tonnes of freight handled by air
- \$6.5 trillion by value of cargo handled by air
- This is around 1% by volume, but accounts for 35% of world trade by value.



# A major global employer



**87.7 million**

Jobs worldwide



**\$3.5 trillion**

Global economic impact

Aviation  
industry

**4.1%**

Global GDP



**1,478**

Commercial airlines

**3,780**

Airports with scheduled  
commercial flights

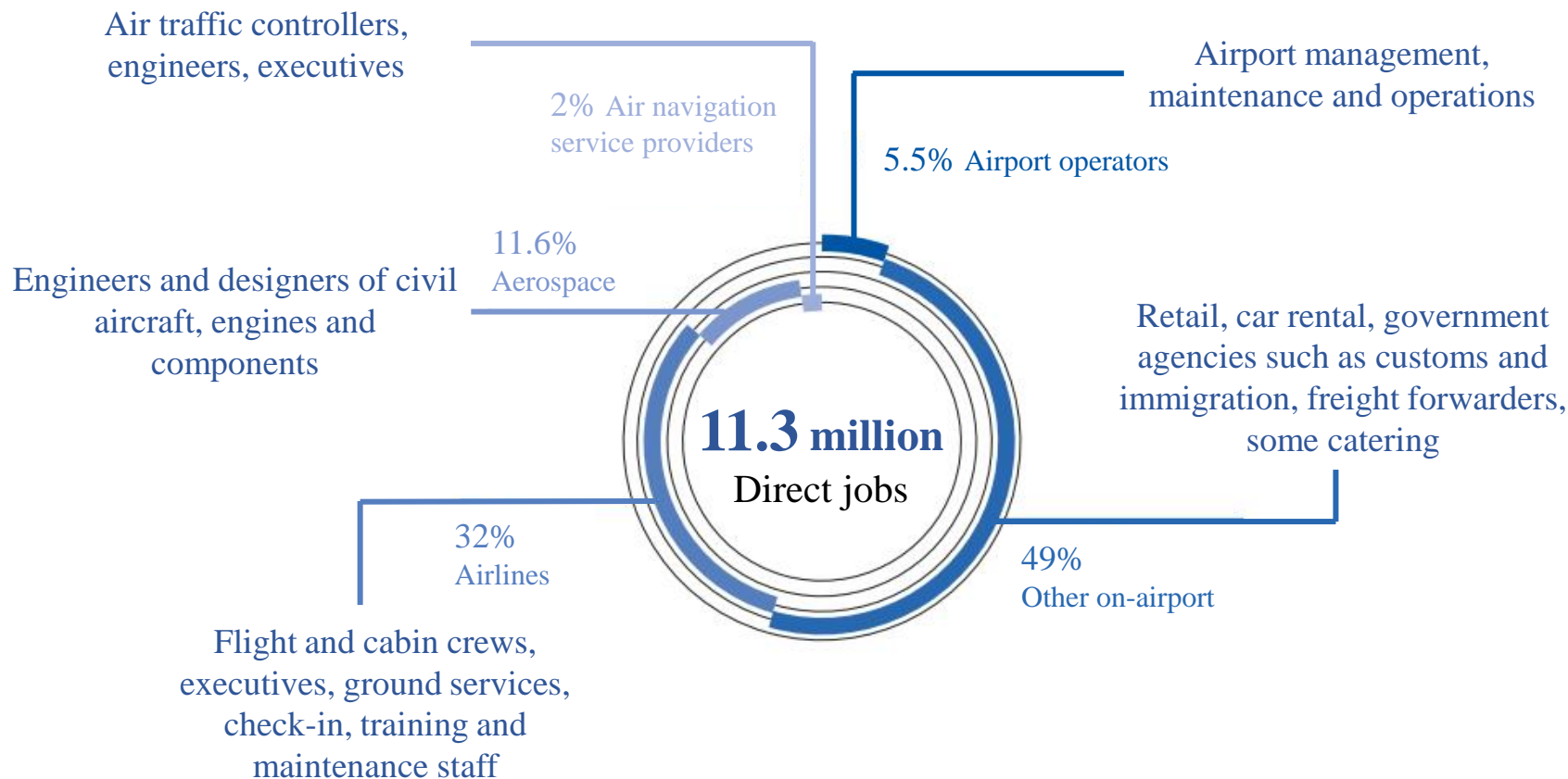
**162**

Air navigation service  
providers

**33,299**

Commercial aircraft in  
service

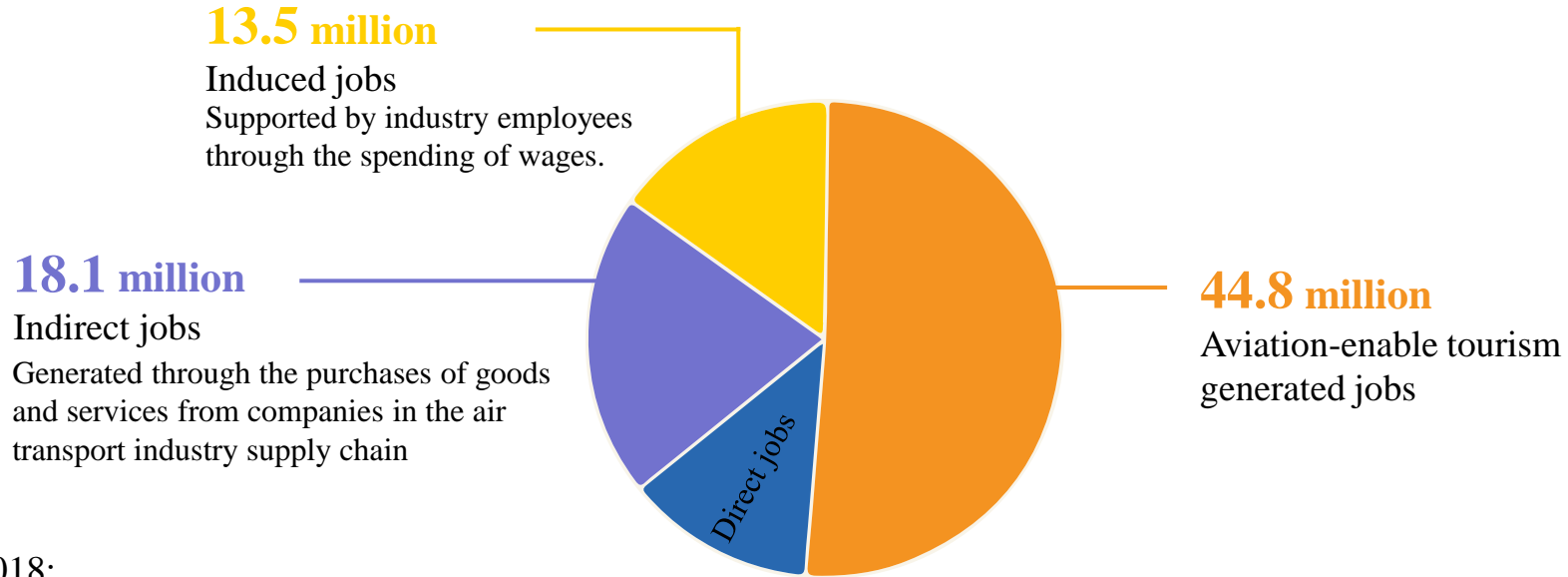
# A major global employer (cont'd)



# A major global employer (cont'd)

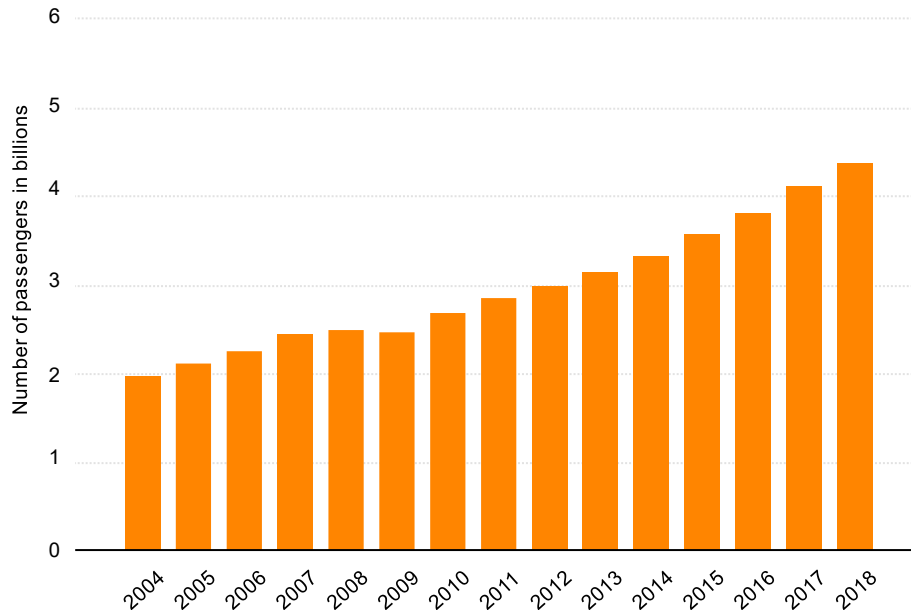


- The jobs benefited from the aviation industry goes far beyond the day-to-day operations of the industry itself.



In 2018:

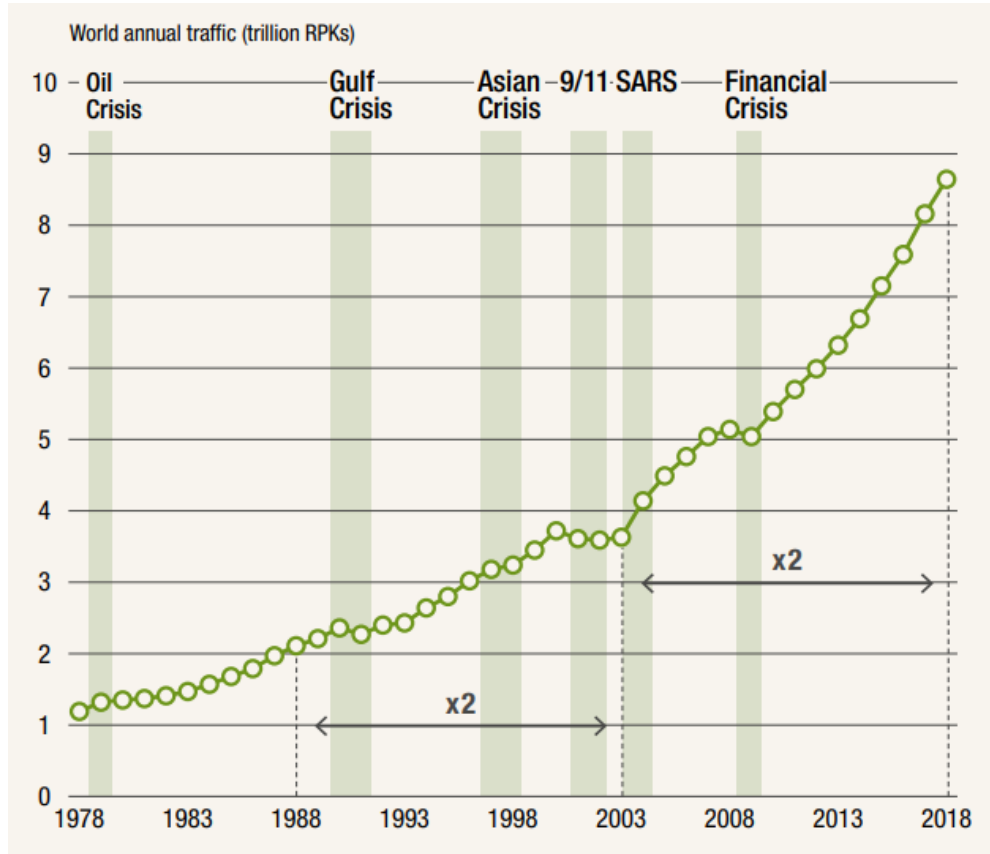
- Airports invested nearly \$51.5 billion in construction projects, creating jobs and building new infrastructure.
- The benefits to society of research and development spending by the aerospace industry are estimated to be much higher than in manufacturing as a whole.
- Every \$100 million of spending on research eventually generates additional GDP benefits of \$70 million, year after year



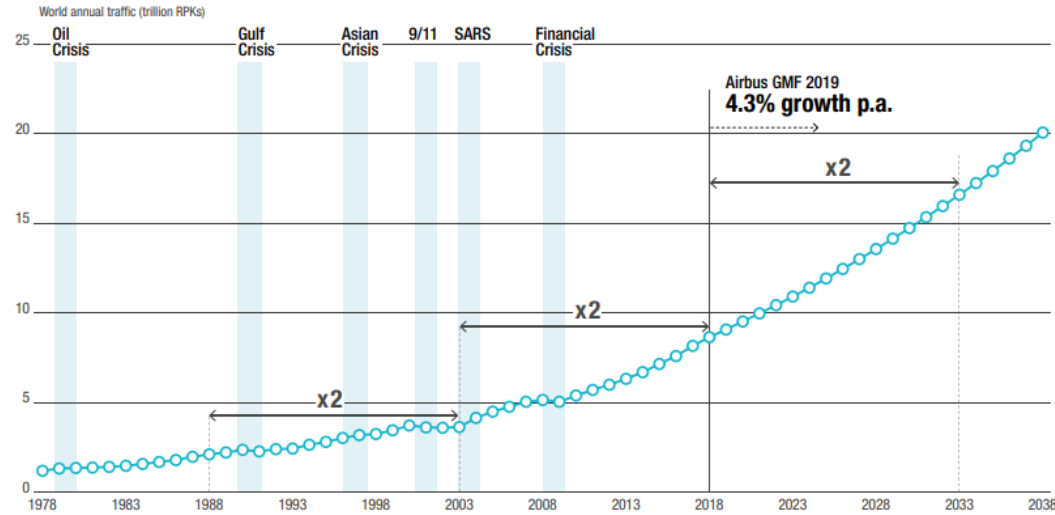
- In 2018, 4.3 billion people used air transport to help them realise their personal, business and tourism needs.
- A growth rate of 6.4% from the year before.



# Historical growth

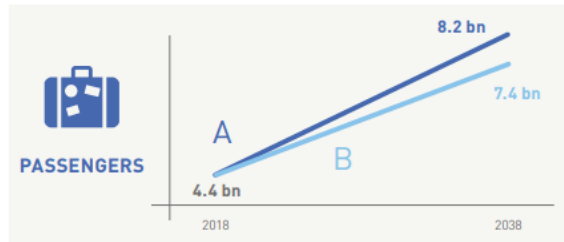
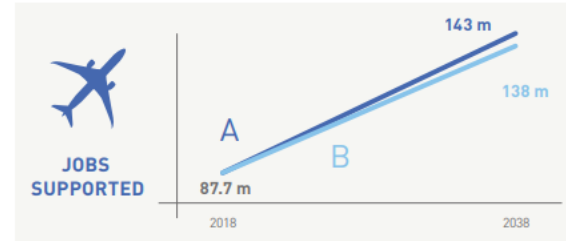
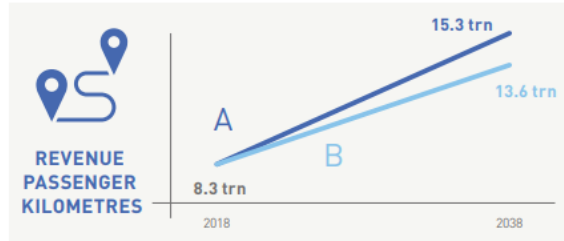


Traffic has proven to be resilient to external shocks and doubles every 15 years.



- 4.3% average traffic growth p.a. from 2019 to 2038.
- The number of passenger kilometres travelled is expected to double between 2019 and 2038.

- Despite near-term Covid-19 related challenges, analysis suggests that demand for air transport will increase by an annual average of 3% over the next 20 years.
- Two scenarios for consideration on how aviation connectivity (and associated support for economic and employment trends) will evolve in the next 20 years.



Growing support for connectivity, employment  
and economic activity, 2018–2038

## Scenario A : The central scenario

- An average annual growth rate in revenue passenger kilometres of 3% for the next 20 years

 **8.2**  
billion  
Passengers 2038

 **143**  
million  
Jobs supported  
2038

 **15.3**  
trillion  
Revenue passenger  
kilometres 2038

 **\$6.3**  
trillion  
Economic  
impact 2038


Enabling factors for this scenario to take place:

- Near-term economic optimism improves.
- Increased business investment supports long-term supply growth.
- Trade between nations continues to grow.
- Flight freedoms are not restricted and are even improved.
- Technological progress continues to reinforce the downward trend in air fares.

## Scenario B : The low growth scenario

- An average annual growth rate in revenue passenger kilometres of 2.7% for the next 20 years

 **7.4**  
billion  
Passengers 2038

 **138**  
million  
Jobs supported  
2038

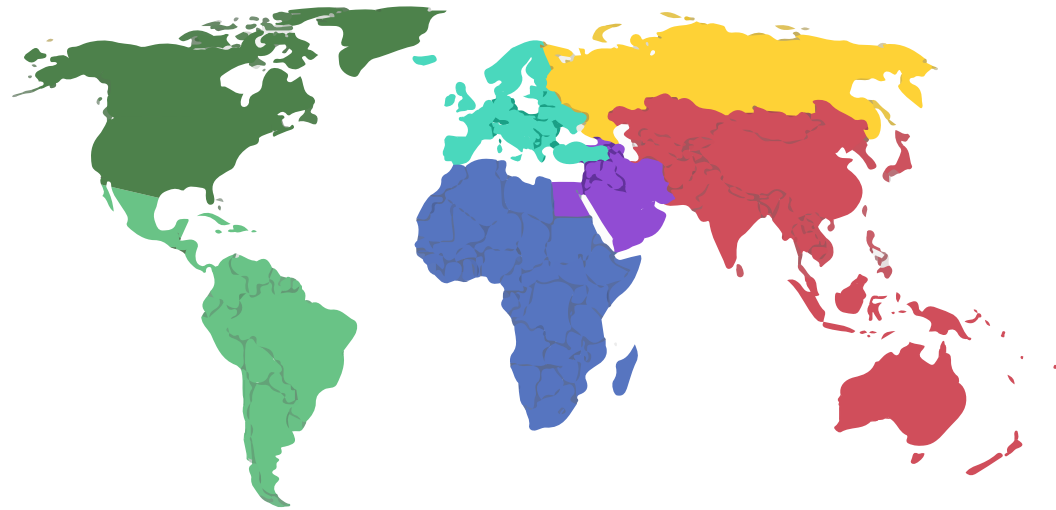
 **13.6**  
trillion  
Revenue passenger  
kilometres 2038

 **\$6**  
trillion  
Economic  
impact 2038

Enabling factors for this scenario to take place:

- Significant reluctance to travel or a shift in propensity to travel due to health-related concerns by passengers, or travel restrictions put in place for lengthy periods of time by governments.
- A significant shift in global trade policy and multilateral, regional and bilateral agreements, with retaliatory tariffs established in response.
- The UK's withdrawal from the European Union is without a free trade deal.
- A trade slowdown that undermines the global recovery.
- No further liberalisation in air markets and even more restrictive policies.
- A slowdown in migration due to a tightening of immigration policies.
- A limiting of the ability of monetary authorities to combat the downturn in demand by relaxing monetary policy.
- Debt accumulates to weigh on consumer spending and business investment.

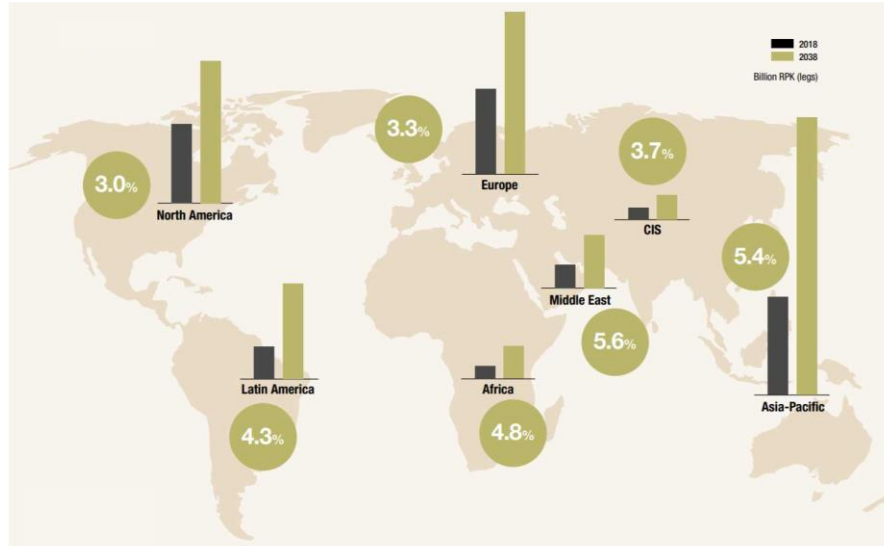




In Aviation, the world is divided into seven regions:

- Asia-Pacific
- North America
- Latin America
- Europe
- Communist Independent States (CIS)
- Middle East
- Africa

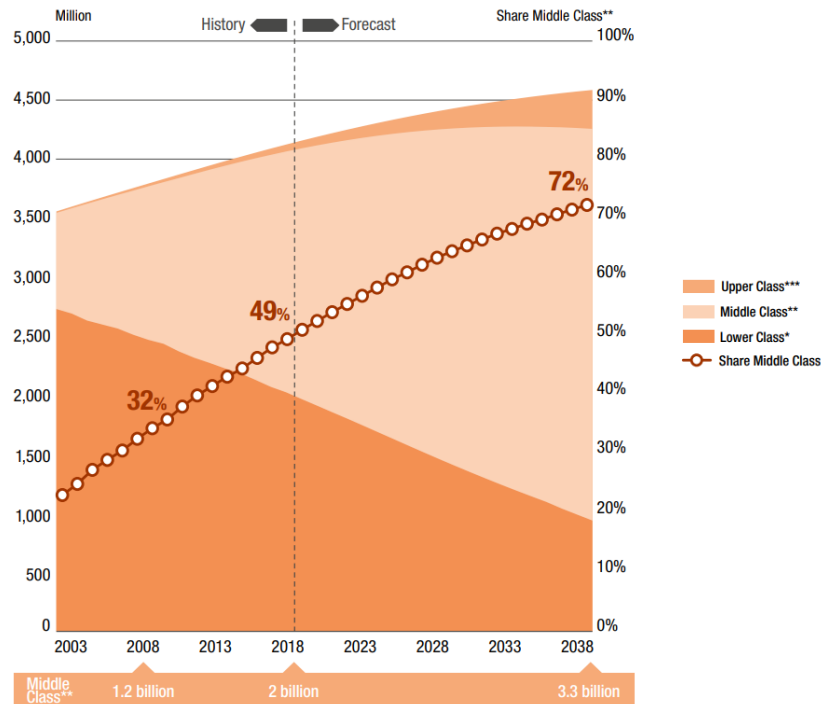
- Since 2012, Asia-Pacific region has become the largest air transport market in the world.
- The air transport market in Asia-Pacific region will continue to grow.
- Middle East and Africa are the other two emerging market regions that expect high growth.



Growth from and to the region per annum

In 2018:

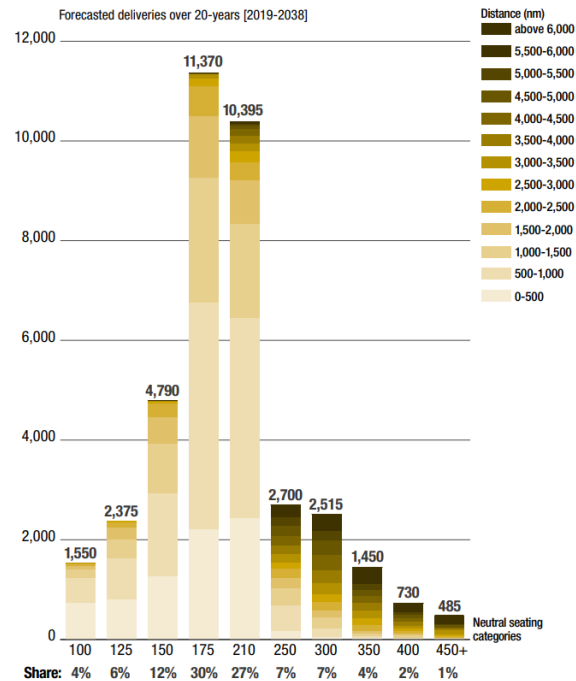
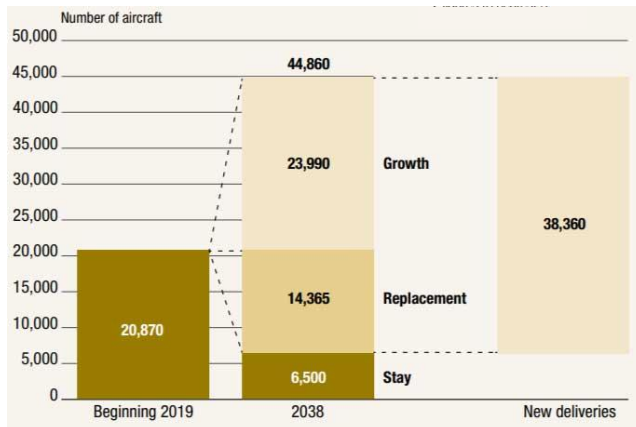
- Asia-Pacific region is the largest (and fastest growing) air transport market in the world with 1.7 billion passengers, followed by Europe (1.2 billion) and North America (1 billion).
- Over 30% of the industry is based in Asia-Pacific region.
- Around 40% of the world's cargo market is in Asia.
- Nearly 50% or 2 billion people could be considered middle-class.
  - Projected to grow still further to 72% or 3.3 billion people in 2038.



To meet the expected demand, the number of in-service aircraft will double.

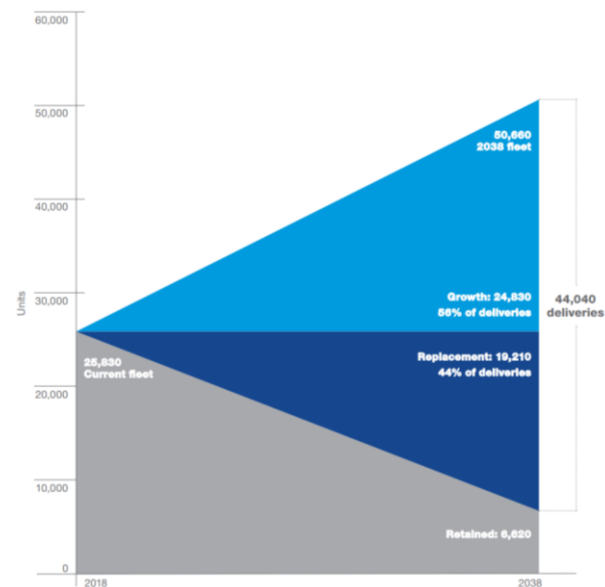
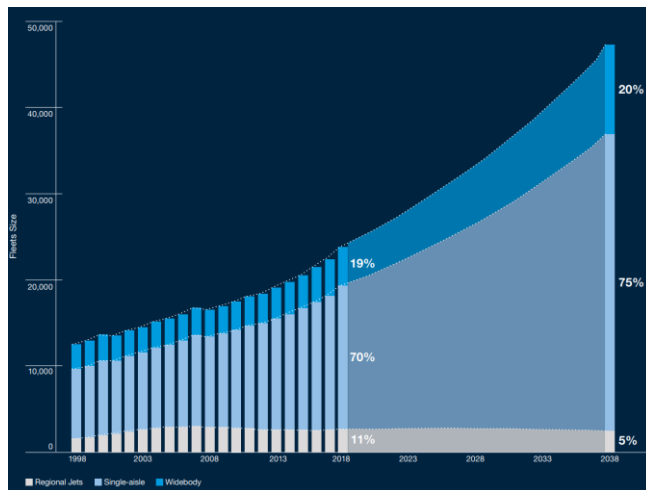
## Airbus prediction – next 20 years

- 38,360 commercial passenger jets will be delivered over the next 20 years.
- 175 seats aircraft & 210 seats aircraft comprise over 50% of new deliveries.



## Boeing predictions – next 20 years

- 44,040 airplanes will be delivered over the next 20 years.
- Single-aisle airplanes comprise nearly 75% (more than 35,000 passenger airplanes) of the global passenger jet fleet.
  - Single-aisle airplanes are fundamental to the business strategy of the rapidly growing low cost carriers and airlines due to their size and flexibility.



# Fleet forecast 2019-2038

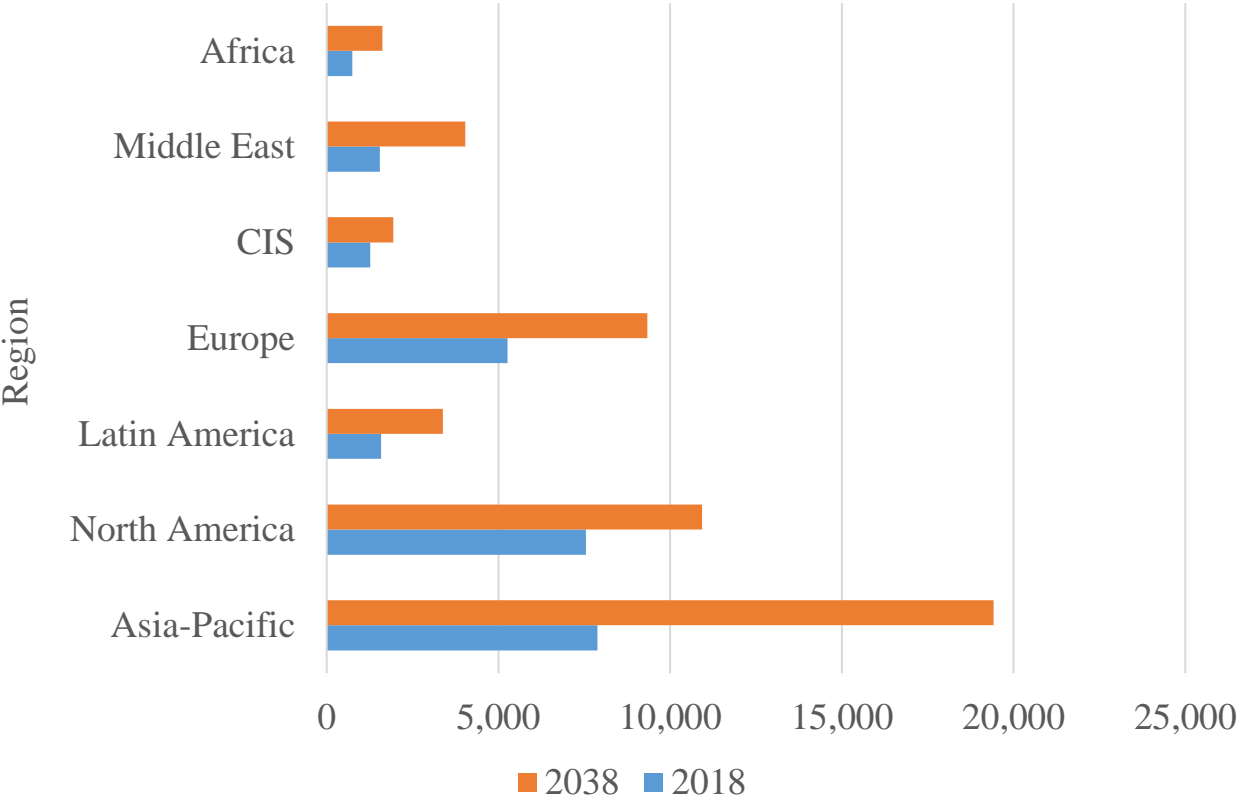


2018 Fleet	Asia-Pacific	North America	Latin America	Europe	CIS	Middle East	Africa	World
Regional jets	140	1,840	90	260	200	50	130	2,710
Single-aisle	5,680	4,130	1,240	3,740	770	670	400	16,630
Widebody	1,710	670	160	950	130	750	150	4,520
Freighter	350	910	90	310	170	80	60	1,970
<b>Total</b>	<b>7,880</b>	<b>7,550</b>	<b>1,580</b>	<b>5,260</b>	<b>1,270</b>	<b>1,550</b>	<b>740</b>	<b>25,830</b>

2038 Fleet	Asia-Pacific	North America	Latin America	Europe	CIS	Middle East	Africa	World
Regional jets	260	1,680	30	80	330	30	90	2500
Single-aisle	13,950	7,060	2,890	7,070	1,210	2,000	1,020	35200
Widebody	4,080	990	340	1,720	200	1,860	370	9560
Freighter	1,130	1,200	120	470	200	140	140	3400
<b>Total</b>	<b>19,420</b>	<b>10,930</b>	<b>3,380</b>	<b>9,340</b>	<b>1,940</b>	<b>4,030</b>	<b>1,620</b>	<b>50,660</b>



# Fleet forecast 2019-2038





- In 2019, 4.5 billion people travelled on scheduled air transport.
- The global air transport system provided a care-free and boundary-free way for these passengers to:
  - Head off on holiday
  - Travel for business
  - Fly home to see relatives and friends
  - A combination of the above

The most obvious social benefits that air transport brings to our society:

- Facilitate tourism and trade, which provide jobs, improve living standards, alleviate poverty and increase revenue from taxes.
- Facilitate the development of social and economic networks, and integration between people.
- Increase cross-border travel creates closer relationships development between countries. To experience and learn from other cultures.
- Offer a vital lifeline to communities. The high speed and rapid response of air transport allow delivery of urgently needed assistance wherever required .

- With the projected growth in air traffic (and to replace retiring professionals ), there is a need to recruit and train thousands of new staff.
- Airlines project a need for more staff, particularly in highly skilled roles such as engineers and designers of aircraft, pilots and maintenance technicians.

## Pilot employment

The overall number of aircraft will almost double over the period from 2018 to 2038. 645,000 new commercial airline pilots will be needed to fly the new aircraft over the next 20 years:

- Asia Pacific – 244,000
- North America – 131,000
- Latin America – 41,000
- Europe – 118,000
- CIS – 23,000
- Middle East – 64,000
- Africa – 24,000



## Technician employment

The airplane manufacturer has also projected a need for 632,000 technicians in the next 20 years to 2038:

- Asia Pacific – 249,000
- North America – 123,000
- Latin America – 39,000
- Europe – 111,000
- CIS – 23,000
- Middle East – 65,000
- Africa – 22,000





- Jobs in air transport are not confined to engineers and designers of aircraft, pilots and maintenance technicians , it cover a wide range of activities and skills. These include:
  - Air traffic control and airspace design planning
  - Logistics for airlines and airports
  - Complex information technology systems on board aircraft and in areas such as baggage handling systems design
  - Service industry support jobs such as chefs in catering companies
  - Creative positions in design and marketing
  - Customer services in airline ticketing, check-in, cabin crew and sales
  - Airfield workers
  - Air traffic controllers
  - Emergency response personnel at airports
  - Leadership, management and executive roles
- Safety is the upmost important aspect of aviation. Many roles in the air transport sector therefore require highly qualified professionals and a significant amount of training.
- With the growth in the aerospace sector, development of innovative and skilled workforce is required especially in emerging countries not normally been associated with aircraft manufacturing and where a culture for safety and responsibility is not as developed.

- Aviation's crucial tourism role: aviation plays a central role in supporting tourism.
- 58% of international tourists now travel by air.
- Tourism is particularly important in many developing countries, where it is a key part of economic development strategies.
- E.g. Air transport supported 7.7 million jobs and \$63 billion in African economic activity in 2018.
  - 2.2% of all employment and 2.7% of all GDP in Africa.
- In some island states, tourism can have an overwhelming influence on the national economy.





- Air services play an essential role in assistance to regions facing natural disasters, famine and war.
- They are particularly important in situations where access is a problem, delivering aid, search and rescue services and medical supplies.

For areas of the world with non-existent or poor road infrastructure, aviation is the community's lifeline:

- In the Russian, Canadian and Scandinavian far north, and in many other remote communities and small islands, access to the rest of the world is often only possible by air.
- In countries of such as Indonesia, spread across 6,000 inhabited islands, air transport is relied upon for speedy and reliable contact between communities, business links and healthcare.
- In the heart of Australia, the famous Royal Flying Doctor Service allows communities in the middle of this massive continent to receive regular medical attention.

*Thank  
You!*