AIRPORT & RAILWAY ENGINEERING

Airport Engineering

Syllabus

- Introduction
- Aircraft Main Parts
- Airport Elements
- Airport Types
- Aircraft Characteristics Related to Airport Design
- Selection of Site for the Airport
- Wind Direction Analysis
- Airport Planning
- Geometric Design of Airports
- Airport Capacity
- Airport Marking and Lighting
- Structural Design of Airport Pavements
- Airport Drainage

CE410 Civil Electives (2,0,0):- selected topics in structural, soil mechanics and foundation, water, economy and construction management, transportation, selected topics in advanced mathematics, statistics and numerical engineering. Detailed syllabus will be decided by specialist groups and should be approved before announcement.
Note: Fourth year students will be divided to groups for different electives and the student shall fulfil at least one of these electives.

References

1- Planning and Design of Airports, by Moronelf, R and Makelvey. 3rd Edition, 1983. MacGraw Hill Book Company
2- Ashford, Nand Wright, PPH Airport Engineering

Introduction

Airport: Is an air field equipped with control tower and hangars as well as accommodation for passengers and cargo

Aerodrome: A defined area on land or water including any building, installation, and equipment intended to be used either wholly or in part for the arrival, departure and service movement of aircraft

Aerodrome reference point: Designated geographical location of an aerodrome

Aircraft: A device that is used or intended to be used for flight in the air.

Airplane: An engine-driven fixed-wing aircraft heavier than air, that is supported in flight by the dynamic reaction of the air against its wings.

General Aviation Types

1- Business flying
2- Commercial flying
3- Personal flying
4- Instructional flying

Typical Air Trip

Origin – walking – taxi - Parking – walk - Ticket - counter check in - walk - Gate - walk or bus – Aircraft - Taxiway - Runway

Advantage

1- Rapidity
2- continuity
3- Accessibility

Limitations

1- Operating expenses
2- Weight carrying capacity
3- Weather conditions
4- Flight rules

Airport Classification

According to Community Size:

1- Small (population < 25000)
2- Medium (25000 < population < 250000)
3- Large (population > 250000)
4- Global centers

According to Typa of Service

1- With scheduled services
2- With non scheduled services
3- With mixed services

Functional classification
1- Military
2- Local ninterest
3- National system

ICAO Classification for the Purpose of Geometric Design
Uses two element reference code, numeric and alphabetic designation
The code No. 1 – 4 classify the length of the runway available
The code letter A – E classify the wing span, outer main gear wheel span

Description
Element 1 of the Code is as follows:
Field length means the balanced field length (which is when the take-off distance required is equal to the accelerate-stop distance required) if applicable, or take-off distance in other cases. Aeroplane reference field length is defined as "the minimum field length required for take-off at maximum certificated take-off mass, at sea level, in ISA conditions in still air and with zero runway slope as documented in the AFM or equivalent document.
Element 2 of the Code is derived from the most restrictive of either the aircraft wingspan or the aircraft outer main gear wheel span. The categories are as follows:
It should be noted that Element 2 is often used on its own since it has direct relevance to detailed airport design. It also has a parallel but differently defined code use by the FAA, the Airplane Design Group (ADG(

Code number	Aeroplane reference field length	Typical aeroplane
1	< 800 m	DE HAVILLAND CANADA DHC-6/PIPER PA-31
2	800 m but < 1200 m	ATR42/BOMBARDIER Dash 8 Q300
3	1200 m but < 1800 m	SAAB 340/BOMBARDIER Regional Jet CRJ-200
4	1800 m and above	BOEING 737-700/AIRBUS A-320

Code letter	Wingspan	Outer main gear wheel span	Typical aeroplane
A	< 15 m	< 4.5 m	PIPER PA-31/CESSNA 404 Titan
B	15 m but < 24 m	4.5 m but < 6 m	BOMBARDIER Regional Jet CRJ-200/DE HAVILLAND CANADA DHC-6
C	24 m but < 36 m	6 m but < 9 m	BOEING 737-700/AIRBUS A-320/EMBRAER ERJ 190-100
D	36 m but < 52 m	9 m but < 14 m	B767/AIRBUS A-310
E	52 m but < 65 m	9 m but < 14 m	B777/B787 Series/A330
F	65 m but < 80 m	14 m but < 16 m	BOEING 747-8/AIRBUS A-380-800

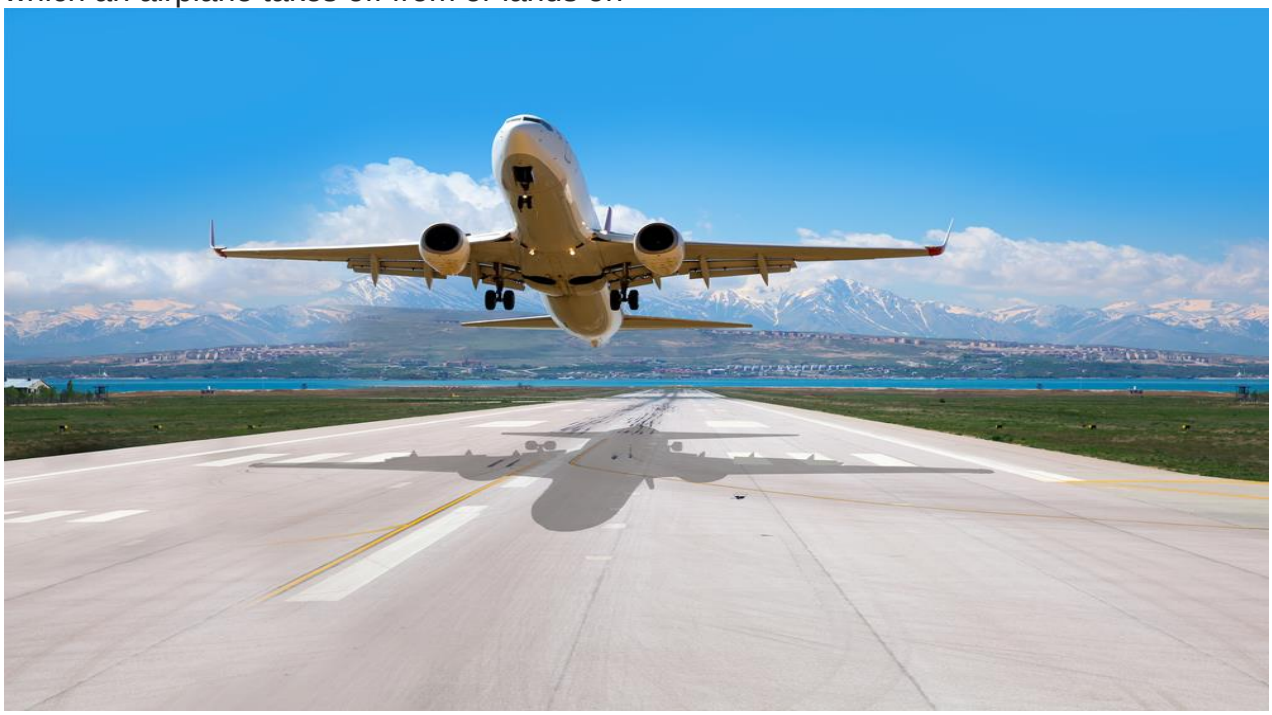
Airport Works:

- 70% civil engineering
- 15% Architectural engineering
- 10% Electrical eng
- 5% Mechanical engi.

Airport Elements

1- Runway
2- Taxiway
3- Apron
4- Terminal building
5- Hangars
6- Tower

Runway: At an airport, the **runway** is the long strip of ground with a hard surface which an airplane takes off from or lands on



Taxiway: A taxiway is a path for aircraft at an **airport** connecting runways with aprons, hangars, terminals and other facilities. They mostly have a hard surface such as asphalt or concrete, although smaller general **aviation airports** sometimes use gravel or grass

Apron: The airport apron or apron, sometimes known as tarmac, is the area of an airport where aircraft are parked, unloaded or loaded, refueled, or boarded. ... The apron is designated by the ICAO as not being part of the maneuvering area. All vehicles, aircraft and people using the apron are referred to as apron traffic

Terminal building: An **airport terminal** is a building at an airport where passengers transfer between ground transportation and the facilities that allow them to board and disembark from aircraft.

Within the terminal, passengers purchase tickets, transfer their luggage, and go through security. The buildings that provide access to the airplanes (via gates) are typically called **concourses**. However, the terms "terminal" and "concourse" are sometimes used interchangeably, depending on the configuration of the airport.

Smaller airports have one terminal while larger airports have several terminals and/or concourses. At small airports, the single terminal building typically serves all of the functions of a terminal and a concourse. Some larger airports have one terminal that is connected to multiple concourses via walkways, sky-bridges, or underground tunnels

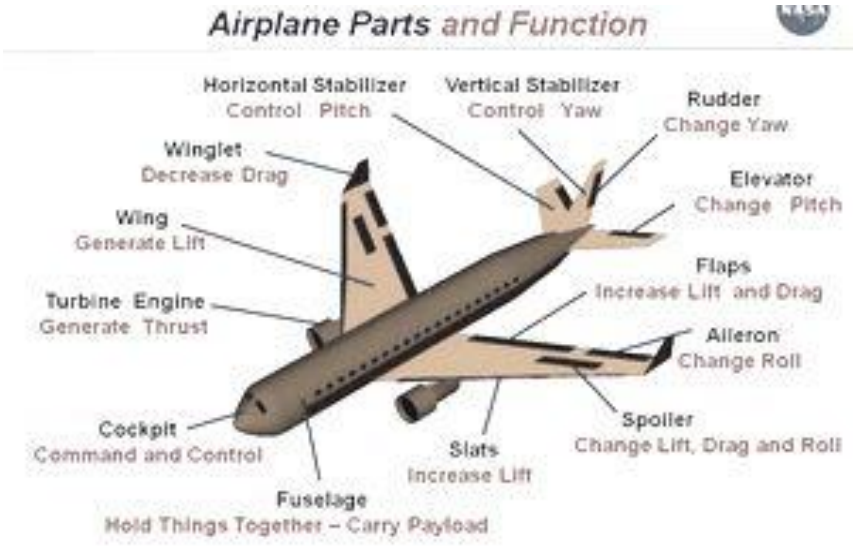
Hangars:

A hangar is a closed building structure to hold aircraft, or spacecraft. Hangars are built of metal, wood and concrete. The word *hangar* comes from Middle rench *hanghart* ("enclosure near a house"), of Germanic origin, from Frankish **haimgard* ("home-enclosure", "fence around a group of houses"), from **haim* ("home, village, hamlet") and *gard* ("yard").

Control Tower: A control tower is a building at an airport from which instructions are given to aircraft when they are taking off or landing.

The Essential Parts of Transport Aircraft

1- Engine
2- Propeller
3- Fuselage
4- Wings
5- Three controllers
6- Flaps
7- Under carriage (landing gear)



Aircraft Engine

An engine that is used or intended to be used for propelling aircraft. It includes turbos upper chargers, appurtenances, and accessories necessary for its functioning, but does not include propellers

Fuselage
Airframe: The fuselage, booms, nacelles, cowlings, fairings, airfoil surfaces (including rotors but excluding propellers and rotating airfoils of engines), and landing gear of an aircraft and their accessories and controls.

Controlling the Motion of Flight

In order for an aircraft to reach its destination, the forces of flight have to be precisely manipulated. To do this, the aircraft has three control surfaces which can direct airflow in very specific ways.

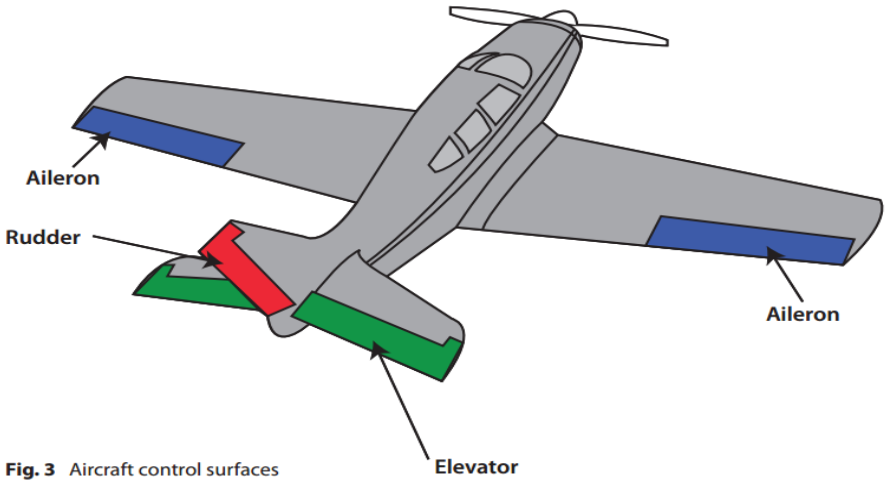
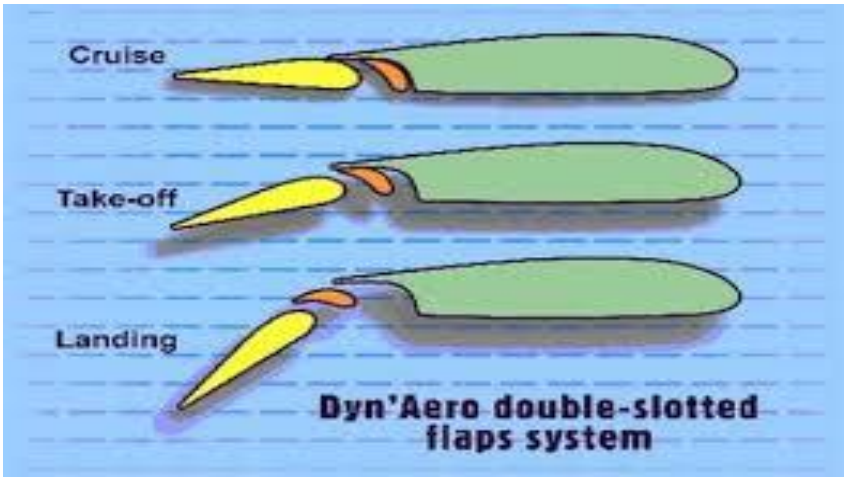


Fig. 3 Aircraft control surfaces



Flaps
Flaps are devices used to alter the lift characteristics of a wing and are mounted on the trailing edges of the wings of afixed-wing aircraft to reduce the speed at which the aircraft can be safely flown and to increase the angle of descent for landing. They do this by lowering the stall speed and increasing the drag. Flaps shorten takeoff and landing distances.

Undercarriage

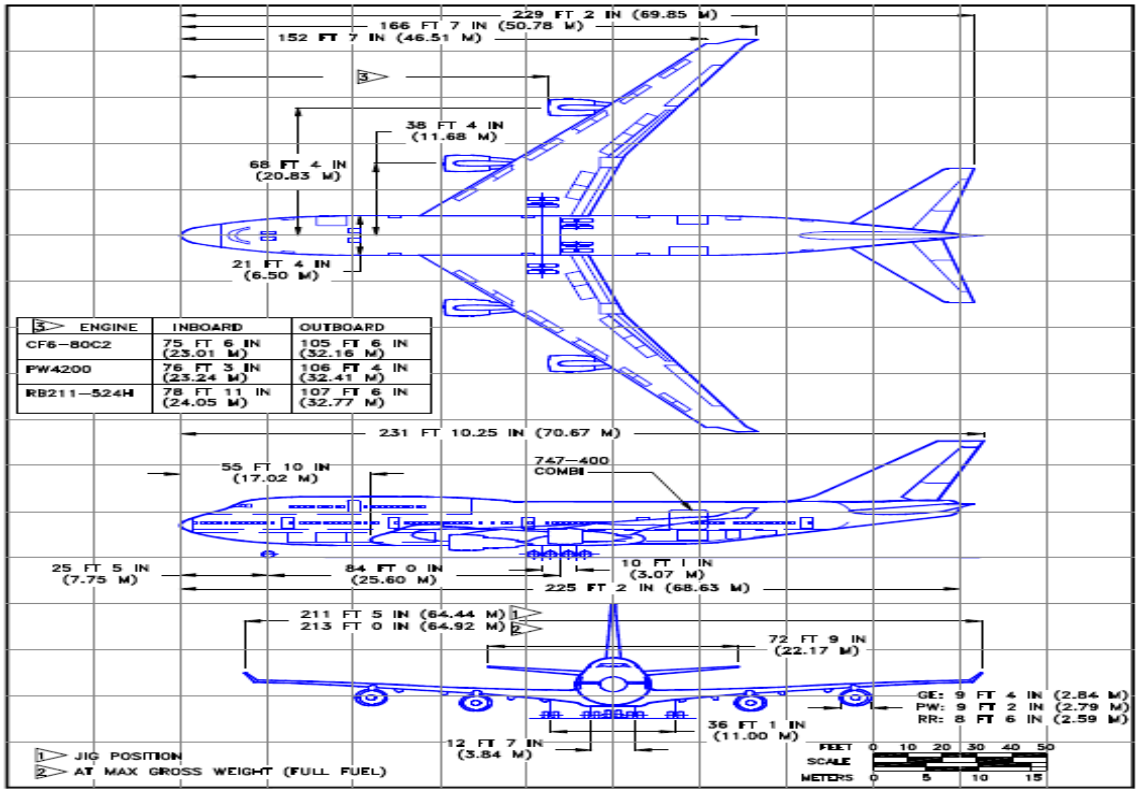
Aircraft Data Needed for The Design of Airports

1- Size
2- Turning radius
3- Maximum takeoff weight
4- Aircraft capacity
5- Type of engine
6- Takeoff and landing distances
7- Landing gear configuration

Size

Aircraft size has a great effect on size of:

i- Parking apron
ii- Configuration of terminal building
iii- Width of Runway
iv- Width of Taxiway
v- Distance between runway and the taxiway



2.2.1 GENERAL DIMENSIONS
MODEL 747-400, -400 COMBI, -400ER

Turning Radius on the Ground

Between 70 – 90 ^{o}

Has an effect on:

1- Apron
2- Radius of curves at the end of taxiway

Maximum Takeoff Weight

Used in structural design of pavements of:

1- Runway
2- Taxiway
3- Apron

Aircraft Capacity

1- Regarding fuel, passengers, cargo, …etc
2- Has an effect on:
3- The fuel storage facilities
4- Dispensing methods
5- Cargo handling facilities required

Maximum Seating Capacity: The maximum number of passengers specifically certificated or anticipated for certification

Maximum cargo volume: The maximum space available for cargo

Usable fuel: Fuel available for aircraft propulsion

Engine Type

1- For noise and air pollution control
2- There are four types:
3- Piston engine
4- Turbo jet
5- Turbo propeller
6- Turbo fan

Piston engine
Is just similar with car engine except with several different.

Jet Engine

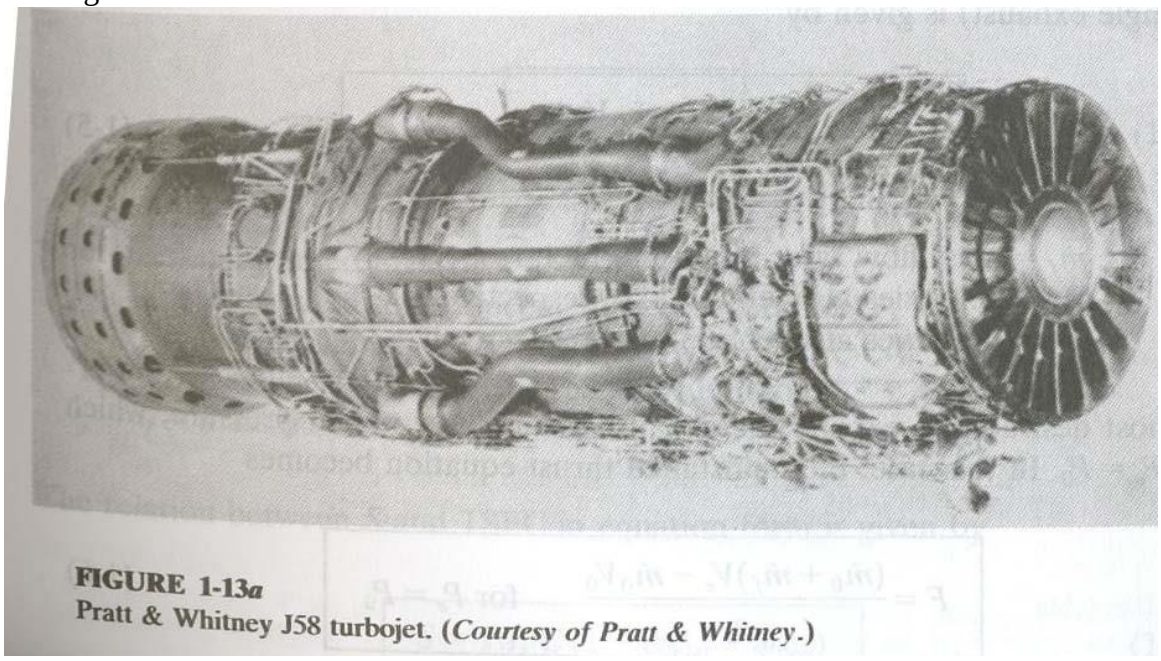
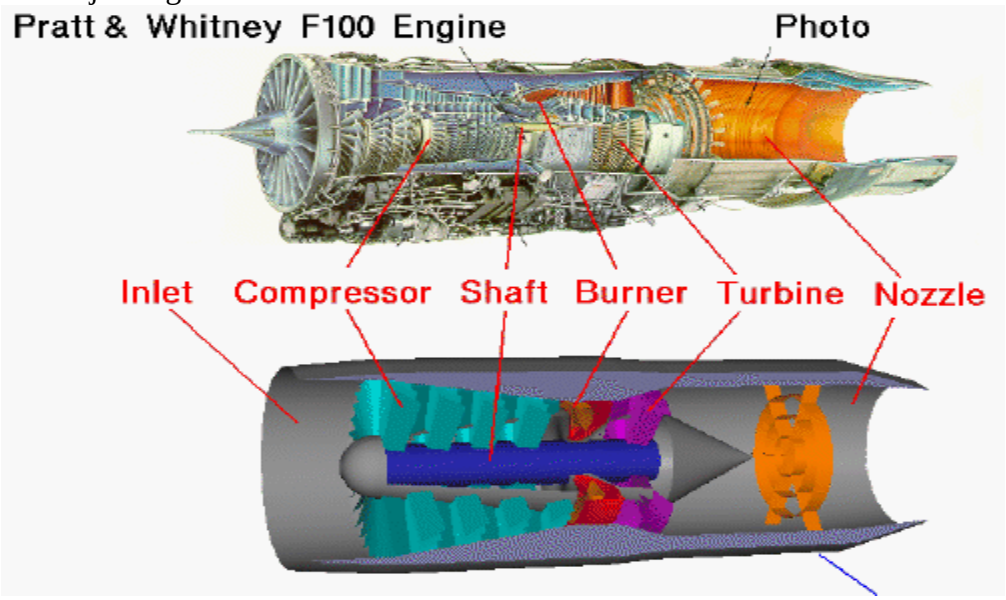


FIGURE 1-13*a*
Pratt & Whitney J58 turbojet. (*Courtesy of Pratt & Whitney.*)

Jet Engine

- Jet aircraft make use of turbines for the creation of thrust.
- Consumes more fuel but provide much more thrust than a piston engine.
- Fly faster than propeller driven aircraft.
- Greater weight capacity
- Example: Airbus A340 and Boeing 777, can carry hundreds of passengers and several tons of cargo, and are able to travel for distances up to 13 thousand kilometers.
- Noisy, this makes jet aircraft a source of noise pollution.

Turbo-jet Engine



Turbo-prop Engine

The propeller located at the front of engine

The propeller converts the power developed by the engine into thrust as efficiently as possible under all operating conditions.

These aircraft are popular with regional airlines, as they tend to be more economical on shorter journeys.

Landing Gear Configurations

Affects the structural design of pavements (determination of pavement layers thicknesses)

Some Types of Landing Gear Configurations

1- Single conventional
2- Single tricycle
3- Twin Tricycle
4- Twin Tricycle type 2
5- Single tandem tricycle
6- Twin tandem tricycle
7- Twin bicycle

8- Twin twin bicycle
9- Dual twin tandem tricycle
10- Double twin tandem

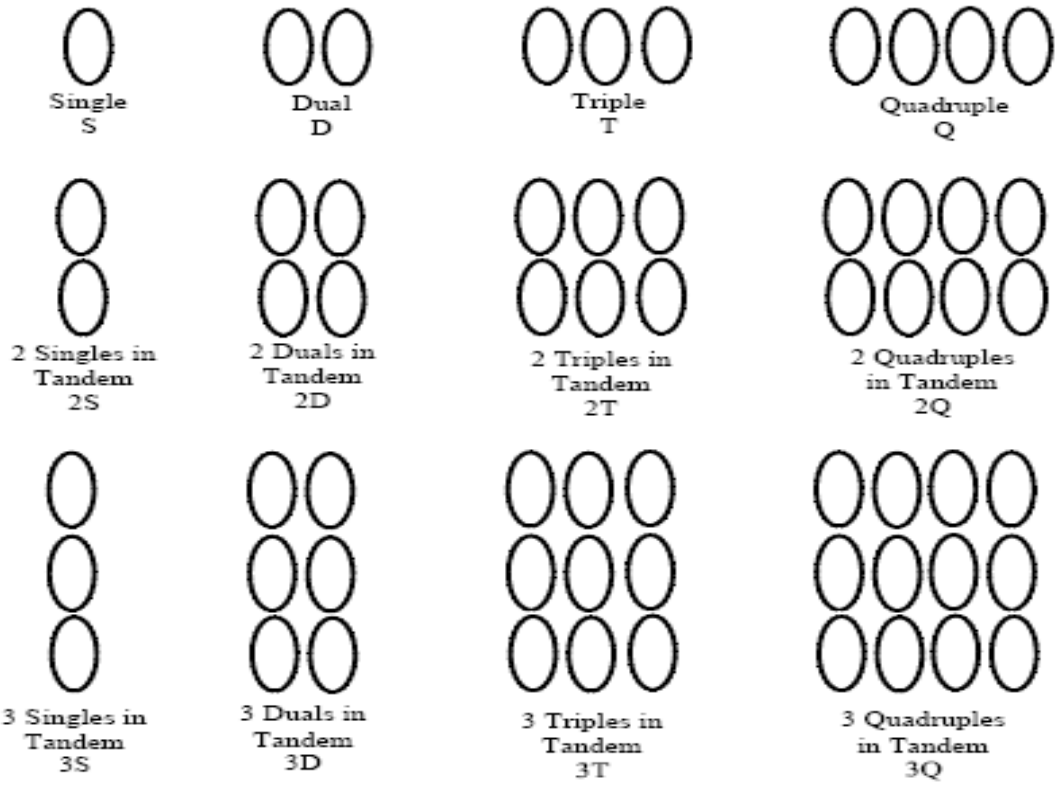


Figure 2. Generic Gear Configurations. Increase numeric value for additional tandem axles.

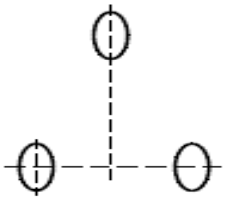


Figure 3. S - Single Wheel Main Gear with Single Wheel Nose Gear

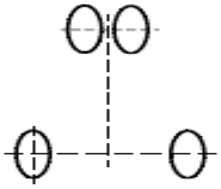


Figure 4. S - Single Wheel Main Gear with Dual Wheel Nose Gear

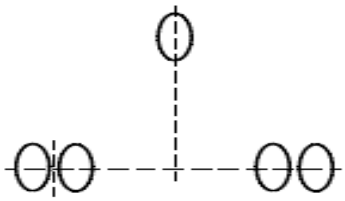


Figure 5. D - Dual Wheel Main Gear with Single Wheel Nose Gear

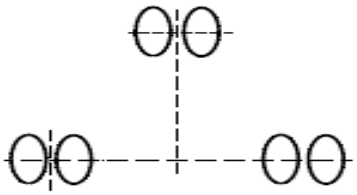


Figure 6. D - Dual Wheel Main Gear with Dual Wheel Nose Gear

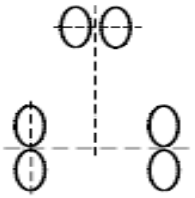


Figure 7. 2S - Two Single Wheels in Tandem Main Gear with Dual Wheel Nose Gear, Lockheed C-130

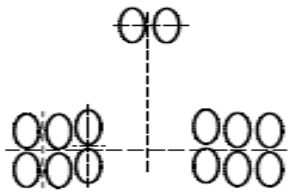


Figure 8. 2T - Two Triple wheels in Tandem Main Gear with Dual Wheel Nose Gear, Boeing C-17

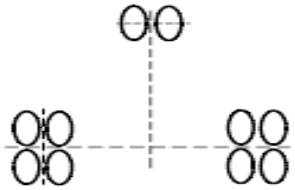


Figure 9. 2D - Two Dual Wheels in Tandem Main Gear with Dual Wheel Nose Gear

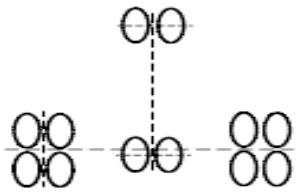


Figure 10. 2D/D1 - Two Dual Wheels in Tandem Main Gear/Dual Wheel Body Gear with Dual Wheel Nose Gear, McDonnell Douglas DC-10, Lockheed L-1011

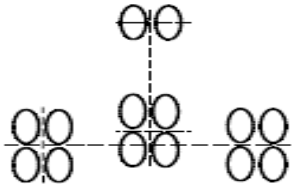


Figure 11. 2D/2D1 Two Dual Wheels in Tandem Main Gear/Two Dual Wheels in Tandem Body Gear with Dual Wheel Nose Gear, Airbus A340-600

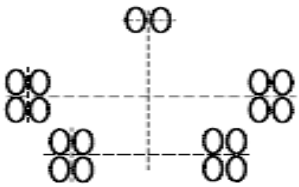


Figure 12. 2D/2D2 - Two Dual Wheels in Tandem Main Gear/Two Dual Wheels in Tandem Body Gear with Dual Wheel Nose Gear, Boeing B-747

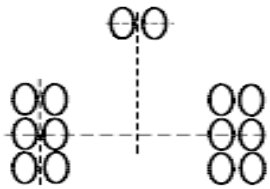


Figure 13. 3D - Three Dual Wheels in Tandem Main Gear with Dual Wheel Nose Gear, Boeing B-777

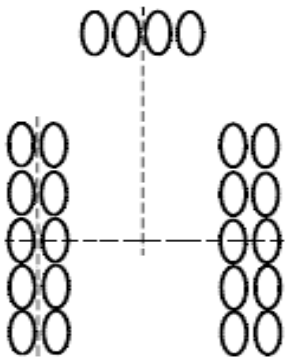


Figure 14. 5D - Five Dual Wheels in Tandem Main Gear with Quadruple Nose Gear, Antonov AN-124

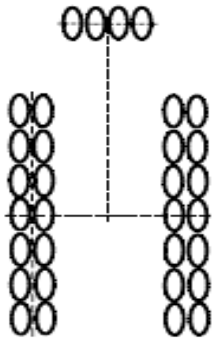


Figure 15. 7D - Seven Dual Wheels in Tandem Main Gear with Quadruple Nose Gear, Antonov AN-225

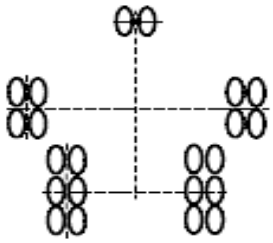


Figure 16. 2D/3D2 - Two Dual Wheels in Tandem Main Gear/Three Dual Wheels in Tandem Body Gear with Dual wheel Nose Gear, Airbus A380

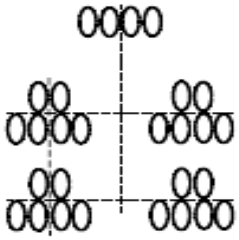


Figure 17. C5 - Complex Gear Comprised of Dual Wheel and Quadruple Wheel Combination with Quadruple Wheel Nose Gear, Lockheed C5 Galaxy

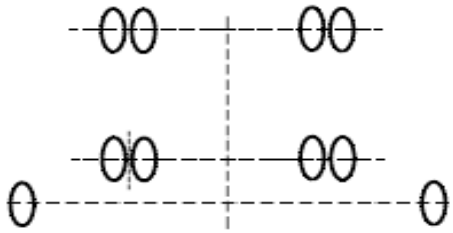


Figure 18. D2 - Dual Wheel Gear Two Struts per Side Main Gear with No Separate Nose Gear (note that single wheel outriggers are ignored), Boeing B-52 Bomber

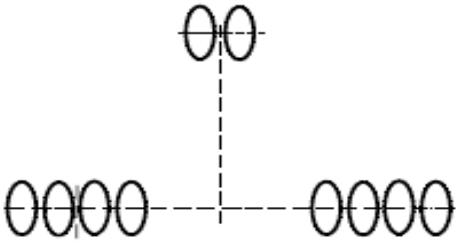


Figure 19. Q - Quadruple Wheel Main Gear with Dual Wheel Nose Gear, Hawker Siddeley HS-121 Trident

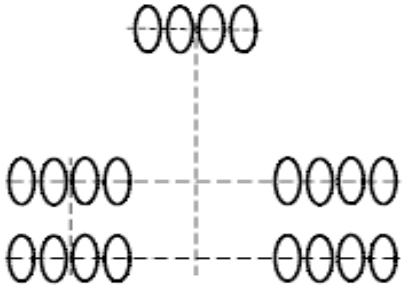
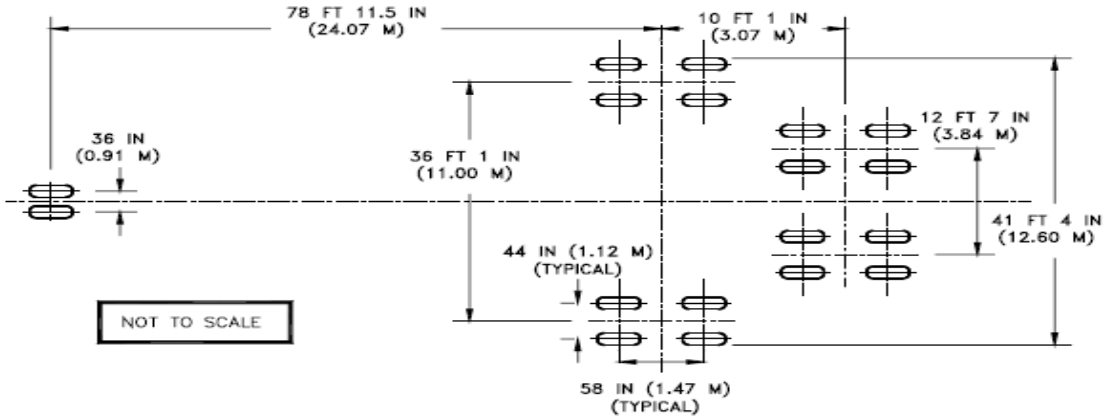


Figure 20. Q2 - Quadruple Wheels Two Struts per Side with Quadruple Nose Gear, Ilyushin IL-76



Aircraft Weight:

- **Manufacturer's empty weight (MEW)**
  Also called *Manufacturer's Weight Empty (MWE)* or *Licensed Empty Weight*
- It is the weight of the aircraft "as built" and includes the weight of the structure, power plant, furnishings, installations, systems and other equipment that are considered an integral part of an aircraft.
- This excludes any baggage, passengers, or usable fuel[2].
- **Zero-fuel weight (ZFW)**
- This is the total weight of the airplane *and* all its contents (including unusable fuel), but excluding the total weight of the usable fuel on board.
- As a flight progresses and fuel is consumed, the total weight of the airplane reduces, but the ZFW remains constant.
- Maximum zero fuel weight (MZFW) is the maximum weight allowed before usable fuel and other specified usable agents (engine injection fluid, and other consumable propulsion agents) are loaded.
- **Operating empty weight (OEW)** (Roughly equivalent to *basic empty weight* on light aircraft)
- It is the basic weight of an aircraft including the crew, all fluids necessary for operation such as engine oil, engine coolant, water, unusable fuel and all operator items and equipment required for flight but excluding usable fuel and the payload.
- **Payload**
- It is the carrying capacity of an aircraft. It includes cargo, people, extra fuel. In the case of a commercial airliner, it may refer only to revenue-generating cargo or paying passengers.
- **Maximum takeoff weight (MTOW)**
- This is the maximum weight at which the pilot of the aircraft is allowed to attempt to take off.
- **Maximum landing weight (MLW)**
- This maximum weight at which an aircraft is permitted to land[2].
- The following image depicts takeoff weight components.
- **Maximum ramp weight (MRW)**
  also called maximum taxi weight (MTW)
- It is the maximum weight authorized for maneuvering (taxiing or towing) an aircraft on the ground.

- **Aircraft gross weight**
- It is the total aircraft weight at any moment during the flight or ground operation. This decreases during flight due to fuel and oil consumption.

The difference between usable fuel and unusable fuel:
Usable fuel is the fuel on board an aircraft that can actually be used by its engines.
unusable fuel the small amount of fuel that cannot be drained from the tanks.

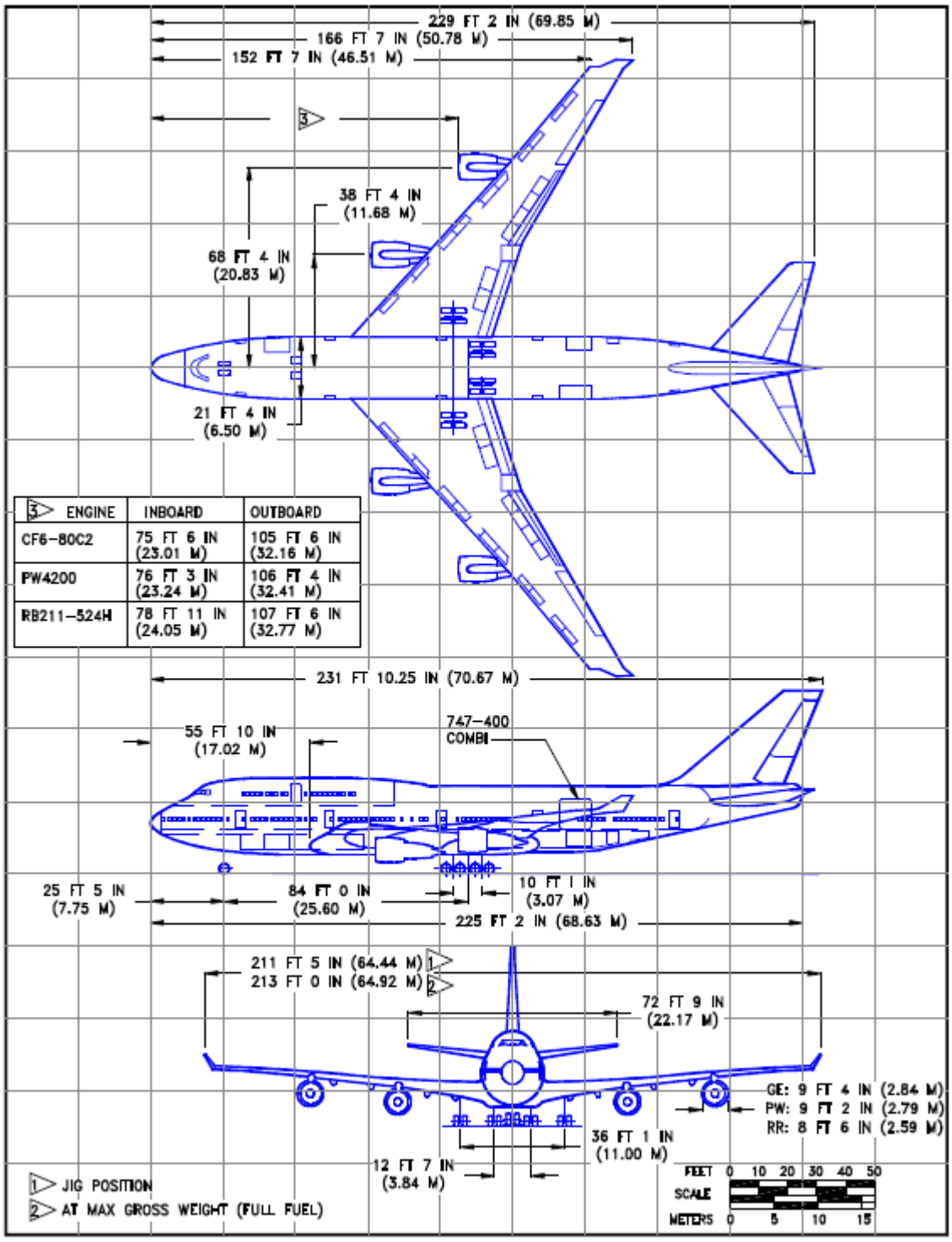
- For calculation of range, usable fuel is used.
- For weight and balance total fuel (usable + unusable) is used.

CHARACTERISTICS	UNITS	CF6-80C2B1 ENGINES				
MAX DESIGN	POUNDS	803,000	836,000	853,000	873,000	877,000
TAXI WEIGHT	KILOGRAMS	364,235	379,204	386,915	395,987	397,801
MAX DESIGN	POUNDS	800,000	833,000	850,000	870,000	875,000
TAKEOFF WEIGHT	KILOGRAMS	362,874	377,843	385,554	394,626	396,894
MAX DESIGN	POUNDS	574,000	574,000	630,000	630,000	630,000
LANDING WEIGHT (1)	KILOGRAMS	260,362	260,362	285,764	285,764	285,764
MAX DESIGN	POUNDS	535,000	535,000	535,000	542,500	542,500
ZERO FUEL WEIGHT (2)	KILOGRAMS	242,672	242,672	242,672	246,074	246,074
SPEC OPERATING	POUNDS	394,088	394,088	394,088	394,088	394,088
EMPTY WEIGHT (3)	KILOGRAMS	178,756	178,756	178,756	178,756	178,756
MAX STRUCTURAL	POUNDS	140,912	140,912	140,912	148,412	148,412
PAYLOAD	KILOGRAMS	63,917	63,917	63,917	67,319	67,319
TYPICAL SEATING CAPACITY	UPPER DECK	42 BUSINESS CLASS				
(INCLUDES UPPER DECK)	MAIN DECK	24 FIRST, 32 BUSINESS, 302 ECONOMY				
MAX CARGO - LOWER DECK	CUBIC FEET	5,536	5,536	5,536	5,536	5,536
CONTAINERS (LD-1)	CUBIC METERS	157	157	157	157	157
MAX CARGO - LOWER DECK	CUBIC FEET	835	835	835	835	835
BULK CARGO	CUBIC METERS	24	24	24	24	24
USABLE FUEL CAPACITY (4)	U.S. GALLONS	53,765	53,763	53,765	57,065	57,065
	LITERS	203,501	203,493	203,501	215,991	215,991
	POUNDS	360,226	360,226	360,226	382,336	382,336
	KILOGRAMS	163,396	163,396	163,396	173,425	173,425

NOTES:

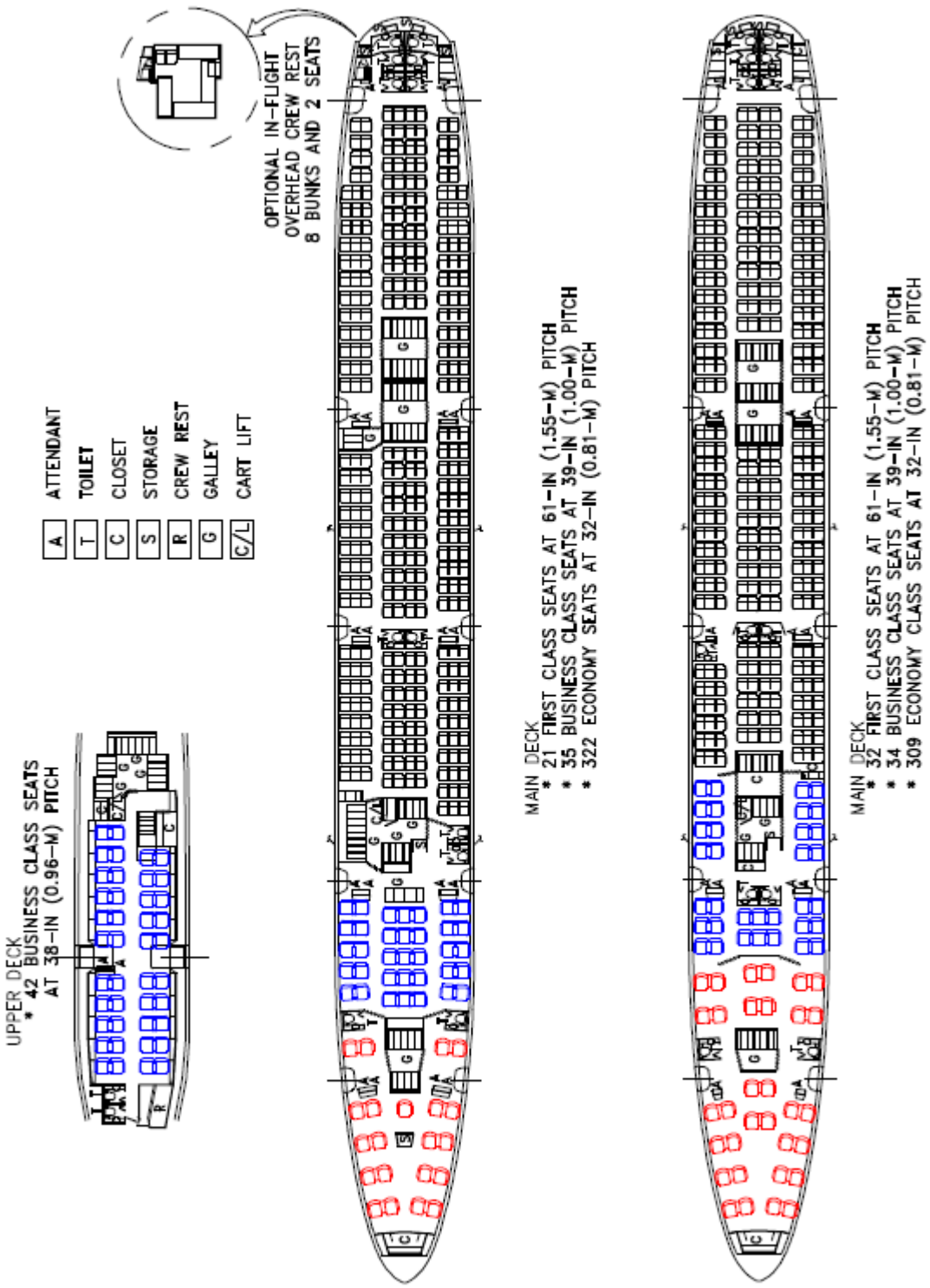
1. 630,000 LB LANDING WEIGHT IS OPTIONAL
2. 542,500 LB ZERO FUEL WEIGHT IS OPTIONAL
3. SPEC OPERATING EMPTY WEIGHT REFLECTS THREE-CLASS 400-PASSENGER ARRANGEMENT AND STANDARD ITEM ALLOWANCES. ACTUAL OEW WILL VARY WITH AIRPLANE CONFIGURATION. CONSULT USING AIRLINE FOR ACTUAL OEW.
4. OPTIONAL TAIL FUEL OF 3,300 US GAL IS REFLECTED IN THE HIGHER FUEL CAPACITY.

2.1.1 GENERAL CHARACTERISTICS
MODEL 747-400 (GENERAL ELECTRIC ENGINES)



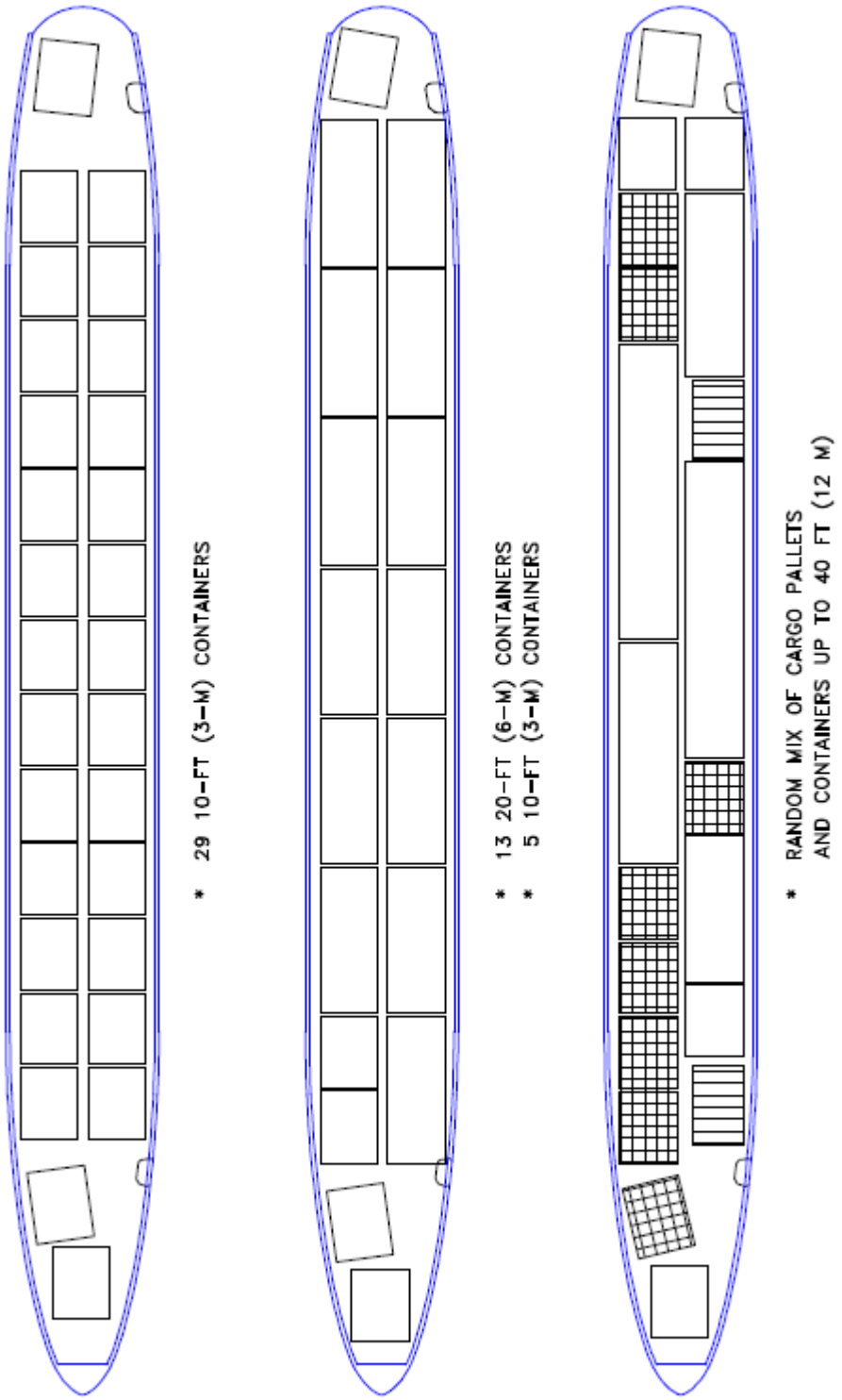
2.2.1 GENERAL DIMENSIONS

MODEL 747-400, -400 COMBI, -400ER



2.4.1 INTERIOR ARRANGEMENTS - TRI-CLASS CONFIGURATION

MODEL 747-400



.5 **INTERIOR ARRANGEMENTS - MAIN DECK CARGO**
MODEL 747-400 FREIGHTER, -400ER FREIGHTER