AIRCRAFT CHARACTERISTICS & IMPORTANT AERONAUTICAL TERMS

Module 02

Airport Engineering

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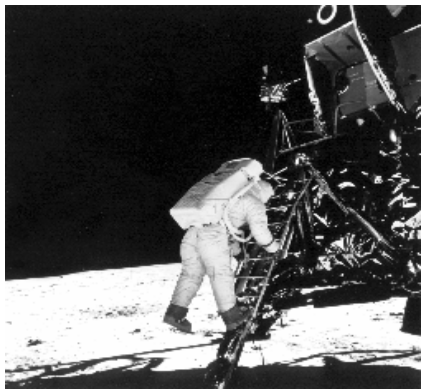
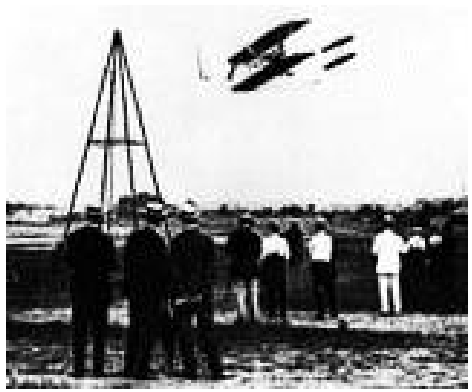
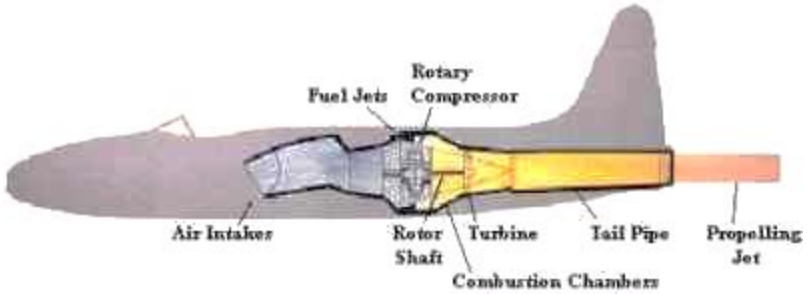
Airport Engineering – Introduction

- 1492 - Leonardo da Vinci theorize about flying machines
- 1783 - Montgolfier brothers invent first hot air balloons
- 1903, 17 Dec , first air machine flown by Oliver Wright
- 1907 - Very first helicopter - unsuccessful design
- 1910 - first civilian commercial flight in Britain
- 1940 - Modern helicopters invented
- 1947 - First supersonic jet flight
- 1969 - First manned mission (Apollo) to Moon







Introduction

- B-747-400D has a seating capacity of 660 passengers
- Airbus can accommodate 853 people in all-economy class configurations
- Concorde had a speed of 2.2 Mach (about 2140 kmph)
- Altitudes reach to 45000 ft
- Singapore Airlines Flight 21 is the longest regularly scheduled non-stop flight covering 9,534 miles (15,343 km) miles in about 18.5 hours flight time

Airport Engineering – Definition

The planning, design, construction, and operation and maintenance of facilities provided for landing, takeoff, loading, unloading, service, maintenance, and storage of aircraft

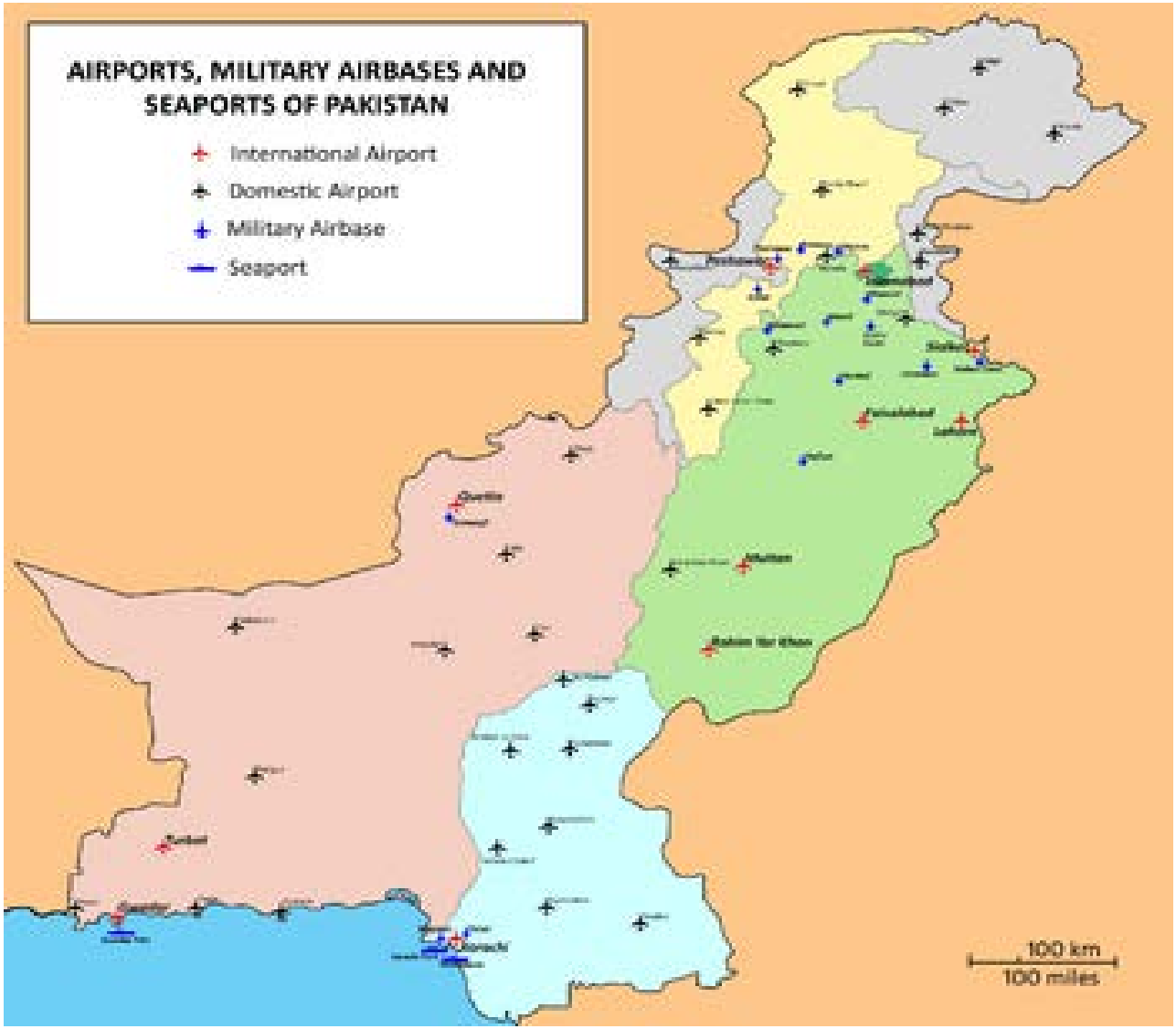
- **Civil Engineer:** **Concerned with airports and allied facilities right from feasibility study to maintenance, renovation and extension**
- **Transportation Engineer:** **His concern is much more. He should also possess sufficient knowledge of air traffic and airport elements affecting air traffic**

Aviation Organizations

- **International Organizations**
  - International Civil Aviation Organization (ICAO)
  - International Air Transport Association (IATA)
- **USA Federal Organizations**
  - Federal Aviation Administration (FAA)
  - Civil Aeronautics Board (CAB)
  - National Transport Safety Board (NTSB)
- **Civil Aviation Authority (CAA)**

- This page lists the civil airports, military airbases and small airports inPakistan. There are an estimated 139 airfields in Pakistan.[1] The largest airport in Pakistan is Jinnah International Airport, Karachi, which can handle 42 aircraft at a time and has 16 passenger gates. It handles 6 million passengers annually and has a capacity of handling 12 million passengers annually. In addition, the international airports at Lahore, Islamabad, Peshawar and Quetta are also major civil airports handling the majority of domestic and international civil aviation traffic in Pakistan.

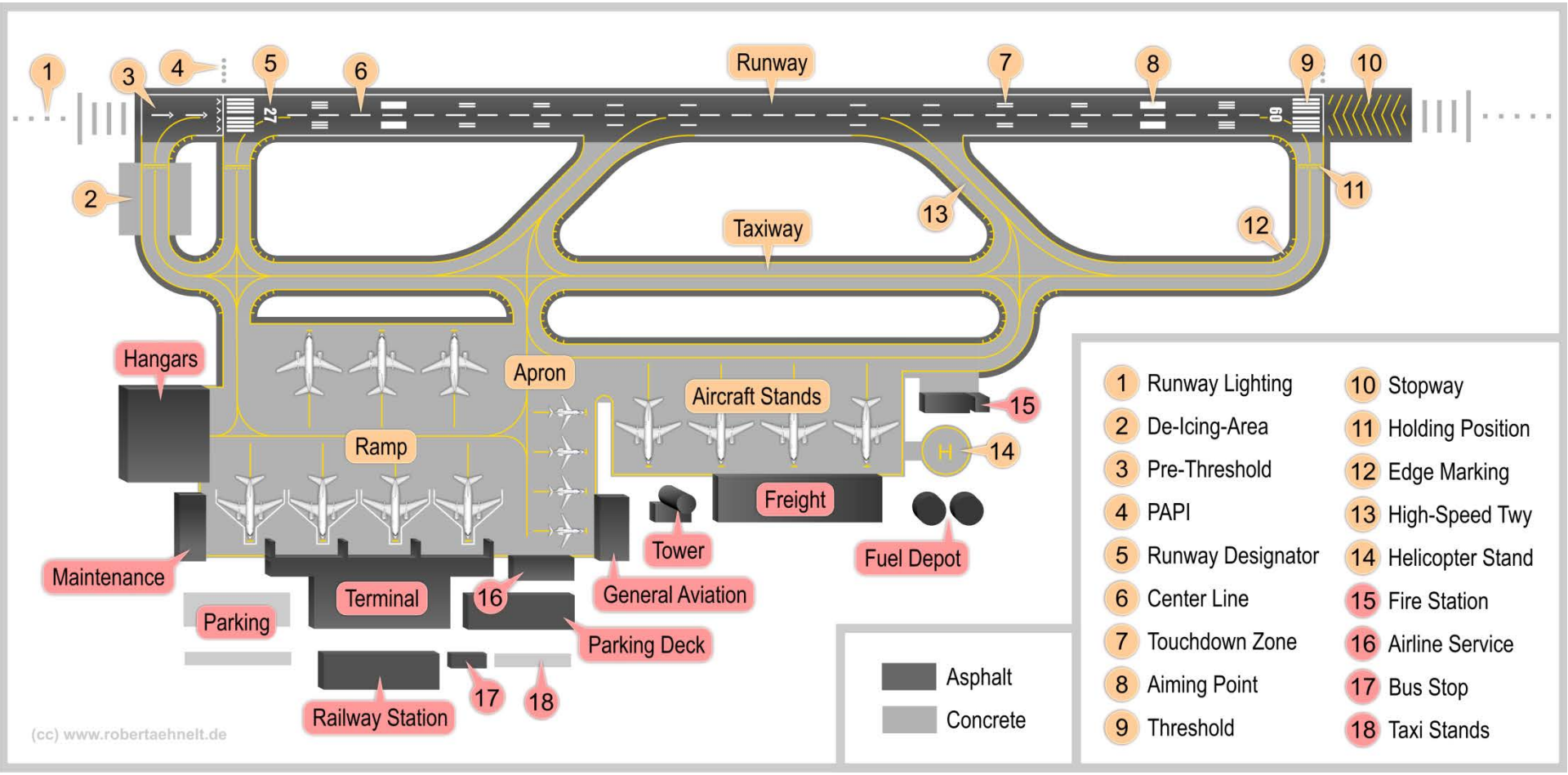
- All civil airports in Pakistan are operated by the Pakistan Civil Aviation Authority, with the exception of Sialkot International Airport, which is the first private airport in Pakistan and South Asia open to domestic and international civil aviation. It is owned and operated by the Sialkot Chamber of Commerce & Industry. All military airbases in Pakistan are operated by the Pakistan Air Force, with the exception of Dhamial Army Aviation Airbase in Rawalpindi and Tarbela Army Aviation Airbase, which are operated by the Pakistan Army.


AIRPORTS, MILITARY AIRBASES AND SEAPORTS OF PAKISTAN
International Airport
Domestic Airport
Military Airbase
Seaport
100 km
100 miles

AIRPORT COMPONENTS

DEFINITIONS

Airport Components



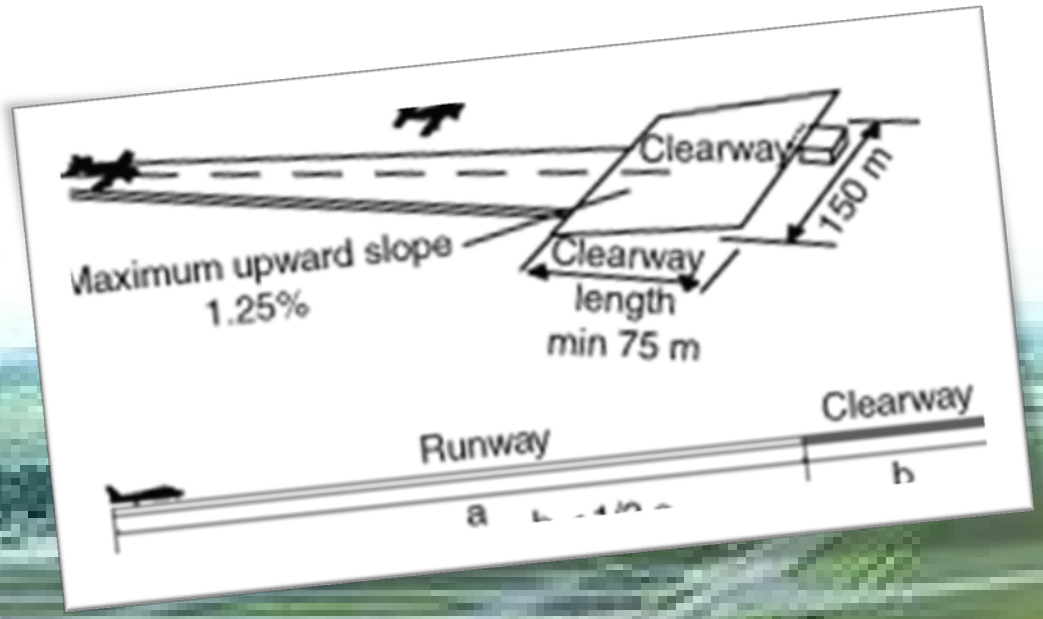
PAPI= Precision approach path finder

Definitions

- **Aerodrome.** Defined area on land or water (including buildings, installations, and equipment) intended to be used either wholly or in part for arrival, departure and surface movement of aircraft
- **Aeroplane Reference Field Length.** Minimum field length required for takeoff at maximum certified takeoff mass, sea level, standard atmospheric conditions, still air and zero runway slope
- **Apron/Ramp.** A defined area, on a land aerodrome, intended to accommodate aircraft for purpose of loading or unloading passenger, mail or cargo, fuelling, parking or maintenance

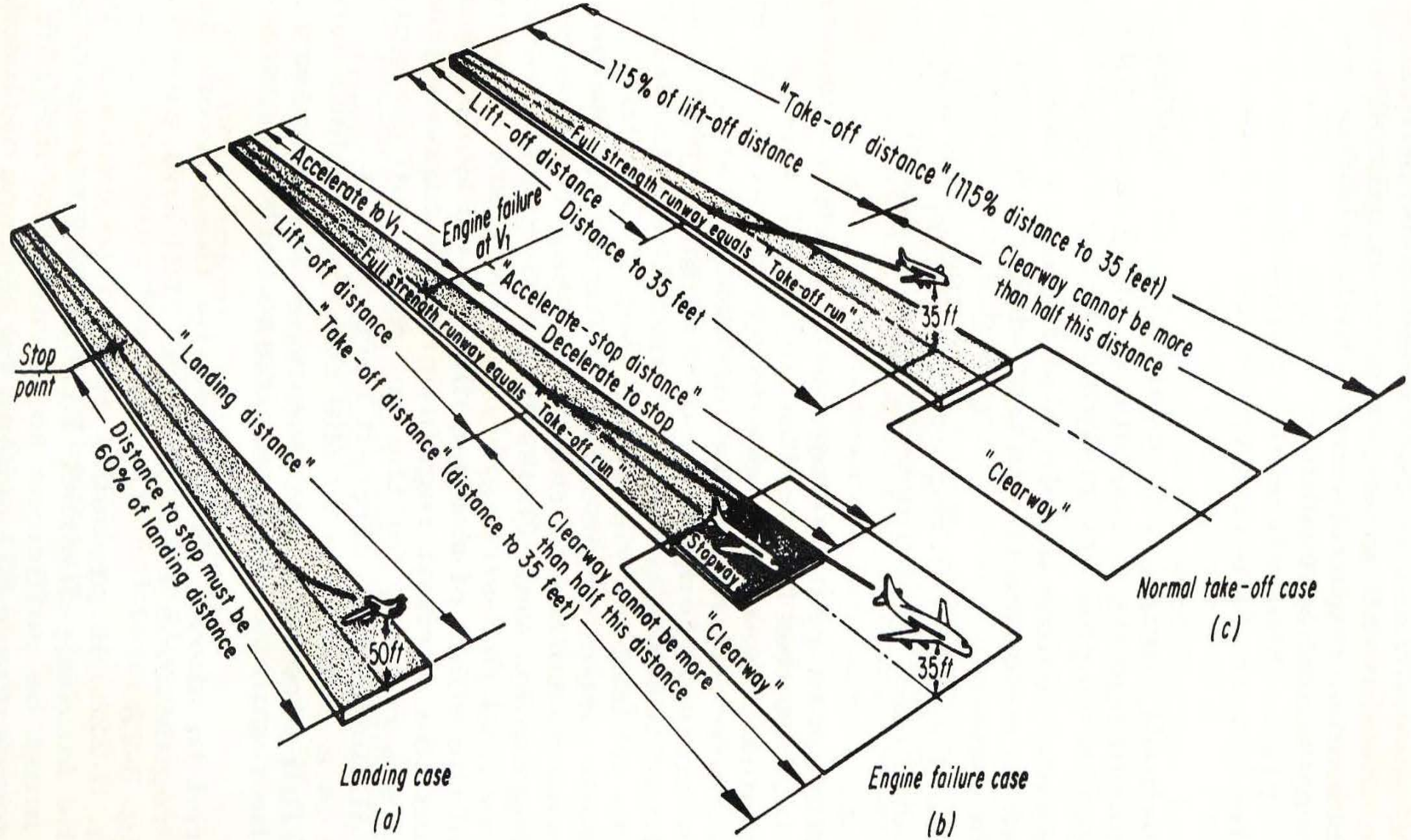
- **Aircraft Stand.** A designated area on an apron intended to be used for parking of an aircraft
- **Clearway.** A defined rectangular area on ground or water under the control of appropriate authority selected or prepared as a suitable area over which an aero-plane may make a portion of its initial climb to a specified height
- **Runway.** A defined rectangular area on a land aerodrome prepared for a landing and take-off of an aircraft
- **Runway Strip.** A defined area including the runway and stop way if provided intended to reduce the risk of damage to aircraft running off a runway and to protect once flying over it during landing or take-off

- **Taxiway.** Defined path on land aerodrome established for taxiing of aircraft and intended to provide a link between one part of an aerodrome to another
- **Taxiway Strip.** An area including a taxiway intended to protect an aircraft operating on a taxiway and to reduce the risk of damage to an aircraft accidentally running off the taxiway
- **Threshold.** The beginning of that portion of runway useable for landing
- **Touchdown Zone.** The portion of runway beyond the threshold where it is intended that the landing aeroplanes first contact the runway
- **Primary Runway.** Runway or runways used in preference to others whenever conditions permit


Clearway
150 m
Maximum upward slope
1.25%
Clearway
length
min 75 m
Clearway
Runway
a
b

Declared Distances

- **Takeoff Run Available (TORA).** The length of the runway declared available and suitable for ground run of an aeroplane taking off
- **Taking off Distance Available (TODA).** The distance of TORA plus the clearway provided
- **Accelerate -Stop Distance Available (ASDA).** The length of TORA plus the length of stop way if provided
- **Landing Distance Available (LDA).** The length of runway which is declared available and suitable for the ground runs of aeroplane landing



Stopway - At least as wide as runway: Must support airplane without damage in aborted take-off.

Clearway - Minimum 500 ft wide: No higher than end of runway, clear of fixed obstacles, and under airport control.

Aerodrome Data

- **Location.** A place where an airport is located.
- **Aerodrome Reference Point.** Designated geographical location of an aerodrome is called Aerodrome Reference Point. It is mentioned in degrees, minutes and seconds in world geodetic system
- **Aerodrome Elevation.** Elevation of the highest point of the landing area with reference to mean sea level
- **Aerodrome Reference Temperature.** It is mentioned in degrees Celsius i.e. CO which is the monthly mean of daily maximum temperatures for the hottest month of the year, averaged over a period of many years

Weight

- It has a direct bearing on thickness of runway, taxiway and apron pavements
- Also affects the length of runway but not valid to assume large heavy aircraft reqs longer runway length

Components of Aircraft Weight

- **Operating Empty Weight (OEW).** Basic ac weight, crew and nec gear weights (excl payload and fuel)
- **Zero Fuel Weight (ZFW)** weight above which all additional weight must be of fuel
- **Max Structural Pay Load (MSPL)** is certified load ac can carry
  - MSPL = ZFW - OEW
  - PL < MSPL

- **Pay Load (PL)** is total revenue-producing load and includes weight of mail, cargo and passengers and their baggage
- **Max Ramp Weight (MRW)** max weight authorized for ground maneuvers including taxi and run up fuel weight
- **Max Structural Take Off Weight (MSTOW)** Weight at brake release for takeoff. It includes taxi and run up fuel and includes OEW, trip and reserve fuel and PL
- **Max Structural Landing Weight (MSLW)** structural capability of aircraft at landing
- **On Landing Weight** of an aircraft is the sum of operating empty weight, the pay load, and fuel reserve. The landing weight can not exceed the maximum structural landing weight of the air craft
- **Total Aircraft Weight** = OEW + PL + Trip Fuel + Res Fuel

Components of Aircraft Weight

OPERATING EMPTY WEIGHT (OEW) includes aircraft, crew and necessary gear weights. **(Not constant and may vary with seating configuration)**

PAY LOAD (PL) is revenue producing load and includes weight of mail cargo and passengers. Less than MAXIMUM STRUCTURAL PAY LOAD (MSPL), the load aircraft is certified to carry

FUEL WEIGHT

ZERO FUEL WEIGHT (ZFW), weight above which all is weight of fuel

RESERVE

TRIP

TAXIING

MAXIMUM RAMP WEIGHT(MRW) maximum weight authorized for ground manoeuvres

MAXIMUM STRUCTURAL TAKE OFF WEIGHT (MSTOW) Weight at brake release authorized at takeoff

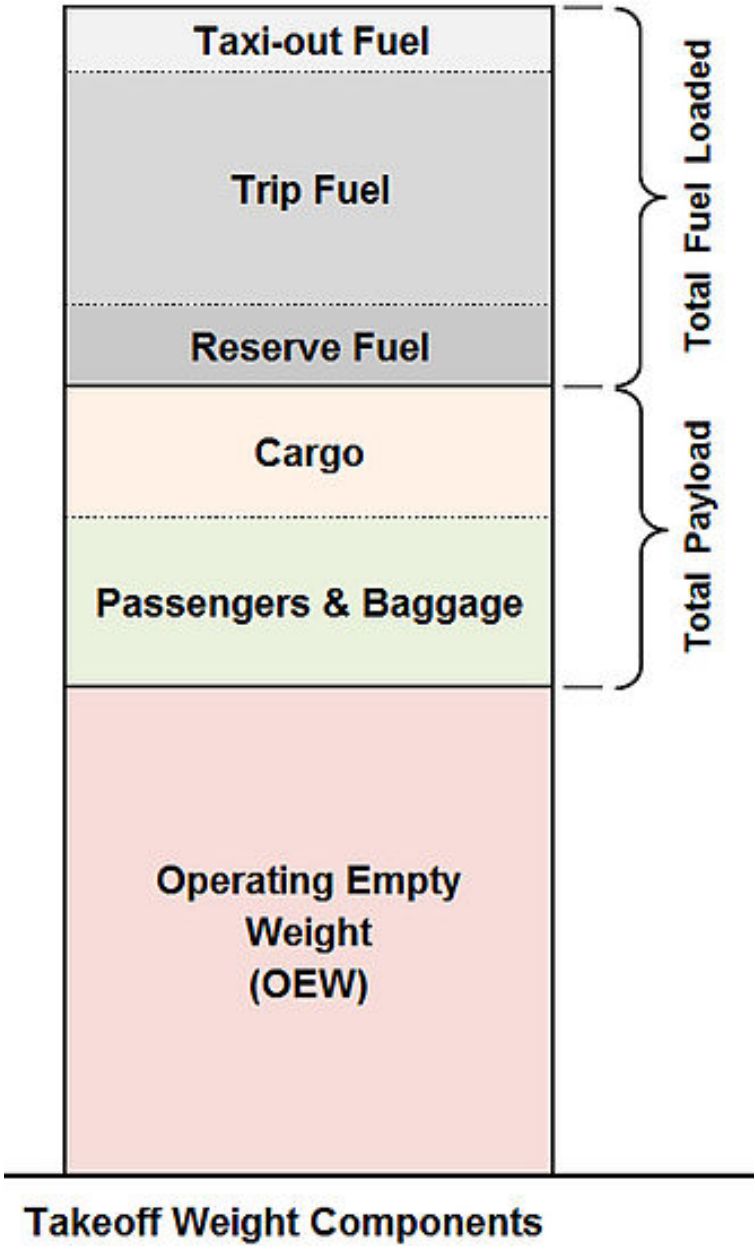
MAXIMUM STRUCTURAL LANDING WEIGHT(MSLW), structural capability of aircraft at landing.

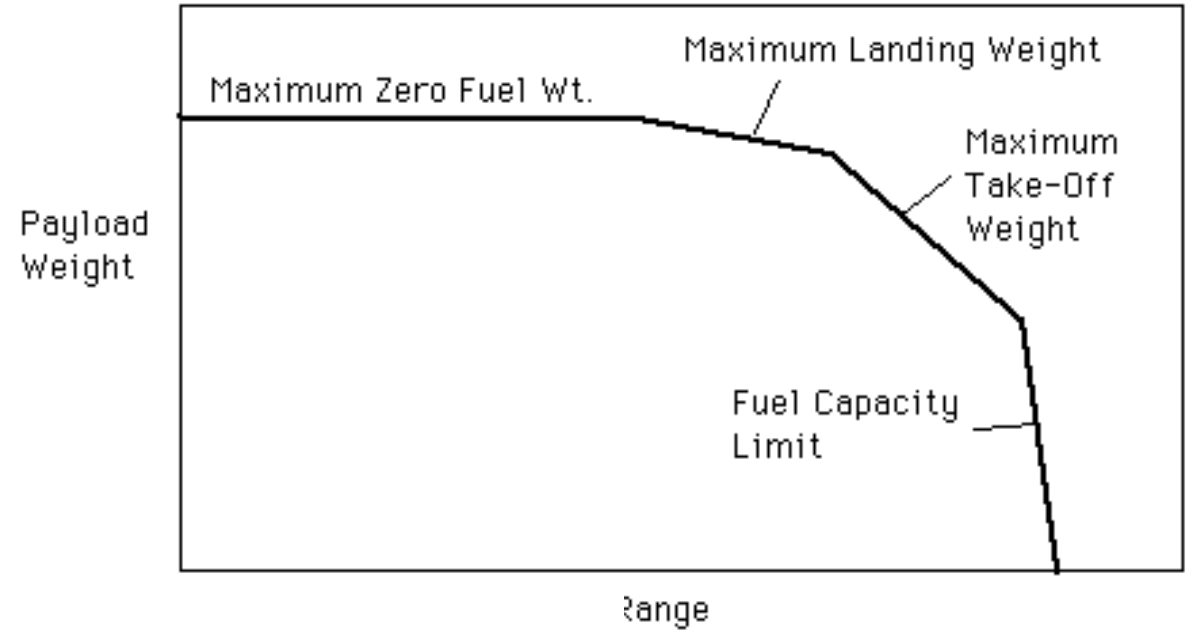
http://www.wikihow.com/Calculate-Aircraft-Payload

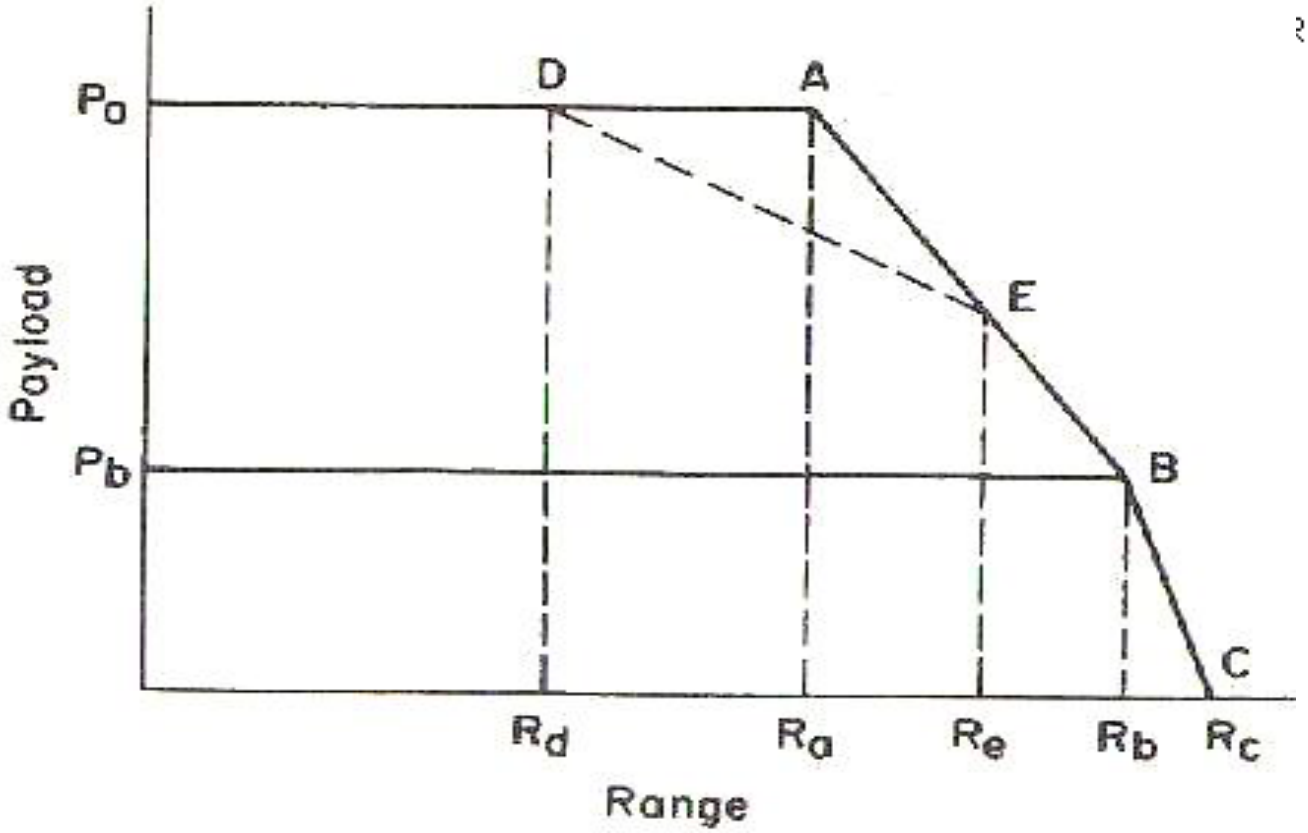
- **Trip Fuel:** Depends on distance to travel, speed, met conditions, altitude and pay load
- **Res Fuel:** Depends on distance to alternative airport, amount of waiting time to land and length of trips
- **Range:**
  - The distance an aircraft can fly without refueling
  - Factor affecting range are pay load, meteorological conditions during flight, speed , fuel, wind, flight altitude and amount of reserve fuel.
  - If pay load is increase range is decrease
- **Passenger & their baggage load** is usually taken as 200 lbs units for computing pay load

Payload and Range Relationship

- Distance to which aircraft can fly is referred as Range
- Main factor influencing range is pay load; revenue producing load
- Other factors are route, altitude, speed, wind and reserve fuel
- Normally the range is increased by decreasing pay load with the weight trade off occurring between the fuel to fly to destination and the payload which can be carried



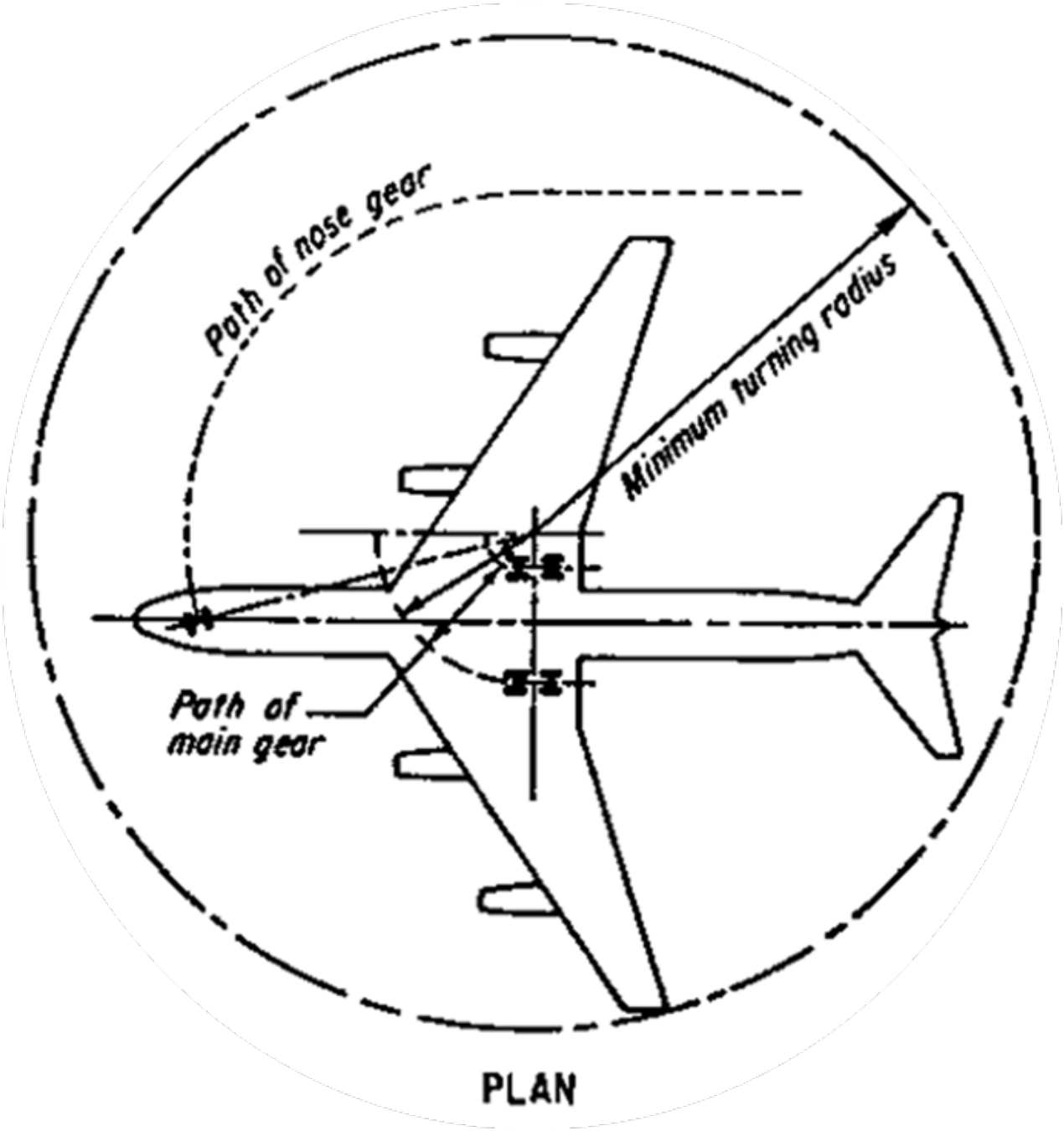

Maximum Landing Weight
Maximum Zero Fuel Wt.
Maximum
Take-Off
Weight
Payload
Weight
Fuel Capacity
Limit
Range


D
A
P_o
E
Payload
P_b
B
C
R_d
R_a
R_e
R_b
R_c
Range

- **Point A** represents the range R_a to which an aircraft can fly with max payload P_a. Aircraft takes off at MSTOW
- **Point B** represents the max range R_b to which an aircraft can fly but payload is to be reduced to P_b so that the aircraft takes off at MSTOW
  - To extend the distance of travel from R_a to R_b the payload has to be reduced in favour of adding more fuel
- **Point C** represents the max distance that an aircraft can fly w/o any payload. Sometimes this is referred to as ferry range, and it is used for delivery of aircraft
  - To travel for a distance R_c, maximum amount of fuel is necessary, but since there is no payload, the takeoff weight is less than maximum
- In some cases the maximum structural landing weight may dictate how long an aircraft can fly with a maximum structural payload
- If this is the case, line DE represents the trade off between payload and range; curve would then follow line DEBC instead of ABC
- The actual payload, particularly in passenger aircraft, is normally less than the maximum structural payload even when the aircraft is completely full. This is due to the limitation in the use of space when passengers are carried

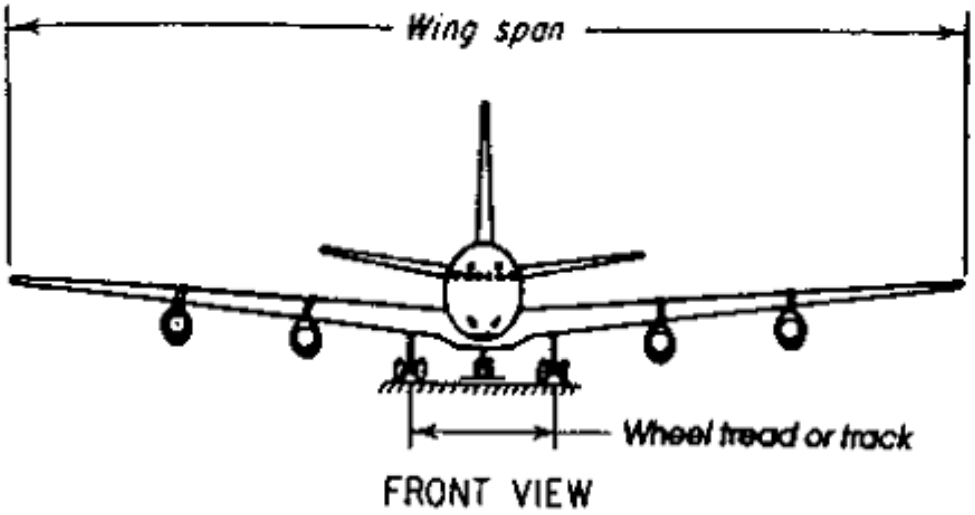
Minimum Turning radius:

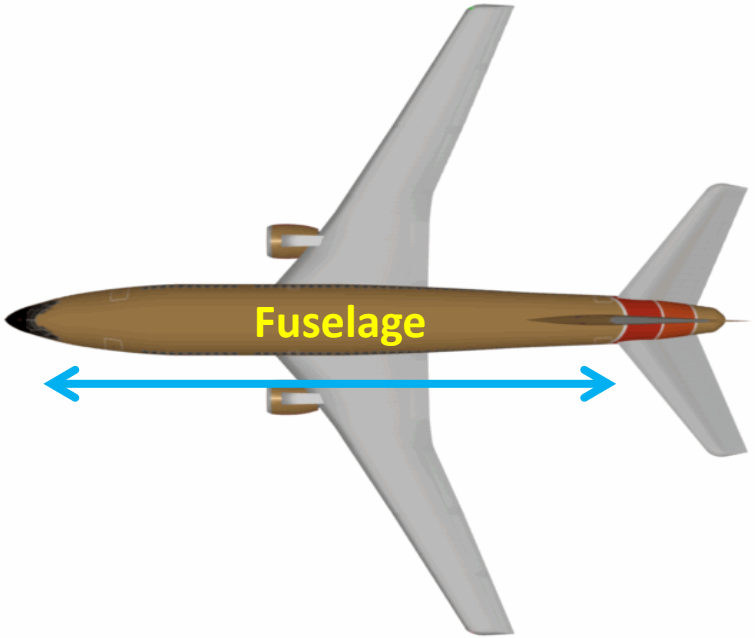
- It is a function of nose gear steering angle
- Larger the angle smaller the radii
- Larger radii is the most critical from the standpoint of clearance to buildings or other aircrafts
- Max steering angles vary from 60 to 80 deg, however lesser steering angle on the order of 50 deg are recommended to prevent excessive wear of tires or scuffing of pavement surfaces
- Knowledge is necessary to determine aircraft position near the terminal building and geometry of movement paths elsewhere
- Minimum turning radius of aircraft helps to decide the radius of taxiway and position of hangers and apron


Path of nose gear
Minimum turning radius
Path of main gear
PLAN

Wing Span and Fuselage Length

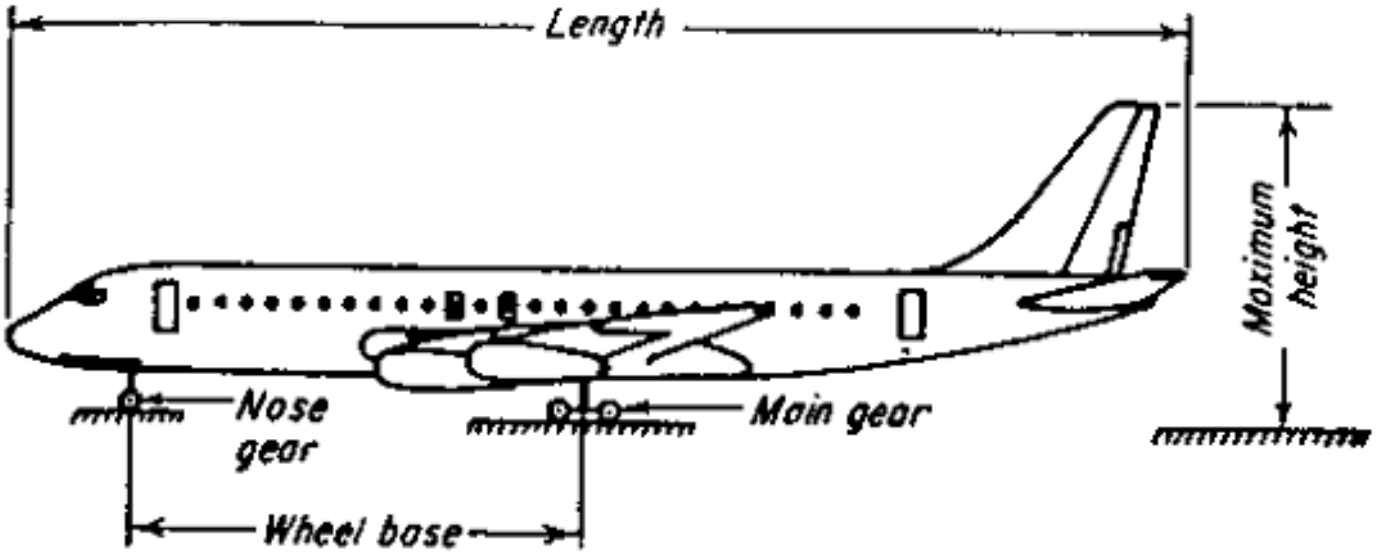
- It is a general function of aircraft weight
- It has a bearing on gate size in aircraft stand, configuration of terminal building, width of taxiways and runways, distance between traffic ways, turning radius on curves etc.
- Instead of increase in fuselage length, multi deck are being preferred





Static Weight on Main and Nose Gear

- Depends on type of aircraft and location of centre of gravity which is also variable because of loading and continuous changes in fuel. Hence the distribution is not constant
- 5% is considered on nose gear and rest equally distributed on all tyres of landing gear. Weight is utilized in pavement and drainage structures design.



SIDE VIEW

Passenger Capacity

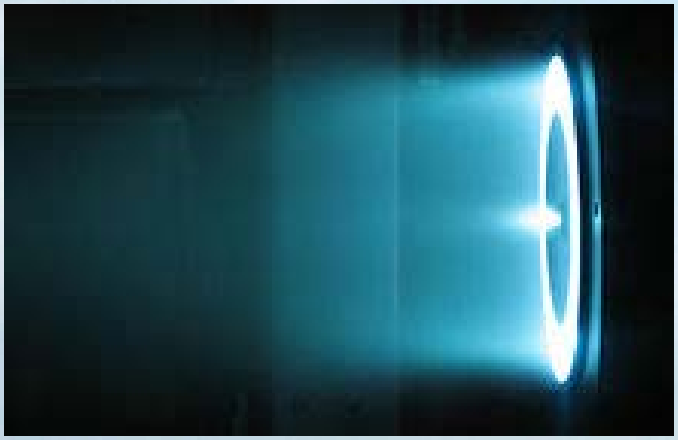
- This has a direct bearing on facilities to be provided on land and airside on airports

Length of Runway

- It increases the area to be acquired if not already done in initial stages. The increase is not in runway length only but in all allied requirements and linked structures

Jet blast

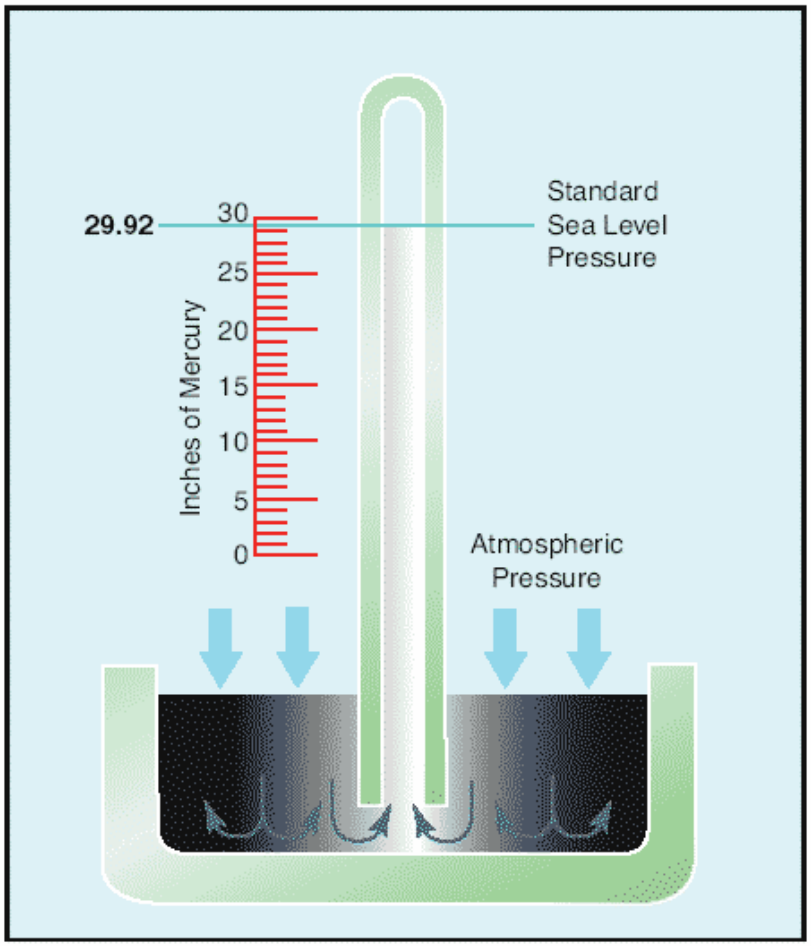
- Turbojet and turboprop aircraft eject hot exhaust gases at high velocities
- Velocity of jet blast is 300 km.p.h thus cause inconvenience to passengers
- Various type of blast fences are use to serve an effective measure for diverting the smoke ejected from blast
- Cement concrete pavement are provided to reduce the effect of jet blast



Take off & Landing Distance

- Take off and landing distance for an aircraft helps in determine minimum runway length
- Distance depends on
  - Altitude of the airport
  - gradient of the runway
  - intensity and direction of wind
  - temperature
  - weight of the aircraft at the time of landing and take off

Tyre pressure and contact area



IMPORTANT AERONAUTICAL TERMS

Standard Atmosphere

- A fictitious atmosphere, representing average conditions found in actual atmosphere in a particular geographic region
- Most commonly used is the one proposed by ICAO
  - from sea level to an altitude of about 36,000 ft (Troposphere) the temp decreases linearly
  - Above 36,000 ft to 65,000 ft, temp remains constant, jet aircrafts fly from 36000’ to 40000 Ft
  - above 65,000 ft (Stratosphere), temperature rises
- Standard Atmosphere is: -
  - Temperature at sea level is 59°F
  - The pressure at sea level is 29.92126 in Hg
  - Temperature gradient from sea level to the altitude at which the temperature becomes - 69.7°F is 0.003566°F/ft

Pressure Altitude

- altitude corresponding to pressure of standard atmosphere
- if the atmospheric pressure is 29.92 inches of Hg, the pressure altitude is zero
- If atmospheric pressure drops to 28.86 inches of Hg, pressure altitude is 1000 ft
- If low pressure occurs at sea-level airport, the geographic altitude would be zero but pressure altitude would be 1000 ft
- For airport planning purposes, it is satisfactory to assume that the geographic and pressure altitudes are equal unless the barometric pressures at a particular site are unusually low a great deal of the time

Aircraft Speed

- The pilot obtains the speed from an airspeed indicator, which works by comparing the dynamic air pressure due to the forward motion of the aircraft with the static atmospheric pressure having specific density
- A nautical mile is 6080 ft and is equal to 1 minute of arc of the earth's circumference. 1 knot is 1 nmi/h; a nautical mile is approximately 1.15 statute miles
- ground speed is the speed of aircraft relative to the ground
- True airspeed is the speed of an aircraft relative to the medium in which it is travelling
- Reference is made to two airspeeds, namely, True Air Speed (TAS) and Indicated Air Speed (IAS)

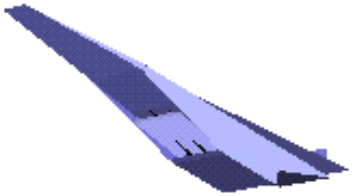
- At high altitudes the density becomes smaller, and thus the IAS is less than the TAS
- As a very rough guide, one can add 2 percent to the IAS for each 1000’ above sea level to obtain TAS
- With the introduction of jet transports the reference datum for speed is often the speed of sound
- Speed of an aircraft is quoted as in terms of TAS
- speed of sound is defined as mach


F/A-18 Sonic Boom

Mach Number

Glenn Research Center

$$\text{ratio} = \frac{\text{Object Speed}}{\text{Speed of Sound}} = \text{Mach Number}$$



Hypersonic
Mach > 5.0

Supersonic
Mach > 1.0

Transonic
Mach = 1.0

Subsonic
Mach < 1.0

http://www.grc.nasa.gov/WWW/k12/airplane/mach.html

Strength of Pavements

- Standard procedures to determine Aircraft Classification Number (ACN) and Pavement Classification Number (PCN) and are laid down in ICAO design manual
- The ACN-PCN method is intended for aircrafts having ramp weight greater than 5700 kg
- An aircraft with an ACN equal to or less than PCN can operate on airport pavement with maximum takeoff weight
- There may be different PCNs if strength of pavement is subject to significant seasonal variation
- **ACN. A number expressing the relative effect of an aircraft on a pavement for a specified standard sub grade category**

ACN for selected aircraft for high subgrade strength				
Aircraft	Max takeoff weight (lbs)	Tyre pressure lbs/in^2	ACN Rigid	ACN Flexible
Airbus A300-B2	313,000	179	37	40
Boeing 737-200	111,000	148	27	25

- **PCN. A number expressing the bearing strength of a pavement for un restricted operations**
  - **Example-I. PCN 80/R/B/W/T means bearing strength of the rigid pavement resting on a medium strength sub grade has been assessed by technical evaluation to be PCN 80 and there is no tyre pressure limitation.**
  - **Example-2. PCN 40/F/B/0.08 MPa/T means bearing strength of flexible pavement, resting on a medium strength sub grade, has been assessed by technical evaluation to be PCN 40 and maximum allowable tyre pressure is 0.80MPa.**
  - **(conversion mega Pascal to pound-force per square inch 145.038 and newton to pounds-force is 0.224809)**

Pavement type codes	
Rigid pavement	R
Flexible pavement	F

Subgrade strength category codes		*Characterized by
	Flexible	Rigid	
High strength	*CBR= 15	*K= 150 MN/m^3	A
	CBR> 13	K> 120 MN/m^3	
Medium strength	*CBR= 10	*K= 80 MN/m^3	B
	CBR from 8 to 13	K from 60 to 120 MN/m^3	
Low strength	*CBR= 6	*K= 40 MN/m^3	C
	CBR from 4 to 8	K from 25 to 60 MN/m^3	
Ultra low strength	*CBR= 3	*K= 20 MN/m^3	D
	CBR < 4	K < 25 MN/m^3	

Maximum allowable tyre pressure category	
High, no pressure limit	W
Medium, pressure limited to 1.50 MPa	X
Low, pressure limited to 1.00 MPa	Y
Very low, pressure limited to 0.50 Mpa	Z

Evaluation method	
Technical evaluation	T
Using aircraft experience	U


QUESTIONS