Runway Engineering

- Runway Engineering includes planning and design of airports
- Planning
  - Airport Master Plan (Airport Layout/ Location)
  - Airport Configuration
  - Air traffic control
  - Air Travel Demand Forecasting
  - Airfield Capacity (Runway, Taxiway and Apron)
  - Terminal Capacity (Arrival and departure)
  - Airport Environmental and Noise issues

Runway Engineering

- Design
  - Aircraft characteristics
  - Structural design airport pavements (runway, taxiway and apron)
  - Geometric design of Airfield
  - Airport lighting, marking and Drainage

Brief Historic Perspective

- 1903- Wright Brothers first flight in North Carolina (120 ft)
- 1914- Air passenger transport began in Germany
- 1918- First International service between France and Spain
- 1918- US postal service (Washington DC and New York)
- 1927- Service between London and New York
- 1927- Pan American Service Miami-La Havana (Cuba)

Brief Historic Perspective

- 1950s – Introduction of Jet Engines
- 1960s (late) – Introduction of Boeing 747
- 1990 – Commercial airlines world wide carried more than 1.0 billions passengers

Regulatory Authorities

- International Civil Aviation Organization (ICAO)
- International Air Transport Association (IATA)
- US Federal Aviation Administration (FAA)
- Pakistan Civil Aviation Authority (CAA)

International Civil Aviation Organization

- Inter-governmental organization formed in 1947 as specialized agency of United Nation (Headquater: Montreal, Canada)
- Objectives
  - Safe and orderly growth of air travel around the world.
  - Aircraft design and operation for peaceful purpose
  - Development of airways, airport and air navigational facilities
  - Requirement for safe, regular, efficient and economic travel
  - Prevent uneconomic waste by unreasonable competition

International Civil Aviation Organization (ICAO)

- Provides opportunity to all countries to operate internationally
- Avoid discrimination between member countries
- Meets every three years to review organization working and set future goals

International Air Transport Association (IATA)

- International organization founded in 1919.
  - To promote safe, regular and economic air transport.
  - To foster air commerce and study the problems connected therewith.
  - To provide a mean for international collaboration
  - To cooperate with ICAO and other international organizations.
- ICAO major focus is on setting standards where IATA is primarily concerned with
  - Traffic coordination
  - Fares, rates and charges for travel agent commission
- Members are from individual airlines representing the country

US Federal Aviation Administration (FAA)

- Objectives
  - Promote safe air carrier operations
  - Controlling the use of airways and promotes civil aeronautical developments
  - Research and development of air navigation facilities
  - Enforce safety standards and regulations including aviation system, equipment devices, materials, concept and procedures.
  - Aircraft registration and issue of safety certificates
  - Aviation accident evaluation
- Training and Education
  - Advisory circulars
  - Establishing design methods and standards

Pakistan Civil Aviation Authority

- Created in December 1982
- Airport management and development
  - Enforces high performance standards for efficiency and service in airport operations and the development of air cargo industries
- Air service development
  - Promotes safe and efficient commercial aviation
  - Promotes trade and economic growth
- Air space management and organization
  - Provides air traffic control service to ensure a safe expeditious flow
  - Provides search and rescue service
  - Airspace capacity in cooperation with ICAO, IATA and other groups.

CAA

- Regulatory and Advisory Services
  - Regulate the operations of Pakistan registered aircraft (training centers)
  - Surveillance of aircraft engineering activities
  - Regulates the operation of aerospace industries and personnel fitness
  - Advises the government on matter related Civil Aviation Authority

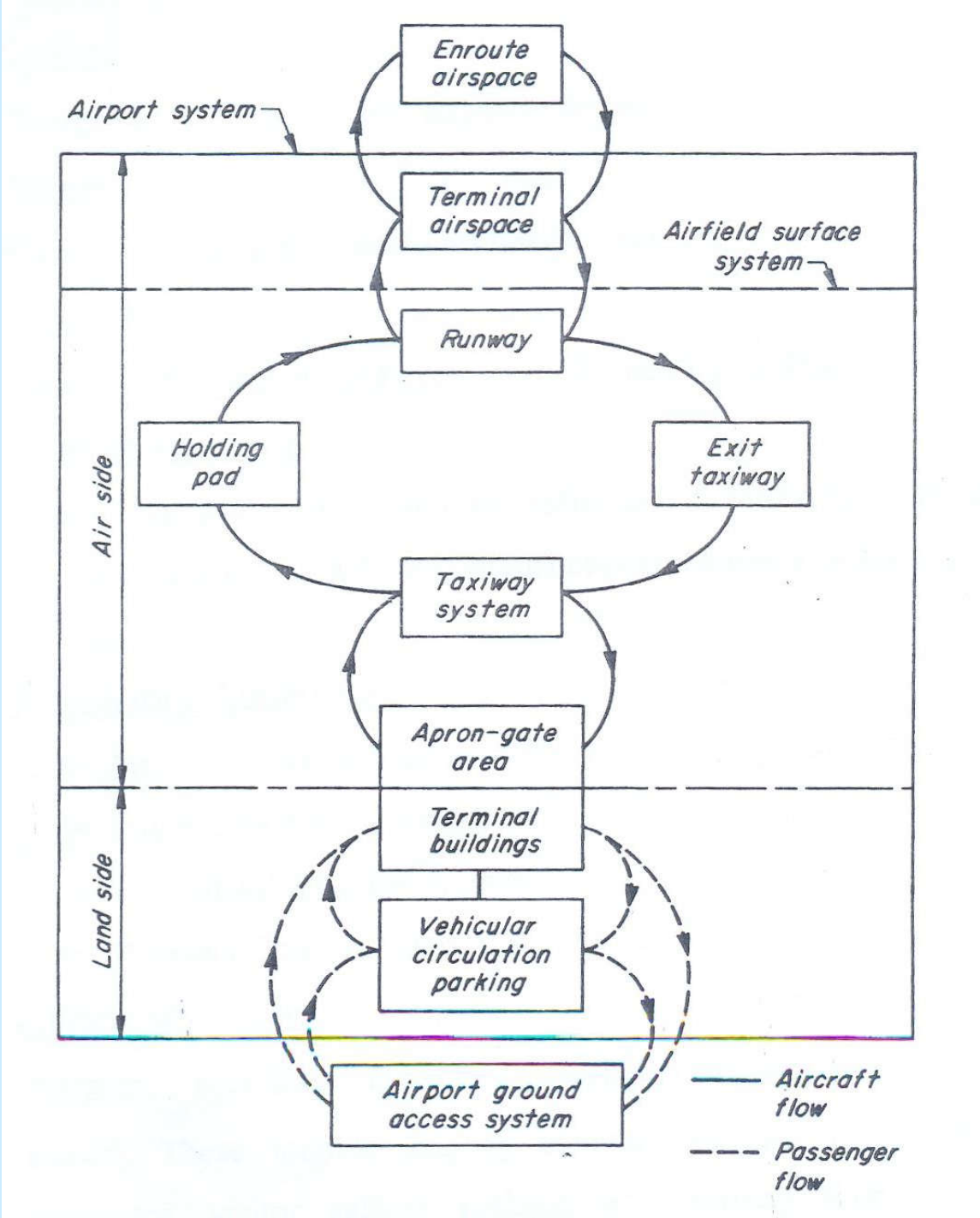
Components of an Airport

- Airport
  - Any area defined on the land (including any building, installation and equipment) intended for arrival/ departure and movement of aircraft.
- Aircraft
  - Flying machine heavier than airpower driven.
- Aviation
  - Flying with the help of machines heavier than air.

Components of an Airport

- General Aviation
  - General aviation is the term used to designate all flying done other than by the commercial airlines.
- Airfield
  - Portion of airport used exclusively for landing and takeoff.
- International Airport
  - Is one handling international air traffic and functioning according to the rule set forth by ICAO. It contains custom facilities in addition to normal facilities.

Layout of an Airport



Layout of Airport

- Terminal building-
  - facilitates passengers arriving at or departing from airport. These include enquiry counter, telephone, security personals, restaurant, visitor gallery, parking area, waiting rooms, wash rooms, baggage clear section
- Apron-
  - parking area for loading and unloading of passengers

Layout of Airport

- Holding apron/ Warmup Pads/ Runup Pads
  - located near the end of runway to hold the planes until runway is clear or some plane that cannot take off due to malfunction. Size should be large so that other planes ready to take off can pas it.
- Taxiway
  - connects runway with other parts of airport e.g aprons, hangers, or paved path for taxing the aircraft to and from the runway.
- Hanger
  - aircraft shelters and maintenance area.
- Air Traffic Control (ATC)
  - includes control tower, guidance system, lighting system etc

Airport Types

- Conventional Take off and Landing (CTOL)
  - Most common (3-4 km) Lahore airport
  - Serving general aviation as well as air carrier
- Reduced take off and Landing (RTOL)
  - For smaller aircraft (85-145 passengers)
  - Runway length 1000-1300 m
  - May allow steep approach to reduce noise and cost
- Short take off and Landing (STOL)
  - Runway length 500-1000 m.

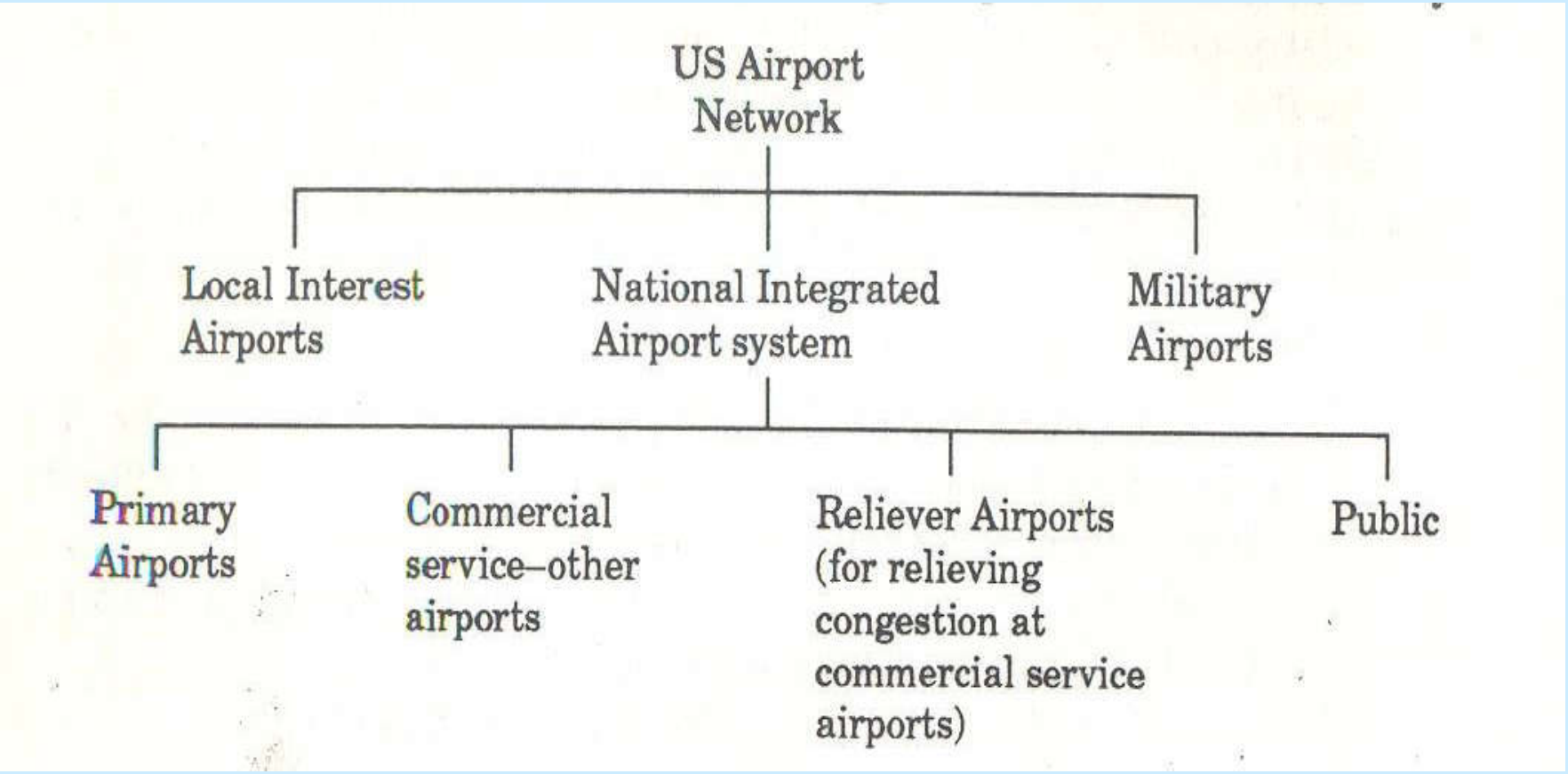
Airport Types

- Vertical takeoff and Landing
  - Commonly called heliports
  - Aircraft lift off and lands vertically
  - Operational area 25-50 square meters

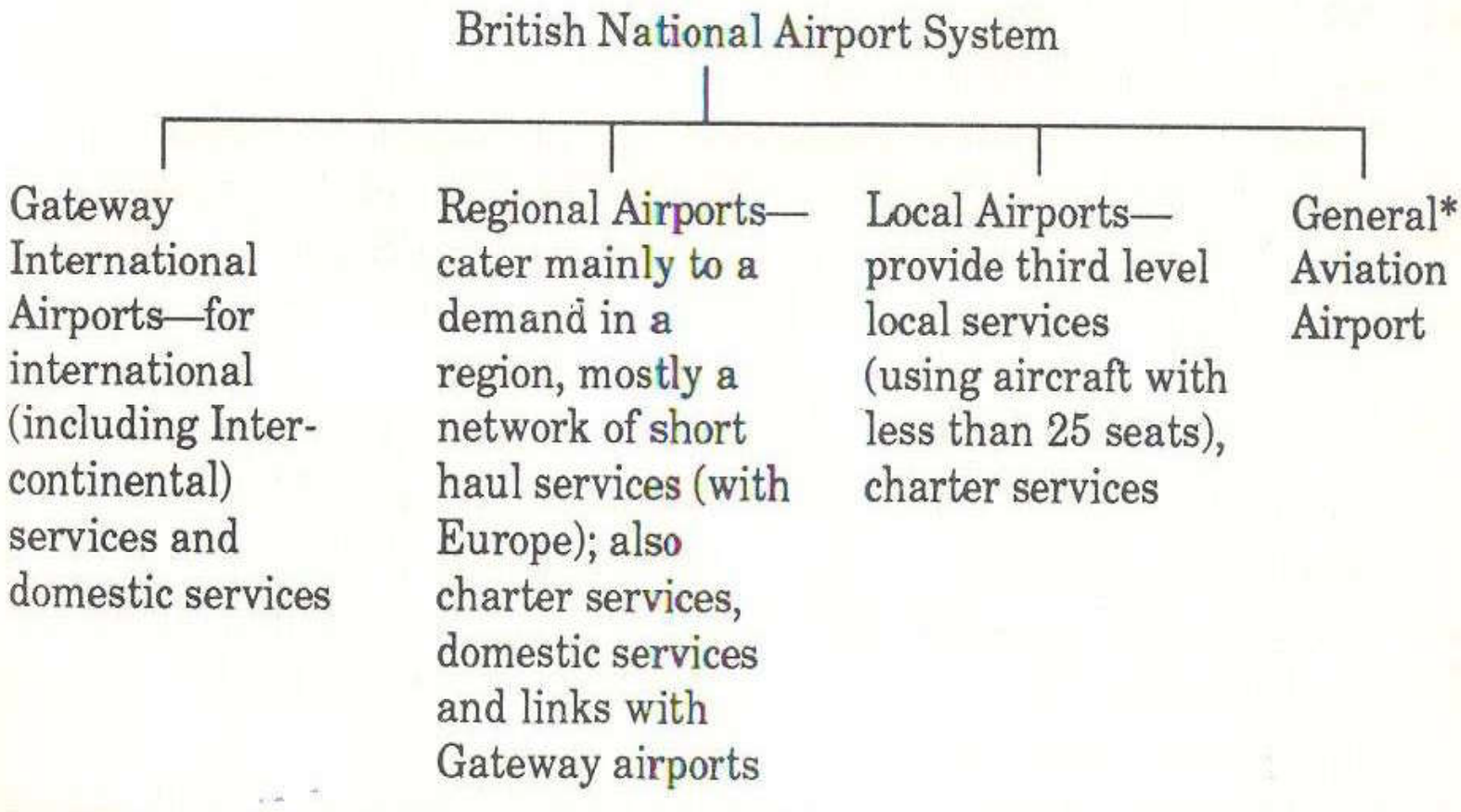
Airport Classification System

- Functional Classification
  - US Airport Network
  - British National Airport System
- Geometric Classification
  - ICAO Airport Reference code
  - FAA Classification

Functional Classification
(US Airport Network)



Functional Classification
(British National Airport System)

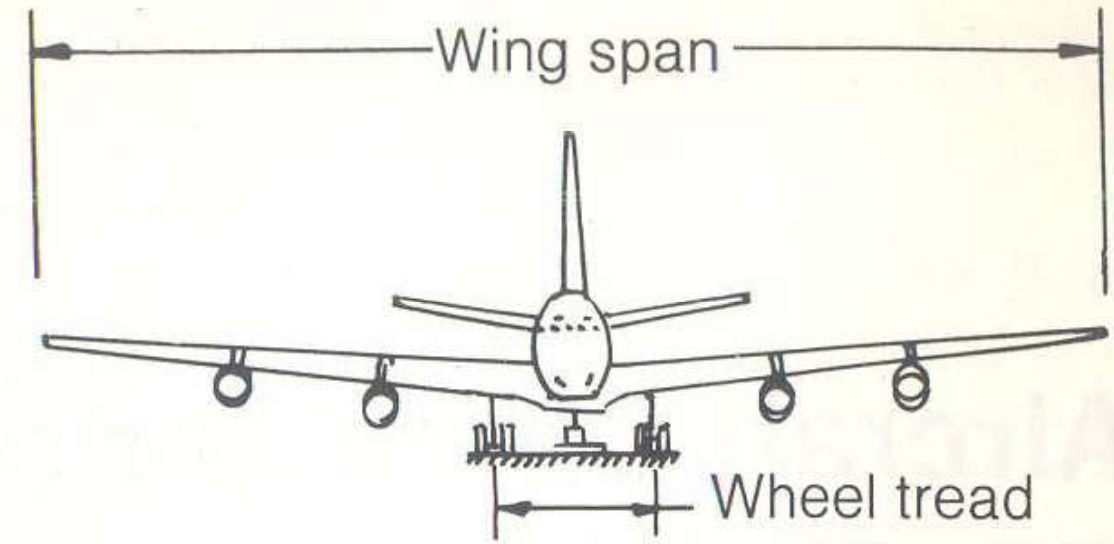


* All flying done other than by commercial airlines is designated as general aviation

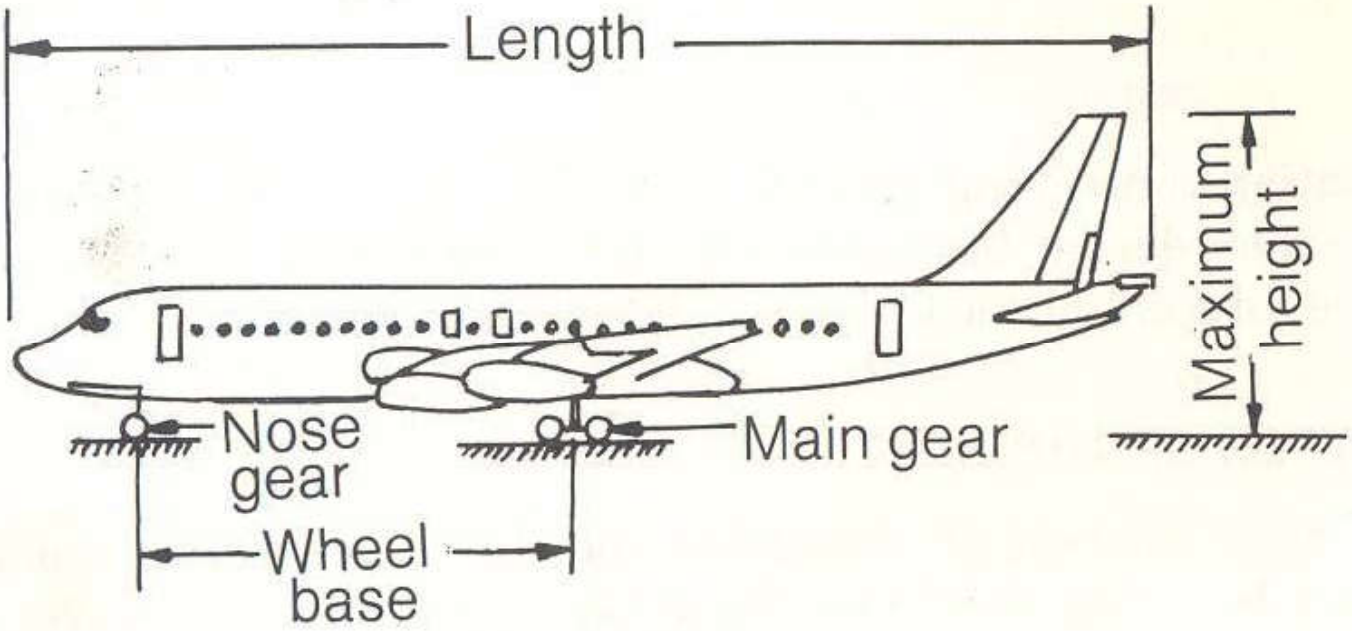
Geometric Classification
(ICAO Airport Reference Code)

Table 1.1 *ICAO Airport Reference Code*

Code number	Field length	Code letter	Wing-span	Outer main gear wheel-span
1	< 800 m	A	< 15 m	< 4.5 m
2	from 800 m up to, but not including 1,200 m	B	from 15 m up to, but not including 24 m	from 4.5 m up to, but not including 6 m
3	from 1,200 m up to, but not including 1,800 m	C	from 24 m up to, but not including 36 m	from 6 m up to, but not including 9 m
4	≥ 1,800 m	D	from 36 m up to, but not including 52 m	from 9 m up to, but not including 14 m
		E	from 52 m up to, but not including 60 m	from 9 m up to, but not including 14 m



(a) FRONT VIEW



(b) SIDE VIEW

Geometric Classification
(FAA Classification)

FAA Classification FAA has developed an aircraft design group concept which groups aircrafts by wing-span and relates airport design standards to these groups.

Airplane Design Group	Wing-span (m)
I	< 15
II	from 15 up to, but not including 24
III	from 24 up to, but not including 36
IV	from 36 up to, but not including 52
V	from 52 up to, but not including 60
VI	from 60 up to, but not including 80

Basic Forces Acting on Aero-Plane

- Airplane, engine driven vehicle that can fly through the air supported by the action of air against its wings.
- Airplanes are heavier than air, in contrast to vehicles such as balloons and airships which are lighter than air.
- Airplanes have rigid wings; movable part of the wings and tail, which make it possible to guide their flight.

Basic Forces Acting on Aero Plane

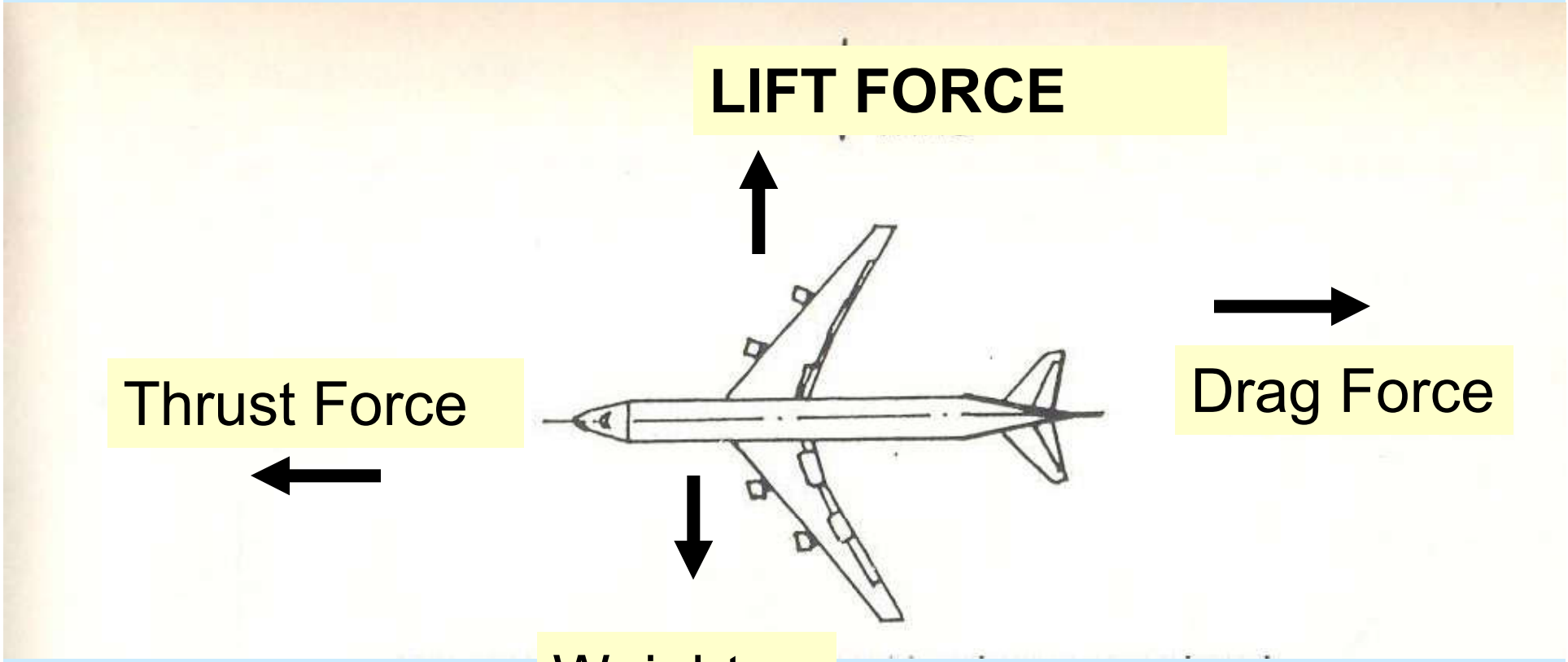
- Modern airplanes range from ultra light aircraft weighing not more than 46 kg to 550 metric tons.
- Land planes (operate from ground), sea planes (operate on water), and amphibians (can operate on both land and sea).
- Airplane lift off using the jet thrust off their engines or rotors (rotating wings)

Basic Forces Acting on Aero Plane

Following are the forces acting on the aero-plane

- Lift force
- Thrust force
- Weight of the aero-plane
- Drag Force

Forces Acting on Aero Plane



Explanation of the Forces

- Weight
  - Every object on the earth has weight. Boeing 747 can weigh up to 870,000 lbs.
- Lift
  - Lift is the aerodynamic force that holds an airplane in the air
  - Upward force on the plane
  - Wings alter the direction of flow of air as it passes.
  - The speed of the airflow and the angle at which the wings meet the on coming air stream also contribute to the amount of lift generated.
  - Depends upon the angle of attack of wind and the orientation of the flaps.

Forces Contributing to Lift

- Bernoulli's equation, a fundamental of fluid dynamic states that as the speed of a fluid flow increases, its pressure decreases
- Newton's third law states that for every action there is an equal and opposite reaction.
- To accommodate both flight regimes (fast and high as well as slow and low), airplane wings have movable sections called flaps.
- This effectively alters the shape of the wing, allowing wing to turn more air and thus create more lift.

Drag

- Drag is an aerodynamic force that resists the motion of an object moving through a fluid.
- Airplane through air, produces friction as it interacts with air fluid and because it must move the air out of its way to do its work.
- A high lift wing surface, may create a great deal of lift for an airplane, but because of its large size, it is also creating a significant amount of drag.
- Drag is minimized by designing sleek, aerodynamic aero-planes, with shapes that slip easily through the air.

Thrust

- Thrust is an aerodynamic force that must be created by an aero-plane to overcome the drag.
- Force that propels an airplane forward through the air. It is provided by the airplane's propulsion system; either a propeller or jet engine or combination of the two.

Types of Aircraft Engine

According to the type of propulsion and thrust generating medium, air craft can be categorized into

- Piston
- Turbine

Piston Engine

- All propeller driven aircrafts powered by gasoline fed reciprocating engines are designated as piston-engine aircraft.

Turbo Prop

- Propeller driven aircrafts driven by turbine engines are known as Turbo Props.

Turbo Jet

- Those aircraft which are not dependent on propellers for thrust but which may obtain thrust directly from the turbine engine.

Turbo Fan

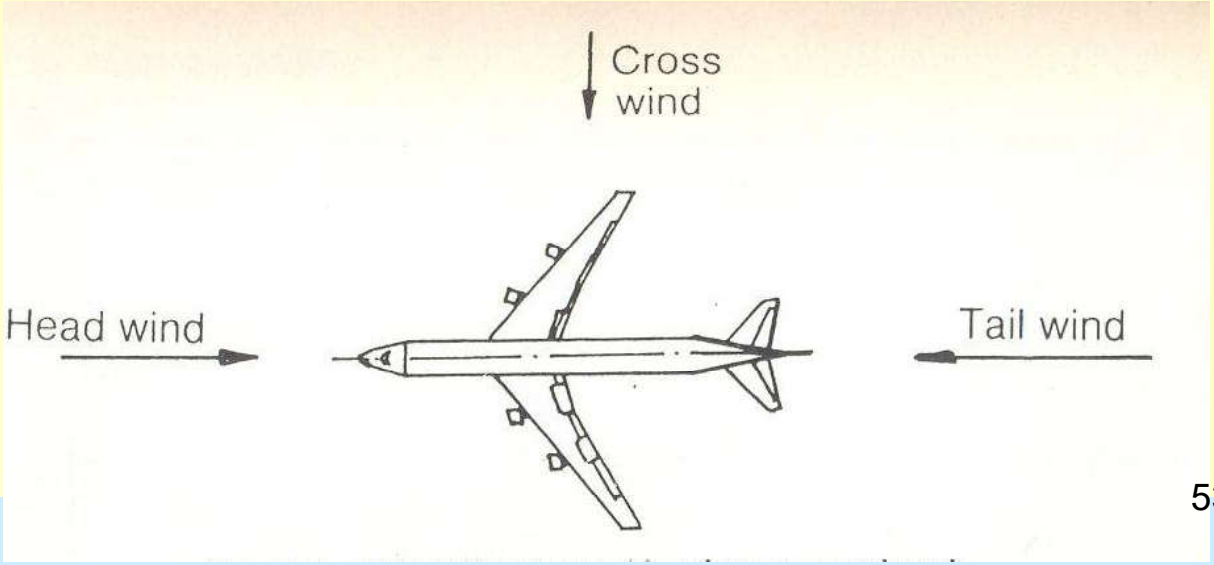
- When a fan is added to the turbo-jet engine to increase the thrust of the engine it is designated as Turbo Fan.

Important Definitions

- Ground Speed
  - Speed of aircraft relative to ground.
- Air Speed
  - Speed of aircraft wing (air speed across the wings)
  - If the ground speed of an aircraft is 600 km/hr and speed of the wind in opposite direction is 100 km/hr; air speed is 700 km/hr.

Super and Subsonic Aircrafts

- Reference datum for speed of aircraft is the speed of the sound.
- Most military aircraft are super sonic having mach number more than 1
- Transport aircrafts are subsonic having mach number less than 1.



Important Definitions

- Mach Number
  - Ratio between aircraft speed and speed of the sound
  - Speed of the sound at -25ºC is 1138 km/hr; 0º C is 1194 km/hr and at 30ºC is 1263 km/hr.
- Knots
  - I minute of arc of earth = nautical mile~ 1.852 km
  - Total nautical miles (equator) = 360*60 = 21,600 (40,000 km)
  - I knot = nautical miles/ hour = 1.852 km/hr.

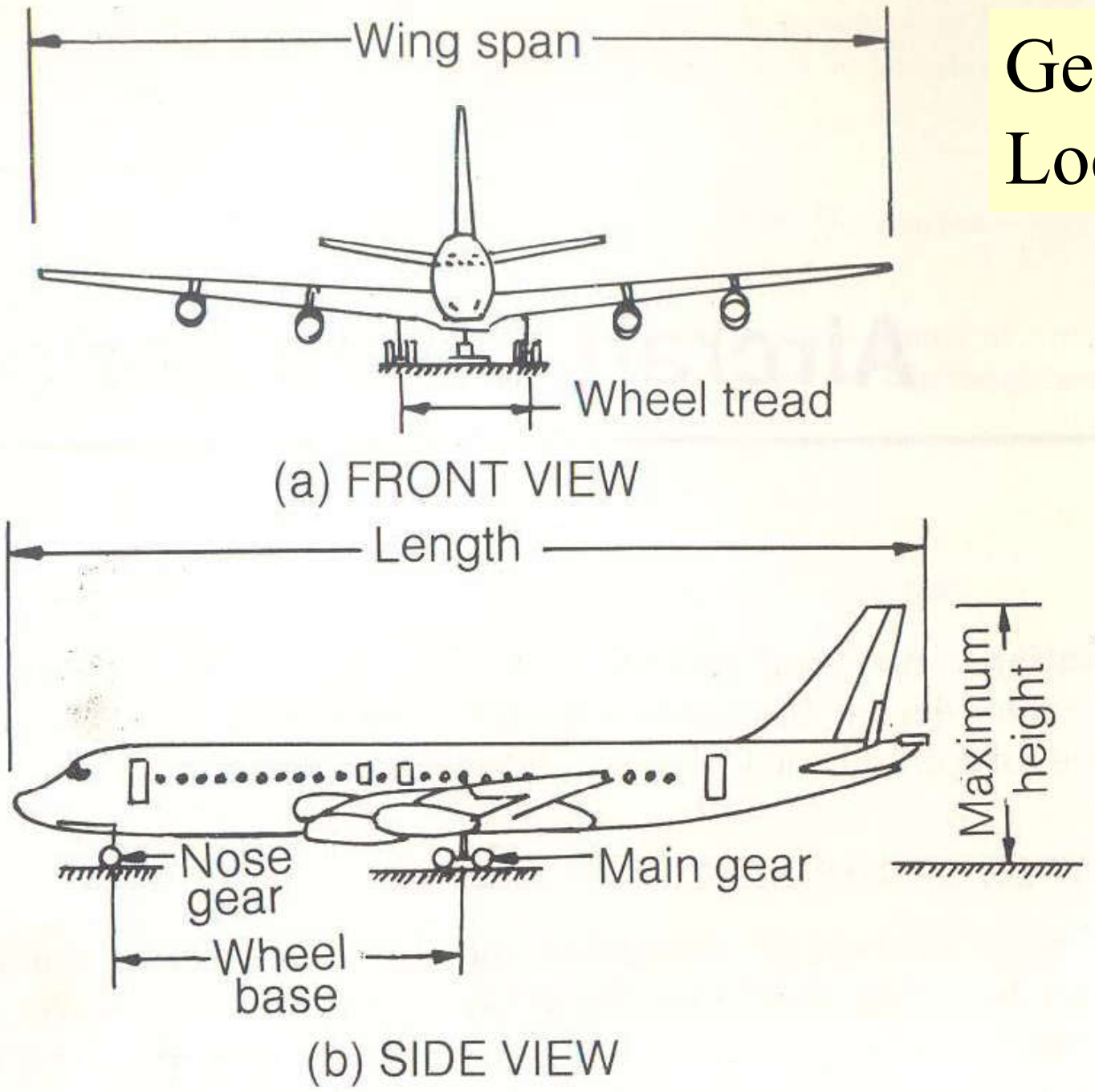
Characteristics of Transport Aircraft

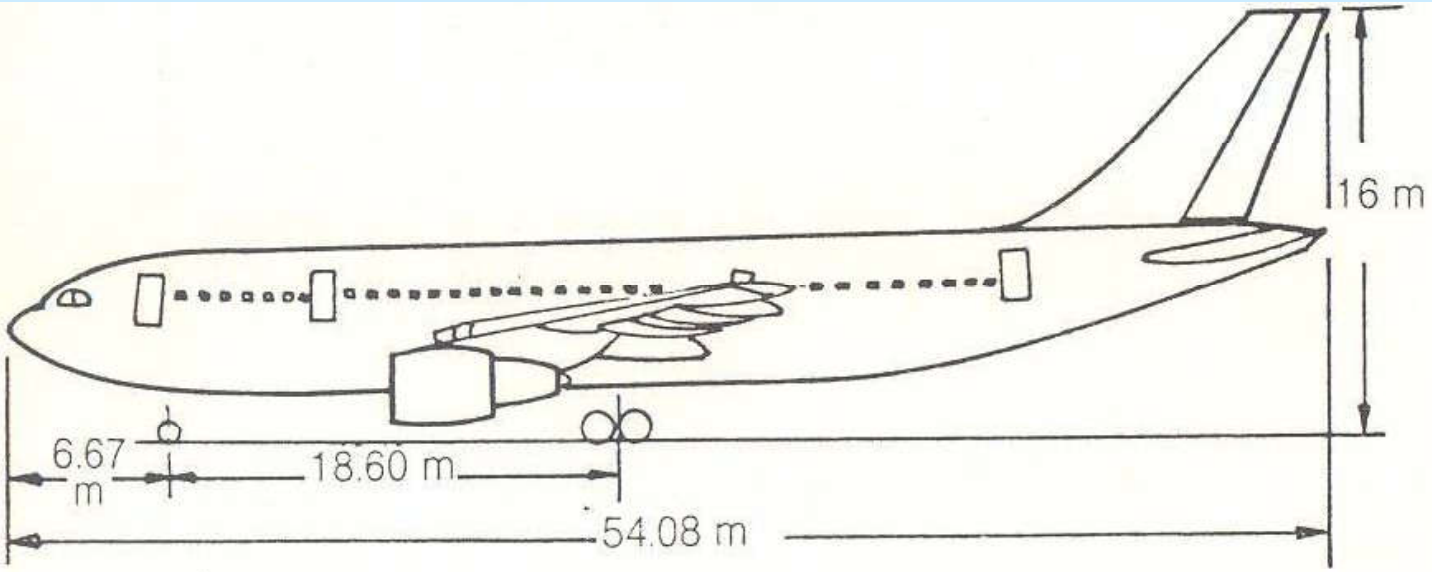
- Type of aircraft
- Aircraft dimensions
- Turning radius
- Aircraft speed
- Maximum structural take off weight
- Wing span and total length
- Wheel base
- Number and types of engines
- Payload (revenue generating load)
- Gear configuration
- Aircraft capacity
- Operating range

Size of Aircraft

- The center to center distance between the two gear system is known as wheel base.
- Wheel tread is the central distance between the main gears on either side.
- Span of the wings- decides the width of taxiway, size of aprons and hangers
- Fuselage/ length of aircraft- decides the widening of taxiway on curves, size of aprons and hangers

Gear Location





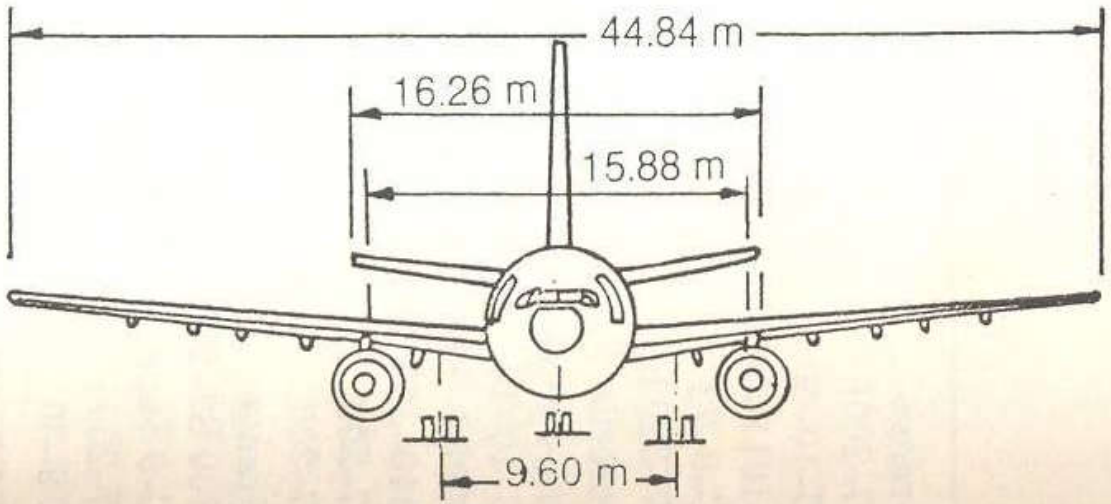


Fig. 2.2(a) *AIR BUS Model A 300–600: General airplane dimensions (Courtesy: Manufacturer)*

Size of Aircraft

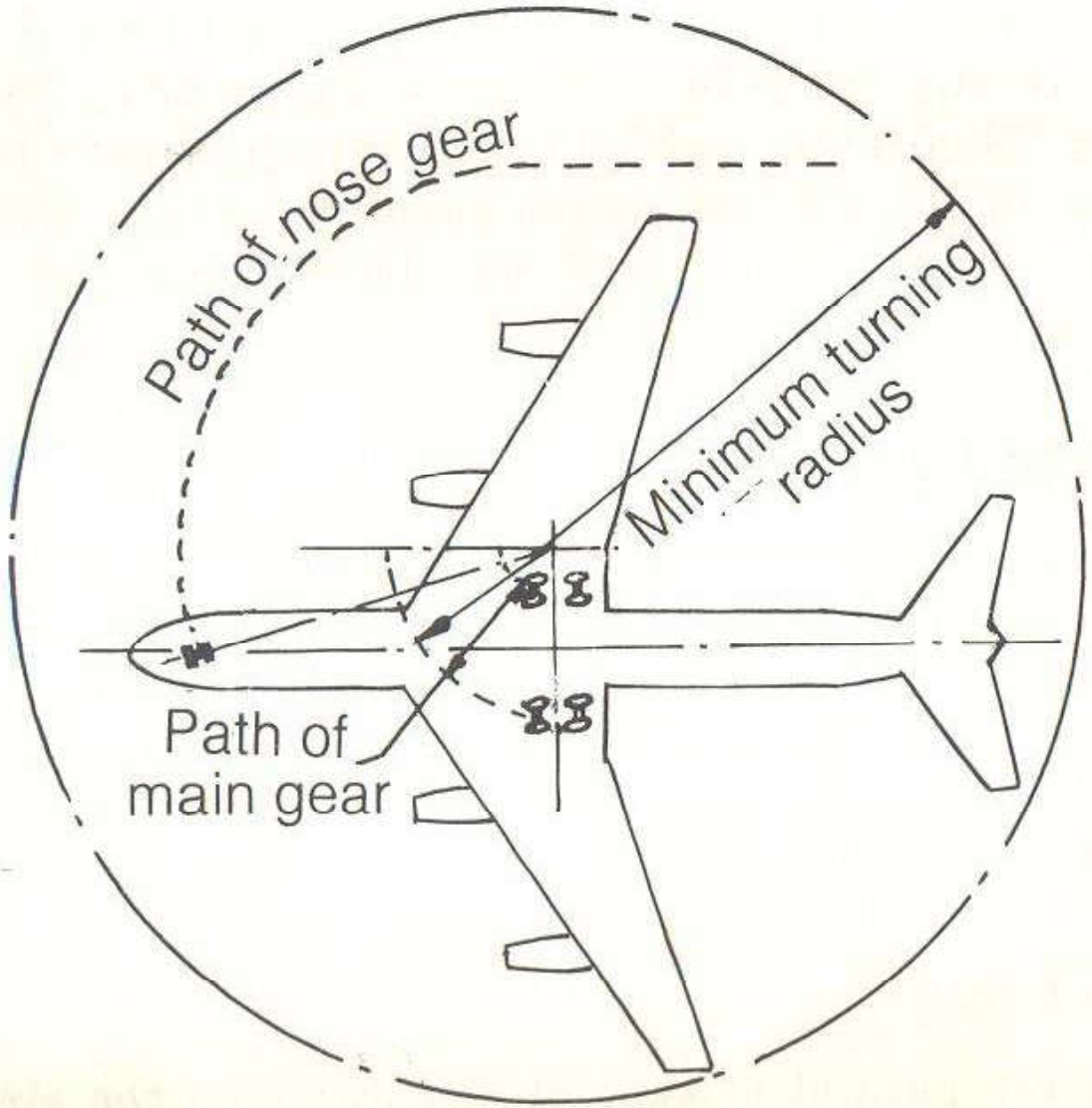
- Height- decides the height of the hanger gate and various installations at hangers
- Distance between main gears- governs the minimum turning radius of the aircraft
- Wheel base- decides minimum taxiway radius
- Tail width- required for size of parking and aprons.

Radius Requirement for the Aircraft

- For establishing the path of movement of aircraft on airport and determining position of aircraft near the terminal, it is necessary to know the movement capability of the aircraft
- The turning radius is a function of nose gear steering angle.
- When the radius is minimum, it produces excessive tyre wear.

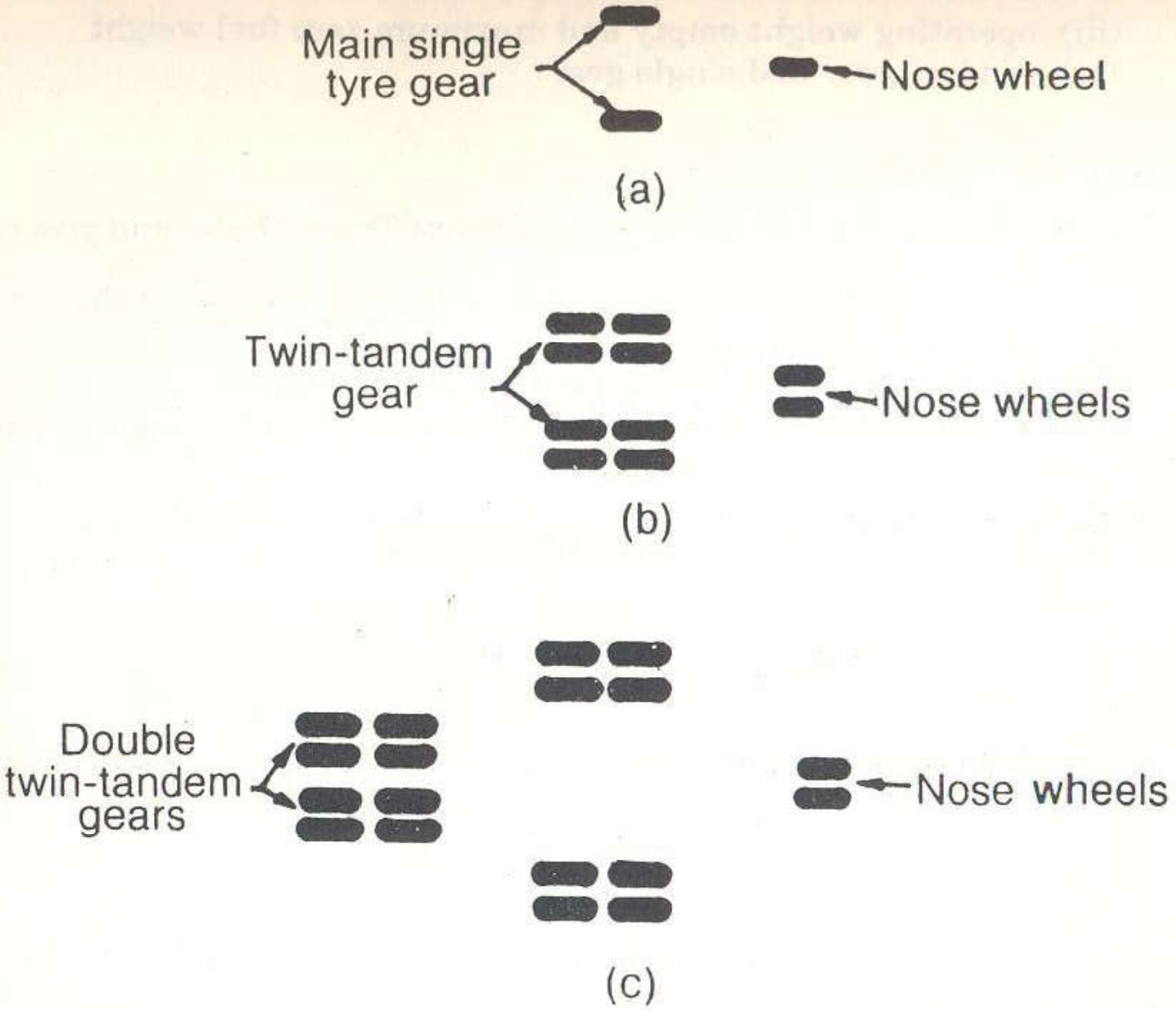
Radius Requirement for the Aircraft

- Maximum radius is critical with regards the clearance to the adjacent buildings/ aircrafts.
- Maximum turning radii to reduce the excessive tire wear and shearing the pavement surface.
- New aircraft has the capability to swivel the main gears for sharp turns.



(c) PLAN

Fig. 2.1 *Aircraft dimensions—definition figure*



Typical Wheel Configuration of Aircraft

Components of Aircraft Weight

- Aircraft weight influences the thickness and length of the runway.
- Operating Empty Weight
- Payload
- Zero fuel weight
- Maximum structural Landing Weight
- Maximum takeoff weight
- Maximum ramp weight

Components of Aircraft Weight

- Payload- revenue generating load (passengers & cargo)
- OEW- operating empty weight is the weight of the aircraft without fuel and payload includes pilot, crew and empty seats. Depends upon seating configuration. It does not include payload and fuel.

Components of Aircraft Weight

- ZFW- zero fuel weight above which all additional weight must be fuel
- MTOW- maximum takeoff operating weight- structurally the maximum demonstrated mass at take-off for safe flight (excludes run-up fuel and includes OEW, fuel & payload). Longer trips requires more fuel with less payload

Components of Aircraft Weight

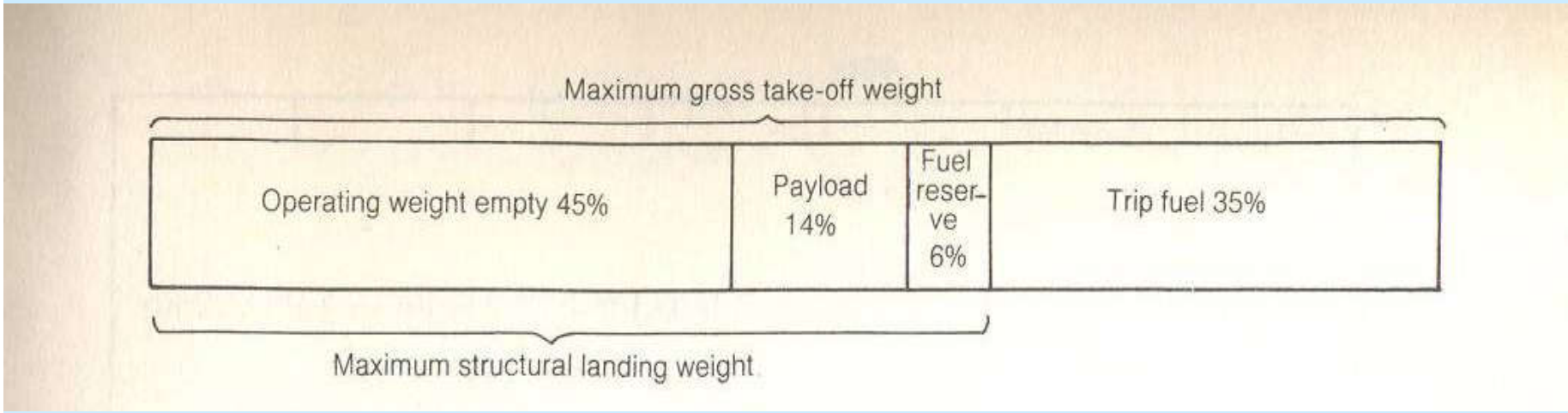
- MALW- maximum allowable landing weight is the maximum demonstrated landing weight to keep the landing gear intact at maximum sink rate (vertical speed)
- MSPW maximum structural payload weight is the maximum demonstrated payload to be carried without stressing the aircraft fuselage (ZFW-OEW)

Components of Aircraft Weight

- MTW- maximum taxiway weight (maximum ramp weight) for ground maneuvering. Usually slightly more than MTOW (includes run-up fuel)
- DTW- desired takeoff weight is the weight of aircraft (plus reserve), payload and OEW to complete a given stage length

  DTW = Payload + OEW + required Fuel

Schematic Sketch for Aircraft Weight



PayLoad- Range Charts

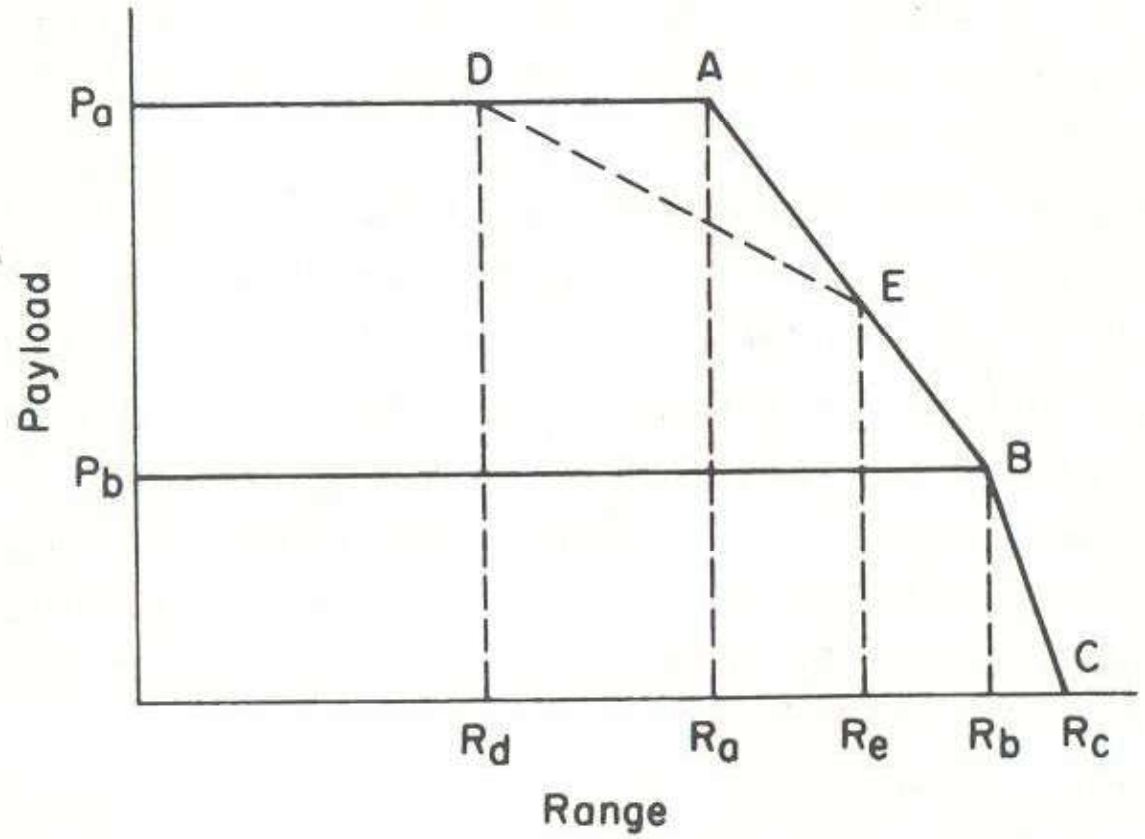


Figure 3-14 General representation of the relationship between payload and range.

Payload-Range

- Range- distance the aircraft can fly is called range
- Range increases as payload decreases
- Point A: range at maximum payload, fuel tank not completely filled.
- Point B: fuel tank completely filled. Aircraft take off at MTOW
- Point C: maximum distance without payload (ferry range). Take off weight less than maximum

Payload-Range

- For the maximum structural landing weight, path DE is followed. (How long the aircraft can fly with maximum structural payload).
- The shape of payload versus range curve would follow the line DEBC rather than ABC if the payload is limited by maximum structural landing weight.