AIR TRANSPORTATION SYSTEMS

III B. Tech V semester (Autonomous IARE R-16)

BY

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CO's	Course objectives
CO1	Apply knowledge and skills in the aviation industry and make more effective decisions for organization.
CO2	Provide insight into current trends and issues in civil aviation, such as aviation safety and security, law and new technology..
CO3	Understand complexity of air transport operation and to find best solution for the issues..
CO4	Understand many transport issues involved in handling passengers, freight of aircraft.

UNIT - I

AVIATION INDUSTRY

The Airport


The Airport
Even before boarding a plane, air transport can be frustrating and time consuming. The inconvenience of airport traffic, long lines, delays and low quality service has influenced many people to find alternative transportation.

Passenger Safety

Since the events of September 11, 2001 the need for airline security has become increasingly evident. A lack of air traffic controllers to supervise the skies and recent safety violations also threaten passenger safety. Some fear that the number of recent emergency landings and aircraft crashes represent an alarming trend.

Transport Concerns

In addition to unpleasant travel conditions, shortages of well-qualified pilots, aircraft engineers, and air traffic controllers contribute to challenges jeopardizing the future of air transport.

Unpleasant Travel

Challenges surrounding air transport include flight cancellations, delays, and boarding denials. Busy airports have become common sources of traveler chaos, discomfort, and misery.

"A la carte pricing"

To generate additional profit, more and more airlines have been engaging in "a la carte pricing," which is the process of charging passengers additional money for various "extras" that were previously included in the price of a ticket, such as for checked luggage, meals, pillow and blanket kits, and aisle or window seats.

Environmental Impact

Low fuel efficiency and the resulting carbon emissions contribute to a deteriorating environment. The Airbus's large A380 is an example of a luxury plane that adds comfort and spaciousness at the expense of adding extra weight which compromises fuel efficiency.

The Entertainment Factor

Passengers on planes will soon be able to use their cell phones during flights, and in-flight entertainment will give them the ability to choose from thousands of on demand offerings which will include everything from movies to television programs to interactive games.

Global Impact

In an economy that is increasingly dependent on global communication, flight continues to play a huge role in connecting people around the world. The effects of air transport on the global economy are far reaching. As major airlines struggle to compete with budget airlines, how does it effect global travel?

Plastic Only, Please

Experts were correct in predicting airlines would take a "Cashless cabin," approach. Many airlines now only accept payment via credit /debit card from passengers who want to purchase movies, meals, drinks, and other onboard items.

The New Look of Air Transport

The air transport industry seems to be on the brink of change. From passenger safety to poor fuel emissions it is evident that new technology and developments are needed. The chaotic, unpleasant experience of air travel continues to be a top priority for struggling airlines

The Future of Air Transport?

Experts expect new, state of the art airplanes to accommodate passengers more comfortably, better fuel efficiency, quieter engines and soundproof cabins to be common. It is anticipated that planes will begin using Global Positioning System satellite signal technology. What else is needed to ensure the future of air transport?

The Geography of Transport for Travel and Tourism

for Travel and Tourism

- Introduction
- Principles of Interaction
- The Elements of Transport
- Transports Costs and Pricing
- Modes, Routes and Networks
- Air Transport
- World Pattern of Air Routes
- Deregulation
- Surface Transport

Introduction

- History of tourism and transport intertwined
- Access – vital link
- Important economic sector
- Often tourist transport is shared
- But a means to an end?

Principles of Interaction

- Complementary
- Intervening opportunities
- Friction of distance (transferability)

The Elements of Transport

- The way
- The terminal
- The carrying unit
- Motive power

Transport Costs and Pricing

- Social/environmental costs
- Private costs
  - Fixed – high
  - Variable – low
- Load factor
- Marginal cost principle
- Differential pricing

Modes, Routes and Networks

- Modes – each distinctive
- Routes – physical and economic conditions
- Networks – links and nodes

Air Transport

- Influential in international and domestic tourism
- Advantages – speed, capacity, direct line
- Disadvantages – terminals, price, fuel

Deregulation

- Most countries deregulating their air transport systems – why regulate?
- Government involved due to tax, environment, planning, consumer protection
- Regulate via fares, route licenses
- Regulation distorts prices, markets and favours existing operators
- Both extremes are bad – monopoly or free competition

Surface Transport

- Road
  - Flexibility
  - Recreational tool; recreational vehicles (RVs)
- Rail
  - Energy efficient
  - Tourism products
- Sea
  - Ferries
  - Cruising

- Aerospace industry, assemblage of manufacturing concerns that deal with vehicular flight within and beyond Earth's atmosphere.
- The term *aerospace* is derived from the word's *aeronautics* and *spaceflight*.

Top 20 air freight carriers

Carrier	Tons (000s)	Carrier	Tons (000s)
1. FedEx	2,796	11. Singapore	467
2. UPS	997	12. Delta	459
3. Lufthansa	794	13. Emery Worldwide	454
4. Japan Air Lines	710	14. British Airways	442
5. Korean	649	15. Burlington Air	430
6. American	604	16. Airborne	397
7. Air France	571	17. Cathay Pacific	395
8. United	536	18. All Nippon	390
9. Northwest	495	19. Air Canada	344
10. KLM	478	20. DHL	301

Environmental Impact

Low fuel efficiency and the resulting carbon emissions contribute to a deteriorating environment. The Airbus's large A380 is an example of a luxury plane that adds comfort and spaciousness at the expense of adding extra weight which compromises fuel efficiency.

Aviation Regulation

- Represents the airlines. Its members are only carriers
- Used to fix prices up until US deregulation
- No longer involved in price management

International Civil Aeronautics Organization (ICAO)

- UN agency, deals with civil aviation issues
- Agency that brings government representatives together to organize a common set of regulation
- Mostly include technical standards, safety standards, and to a lesser degree business standards

Bilateral

- Every scheduled flight (passenger and cargo) that moves between two countries needs to be agreed upon in advance in a treaty between the two countries
- A treaty between two countries, not between any airlines
- A bilateral is a very long and detailed agreement on what rights each country gives each other in regard to airline service

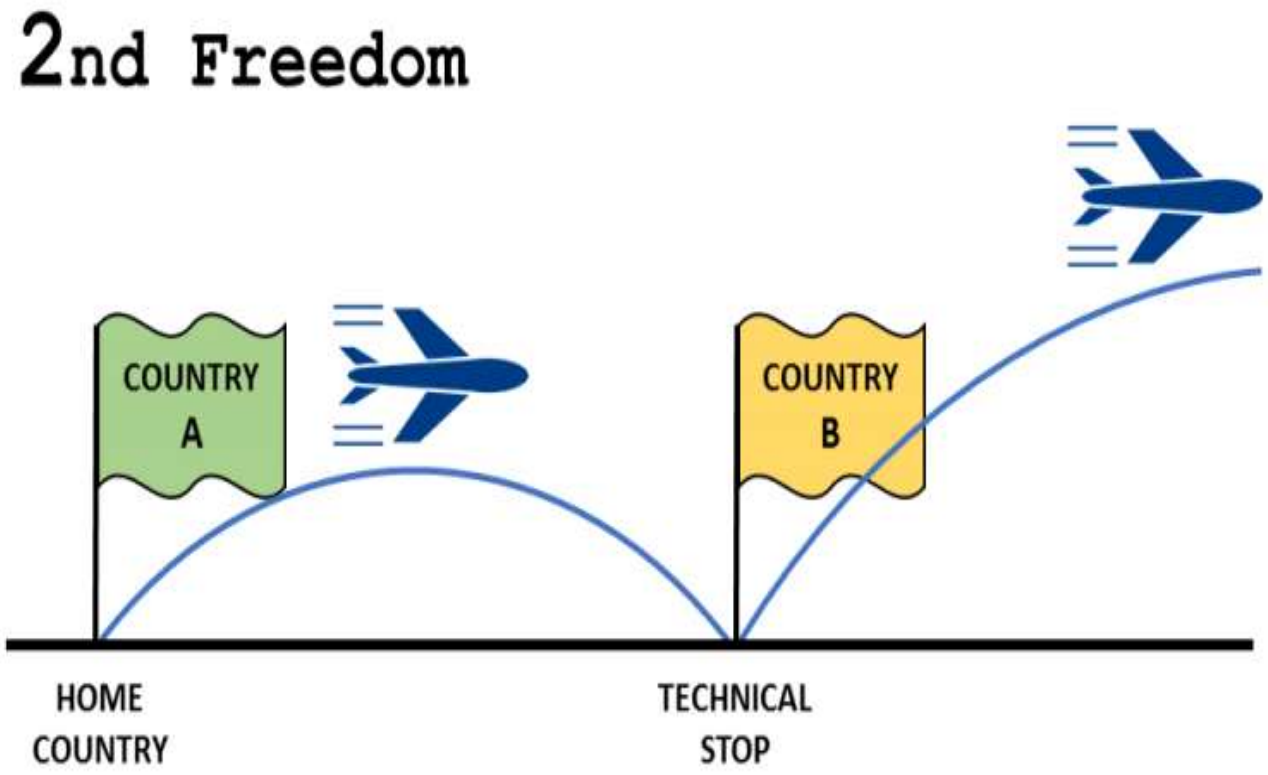
Airline Industry

- The airline industry can be separated into four categories
- International : 130+ seat planes that can take passengers just about anywhere in the world. Companies in this category typically have annual revenue of $1 billion or more
- National - Usually these airlines seat 100-150 people and have revenues between $100 million and $1 billion
- Regional - Companies with revenues less than $100 million that focus on short-haul flights
- Cargo - These are airlines generally transport goods.

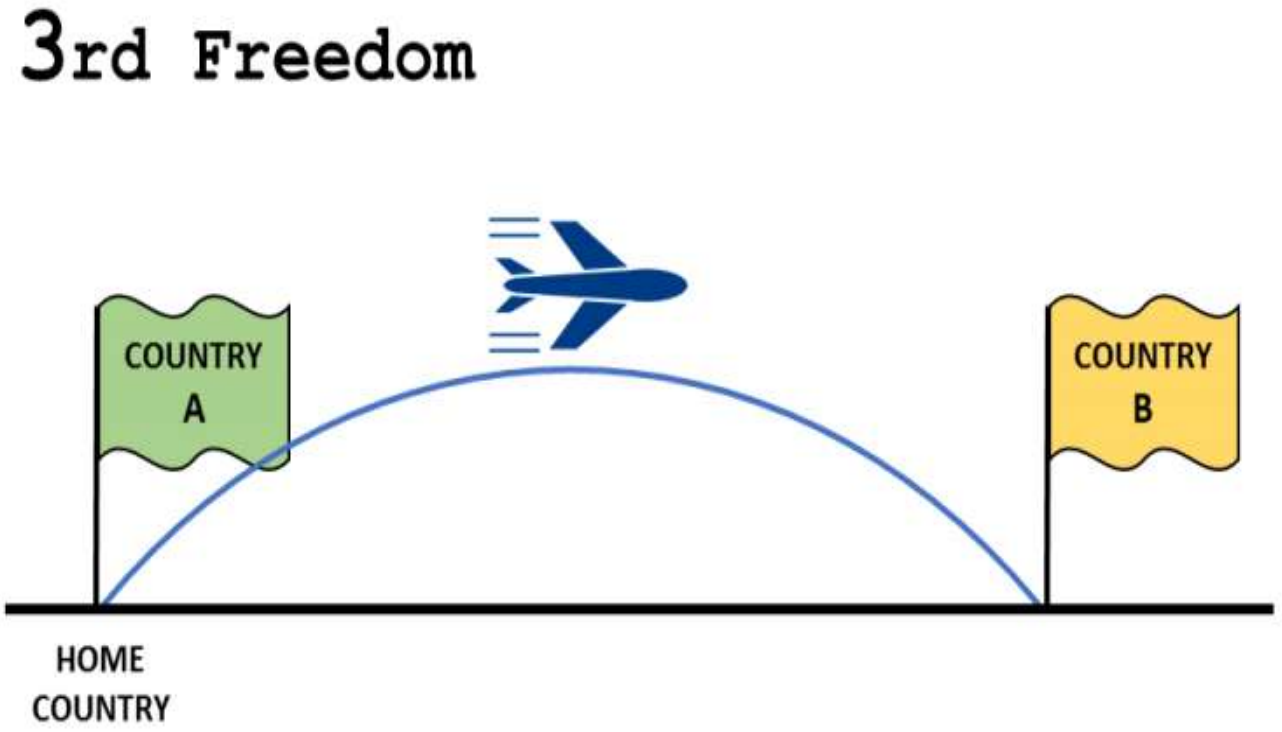
Freedoms of the air

- First freedom, over flight
- Second freedom, service stops
- Third freedom, passenger deliver
- Fourth freedom, repatriation
- Fifth freedom, on carriage

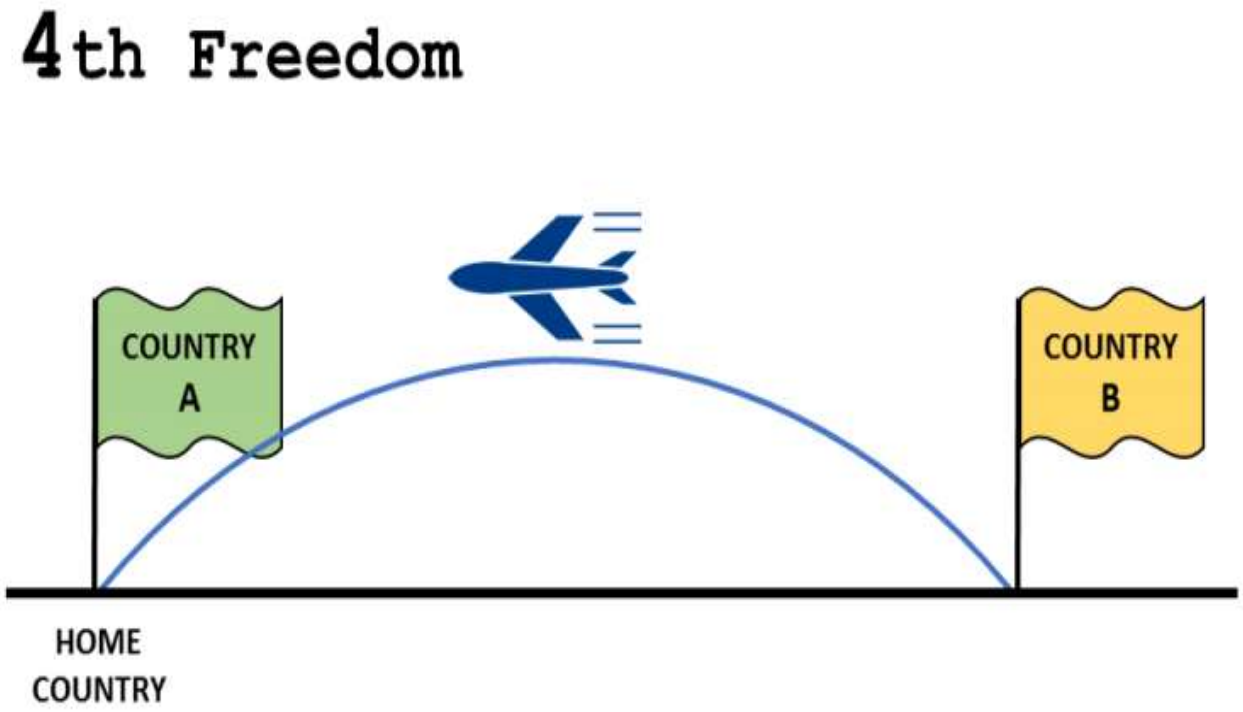
Second freedom, service stops



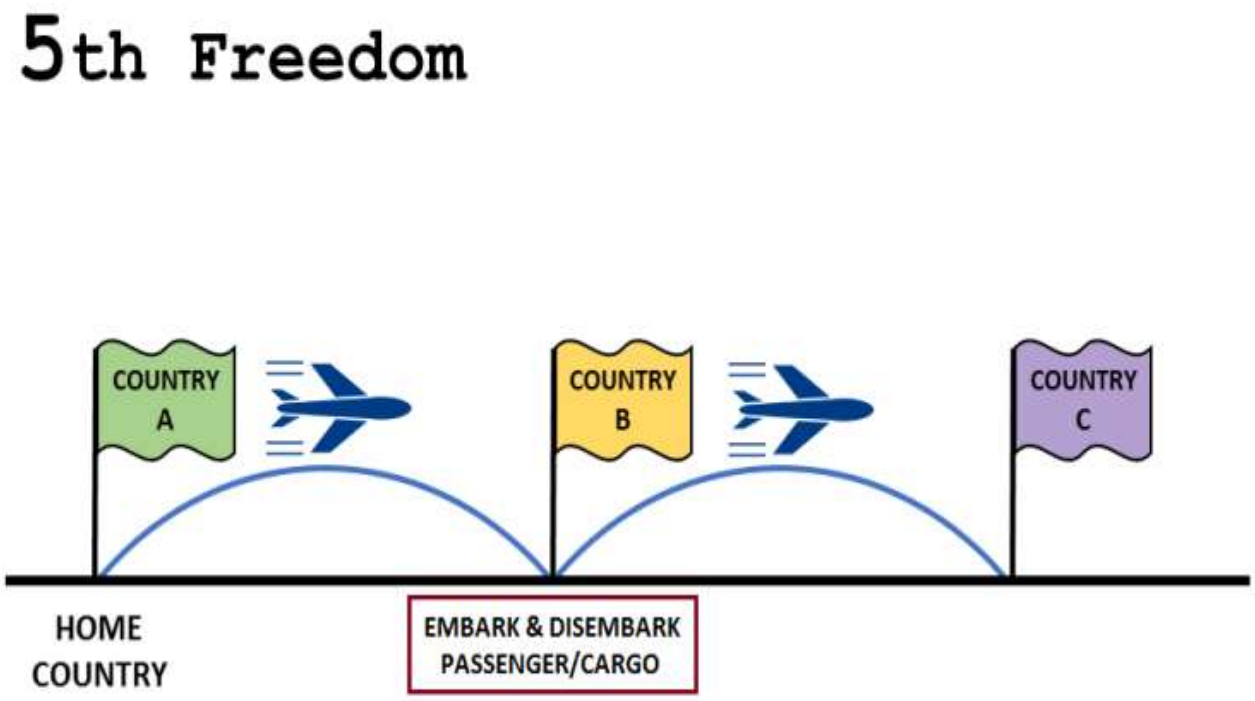
Third freedom, passenger deliver



Fourth freedom, repatriation (the return of someone to their own country)



Fifth freedom, on carriage (These are usually inland freight charges for delivery)



Unit -II

REGULATORY ENVIRONMENT AND OPERATIONAL ENVIRONMENT

The Earth as a habitat

- The planet Earth is a sphere roughly 13 000 km in diameter and surrounded by a relatively thin gaseous layer, the atmosphere.
- The latter is comprised largely of nitrogen and oxygen (four-fifths and one-fifth respectively)
- It has been appreciated, increasingly, that the atmosphere has a close relationship with how flora and fauna develop and thus affects, through climate and physical contexts, the habitats in which we live

- Staying with facts about the Earth, it orbits the Sun, completing one orbit
- This cycle affects many aspects of life and people’s habits, and this in turn affects the demand for travel
- Because the Earth's axis of rotation is inclined (at 23.58) to the plane of the orbit, regions of the planet’s surface receive solar radiation at different rates throughout the year.
- The year is defined into four phases, or seasons – spring, summer, autumn and winter

- the Earth rotates on its axis 365.25 times in a year, making 365 days (each arbitrarily subdivided into 24 hours) per calendar year, with 366 days every fourth (leap) year
- To define position on the Earth's surface, geographers use an angle-based grid system
- A meridian is a line that extends between the two locations around which rotation takes place, which are the planet's natural poles (the North Pole and the South Pole)

The Earth: physical issues affecting demand

- Surface :The planet's surface is the crust, and it is that part of the Earth on which all human activity takes place
- The surface is divided into regions(tectonic Plates)that move, infinitesimally slowly, across the Earth's surface, carried by the flow patterns in the magma beneath the crust
- Where plates meet, the surface is ruptured and pushed upwards, creating mountains, and where they subdivide, which is usually in oceans, there are rifts, upon which volcanoes will form.
- There can also be volcanoes over regions where two plates meet, especially if one subducts beneath the other

- These geological features define the shapes of continents and affect the fertility of land, and often accessibility, and thus govern how population is distributed over the Earth's landmasses
- Intrinsically all the land that is populated is in the form of islands, either large or small
- Between the landmasses there is water. The level of the water varies diurnally, owing to gravitational effects creating tides, and can be referred to as the mean sea level (MSL).
- The accurate measurement of terrain height has resulted in maps that express height above mean sea level (AMSL)worldwide.

- Knowledge of the relative height of terrain is especially important in aviation, either with regard to being significant to operations around airports or because in some parts of the world
- The landmass rises high enough to represent a significant en route hazard to aviation

Core

- The Earth comprises layers of material, the properties of which are manifold, but which have only an occasional impact on aviation
- Examples are volcanic ash, which can be a hazard to aviation because of its abrasive and suffocating nature, and earthquakes, which are hardly welcome anywhere
- The central part of the Earth comprises molten rock that has a high proportion of iron in its content, which is responsible

- The field emerged through ‘magnetic poles’ that are roughly coincident with the natural poles, and thus a magnetically sensitive needle will align itself to the direction of the magnetic poles
- Across most of the Earth’s surface it will be at a small angular displacement from the ‘true’ pole; this is a predictable error, called magnetic variation
- This kind of field detector

Magnetic compass

- Nautical navigators used the magnetic compass to guide the direction of travel between times when they could observe the sun or stars
- Aircraft navigation initially inherited this discipline and the legacy where the magnetic compass, simple as it is, is still installed

HSI

- In recent decades very accurate measurement of terrain elevation has been achieved with satellite-based ‘geodetic’ measuring techniques
- Nowadays the most accurate, and globally reconcilable, position references on the Earth are those expressed as World Geodetic System (WGS) coordinates
- The main reference used isWGS84

CONTINENTS

- These are the largest landmasses and have been the cradles for distinct cultural divisions in humanity.
- Over preceding centuries travel between these regions has risen from a trickle, through recorded periods
- The exploration, to the time when sea-going vessels have been able to convey significant numbers of people, thus adding momentum to migratory patterns.

- merchant ships have been able to carry goods for international trade.
- When the aero plane appeared it brought the time taken to travel anywhere in the world down to an insignificant proportion of a lifetime, and led to an explosion in the demand for travel
- The aero plane has opened

The shape of demand

- Knowing what ‘demand’ (passengers per unit of time) there is for a service at the present time is essential to planning the introduction of a transportation service
- The desire is to provide a service that will continue to serve demand
- Thus some idea is desirable as to how service demand will evolve over time. This is traffic forecasting.

- Traffic forecasters tend to divide the world's population into entities and to assess what propensity there is to travel between various clusters of people
- One way to do this is to subdivide them as national populations, within some 200 countries
- In most nations there is one city that is the administrative, legislative and governmental hub which is referred to as the capital city.
- It is usual for the capital city to have the busiest airport

Demand forecasting

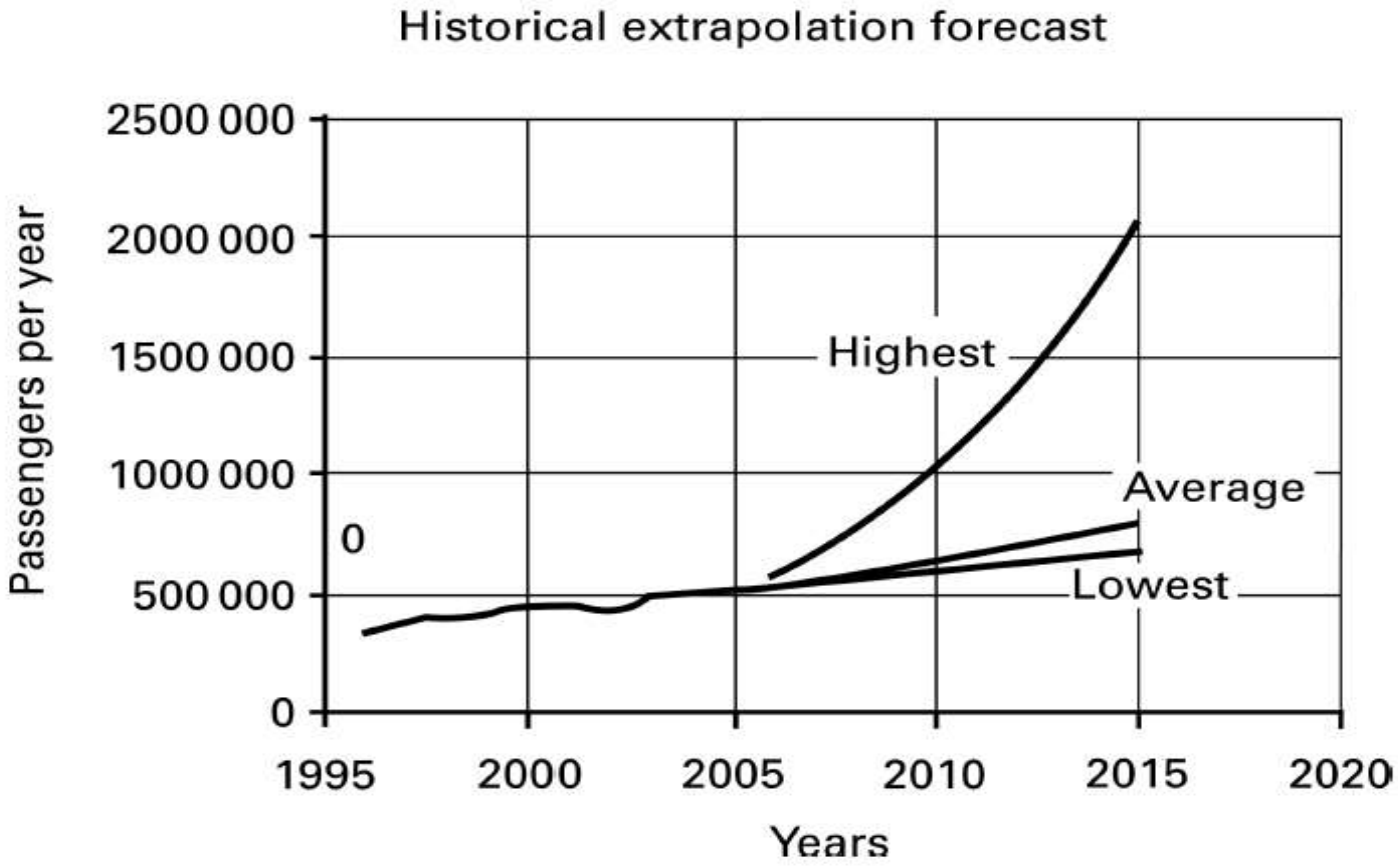
Demand forecasting is a combination of two words

- Demand means outside requirements of a product or service
- forecasting means making an estimation in the present for a future occurring event

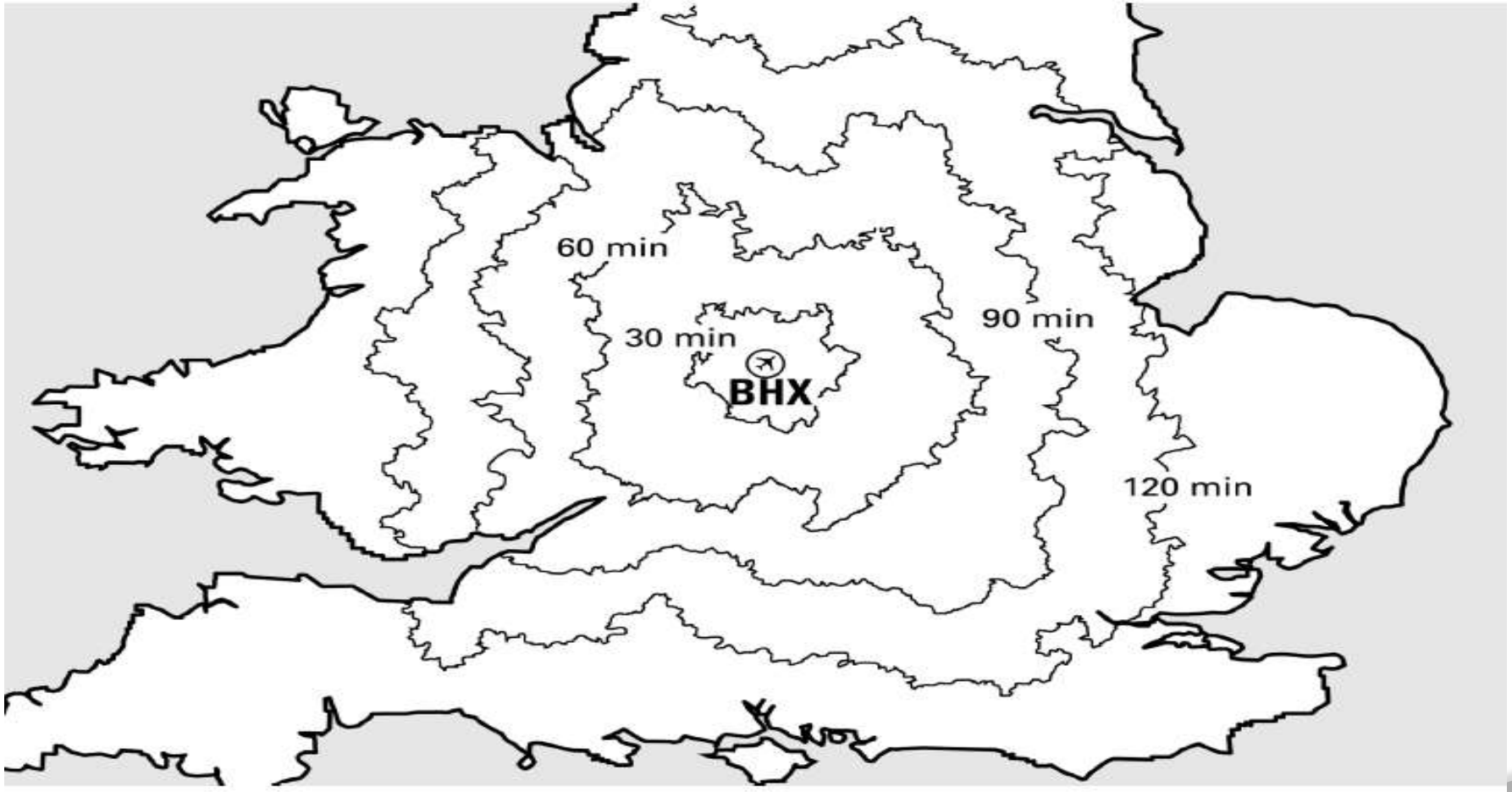
Traffic forecasting attempts to predict the demand on routes,

Historical demand forecasting

- Historical data from previous years these may be a practical measurement that can be adapted to forecast a predicted demand
- This is the least risky way of predicting demand
- Plotting such data as points, with demand (passengers per unit of time) on the vertical axis and years across the horizontal axis, will invariably reveal that the data points are ‘scattered’



2.2 Example of a historical traffic extrapolation.



2.3 An airport isochrome diagram (Source: Birmingham Airport).

Theoretical demand models

- A gravity model equation predicts the scale of demand between two locations by assuming there is attractiveness which is proportional to:
- The population at each location, such that as population increases so does demand
- The distance between them, such that as distance increases demand decreases

The formula can be factored in many ways

$$\text{Passenger demand} = k\,\frac{P_1\ P_2}{r^2}$$

where
P1 and P2 are the populations at locations 1 and 2 respectively
r is the distance between them
k is a factor that reconciles

The reliability of forecasts

A good forecaster is one who has a reputation for making good predictions, and the common wisdom is that consistently good results indicate there is a sharp mind behind the analytical processes on which the forecasts are built.

The breadth of regulation

- There are two major aspects to regulation
- economic
- Technical
- They are administered separately in most countries and there is a major international coordination body in each sphere these being the (ICAO) looking after safety orientated regulation and the (IATA) looking after commercially sensitive

International Civil Aviation Organisation (ICAO)

- The International Civil Aviation Organization (ICAO) is the supreme legislative body overseeing technical-based aspects of international air transport operations
- ICAO takes responsibility for the framework against which much of the international air law pertaining to operations and safety worldwide .

- ICAO is headquartered in Montreal, Canada, and has regional offices worldwide
- The ICAO Council adopts standards and recommended practices concerning
  - air navigation,
  - infrastructure,
  - flight inspection
  - prevention of unlawful interference,
  - and facilitation of border-crossing procedures for international civil aviation

- Fifty-two countries signed the Chicago Convention on International Civil Aviation also known as the Chicago Convention, in Chicago, Illinois on 7 December 1944
- The 9th edition of the Convention on International Civil Aviation includes modifications from 1948 up to year 2006
- As of January 2019, there are 192 ICAO members
- The Convention has 19 Annexes that are listed by title in the article Convention on International Civil Aviation

The Convention is supported by nineteen annexes containing standards and recommended practices

- Personnel Licensing
- Rules of the Air
- Meteorological Service for International Air Navigation
- Aeronautical Charts
- Units of Measurement to be used in Air and Ground Operations
- Operation of Aircraft

- Aircraft Nationality and Registration Marks
- Airworthiness of Aircraft
- Facilitation
- Aeronautical Telecommunications
- Air Traffic Services
- Search and Rescue
- Aircraft Accident and Incident

- Aerodromes
- Aeronautical Information Services
- Environmental Protection
- Security
- The Safe Transport of Dangerous Goods by Air
- Safety Management (Since 14 November

Group I (chief importance)	Group II (large contributions)	Group III (geographic representation)
• Australia • Brazil • Canada • China • France • Germany • Italy • Japan • Russia • United Kingdom • United States	• Argentina • Colombia • Egypt • India • Ireland • Mexico • Nigeria • Saudi Arabia • Singapore • South Africa • Spain • Sweden	• Algeria • Cape Verde • Congo • Cuba • Ecuador • Kenya • Malaysia • Panama • South Korea • Turkey • United Arab Emirates • Tanzania • Uruguay

International Air Transport Association (IATA)

- The International Air Transport Association (IATA) was created almost at the same time as ICAO, and also with worldwide reach and also headquartered in Montreal
- Founded in 19 April 1945, Havana, Cuba
- Consisting of 290 airlines, primarily major carriers, representing 117 countries.
- IATA has standing and special committees that address airlines, airports, cargo and other civil aviation and travel issues
- IATA tariffs were ticket prices set in the days when economic regulation was stronger than it is today
- At one time all airlines issued 'IATA tickets', which were multi-layered coupons that made every airline

- IATA produce considerable quantities of statistical data concentrated on routes and financial and other business information. These data tend to be derived from member company records
- The IATA Scheduling Services are responsible for the development and maintenance of standards and procedures
- The exchange of schedule data between airlines and airports and airport coordinators, At the six-monthly spaced IATA Schedules Conferences

National authorities

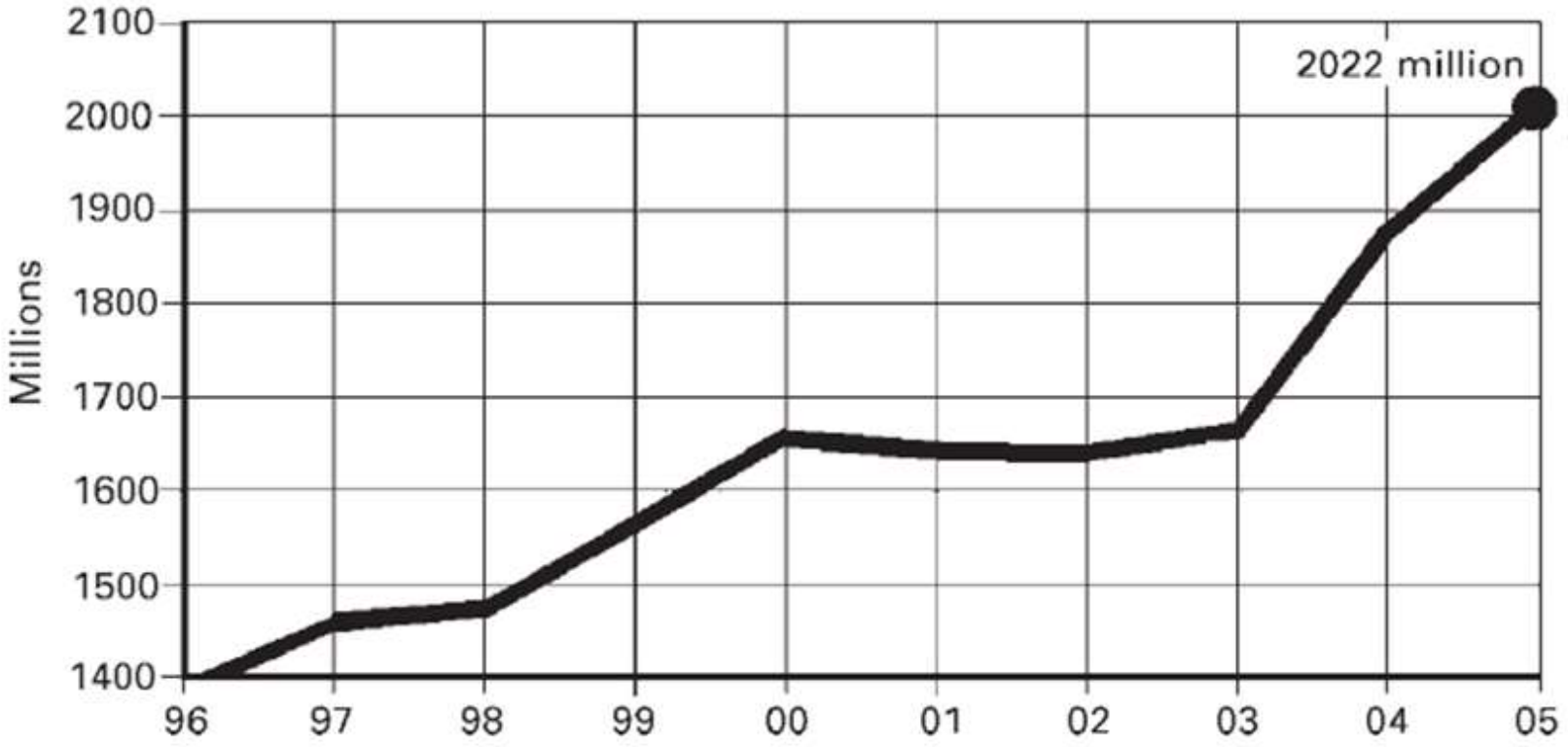
- The national authority is the main point of contact with a regulatory body. Almost every country in the world has a Department of Civil Aviation (sometimes called DCA)
- It can be referred to as the DCA, with the head called the Director-General of Civil Aviation(DGCA).
- It is a part of the national ‘civil service’ and the staff will be partly specialists and partly governmental administrators who move between departments
- In the USA the specialist team is the Federal Aviation Administration (FAA)
- in Britain, the Civil Aviation Authority (CAA)
- In the UK these are termed the Economic Regulation Group (ERG) and Safety Regulation Group (SRG).
- The Airports Authority of India (AAI) was formed on 1st April 1995

Service properties

- It is important to keep track of the scale and characteristics of the air transport business.
- Each national authority collects and collates data on operations to/from airports, conducted by the airlines and other aircraft operators in their region of jurisdiction, and supplies information to the statistical bureau of ICAO.

Service volumes

- **shows that passengers carried annually in all civil**

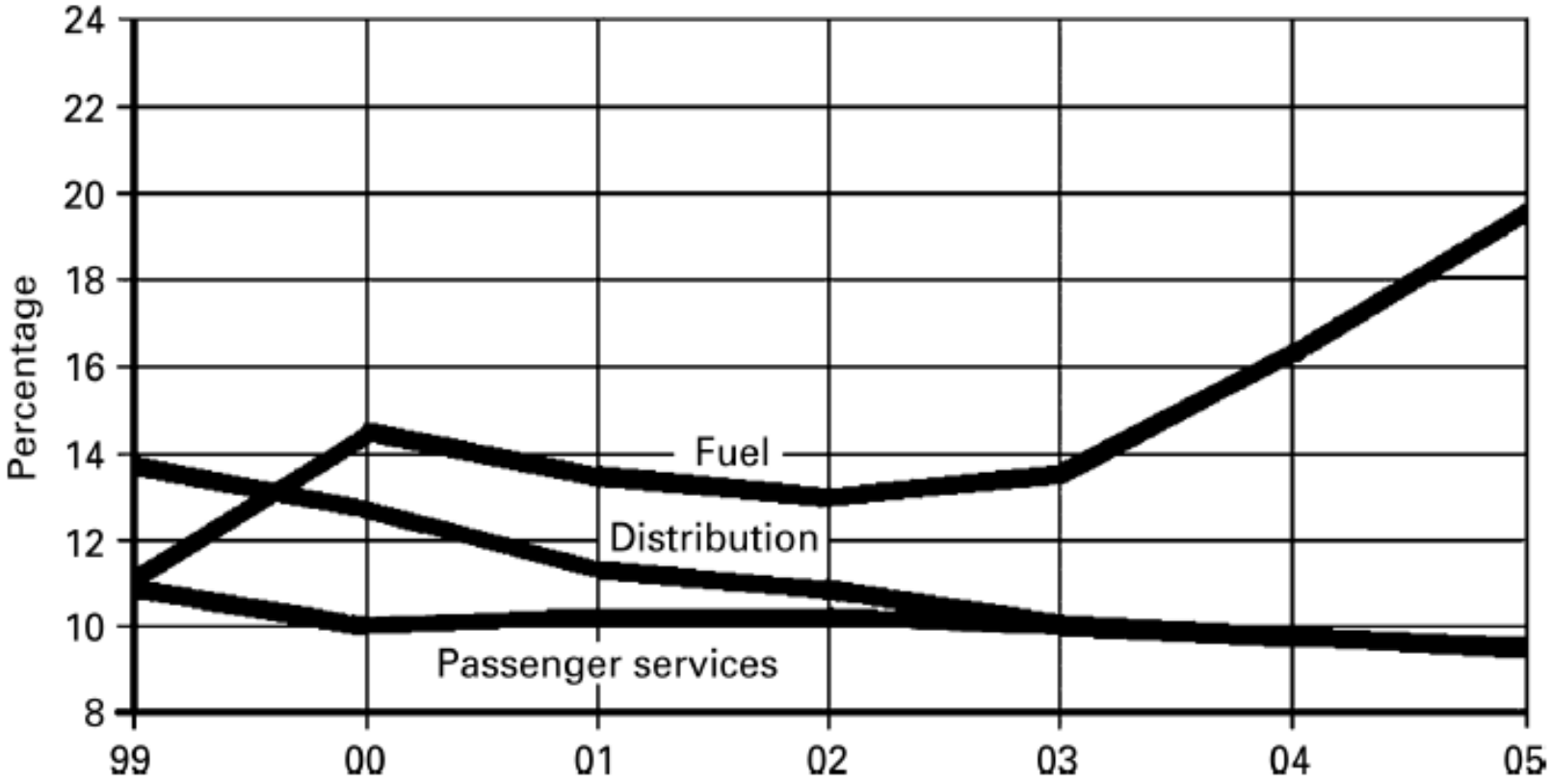


3.1 Total passengers carried, 1996–2005 (Source: ICAO Annual Review, 2006).

Fatal accident rate

3.2 Fatal accidents per 100 million aircraft-km flown on scheduled services, 1986–2005 (Source: ICAO Annual Review, 2006).

percentage of total operating expense

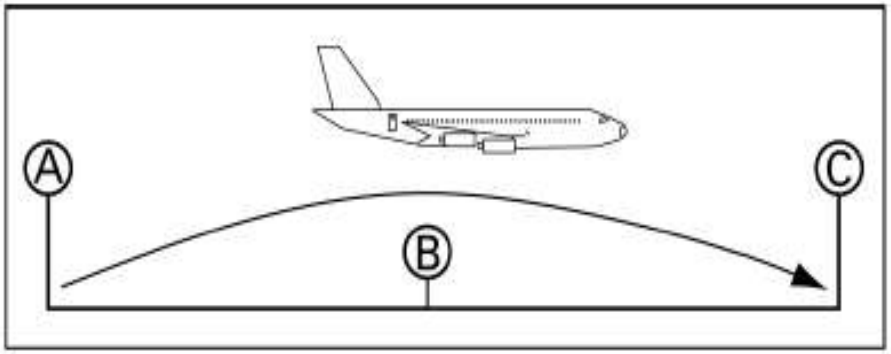


3.3 Costs as a percentage of total operating expense, showing fuel, distribution and passenger service expense trends (1999–2005) (Source: ICAO Annual Review, 2006).

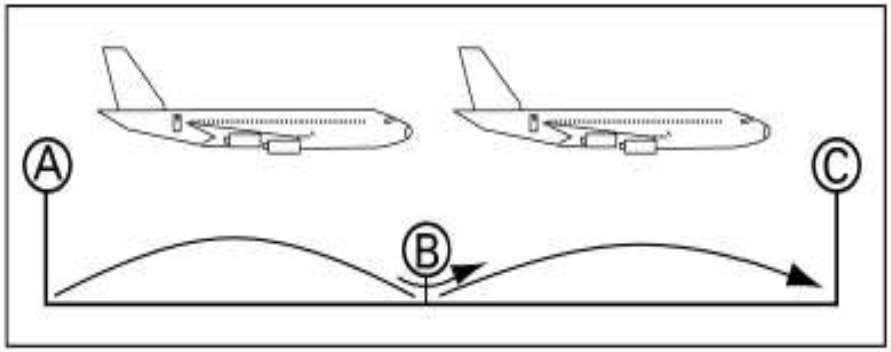
International air service agreements

- An issue that drew delegates to the 1944 Chicago Convention was that a concept in all aviation legislation was acceptance that nations hold ‘sovereignty’ over the airspace above their territory and over water adjacent to that land.
- A consequence of ‘sovereignty’ is that people need permission to fly into and out of, or over, a nation’s airspace. Overflying rights are sometimes taken for granted, but these can need careful pre-planning in some parts of the world.

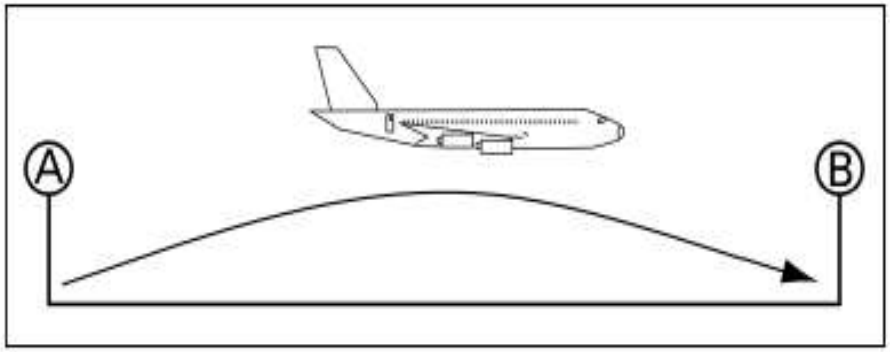
- The ‘freedoms of the air’ that were drafted in 1944 at the Chicago Convention. These were called the 'five freedoms of the air’
- ‘Deregulation’ has taken hold, and similar loosening of trade restraints elsewhere since the 1980s, has led to three additional freedoms
- They are referred as freedoms of cabotage



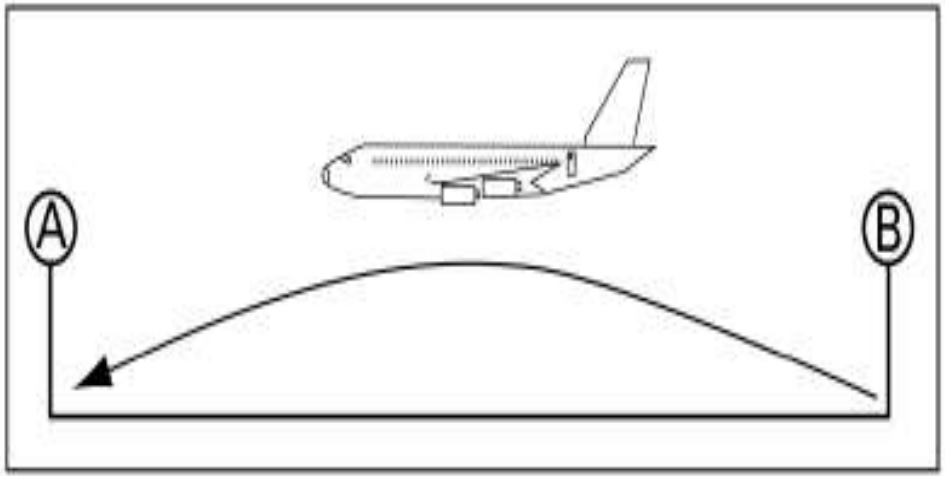
FIRST – the right to overfly territory when en route from one country to another



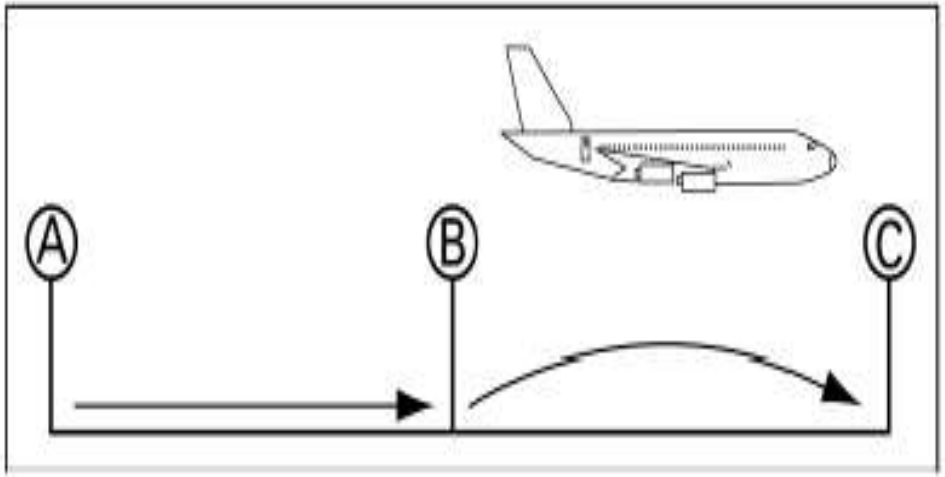
SECOND – the right to make a non-traffic stop (e.g. to refuel, but must not pick up passengers) in a country other than the two served



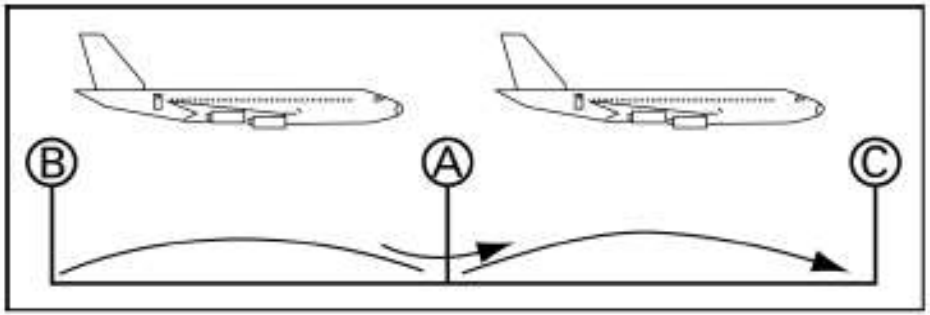
THIRD – the right to carry passengers (or goods) FROM the home country to another country



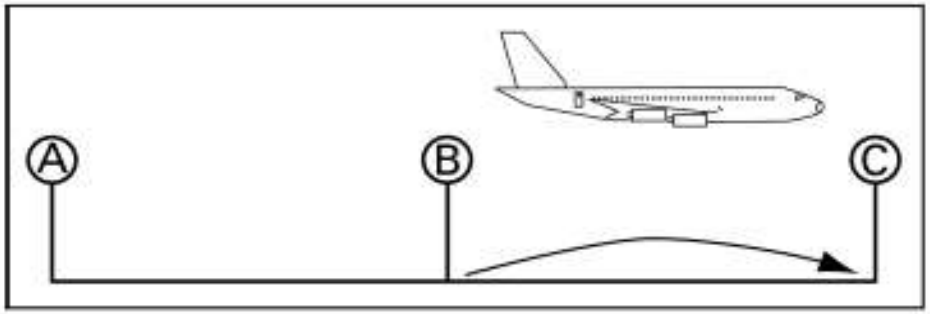
FOURTH – the right to carry passengers (or goods) TO the home country from another country



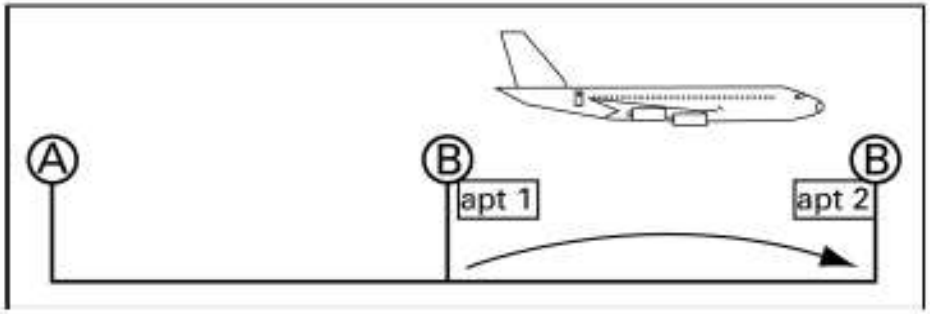
FIFTH – the right to carry passengers (or goods) between two countries by an airline of a third country, with the route beginning or ending in the home country



SIXTH – the right to carry passengers (or goods) between two foreign countries, by stopping or connecting in the home country)



SEVENTH – the right to carry passengers (or goods) between two foreign countries, without extending the route to the home country



EIGHTH – the right to carry passengers (or goods) wholly within a foreign country

3.5 Additional freedoms of the air.

Deregulation

- Civil Aeronautics Board (CAB)
- Route license(had to hold a ‘route license’ for each service they operated)
- Fare(They could also charge whatever fares they wanted)
- ‘Deregulation’ abolished the CAB. It was a milestone in regulatory affairs
- It took shape in the USA in the late 1970s

Privatization

- complete shareholding was acquired by the government
- government ownership
- Deregulation
- partial- privatization.
- The push for privatization has led to the liberation of national airlines

Communication, navigation and surveillance

- There are two ways of conveying information by wireless
- Wireless-telegraphy (w/t)
- radio-telephony (r/t)
- The first system, w/t, is a wireless based version of the telegraphy system that was used throughout the 19th century,

Wireless-telegraphy

- where messages were transmitted using discrete signals, such as the dashes and dots of the Morse code
- needed less power than a voice-carrying system
- These devices were used in the 1930s and phased out by about 1940

Radio-Telephony

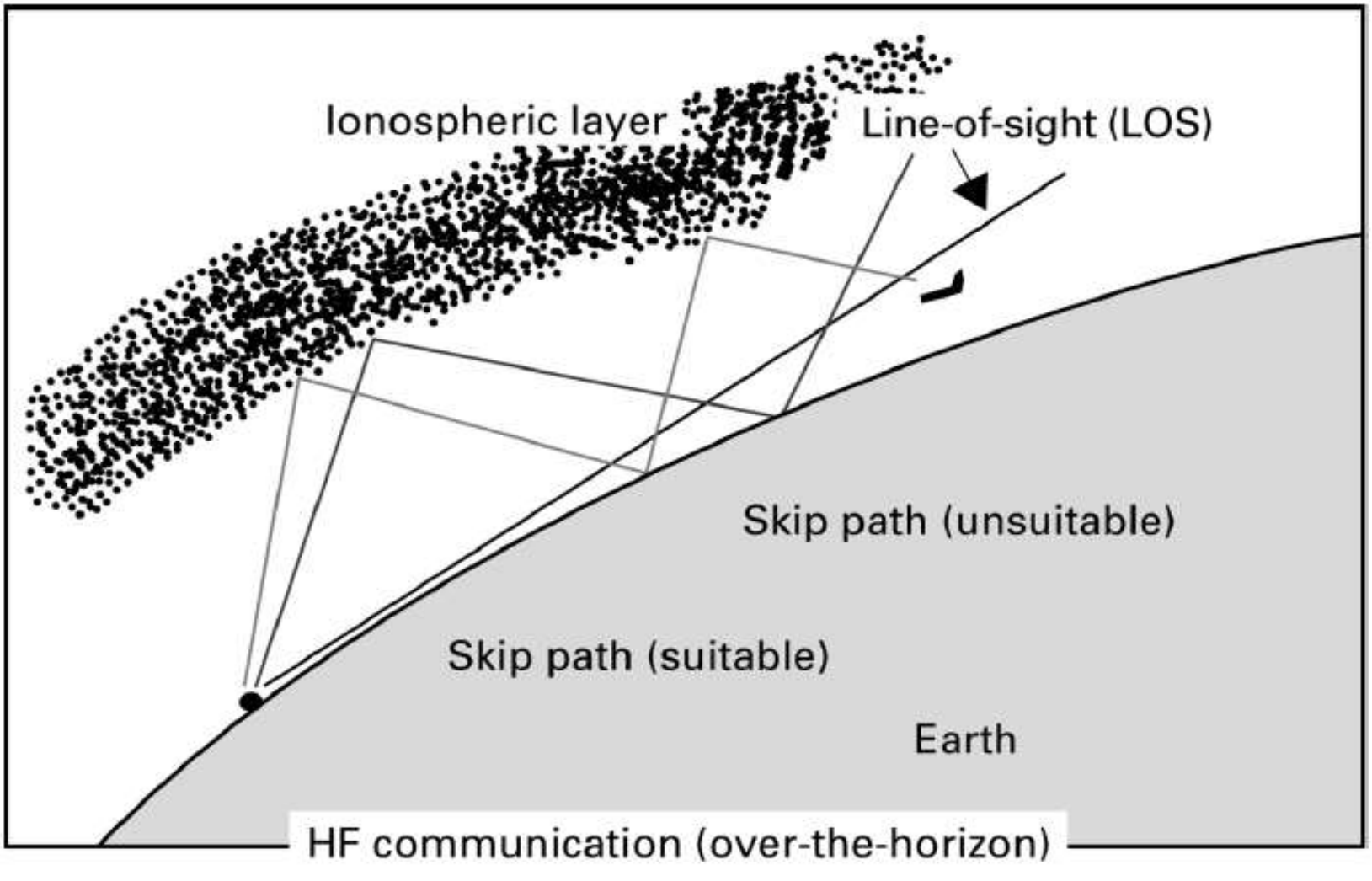
- The r/t system used a radio system that transmitted a voice message as a continuous signal
- This was used as radio broadcast in the 1920s, but needed huge transmitters,
- It was only when compact radio systems that could be installed in aircraft

Very High Frequency(vhf)

- **The continuous-signal radiotelephony (r/t) system that emerged in the 1940s**
- **Air to ground and air to air communications be achieved using voice messages**
- **VHF wavelengths propagate roughly according to line of sight (LOS)**
- **The system uses press-to-transmit**

High-frequency (HF)

- commonplace system to use over oceans and sparsely populated areas and has held this role for over 50 years
- Allows over-the-horizon (OTH) communication
- The nuisance of unpredictable reception is a limitation
- An adjunct to the HF radio is a device called Selcal (selective calling)which is installed on aircraft.


Ionospheric layer
Line-of-sight (LOS)
Skip path (unsuitable)
Skip path (suitable)
Earth
HF communication (over-the-horizon)

Aircraft Communication Addressing And Reporting System (ACARS)

- Digital data link that uses a VHF radio system
- It is digital and not analogue based; it conveys data and not voice
- It has been implemented, appearing first in the late 1970s, and adopted slowly over 20–25 years
- Allow airline flight operation staff to communicate directly with active aircraft

secondary surveillance radar (SSR)

- Equivalent functionality to ACARS
- Mode A/C transponders have been mandatory on aircraft in controlled airspace for some 50 years
- The latest transponder-based system, Mode S, has become mandatory in the last few years
- Aircraft identity (Mode A)
- Aircraft level (Mode C)
- Mode S is functionally similar to the ACARS

Autonomous dependent surveillance (ADS)

- It as a satellite communication system
- Most commonly used system to transmit/receive digital messages in long-haul operations
- The dominant communication system in the 2015–2020 period

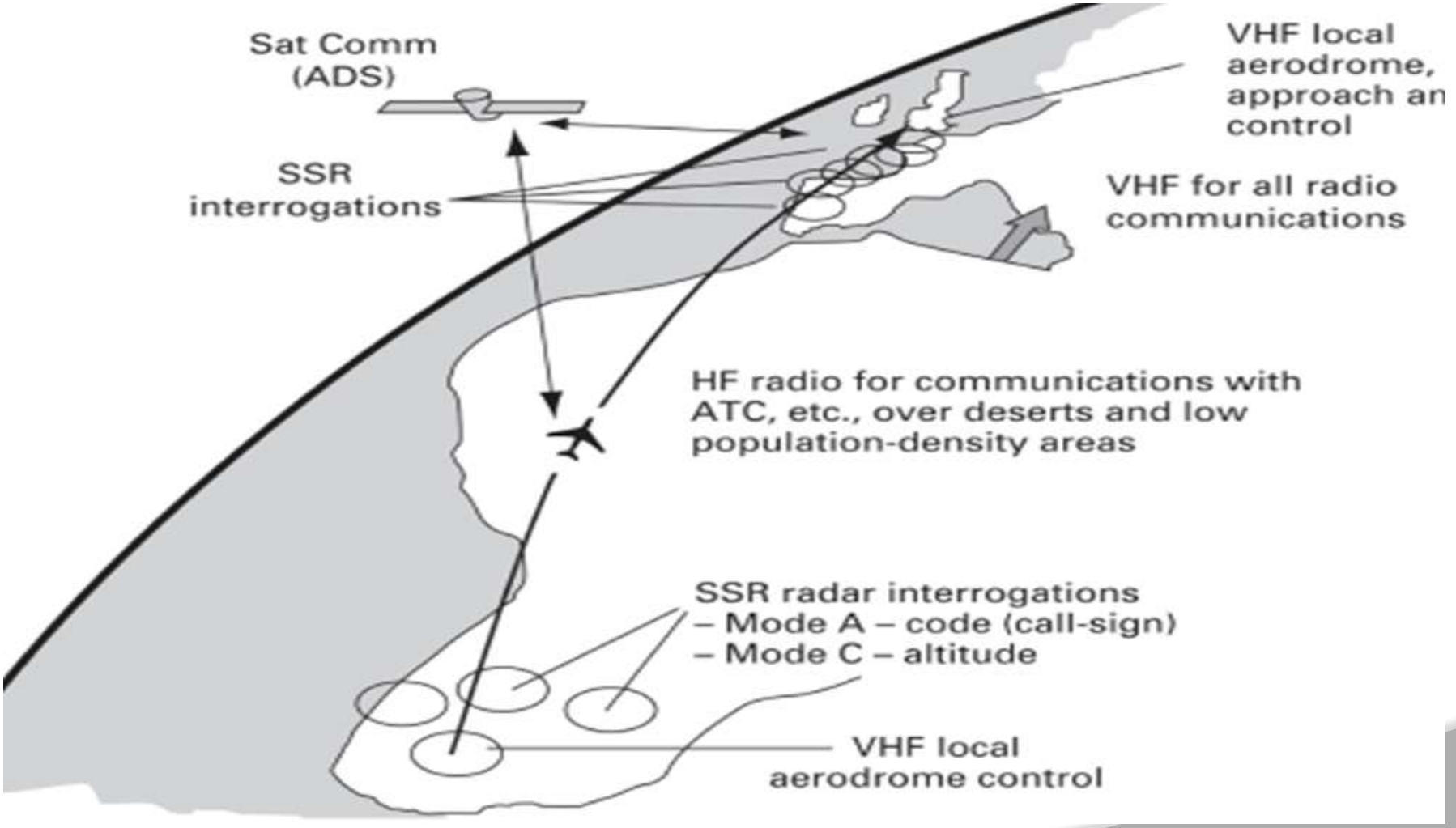
VHF – line-of-sight system, used for local ATC

HF – over the horizon system, used for services over water and deserts, etc.

ADS – trialled in 1990s, will transform communication system performance in the 'HF radio' regions

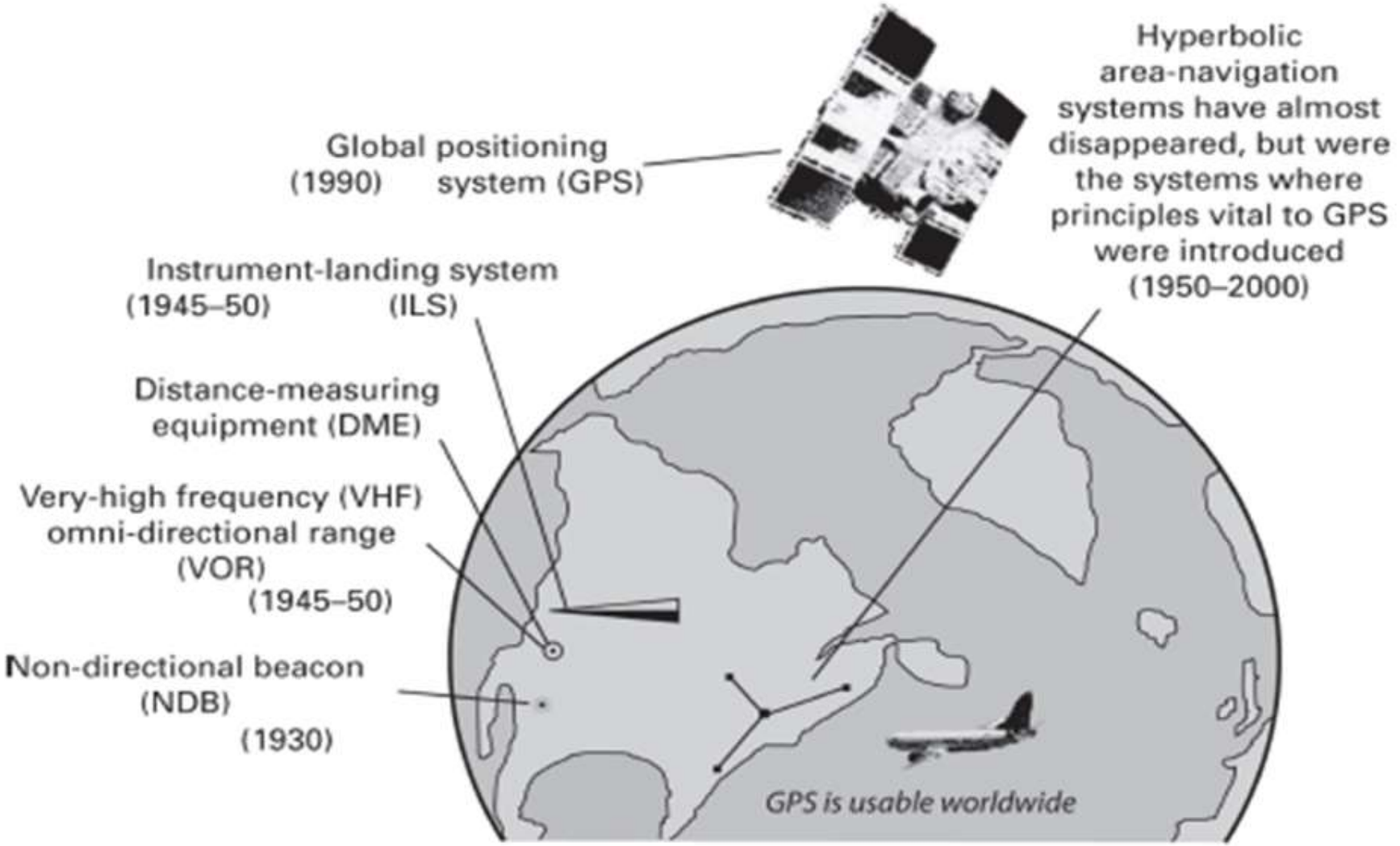
ATC transponder – a simple coded message system (downlink only in Mode A/C) (SSR = secondary surveillance radar)

NAVIGATION


Sat Comm
(ADS)
SSR
interrogations
VHF local
aerodrome,
approach an
control
VHF for all radio
communications
HF radio for communications with
ATC, etc., over deserts and low
population-density areas
SSR radar interrogations
– Mode A – code (call-sign)
– Mode C – altitude
VHF local
aerodrome control

Surveillance

- The radio range was the first en route radio nav aid in civil aviation and was withdrawn from use by the 1960s.
- It required a ground-based transmitter and an airborne receiver with a directionally sensitive antenna
- The aerial could be adjusted to make the overlap occur in four directions from a ground station, or beacon


Global positioning system (GPS)
(1990)
Hyperbolic area-navigation systems have almost disappeared, but were the systems where principles vital to GPS were introduced
(1950–2000)
Instrument-landing system (ILS)
(1945–50)
Distance-measuring equipment (DME)
Very-high frequency (VHF) omni-directional range (VOR)
(1945–50)
Non-directional beacon (NDB)
(1930)
GPS is usable worldwide

Airborne elements

- The CNS system elements already described have done much to stimulate change on the airliner flight deck – so much so that pilots whose careers spanned the 1940s to the 1970s saw tremendous change.
- Aircrews are aware of the changes that will occur and keen to ensure that safety-consciousness is maintained.

UNIT-III

AIRCRAFT

Introduction

- Aircraft are the most recognizable element of the air transport system.
- They are iconic within society and are, above all, the root of the solutions to any of the industry‘s pollution problems.
- The understanding needed of airliners is of their value in commercial and service terms.
- There is no easy way of changing the course along which aviation technology is orientated

COSTS

- Aircraft are considerably more expensive in terms of cost per unit of mass than simpler items. For example, an airliner will cost between 800 and 400 US$/kg (note that all prices will be quoted in US dollars).
- As an example of how expensive an airliner is, if a family car that took to the road at 1.5 ton maximum and was sold at an equivalent scale it would cost in the order of $750 000
- Banks and finance companies or, occasionally, airlines themselves finance the purchase of aircraft, and they must expect an aircraft‘s capital cost to be recovered during its operational life.
- As well as seeking to recover this initial cost, it has to be borne in mind that running and servicing an airliner incurs additional costs.

PROJECT CASH-FLOW

- Those manufacturers who have tried to break the mold about the variables involved inevitably have been ruled out of the business.
- Boeing continues a long-standing name, but on the way has subsumed Douglas, and at times has owned and operated other companies that it has sold on again.
- Airbus in Europe evolved from a consortium of European manufacturers.

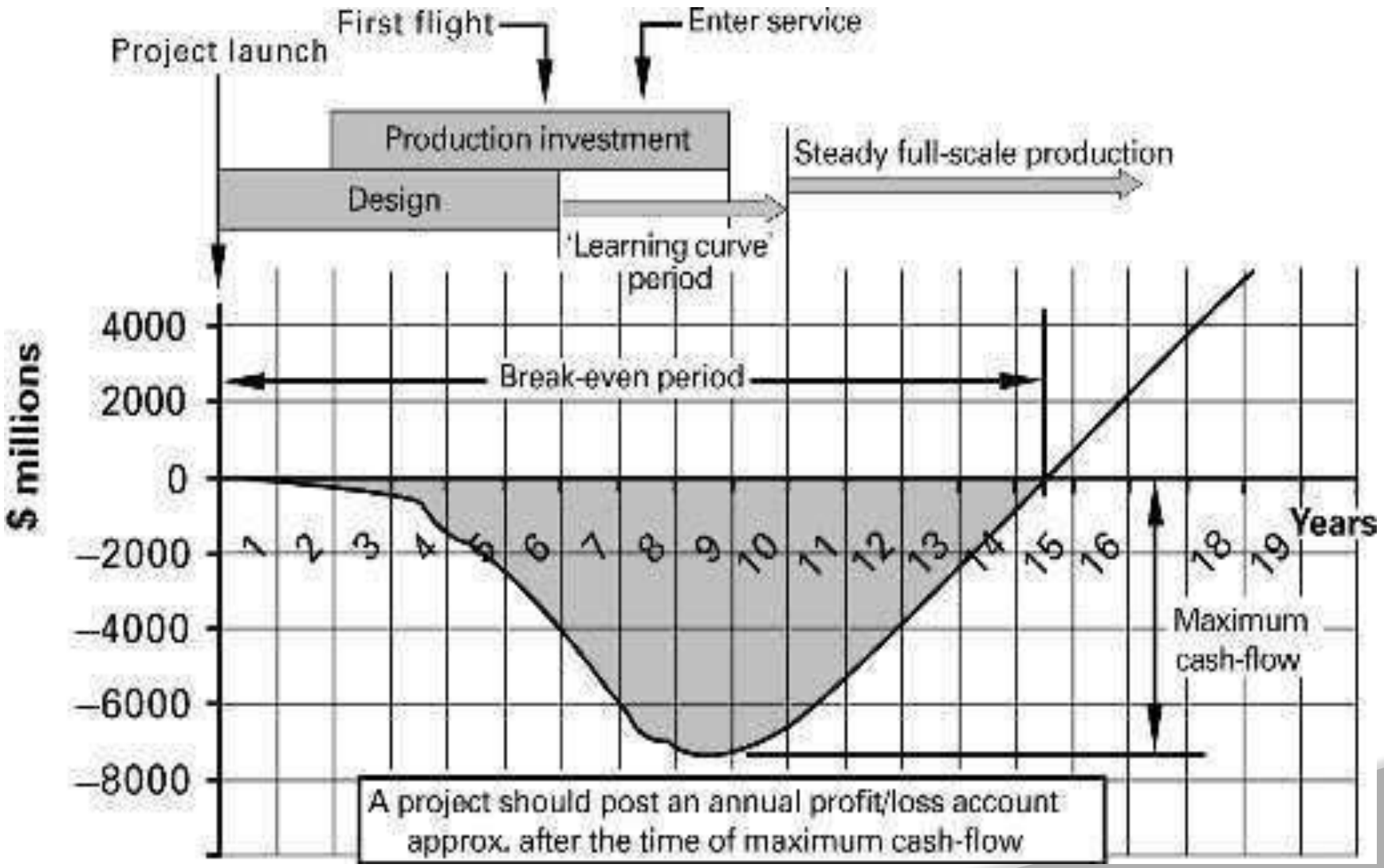
Estimated current aircraft programmed costs

Project	Production rate (aircraft/year)	Maximum cash-flow ($ millions)	Break-even period (years)
EMB-170	48–72	1600–2000	16.5–17.5
Boeing 787-9	48–72	7500–10 000	16.5–17.5
Airbus A380	48	15 000	16.5–17.5

AN AIRCRAFT CASH-FLOW

- On the diagram the maximum cash-flow value and the break-even period are annotated.
- The range in cash-flow values is based on assuming different levels of subcontractor liability, or cost sharing.
- There are many hidden factors, perhaps subsidies that are unacknowledged, and pay rates from country to country can influence the costs greatly.
- In Brazil, where the EMB-170 has been developed, the labour costs are considerably less than in the USA or Europe, but the company relies on subcontractors that do face US and European costs,
- so while the illustrative estimates are good for comparison they may be wide of the real data.

AN AIRCRAFT PROGRAMME CASH-FLOW CURVE



AIRCRAFT PRICE

- The quoted prices for some leading aircraft types, at early 2006, are shown in Table.
- The range of data represents the price range for oldest and newest examples of each aircraft type, so where a type has been in production for many years the oldest aircraft, like used cars, are relatively much cheaper than new production examples.
- There are tales of aircraft being bought well

Compatibility with the operational infrastructure

- The standards they use are the Federal Airworthiness Requirements (FAR) in the USA and the Joint Airworthiness Requirements (JAR) in Europe. a complete test specimen
- airframe will have been used to validate a lot of assumptions in this regard. Its systems and components, from engines to light-bulbs, will have been shown to be able to meet the needs demanded by risk assessments of failure cases.
- Stemming from these rather esoteric studies many operating principles will have evolved, which will be the basis of the safety management system(SMS) process content implied in the aircraft‘s type of certificate of airworthiness‘ (COA).

Aircraft prices (April 2006)

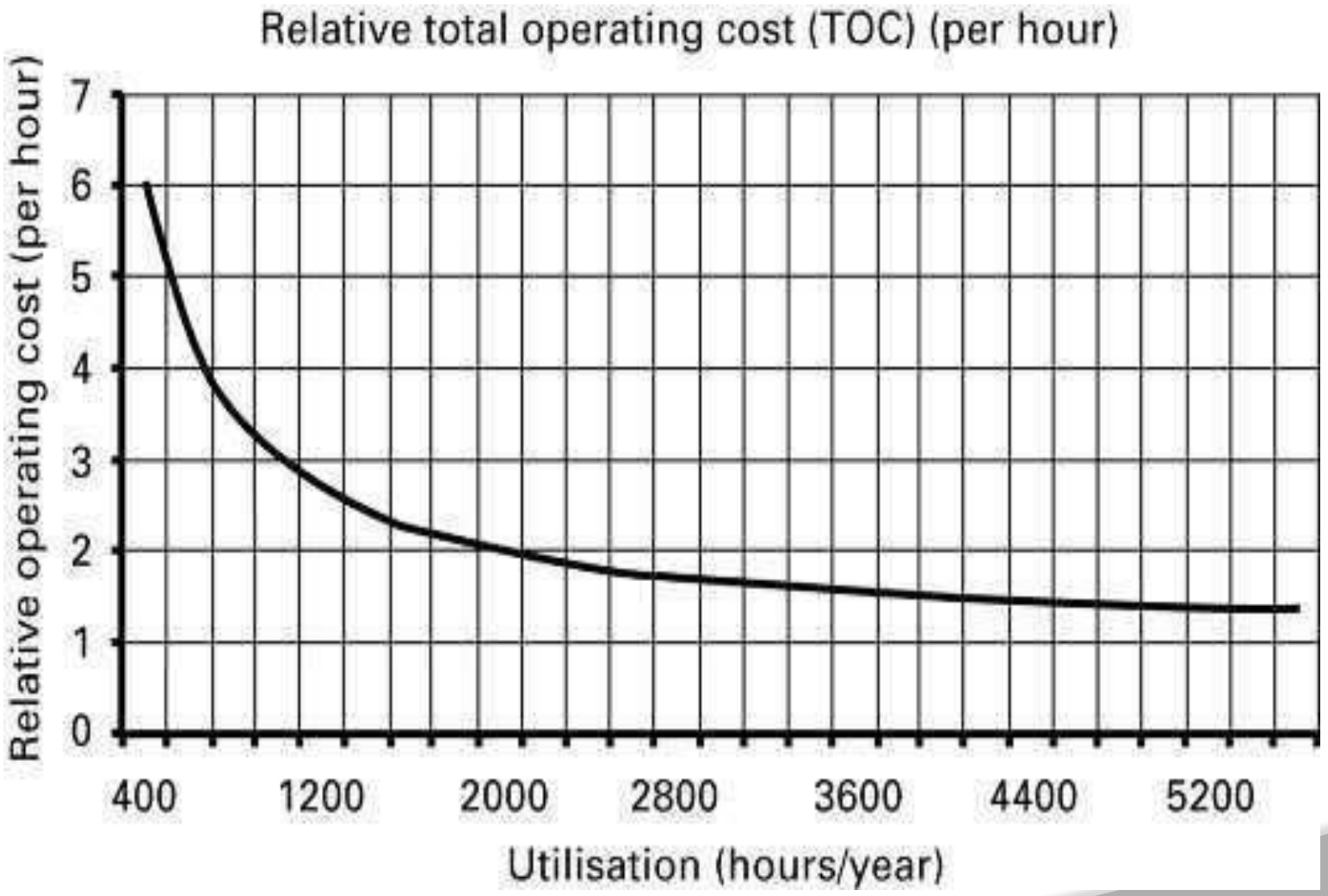
Airbus	$ millions	Boeing	$ millions
A318-100	21.9–28.4	737-300	6.00–15.6
A319-100	18.9–34.9	737-800	28.75–42.75
A320-200	11.95–42.15	747-400	37.3–107.55
A330-200	57.4–88.7	757-200	7–28.55
A340-300	46.8–100.16	767-300ER	19.4–67.75
A340-500	89.9–115.4	777-200ER	85–112
A340-600	92.9–126.4	777-300ER	67.5–136.3

- Operating costs: Operating costs are divided into two regimes.
- Direct costs.
- Indirect costs.
- Direct costs are those incurred at the time of flight. They will include crew salaries (factored to including training, etc.), fuel, on-condition maintenance, airport and air navigation service charges, and so on.
- Indirect costs are those incurred as a matter of ownership. The aircraft value, or the repayment lease if it is not fully owned, will be recovered as an annual repayment cost. Likewise there will be hull insurance, charges attributable to airline functions (administration, ticketing and reservation, building leases), and so on.

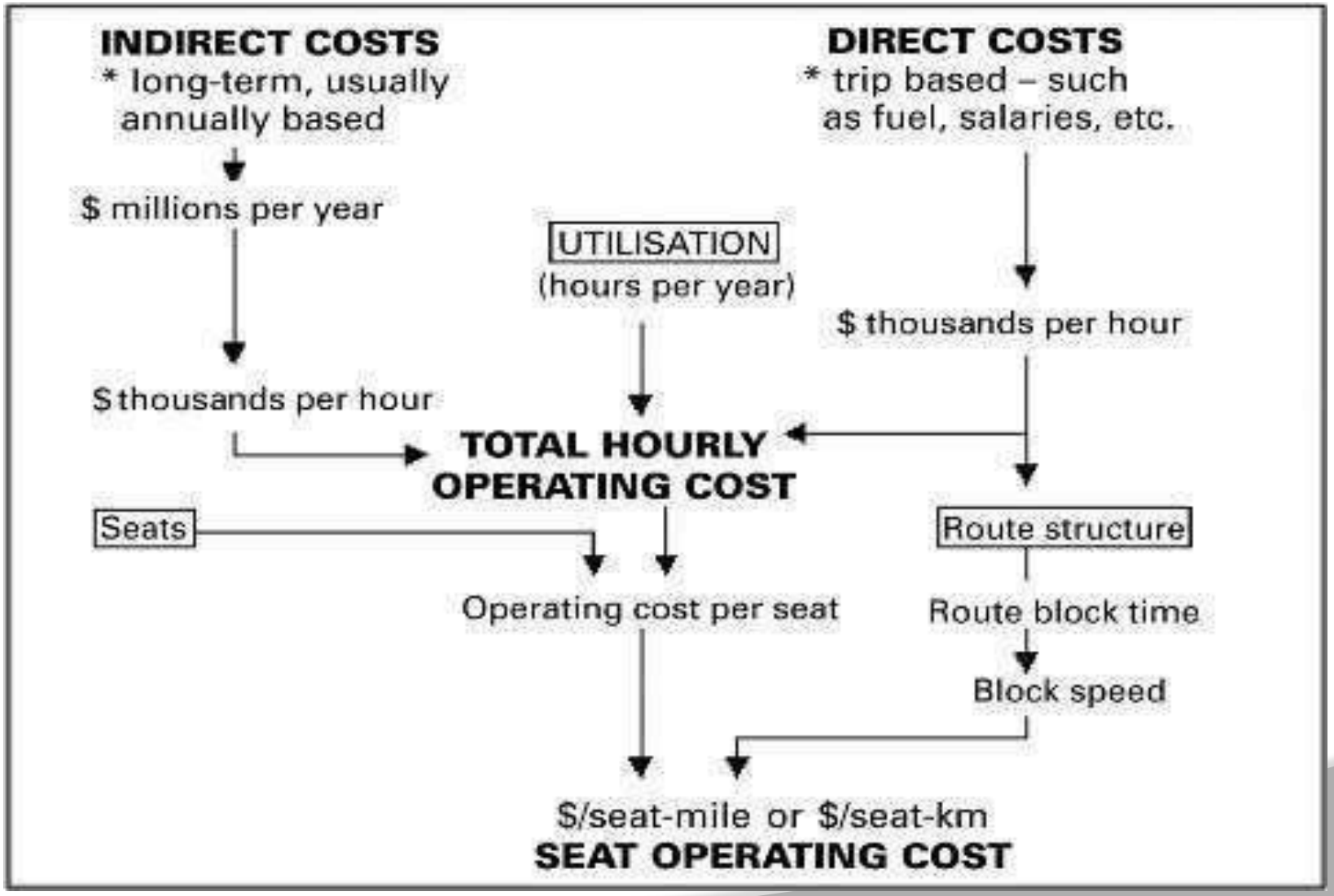
Relative Direct And Indirect Operating Costs Per Hour Related To Utilization

Utilization (h/year)	X_i	X_d	Total
400	10.0	1.0	11
500	8.0	1.0	9
667	6.0	1.0	7
1000	4.0	1.0	5
2000	2.0	1.0	3
4000	1.0	1.0	2
8000	0.5	1.0	1.5

RELATIVE TOTAL HOURLY OPERATING COSTS



COMPONENTS OF AIRCRAFT OPERATING COSTS



TYPICAL AIRCRAFT OPERATING COSTS

	Direct ($/h)	Indirect ($/month)	Utilisation (h/day)	Assumed seats	Flight cost ($)	$/seat cost	$/seat-km cost
747-400							
United	8697	298916	12.1	400	76863.7	190.41	0.029
Northwest	9155	588846	12.6	400	85507.6	213.77	0.033
777-200							
United	6568	95618	12.0	330	54672.8	165.67	0.026
Continental	6283	424875	14.7	330	57971.5	175.67	0.027

BALANCING EFFICIENCY AND EFFECTIVENESS

These two roles will be discussed in conjunction, because it is the way that an airline uses the flexibility that the designer offers that determines much about service qualities. These are:

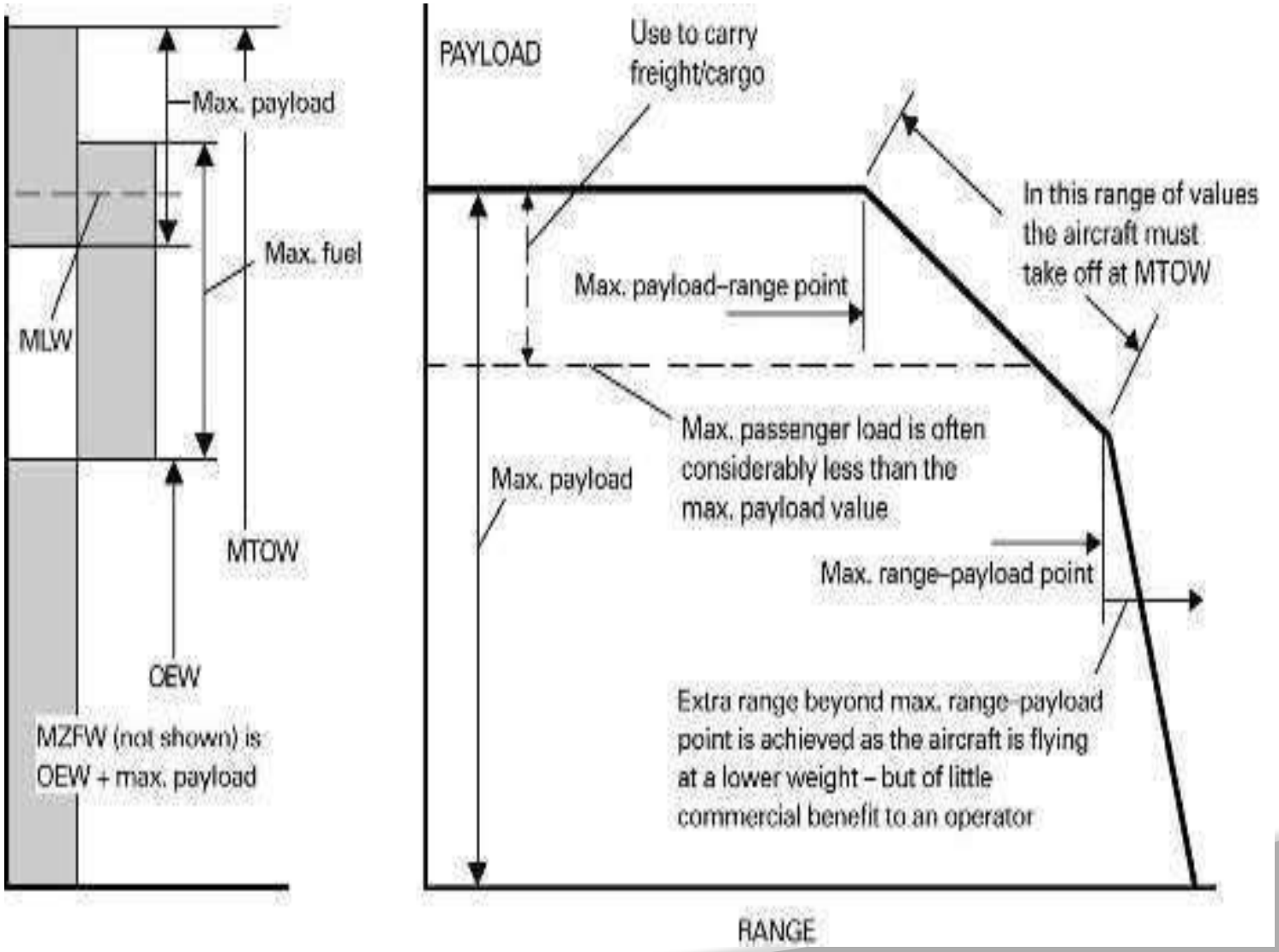
- payload range
- operating speed (and altitude)
- maximum allowable field length performance target operating cost

PAYLOAD–RANGE

The design is limited by the design

- Maximum take-off weight (MTOW) the maximum payload and the maximum fuel load. Because it is a statutory requirement, the MTOW can never be exceeded in operations. The other two mass values are interchangeable.
- A constant in all of this is the operational empty weight (OEW), being the weight of the aircraft prepared for service, but without passengers or fuel on board.

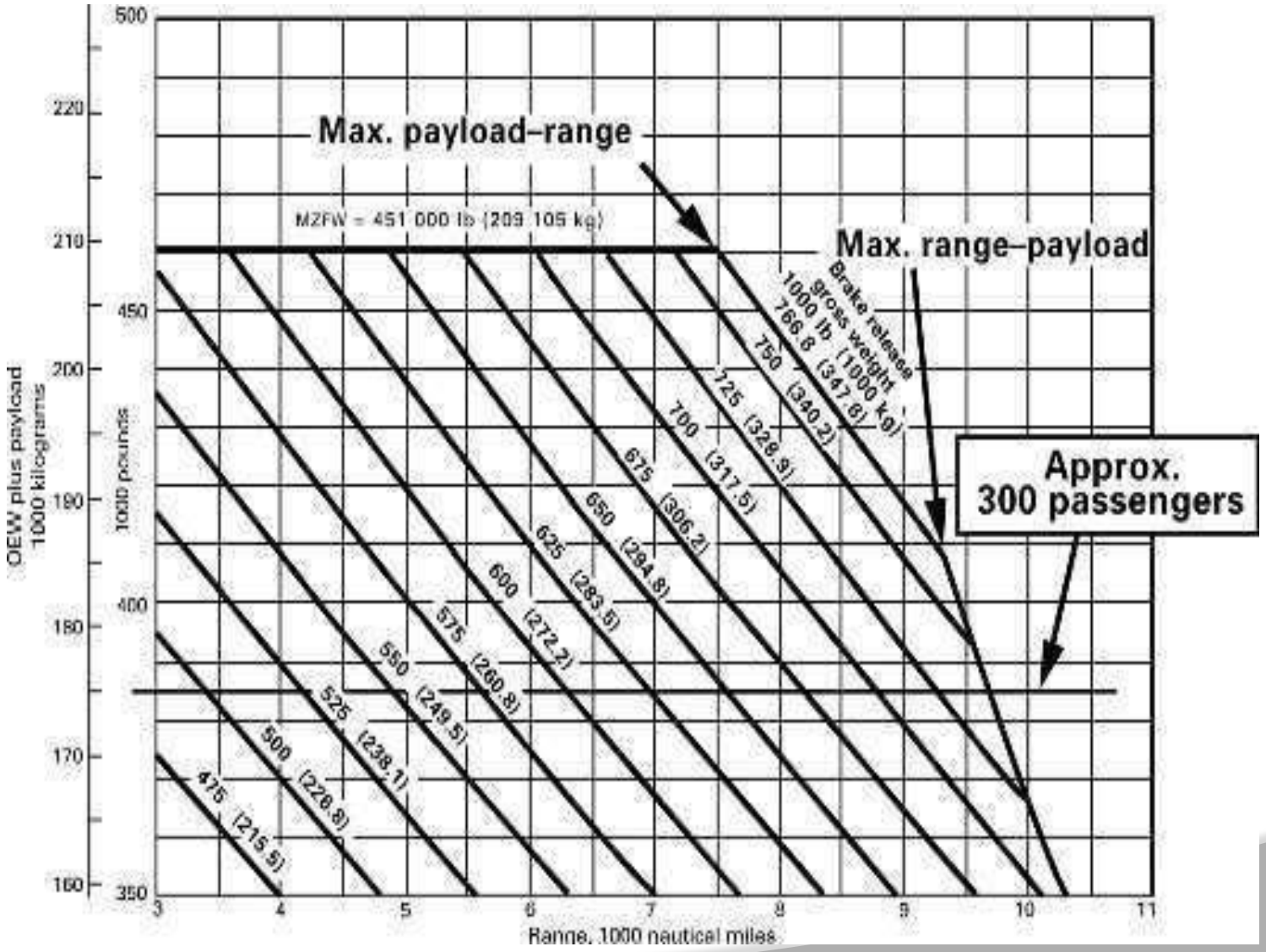
Aircraft Masses And The Associated Payload–range diagram.



The Aircraft Weights

OEW	145 149 kg (320 000 lb)
MTOW	347 814 kg (766 800 lb)
Maximum payload	63 956 kg (141 000 lb)
Maximum fuel	145 541 kg (320 863 lb)

PAYLOAD–RANGE DIAGRAM



FUEL EFFICIENCY

The conversion of this performance to a measure of fuel efficiency requires prior knowledge of what operating conditions have been assumed. In the majority of payload–range assessments the aircraft is assumed to cruise in still air and to carry a nominal reserve of fuel.

fuel used	**131 616 kg**
Maximum range–payload	**41 164 kg–9700 nautical miles**
fuel used	**156 408 kg**

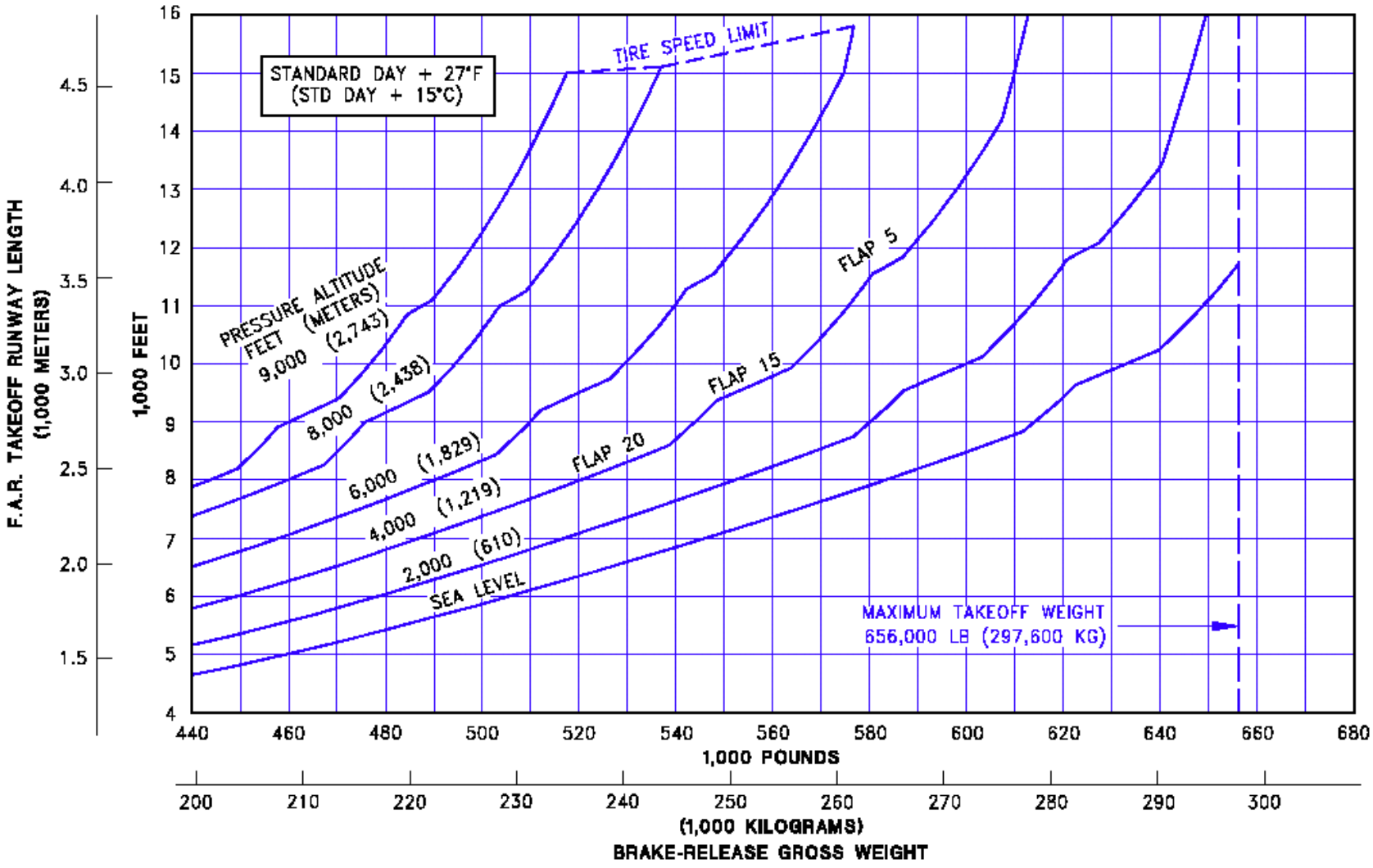
OPERATING SPEED AND ALTITUDE

Which is attributable to the develop The cruising speed of all jet airliners is about Mach 0.7 to 0.9 (410 to 527 knots TAS), with most concentrated in the lower half of this band. Some designers have attempted to offer speeds between 0.82 and 0.88 but the aerodynamic performance is affected by increasing wave drag of the supersonic shock wave that occurs at the speed of sound.

AIRCRAFT FIELD LENGTH PERFORMANCE

- Consideration of cruise performance has intimated a trade-off with field performance, but there is much more to this. The larger the wing, the slower the take-off and landing speeds, and thus the less length of runway is needed to accelerate on take-off and to decelerate on landing.

Take-off Performance Chart (Boeing 777-200lr)



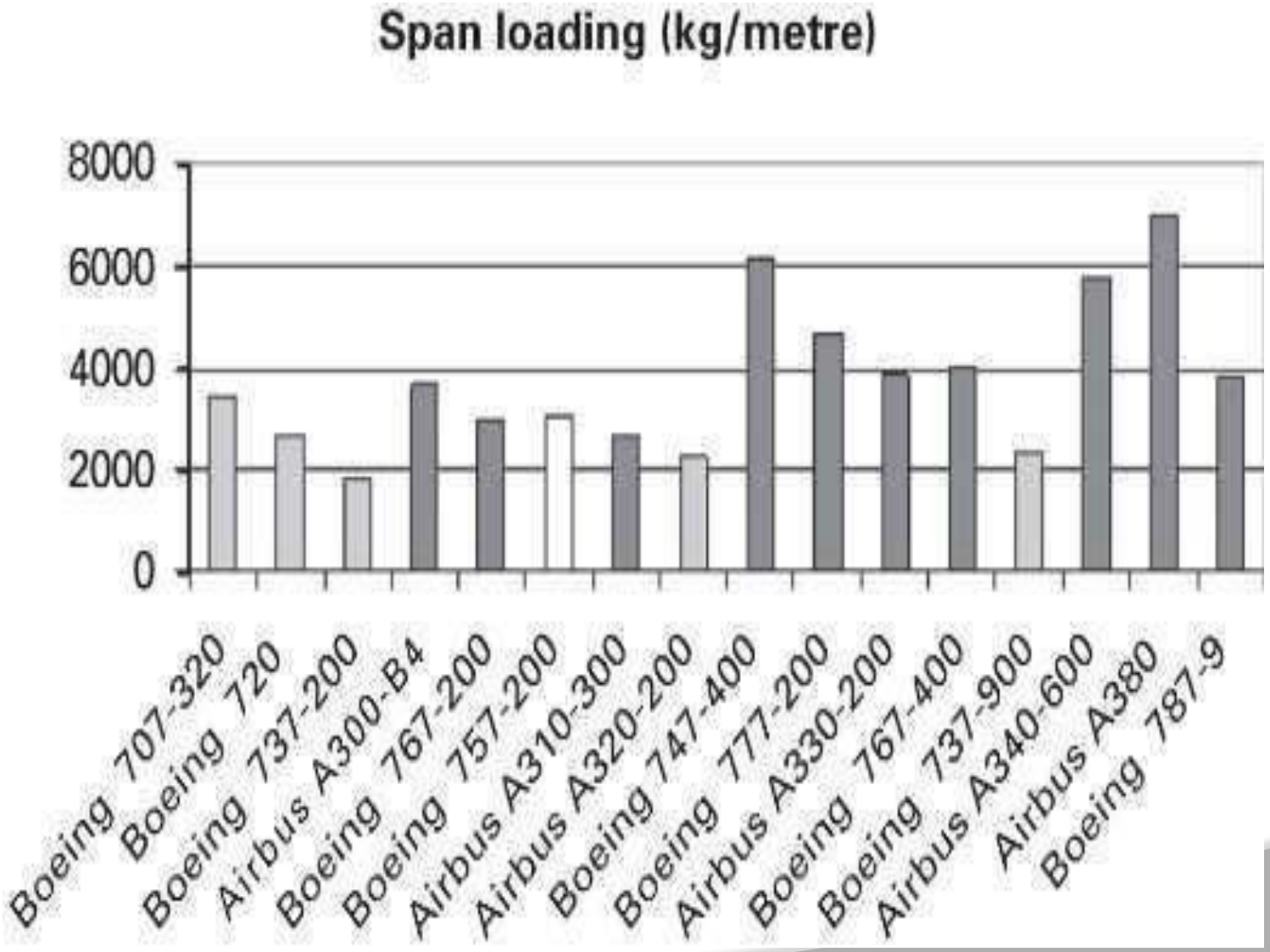
EFFECTIVENESS

- The way that airport stand dimension requirements have been allowed to play such a great influence with regard
- The A380 design (it has am span, against a requirement that it should not exceed 80 m) is an indication that not all technical matters are assessed
- Decisions made solely on technical efficiency criteria.

WAKE-VORTICES

- A significant operational consideration is that wings create a swirl around each wing tip, called a tip-vortex.
- This swirls inwards, causing a downwash‘ behind the aircraft. Sometimes the swirling flow is turbulent and so energy laden that any aircraft entering into this region of flow will face the possibility of being upset.
- This is called wake turbulence, and thus if the vortex strength is large enough to cause the upset‘ of a following aircraft, the separation between it and any following aircraft as they approach a runway has to be increased

Span-loading: Comparing Categories Of Heavy Jets



THE FLIGHT DECK

- The evolution of this part of airliners makes an interesting case study, not least because as systems have been made simpler to use, the crew size has diminished, and now almost all aircraft have a two-place flight deck for the captain and first officer.
- In the 1950s the long -range airliner had two pilots, a flight engineer, a radio operator and a navigator.
- These three additional crew members still have a place on a few older aircraft, but everything on the drawing board
- since the mid-1970s has had a two-place crew compartment.

THE MANUFACTURER'S OVERALL REMIT

- In terms of what they do, the foregoing sections have set out how the aircraft builder has two important in-house objectives:
- First to run a financially viable business
- Second to ensure that their product is compliant with the safety and operating rules set out by the operator‘s own regulatory authorities and the providers of airspace services in the regions of sky within which the aircraft will be used.
- Additionally there are technical objectives that must be addressed and result in an aircraft whose capabilities will meet user‘s expectations

TYPICAL OPERATING COSTS

- The structure of operating costs and their dependence upon many operational variables has already been explored
- The actual cost on a flight will also be affected by such issues as the payload– range and runway length available.
- If the payload–range is limited, by either airport elevation, runway length or air temperature, the operating cost will be affected in some way.
- The dependence on the variables outlined will remain the same, but there will be limitations imposed

UNIT – IV

AIRPORTS AND AIRLINES

Setting Up An Airline

- First an airline must have an owner or owners whose interest will be largely financial.
- Second an airline must decide where it will be based.
- In terms of regulatory oversight it is essential that an aircraft operator applies for a license to operate in and around the area of jurisdiction of an aviation authority.

Modern Airline Objectives

- Aircraft have always won over other modes of transport by offering a ‘faster way to travel to/from destinations.
- Payload expansion has also been a continual objective
- The bigger the aircraft the lower the average seat-km cost.
- Service effectiveness is an even more difficult issue to enumerate.
- Consider the way that the number of seats can be increased or decreased in an airliner’s cabin.
- The seating plan shown in Fig. 6.1 exemplifies a 380-seat three-class (12 first, 54 business and 314 tourist class) cabin plan for an Airbus A340-600.
- It is a configuration that would be suited to long-haul operations.

Route Selection And Development

- In ‘deregulated’ countries the right to fly a route is entirely at the airline’s discretion, subject to there being capacity to handle the required movements at the departure and destination airports.

<u>Airline service parameters such as</u>

- Destinations,
- Frequency of service (flights/day or week),
- Capacity (seats/week or even seats/flight),
- Facilities offered (drinks and food, entertainment etc.)

- The hub and-spoke route structures and are the most common route structures in use today.
- Variations on hub-and-spoke that are commonly encountered include the ‘round robin’.
- This is a service where there is an intermediate stop, such as a route from A to C via B. If B and C are relatively close the return trip might not be conducted back via B, but direct from C.
- In this case the aircraft flies from A to destination B, then from B to the new hub, then back to B and finally returns to A.
- All the crewing and maintenance resources might be at A and thus the new hub’s potential is tested with minimal additional capital or infrastructure investment. This is called

- Route planning requires that suitable routes are selected, that the right aircraft type is selected and that a schedule is constructed that will provide the transfer passenger with convenient connections.
- Analyzing Australian airports using a traffic model to generate expected demand for direct services between the airports shown and five other Australian airports (Adelaide , Brisbane, Hobart, Cairns and Darwin)
- The percentage attractiveness of hub services considering Perth (PER),

Statistics assisting in the selection of a preferred hub

Hub airport	ASP	PER	SYD	MEL
Route data (km)				
Average stage	1817	2882	1591	**1539**
Standard deviation	**365**	527	1026	961
Basic passenger data (passengers/week)				
Direct services	14 895	16 342	**28 583**	26 902
Maximum hubbing potential	26 055	7436	31 759	**34 458**
Combined passenger data (passengers/week)				
Direct + (100–70%)	30 264	16 342	46 825	**50 976**
Direct + (100–60%)	34 257	16 723	**54 656**	53 305
Direct + (100–50%)	36 369	16 723	55 881	**58 238**

- In terms of which airport accumulated the highest number of best results
- Melbourne seems to be the best airport but it would be a brave analyst that suggested that it has a clear advantage over Sydney. the two are very close indeed.
- Alice Spring meanwhile shows the expected advantage in terms of a low standard deviation and it picks up.

AIRLINE FLEET PLANNING

Once the routes are recognized a key decision is getting the right aircraft for the job.

Among aspects that have to be considered are:

- The aircraft should be large enough to offer a reasonably competitive seat-km cost.
- However, it should not be too large as service frequency must be acceptable.
- It should be fast enough to offer a competitive block time. It must be able to fly the necessary range, with adequate payload using the runway(s) available in all likely weather conditions and at all service destinations.

- It must be comfortable enough to win passenger acclaim. The aspects of aircraft and airline operational planning that determine the detail within these areas
- In most airline evaluations and because of competitive pressures, seat-km cost is the most influential selection parameter.
- The second most important parameter is usually payload–range.
- The rest are less important

Annual Utilization And Aircraft Size

- In business traveller operations a daily out-and-back service is the minimum that customers will tolerate.
- If it falls below that frequency the passengers are likely to find an alternative route even if it is not direct.
- Thus the number of flights per week per service that are used in planning a fleet determines a lot.
- The load factor (percentage of seats filled) has been calculated on the assumption that demand will be unaffected by service frequency.

- The operating cost per seat will also be a function of the size of aircraft.
- For example, the larger aircraft (assuming it is as well utilised as a small aircraft) will offer more opportunity to sell seats at a lower price
- When seat requirements do not match frequency a common solution is to use different aircraft types – smaller aircraft on the ‘thinner’ routes so that a consistent frequency of service is maintained.

SEATING ARRANGEMENTS

In terms of seating aircraft can be categorized under two broad headings:

- Wide-body (or twin-aisle) and
- Narrow-body (or single-aisle)
- Single-aisle aircraft can have between two and six seats per row with the aisle near to the centre (maximum headroom) portion of the cabin cross-section.
- A six seats per row single-aisle layout will have three seats either side of the aisle.

- A wide-body aircraft they usually require that there are two aisles, and generally impose a limit at 10 seats per row.
- Multi-deck aircraft are subject to additional constraints.
- Seat size can vary greatly

Table 6.3 Surveyed range of seat pitch dimension on several airlines (Source: Business Traveller 2007)

Seat category	Sample	Min–max pitch (cm)	Average cm (in)
First	28	90–231	197.0 cm (77.6 in)
Business	126	86–198	140.8 cm (55.4 in)
Economy	159	76–94	81.5 cm (32.1 in)

INDIRECT OPERATING COSTS

- There are several airline ownership models, ranging from one where everything that is used is owned and where staff are employed to conduct everything ‘in-house’ (till 1960)
- To one that leases as much as possible and subcontracts as much labor as possible (now a days)
- By using subcontracted labor the airline has all the components more loosely federated

- Some permanent employee positions are unavoidable.
- These include those associated with the airline's operating license an executive-level 'board' to conduct strategic management
- And individuals who will contribute to continuity of purpose at all stages below executives – ranging through middle management, supervisory and 'production' levels.

Aircraft: Buy Or Lease

- In the last few decades airlines to avoid the capital expenditure involved when aircraft are purchased directly by leasing their fleet from an intermediary leasing company.
- As aircraft are very expensive they lock money in assets.
- If the aircraft can be leased the lease costs can be repaid from revenue and the need to borrow capital will be reduced.
- This minimizes capital investment and where assets are available it may allow alternative investment opportunities to be explored that will diversify and strengthen the airline.

- One reason why a leasing company can provide aircraft at relatively favorable terms is that they will bid for a larger quantity of production slots than most airlines and thus have a special relationship with the aircraft manufacturer.
- Large airlines sometimes lease part of a fleet and buy the remaining aircraft

Revenue Generation

- Fares are not the sole source of revenue for an airline, but this is the most significant income source
- The commercial specialists in an airline coordinate with route and fleet planners, determining the pattern of frequency of service, seats configuration, the impact of a lease/ purchase deal, etc
- A low-cost carrier might demand that a late-booking passenger pays over ten times the price for a seat as the early-booking passenger.

- On a ‘traditional’ carrier, as has been hinted already, the cabin might be divided into compartments and the price of the seats, while again not immune from a time-before-flight variation formula
- Access to seats at two different fares will always favor the lower fare so low fares are usually released early in the booking period and the price will increase as the date of operation approaches.

COMPUTERISED RESERVATION SYSTEMS

- In the 1950s and 1960s there was a tendency for all airlines that offered licensed air services to be members of the International Air Transport Association (IATA) and it was IATA that set the fares
- Fare structures came in for a major overhaul, however, when computerized reservation systems (CRS) were introduced by the major airlines in the late 1960s.

- A customer could enter a local shop (the airlines had their own booking offices in all major towns) and book a ticket through the airline clerk or telephone an enquiry
- Initially a variety of ticket options were used introducing terms that have characterized the changes that were occurring within

- Advanced-purchase excursion (Apex) tickets. Basically this was to buy well in advance and get an economy ticket at discount. Airlines put very tight controls on ticket validity, but this still appealed to those on long haul flights visiting friends and relations (VFR passengers).
- Business class. The full economy fare passengers objected to having discount passengers on the same seat rows, so the airlines introduced a better-quality service. Modern business class equates to the old-time economy – modern economy is a lesser quality product

- By the mid-1980s there was a particularly serious operational complaint, which was that the CRS was often ‘biased’
- the presence of CRS has not been the most important issue, insofar as software-based processes have evolved on the back of the databases with the system

YIELD MANAGEMENT

- For every route there will be a yield target
- Yield managers must attract rather than deter customers, so they try to maximize load factor.

Table 6.4 Hypothetical fare and seats demand relationship

Fare ($)	Seats sold
0	100
20	100
40	100
60	100
80	100
100	100
120	80
140	62
160	46
180	32
200	20
220	10
240	5
260	2
280	0

- Consider a hypothetical service operated by a 100-seat aircraft, where, with a single fare, the prognosis is that demand will follow the fare, as shown in Table 6.4.
- A zero-fare operation might fill the aircraft, but revenue would be zero. Likewise, if the fare was very high, $280 shown, the situation is the same in terms of revenue because the demand is now zero.
- An airline can ‘overbook’ passengers meaning that they will issue a total number of tickets that exceeds the number of seats on the aircraft.
- This is policy and the resolution of overbooking is an operations issue.

Integrating Service Quality Into The Revenue Generation Process

- overbooking’ to protect against ‘no-show’ and ‘go-show’ eventualities is tantamount to taking risk with customers.
- The yield management description has shown that these are often late-booking travellers, which means that they are the people that the airline depends on to make a profit.
- An average over a number of events. On 50% of occasions the load will be higher. If the average load factor is 60%

- The chances of a load reaching 100% is less likely than if the average passenger load factor was 70 or 80%.
- A technique is needed that will determine what proportion of passengers are likely to be turned away either on enquiry or at the gate.
- One technique that provides some useful insights into equivalent service quality related issues that have yet to emerge is a technique called ‘spill factor’ analysis.

The kind of issues that must be tracked to ‘understand’ why demand varies are quoted to include:

- seasonal (winter/summer)
- daily (weekdays/weekends)
- time of day
- holiday

- Spill factor theory suggests that if the aircraft capacity (maximum number of passengers/flight) is C the expected load can be expressed in the following way:

$$\text{Expected load} = (\mu - C)\, F_0\, [(C-\mu)/\sigma] - \sigma\, f_0[(C-\mu)/\sigma] + C$$

where $f_0(x)$ and $F_0(x)$ are expressions from normal distribution probability

- It is also possible to use passenger spill data to estimate the cost/revenue benefits for an airline.
- The example in Table 6.8 assumes that the loss of one spilled passenger is $200 (route fare) and the extra operating cost of one added seat is $50
- From the above analysis it can be concluded that:
- It is well worth adding 7 extra seats to the available capacity.
- It is not worth adding 14 or more seats.

Marketing the seats

- The concern in these notes is largely in planning as the mechanisms that will be used to sell seats (marketing)
- The airline will pursue a policy and planning stage that will reflect the way they will market the products or airline 'brand'.
- Demand can be tailored by successful marketing policy and in yield management the impact of marketing initiatives can be monitored.
- Thus used to fine-tune the revenue-generation process.
- This is a concern that affects how a company manages the sale of a perishable commodity

AIRLINE SCHEDULING

- The scheduling process is where many of the implications that stem
- The scheduler must ensure that each aircraft is allocated to perform the services planned.
- The information needed is:
- Routes to be served
- Time-zone of each destination relative to the hub
- Number of flights/week per route
- Block time on each route
- Number of aircraft in fleet.

- The scheduler allocates each aircraft to each service taking into account:
- Turnaround time: the minimum time needed to empty and refill an aircraft when it passes through an airport .
- Where aircraft will be overnight as not all will necessarily be at the hub on every night of the week .
- The time of the day when passengers will want to fly.

- The turnaround time is governed by logistical and aircraft servicing needs.
- Therefore the longer the preceding flight, the more likely it is that the aircraft will need more time to refuel, to clear rubbish from the cabin, to restock the galleys etc.
- With fast turnaround bringing substantial benefits when it comes to agreeing airport

- Some of the issues that human interference adjusts for are:
- Early departures and distributing aircraft in ‘departure waves’
- Late arrivals and distributing arrivals in ‘arrivals waves’
- Introducing the chance for aircraft to switch schedules or built-in ‘robustness’
- Ensuring that aircraft at the end of a day are where they start the next day.

EVALUATING SUCCESS

- Having navigated through an airline planning process that has considered route planning, fleet planning, yield management and fleet scheduling
- There should be enough evidence to be able to measure the airline’s likely performance

FINANCIAL VIABILITY

- This can be assessed in the simplest possible way by comparing revenue and expenditure over a given period of time.
- It is comforting if revenue exceeds expenditure
- The difference is profit before tax and any other hidden expenditures are

- The most common expression of financial performance associated with this viewpoint is the profit/loss statement.
- Most airlines will supply to their economic regulators a monthly profit/loss statement, which may be published several months in arrears and over a 12-month period to present an annual account

They will show for instance

- Seasonal variations, which might be most pronounced on ‘regional’ airlines
- Public/bank holiday variations, which might coincide with religious festivals
- Global influences, a downturn in economic performance, a natural or other disaster and similar events.
- Airlines often sit on large amounts of cash paid by customers in advance of flights

REGULATORY COMPLIANCE

- Safety compliance is largely an airline operation responsibility.
- The airline will have a license and some of the named staff requirements and operating region limitations
- The named staff will have a responsibility to ensure compliance with crew flight-time limitations (FTLs), mandatory training requirements, an aircraft certificate of airworthiness

- Regulators also analyze mandatory occurrence reports (MORs) and in some countries they will be given access to databases that are run by organizations that do not have a regulatory mandate
- A good safety regulator will seek to solve issues in this manner rather than wait for serious incidents and then to invoke their most powerful mandate, of revoking the license of an individual, a group of individuals or an organization

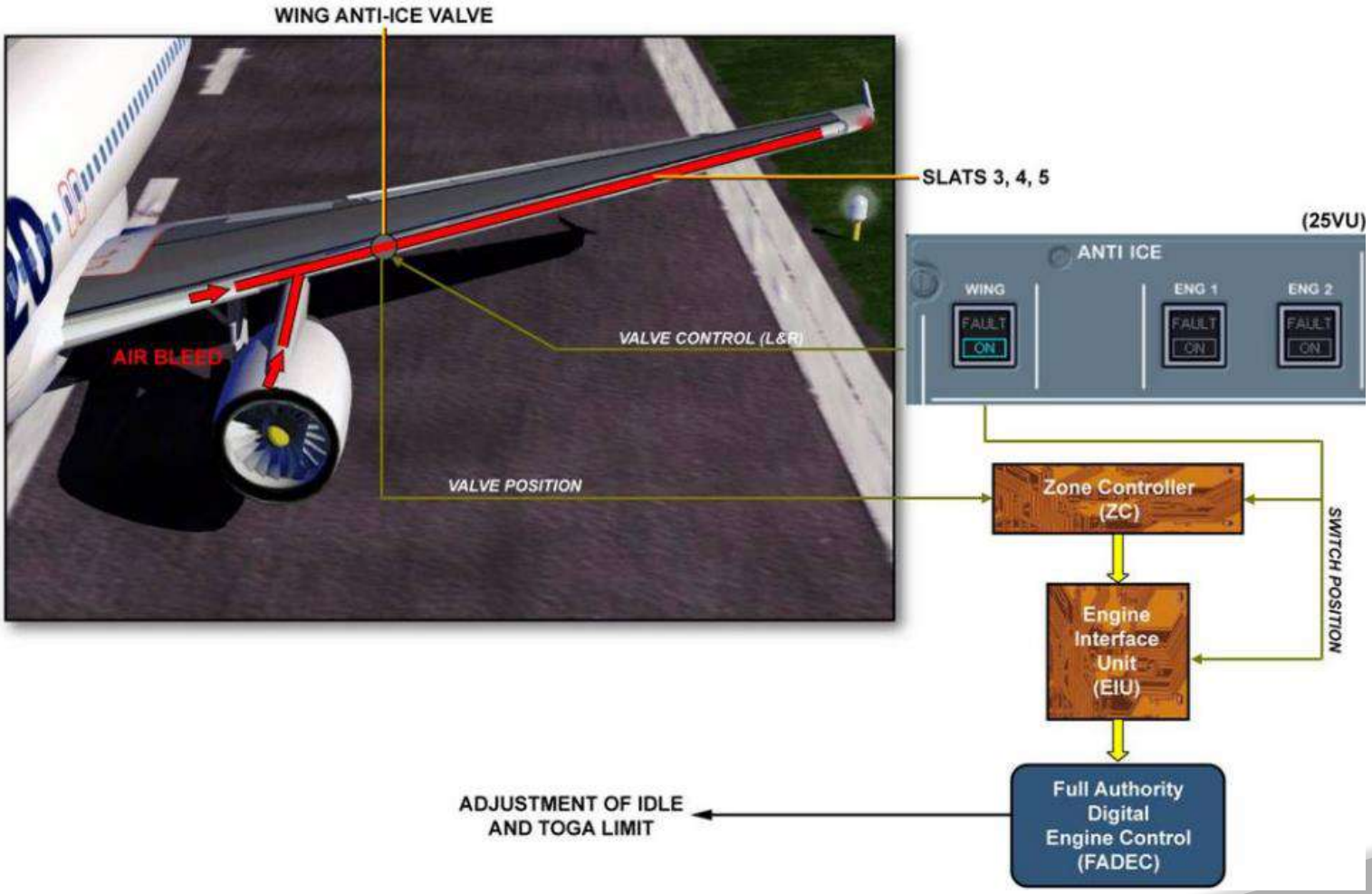
EFFICIENT USE OF RESOURCES

- Aircraft annual utilization is one with most airlines nowadays trying to get several thousands of flying hours per year from each of their aircraft.
- An airline will audit the utilization of such facilities as the maintenance hangars, flight training simulators, specialist ramp equipment, and even the baggage bins and galley carts

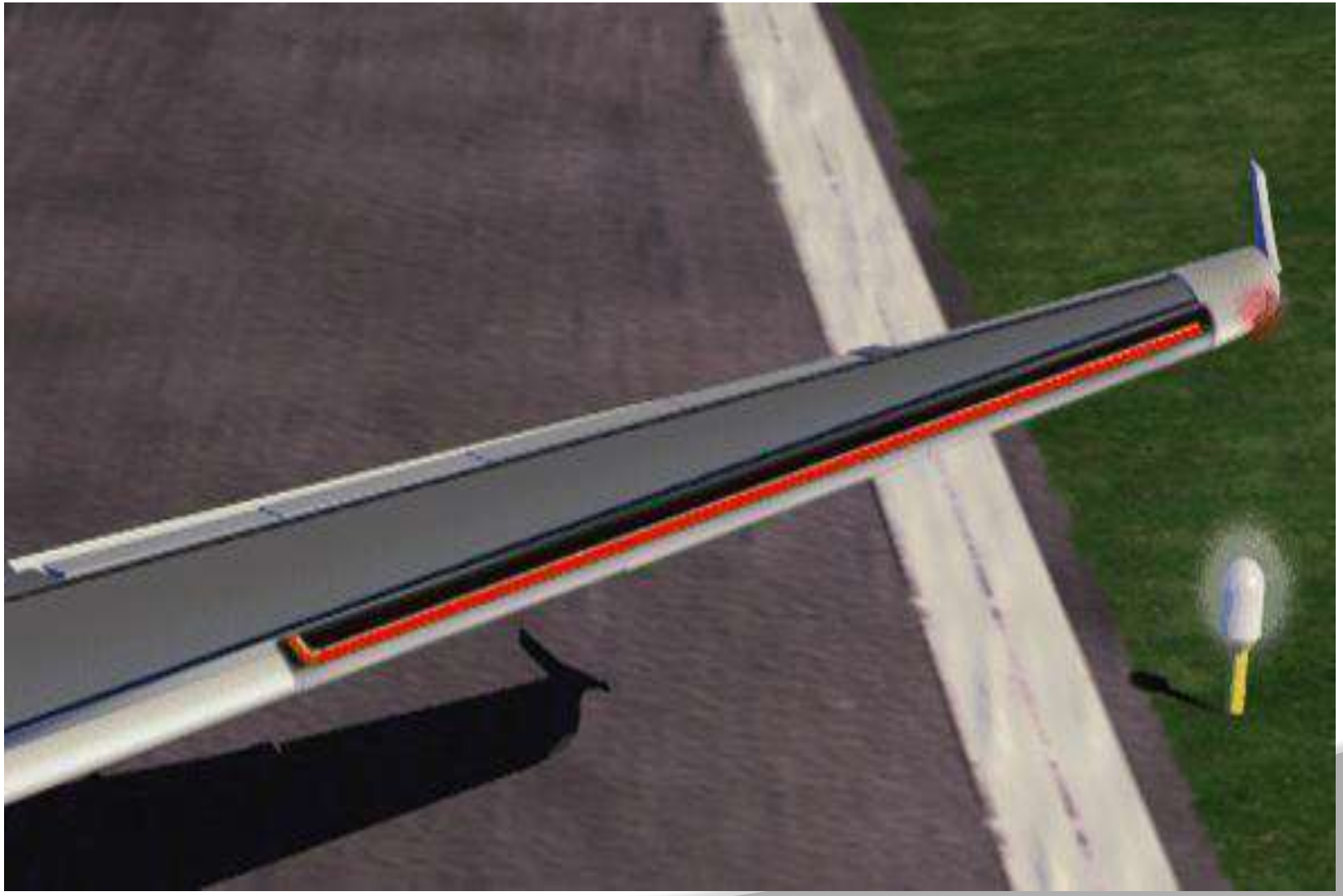
EFFECTIVE SERVICE

- Effective service is about the attainment of corporate goals that focus on customer satisfaction.
- A passenger will be attracted back to an airline whose service has suited their needs
- Airlines that desire such wide success regularly have three-class cabins to attempt that, but some airlines use just one-seat configuration and tailor demand, capacity, time and price as carefully as possible

Wing Anti-Ice Valve



WING ICE PROTECTION SYSTEM



CONTROL AND INDICATIONS

- ANTI ICE indication
- In white when p/b is pressed arrow
- Not displayed when valve is closed
- Green – normal open
- Amber
- Valve open and press is low or high
- Valve open on and for more than 10 sec

ENGINE AIR INTAKE ICE PROTECTION

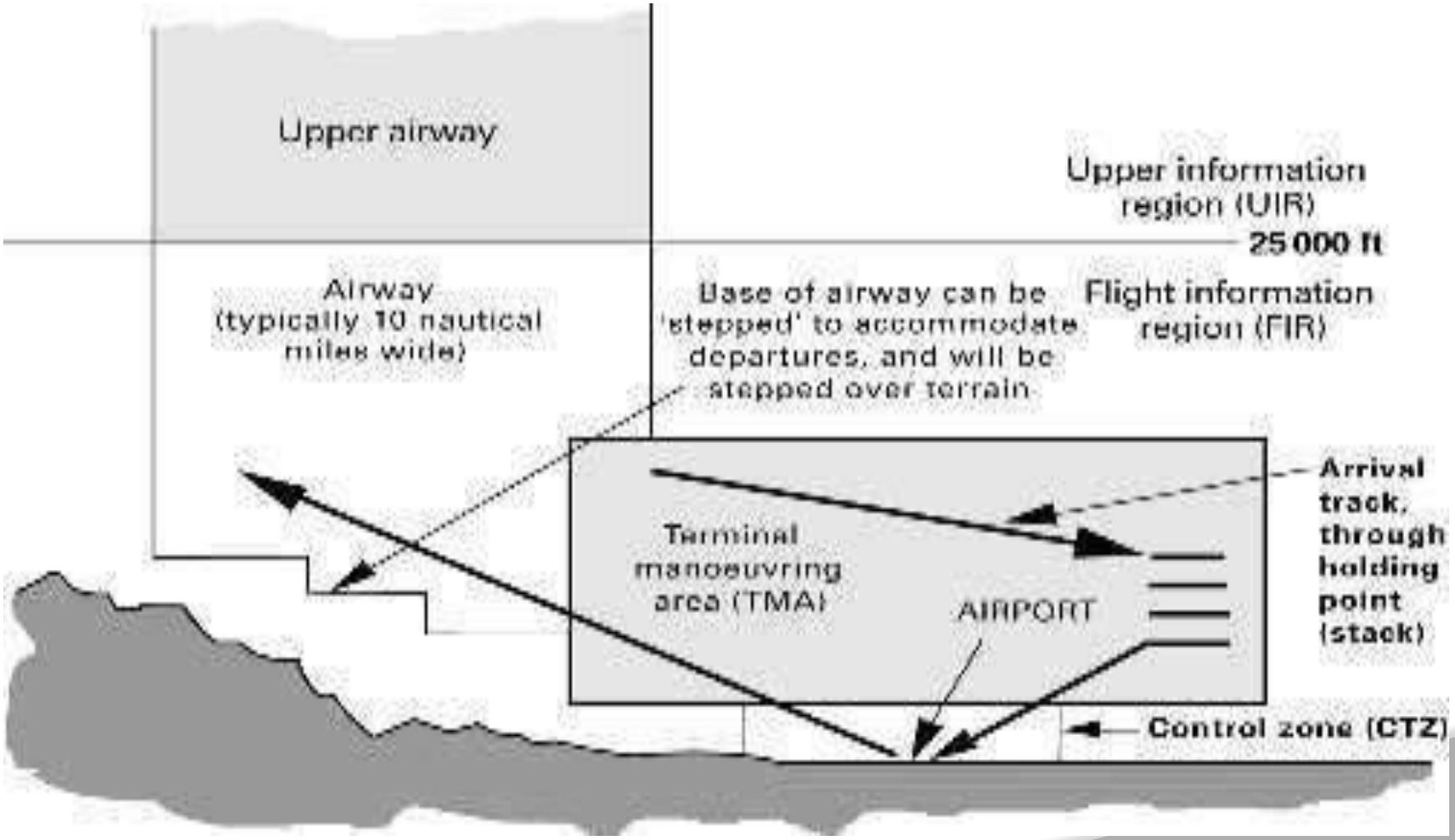
- Protects leading edge of air intake cowls
- Normally selected only in icing conditions
- Air bleed is from fifth stage of HP compressor

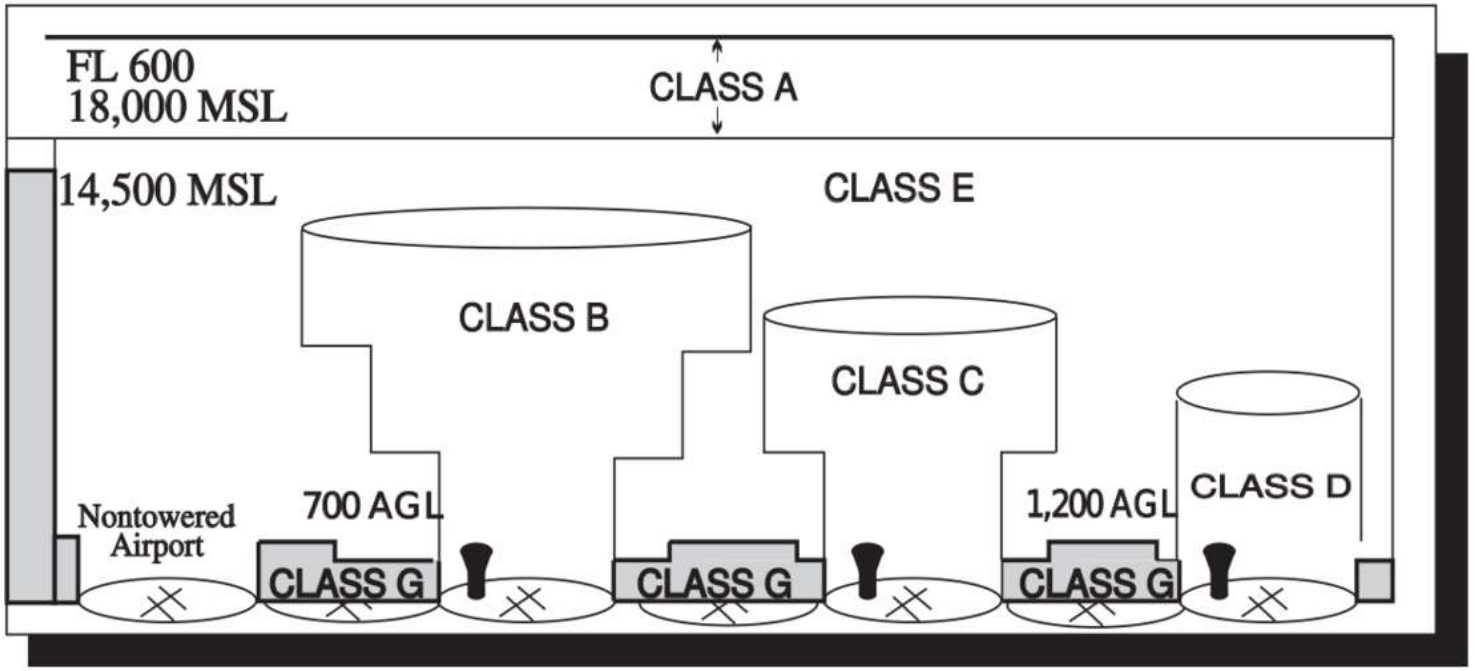
UNIT – V

AIRSPACE

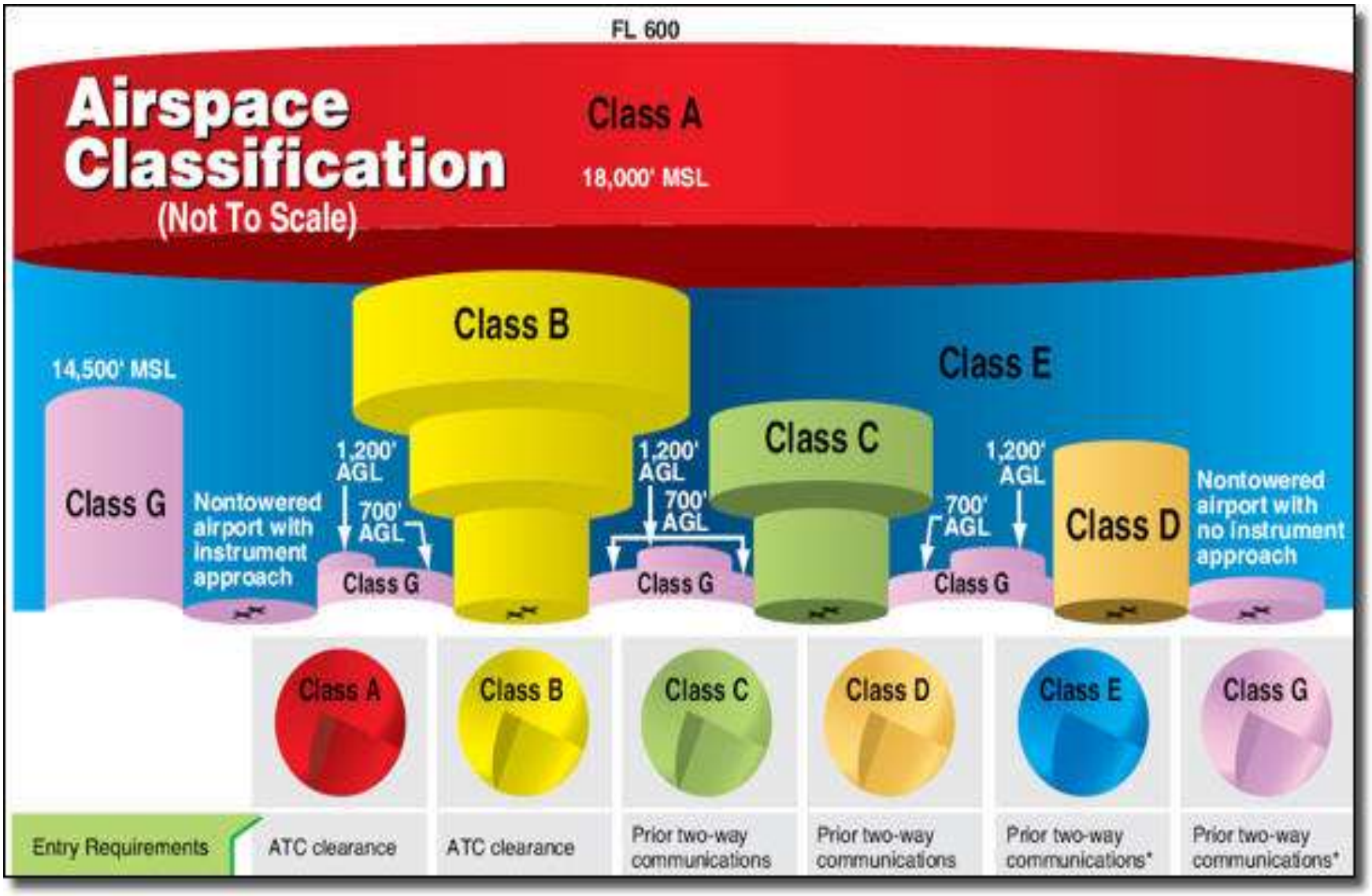
CATEGORIES OF AIRSPACE

There are seven categories defined in ICAO Annex 11, characterized as A through to G, with the highest level of service offered in Category A and the most basic service in Category G


Upper airway
Upper information region (UIR)
25 000 ft
Airway (typically 10 nautical miles wide)
Base of airway can be 'stepped' to accommodate departures, and will be stepped over terrain
Flight information region (FIR)
Terminal manoeuvring area (TMA)
AIRPORT
Arrival track, through holding point (stack)
Control zone (CTZ)

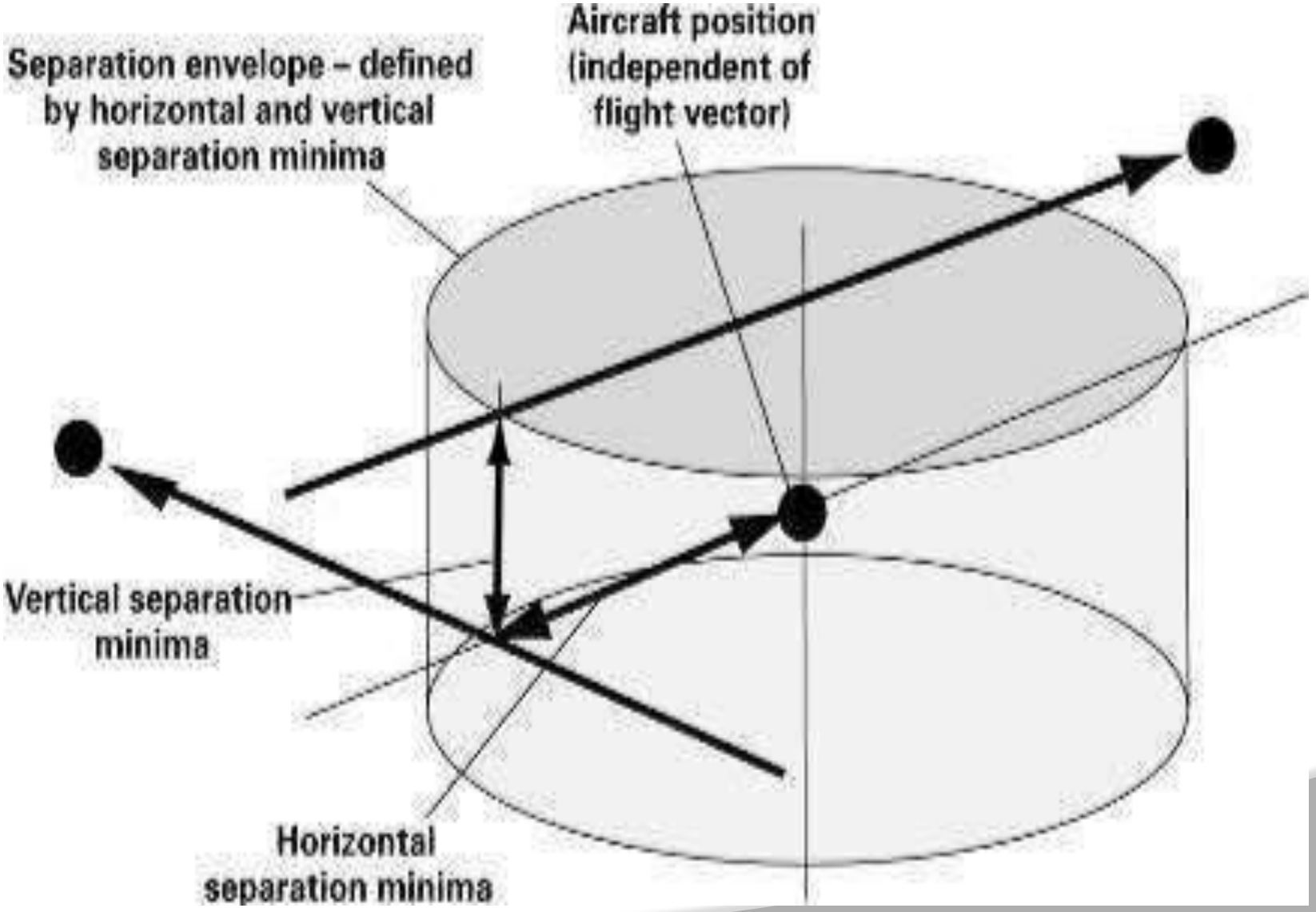


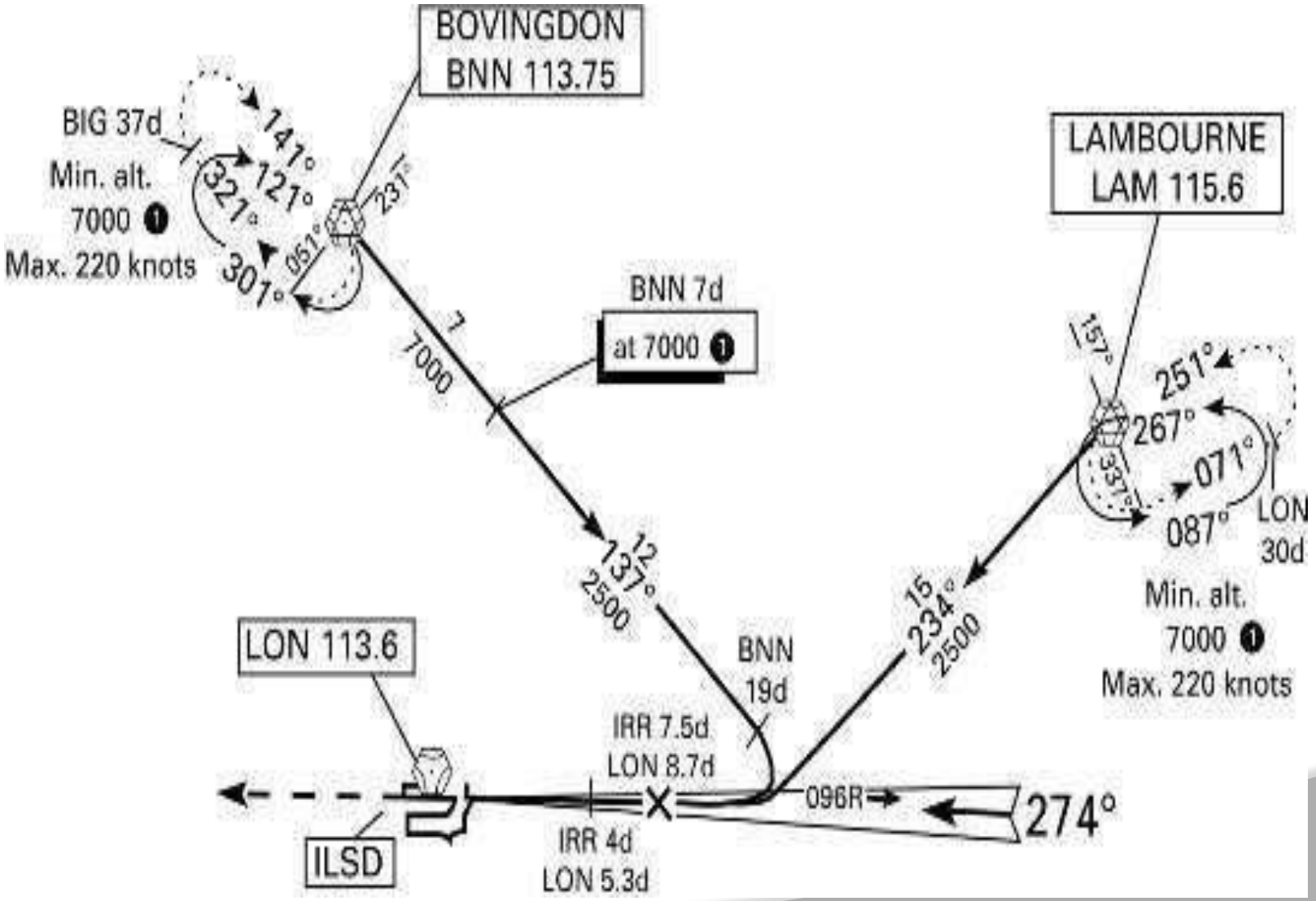
MSL - mean sea level
AGL - above ground level
FL - flight level


FL 600
Airspace Classification
(Not To Scale)
Class A
18,000' MSL
Class B
14,500' MSL
Class E
Class C
1,200' AGL
700' AGL
1,200' AGL
700' AGL
1,200' AGL
700' AGL
Class G
Nontowered airport with instrument approach
Class G
Class G
Class G
Class D
Nontowered airport with no instrument approach
Class A
Class B
Class C
Class D
Class E
Class G
Entry Requirements
ATC clearance
ATC clearance
Prior two-way communications
Prior two-way communications
Prior two-way communications*
Prior two-way communications*

SEPARATION MINIMA

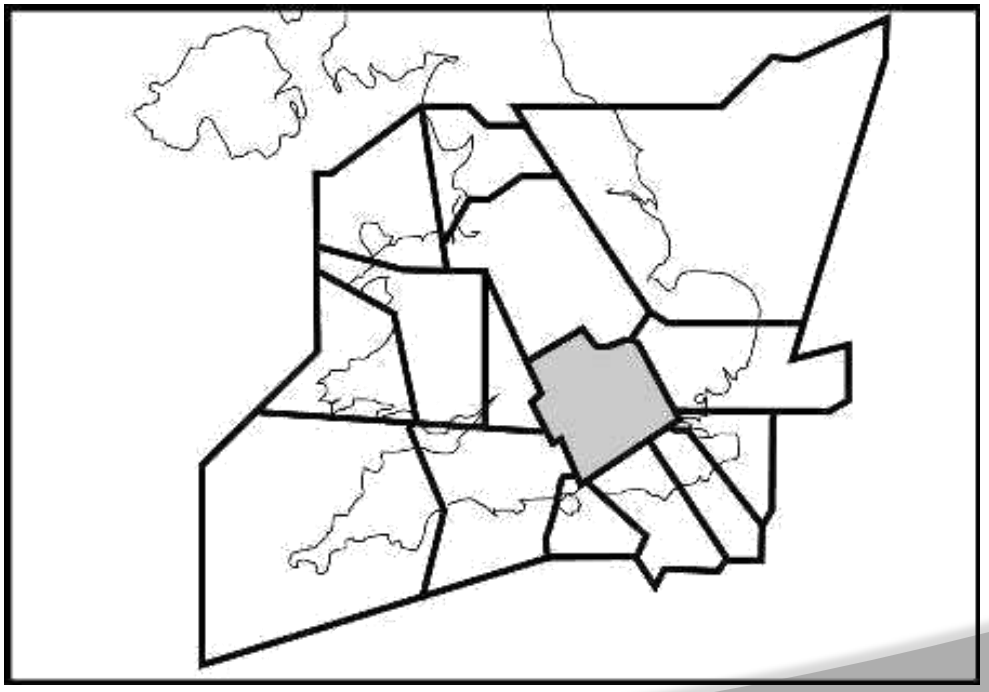
- The concept of separation minima is at the heart of ATC operations.
- The principle is intrinsically simple; there should be a minimum distance between two adjacent aircraft that will never be infringed.
- The minima are expressed as horizontal and vertical separation distances

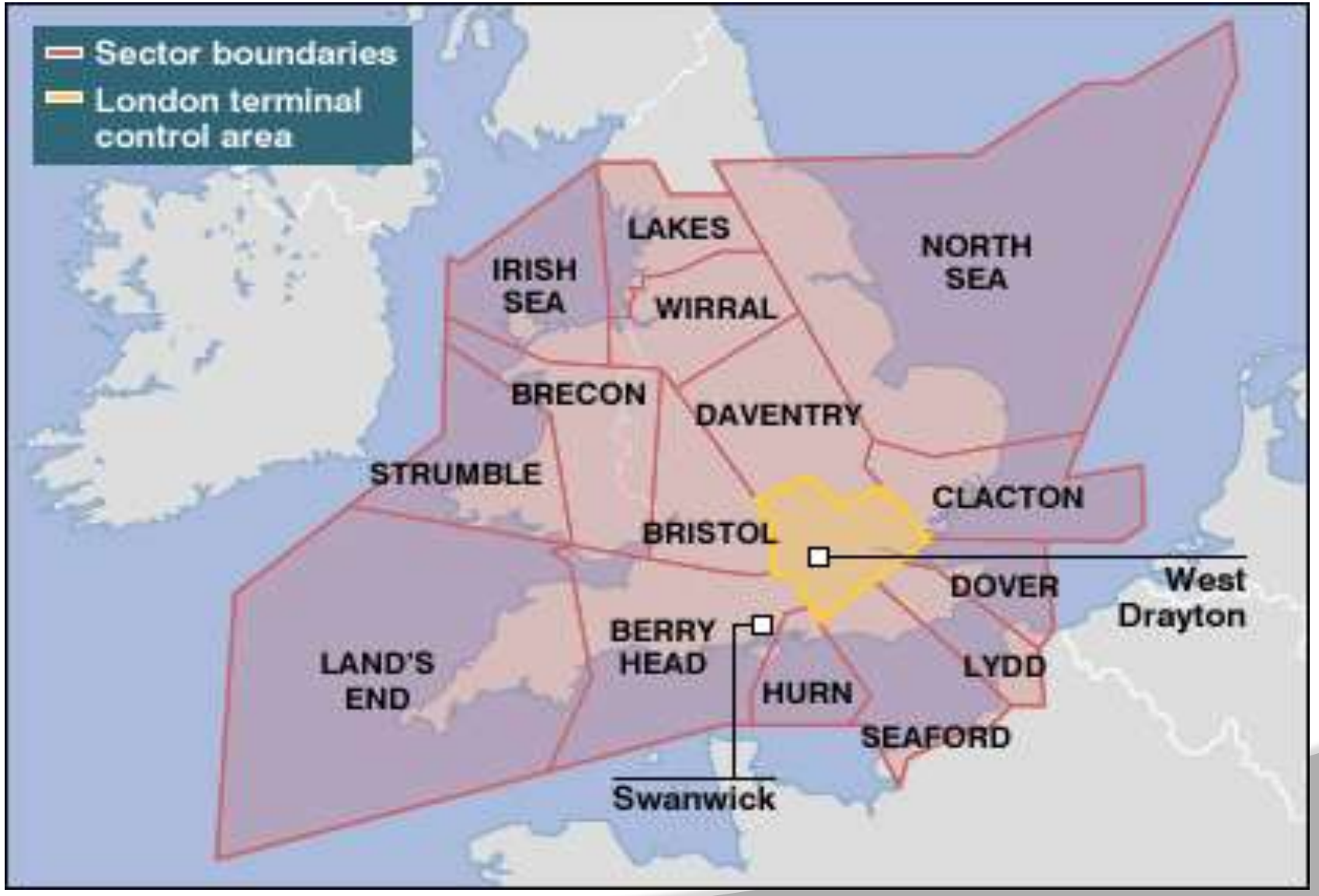

Separation envelope – defined by horizontal and vertical separation minima
Aircraft position (independent of flight vector)
Vertical separation minima
Horizontal separation minima


BOVINGDON
BNN 113.75
BIG 37d
Min. alt.
7000 ❶
Max. 220 knots
141°
121°
321°
301°
051°
231°
BNN 7d
at 7000 ❶
7
7000
LAMBOURNE
LAM 115.6
157°
251°
267°
337°
071°
087°
LON
30d
Min. alt.
7000 ❶
Max. 220 knots
12
137°
2500
15
234°
2500
LON 113.6
BNN
19d
IRR 7.5d
LON 8.7d
096R
274°
IRR 4d
LON 5.3d
ILSD

AIRSPACE SECTORS

- ATC is about vectoring aircraft, and because there is so much decision making involved it is a human based business, so the capacity of the human being to handle more and more aircraft simultaneously is a necessary limit on the capacity of ATC functions

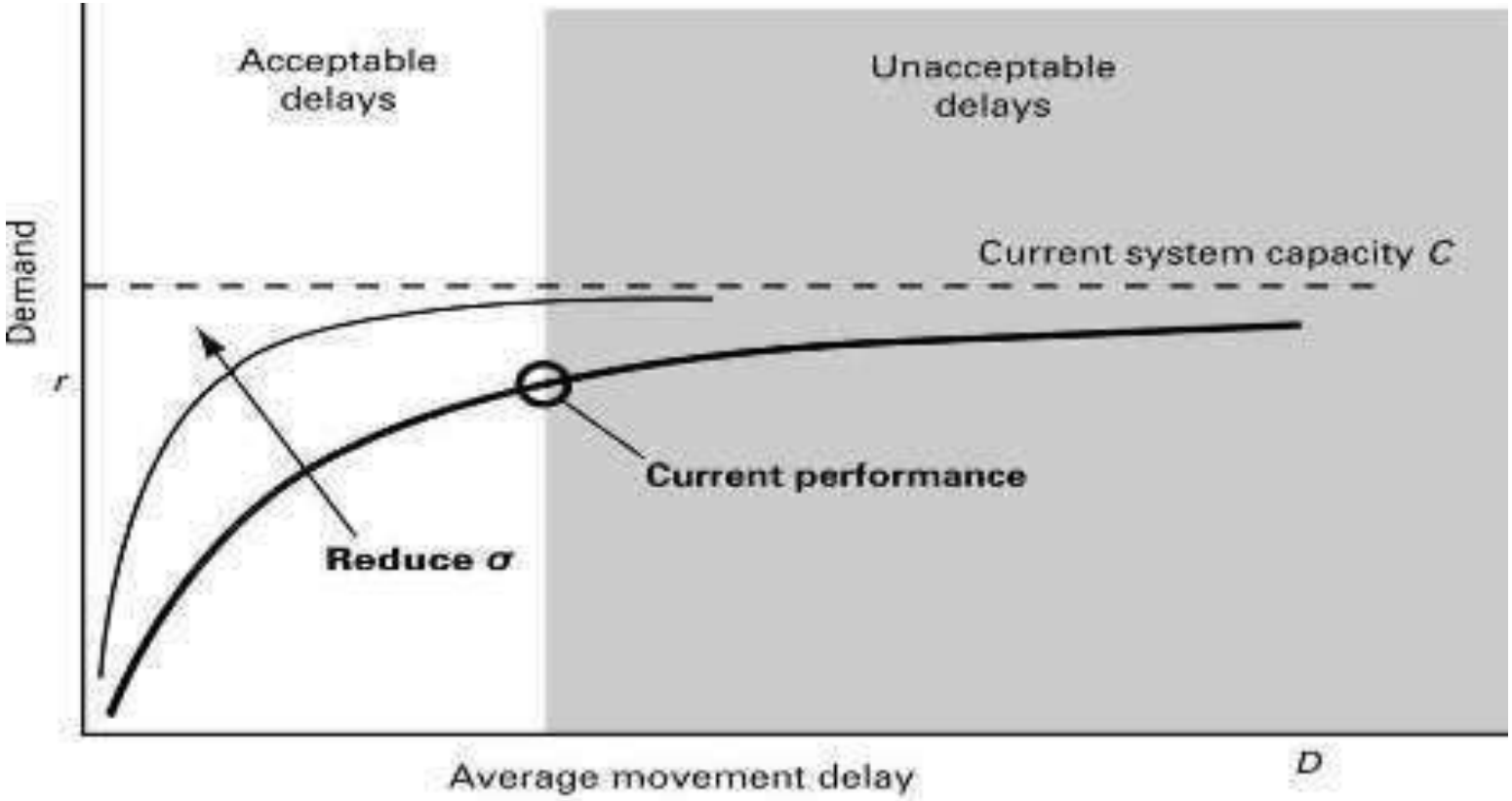



Sector boundaries
London terminal control area
LAKES
IRISH SEA
WIRRAL
NORTH SEA
BRECON
DAVENTRY
STRUMBLE
CLACTON
BRISTOL
DOVER
West Drayton
BERRY HEAD
LAND'S END
LYDD
HURN
SEAFORD
Swanwick

CAPACITY, DEMAND AND DELAY

- The most well-documented tool in the arsenal of ANSPs, when they come to justify choices that balance the desire for orderly and expeditious service within their area of responsibility, is illustrated in a traffic flow diagram, where delay, capacity and demand are all related
- If the demand was perfectly regular (implying that all aircraft were spaced evenly from one another), s = 0, and the delay curve would rise from the origin, proceed straight up the Y axis (i.e. no delay at any demand level) and, as demand reached the capacity level, the line would go horizontally to the right.
- This is a theoretical solution, not least because aircraft (indeed any set of vehicles or individuals in a system) operate at different speeds.

Capacity, demand and delay relationship



$$D = \left(\frac{1}{1-r}\right) + \left(\frac{r\lambda + \lambda\sigma^2}{2}\right), \qquad r = \frac{\text{rate of arrivals } (\lambda)}{\text{system capacity } (C)}$$

where σ = variation in service rate
D = average movement delay

A Brief Chronology Of Air Traffic Control System Evolution

Stage 1: procedural ATC system

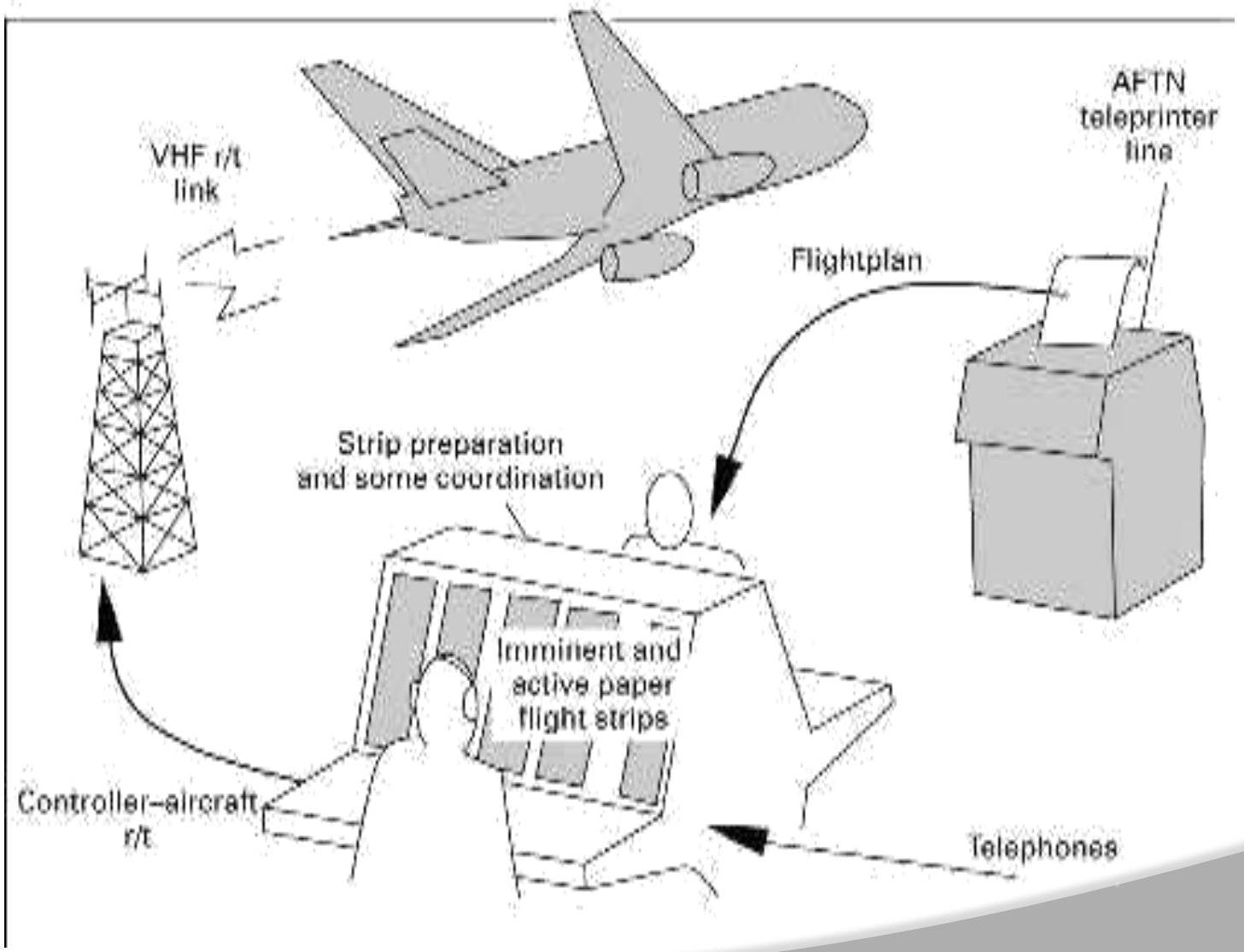
- They require that aircraft file a flight plan a declaration of all relevant flight intentions.
- A telecommunication system to distribute the flight plan to all relevant ATC units
- Paper strips, at the ATC units, on to which flight details are written reporting points‘ over which aircraft report their positions as they fly their routes
- A radio system (invariable radio r/t) to communicate between aircrew and ATC units

- Two issues to appreciate in the human interface display and control

- Display is the function of presenting information in a way that is understandable to the person tasked to make decisions.

- Control is the function whereby decisions having been made, the instructions can be issued.

Schematic diagram of a Stage 1 (procedural) ATC system



Stage 2: procedural ATC with radar assistance

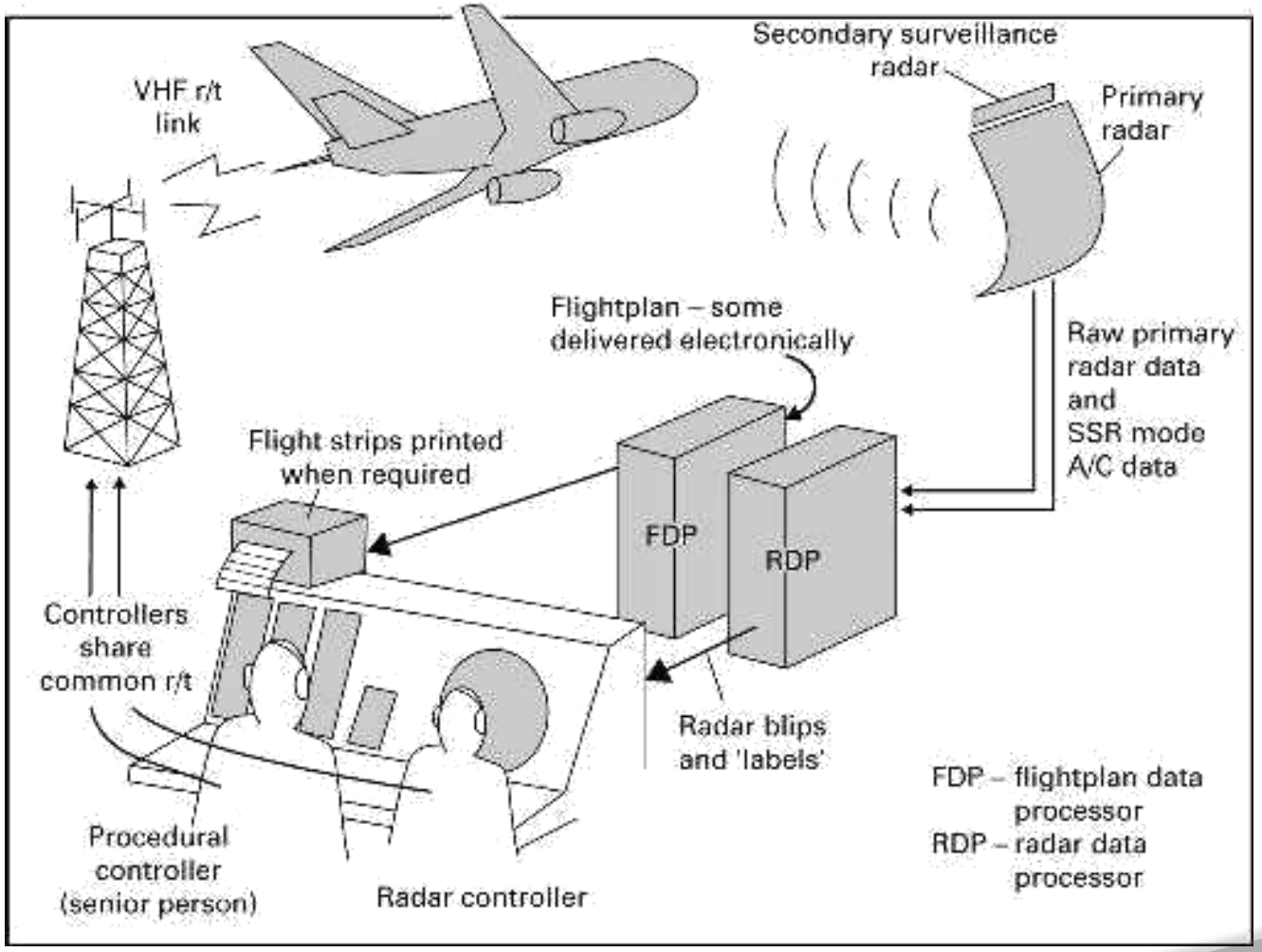
- In the 1960s ATC began to use radar in earnest. Some radar applications had arrived after World War II, with surveillance approach radar (SAR) serving the aerodrome ATC units, which developed the approach‘ function using this system
- The SAR radar was a short-range, relatively narrow field of- view and fast-rotating, radar
- Long-range area radars were located in strategic positions

Stage 3: the first–generation ‘automated’ ATC system

- In the ATCC, radar and computers were combined, creating an installation that was a major leap forward in the way that radar provided real-time surveillance within the ATCC

- Two large computers were usually installed, and their functions were: The flight -data processor (FDP) collected the flight-plan data and kept an up-to-date log of aircraft call signs, the transponder code they were allocated and the route they would fly.

Schematic diagram of a first-generation automated ATC system



CATEGORY 1

- These are operations conducted when the cloud base is not less than 200 ft AAL and the RVR exceeds 600 m.
- These are decision height and visibility minima applicable to a competent aircrew conducting a visual or radar-assisted approach.

CATEGORY 2

- These are operations conducted when the cloud base is not less than 100 ft AAL and the RVR exceeds 300 m.
- These are decision height and visibility minima applicable to a competent aircrew conducting a visual or radar-assisted approach, with flight-director assistance, or a Category 2 cleared automatic flight control system.
- A go-around (missed approach) can be instigated at down to 100 ft in height.

CATEGORY 3

- These are operations conducted when the cloud base is below 100 ft AAL and the RVR is less than 300 m.
- There are three weather minima subsets in this category:

- Category 3a: 100 ft maximum cloud base/300 m maximum RVR

- Category 3b: zero ft decision height/75 m maximum RVR

- Category 3c: zero ft decision height and zero m RVR – total fog.