

Chapter 2

Data collection and preliminary three-view drawing

(Lectures 4 and 5)

Keywords : Importance of collection of data on existing airplanes similar to the proposed design; suggested airplane data sheet; preliminary three-view drawing based on data collection.

Topics

2.1 Introduction

2.2 Data Collection

2.3 Preliminary three-view drawing

Exercises

Appendix 2.1 – Suggested airplane data sheet

Appendix 2.2 – Definition of some terms used in Appendix 2.1

Chapter 2

Lecture 4

Data collection and preliminary three-view drawing - 1

Topics

2.1 Introduction

2.2 Data Collection

Appendix 2.1 – Suggested airplane data sheet

Appendix 2.2 – Definition of some terms used in Appendix 2.1

2.1 Introduction

The design of an airplane begins after the specifications/design requirements are given or arrived at. As mentioned in remark (ii) of section 1.8, it is assumed that the specifications of the airplane, to be designed have already been arrived at. As a next step, two topics are discussed in this chapter viz.

(a) data collection and (b) preparation of a preliminary three view drawing,

2.2 Data collection

Airplane design is an evolutionary process. The data on existing airplanes, similar to the proposed design, provide the necessary guidance for arriving at appropriate initial design values. The sources of design data are:

1. Jane's All The World's Aircraft (Ref.1.21)
2. Books cited in chapter 1
3. www.arnoldpublishers.com/aerodata
4. The Websites of airplane manufacturers such as Boeing, Airbus Industries and others mentioned in exercises 1.7.

A typical format for collection of airplane data is given in Appendix 2.1.

It may be mentioned that this format includes information about the following aspects.

- (a) General features of the airplane.
- (b) Geometrical parameters of the major components of the airplane.
- (c) Various types of weights of the airplane.

(d) Performance parameters.

Remarks:

- (i) Meanings of some of the terms used in Appendix 2.1 are given in Appendix 2.2.
- (ii) The somewhat detailed format for data collection, given in Appendix 2.1, would be useful during subsequent steps of preliminary design and the student should try to obtain as much data as possible. Some of the dimensions may not be given directly and can be obtained from the three-view drawing of the airplane.
- (iii) Appendix 10.2 presents the data collected for a jet airplane in the form of a table. The student is advised to follow it.

Appendix 2.1

Suggested airplane data sheet

1. General description of airplane

Name of the airplane:

Type of airplane *:

Name of manufacturer and country of origin:

2. Power Plant

Type of power plant*:

Name:

Engine rating*:

Specific fuel consumption:

Oil consumption :

Weight of power plant:

Overall dimensions of engine:

Diameter (m):

Length (m):

Engine centre of gravity:

Special accessories and controls

No. of engines and their locations:

Intake/propeller details

* See Appendix 2.2 for definition

3. Wing

Planform shape (Fig.A 2.1.1)

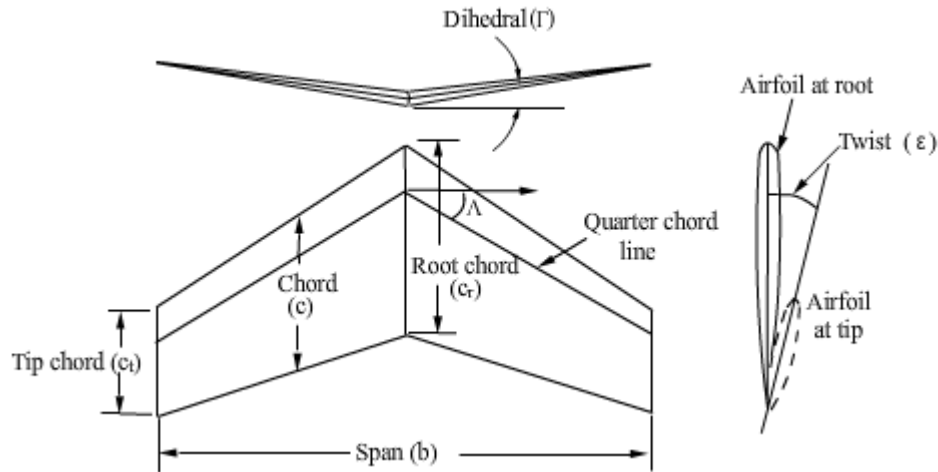


Fig. A 2.1.1 Wing planform

Airfoil section:

Span (m):

Root chord (m):

Tip chord (m):

Area (S) (m^2):

Mean chord* (m):

Mean aerodynamic chord* (m):

Sweep (Λ^0):

Dihedral. (Γ^0):

Twist (ϵ^0):

Incidence (i_w^0):

Flap area (m^2):

Aileron area (m^2):

Type of high-lift devices:

Location of spars:

Taper ratio (λ):

Aspect ratio (A):

Flap area/wing area: or S_{flap}/S

Aileron area/wing area or $S_{aileron}/S$:

Flap chord/ wing chord or c_{flap}/c_{wing} :

Aileron chord/wing chord or $c_{aileron}/c_{wing}$:

Location of wing on fuselage (high wing/mid wing/low wing):

Construction and other details:

4. Horizontal tail surface

Type of horizontal tail *:

Platform shape:

Airfoil:

Span (m):

Root chord (m) :

Tip chord (m):

Area (m^2):

Sweep:

Incidence (i_t^0)*:

Elevator area (m^2):

Tab area (m^2):

Aspect ratio:

Taper ratio:

Elevator area / Tail area:

Tab area / elevator area:

Tail area(S_{ht}) / wing area(S):

Elevator chord / tail chord:

Location of H.tail:

Type of control and aerodynamic balancing*:

Construction and other details:

5. Vertical tail surface

Type of vertical tail *

Airfoil:

Height (m):

Root chord (m):

Tip chord (m):

Area (m^2):

Sweep:

Off-set angle*:

Rudder area (m^2):

Tab area (m^2):

Aspect ratio (A_v)*:

Taper ratio:

Rudder area/tail area:

Tab area / rudder area:

Tail area(S_{vt})/wing area(S):

Location:

Rudder chord/V.tail chord:

Type of control and aerodynamic balancing:

Construction and other details:

6. Fuselage

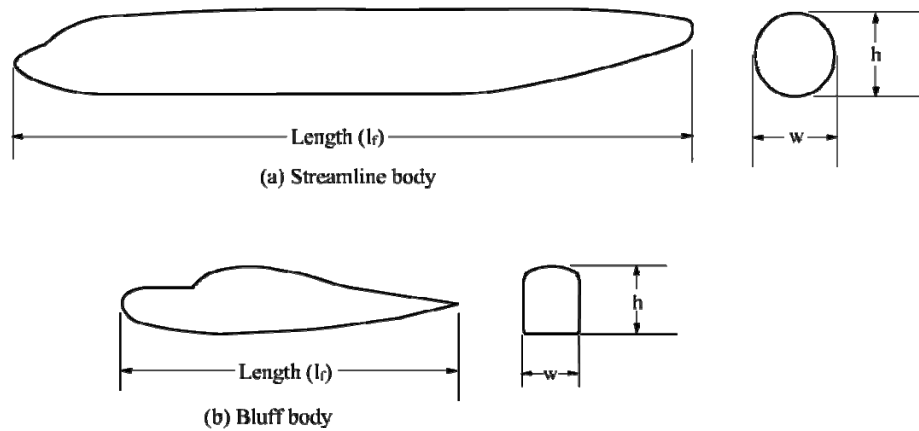
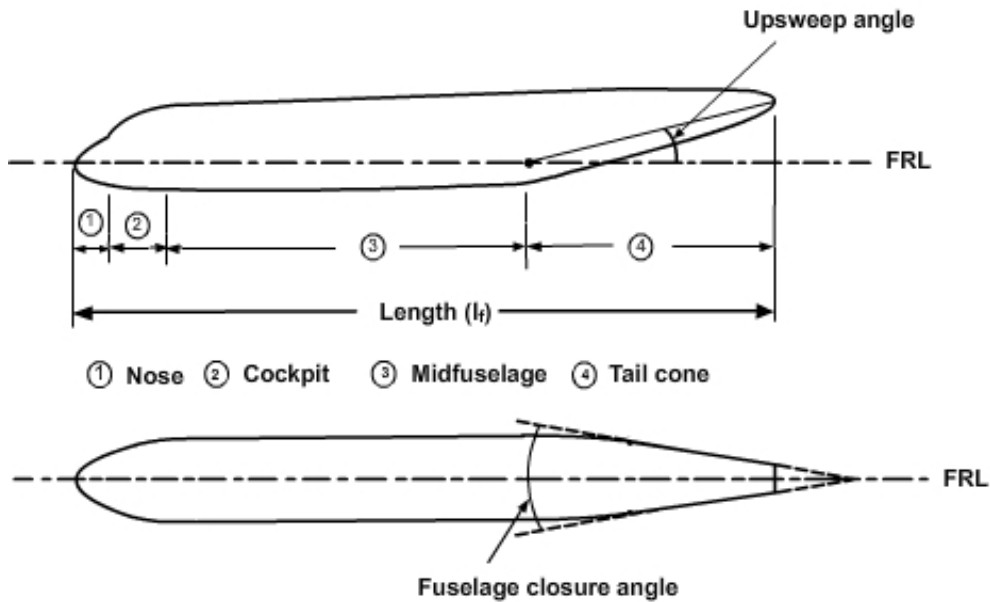
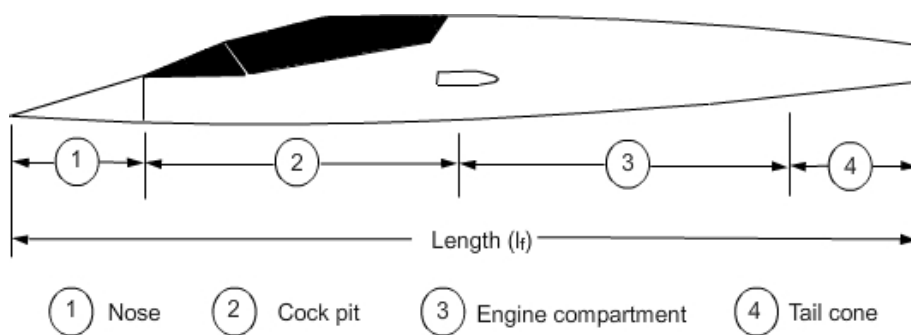


Fig.A 2.1.2 Fuselage parameters



(a) Typical segments of a passenger airplane fuselage



(b) Typical segments of a military airplane fuselage

Fig. A 2.1.3 Typical segments of fuselage

Length (m):

Length of nose (l_{nose}):

Length of cockpit ($l_{cockpit}$):

Length of tail cone ($l_{tailcone}$):

Length of payload compartment:

Length of midfuselage

Upsweep angle

Fuselage closure angle

Shape and size of cabin:

Arrangement of payload and auxiliary equipment:

Cockpit:

Number and arrangement of seats:

Cockpit instruments:

Vision (angle):

Construction and other details:

Length(l_f)/wingspan(b):

l_{nose}/l_f :

$l_{cockpit}/l_f$:

$l_{tailcone}/l_f$:

7. Landing gear

Type of landing gear*:

Number and size of wheels:

Tyre pressure:

Wheel base* (m):

Wheel tread* (m):

Location of landing gears:

Means to reduce landing run and other details:

8. Overall dimensions of airplane

Length (m):

Wing span (m):

Height (m):

Landing gear wheel tread (m):

Landing gear wheel base(m):

Length/span: Height/span:
Tread/span:

9. Weights

Pay load* (kgf):
Empty weight* (kgf):
Fuel weight (kgf):
Structural weight (kgf):
Disposable load* (kgf):
Landing weight (kgf):
Normal gross weight (kgf):
Maximum gross weight (kgf):
Payload/gross weight:
Empty weight/gross weight:
Fuel weight/gross weight:
Structural weight/gross weight:
Wing loading*:
Power (or thrust) loading*:

10. Performance

Maximum speed (kmph) at sea level:
Maximum speed (kmph) at altitude :
Landing speed (kmph):
Cruise speed (kmph) and altitude (km):
Maximum sea level rate of climb (m/min):
Service ceiling (km):
Range* or radius of action* (km):
Endurance* (hours):
Take-off run* (m):
Landing run* (m):

Remark:

It may be pointed out that from various items of raw data the ratios like l_f / b , S_t / S , S_{vt} / S etc. are deduced. These ratios are very useful because, as would be discussed later, for similar airplanes such ratios lie in a narrow band and help in arriving at the ballpark figures for airplane under design.

Appendix 2.2

Definitions of some terms used in Appendix 2.1

(source Refs.1.2 & 1.3)

- **Aerodynamic balance:** Method of reducing control-surface hinge moment.
- **Aspect ratio (A):** It is equal to b^2 / S , where, b is the wing span measured from tip to tip perpendicular to the longitudinal axis and S is the gross wing area; gross wing area includes the wing area inside the fuselage.
- **Aspect ratio of vertical tail (A_v):** It is equal to h^2 / S_v , where h is height of vertical tail and S_v is reference area of vertical tail.
- **Disposable load:** MRW (Maximum Ramp Weight) minus OEW (Operational Empty Weight).
- **Empty weight:** Weight of an operational airplane without fuel, payload, crew and other removable items. OEW (Operational Empty Weight) is also used in the same context.
- **Endurance:** Time in hours for which the airplane can remain in flight with a given amount of fuel.
- **Engine rating:** Output as permitted by regulations for specified use e.g. maximum takeoff (2.5 and 5 minute rating), climb (30 minute rating), cruise (maximum continuous rating).
- **Incidence of horizontal tail (i_t):** Angle between reference chord of horizontal tail and fuselage reference line (Fig.A2.2.1).

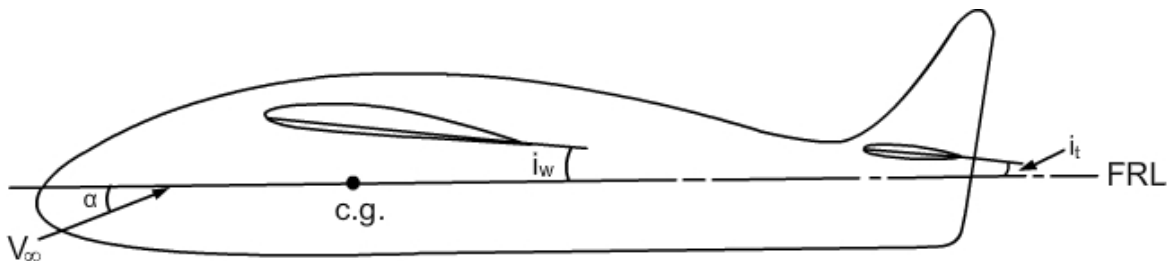


Fig.A2.2.1 Wing incidence(i_w) and tail incidence(i_t)

Note : Generally, i_t is negative

- **Incidence of wing (i_w):** Angle between reference chord of the wing and the fuselage reference line (Fig.A2.2.1).
- **Landing distance:** Horizontal distance covered in descending from screen height and come to a halt.
- **Landing gear types:** a) tricycle or nose wheel, (b) tail wheel and c) bicycle.
- **Landing run:** Horizontal distance covered from the point where the main wheels touch the ground to the point where the airplane comes to a halt.
- **Maximum ramp weight:** Maximum weight permissible for an aircraft. It equals MTOW (Maximum Take off Weight) plus fuel allowance for running main engines and APU (Auxiliary Power Unit) during start, run-up and taxing operations.
- **Mean aerodynamic chord (\bar{c}):** It is given by:

$$\bar{c} = \frac{1}{S} \int_{-b/2}^{b/2} c^2 dy$$

- **Mean chord (S/b) :** Ratio of gross wing area to span.
- **Offset angle:** Angle in plan-view between reference chord of vertical tail and FRL (Fuselage Reference Line).
- **Payload :** That part of useful load for which the airplane is designed or from which the revenue is derived (Ref.1.2).
- **Take-off distance :** Field length measured from brake-release to the point of attaining screen height; screen height is generally 15m.
- **Take-off run :** Field length measured from brake-release to the point where main wheels leave the ground.
- **Taper ratio (λ) :** Ratio of tip chord (c_t) to root chord (c_r).
- **Thrust loading (T/W):** Maximum sea level static thrust divided by MTOW of jet-propelled vehicle.
- **Type of airplane :** Main classification is civil and military. Among civil airplanes there are passenger, cargo, agricultural, sports, ambulance etc.

In military category there are fighter, bomber, reconnaissance, transport etc.

- **Types of horizontal tail** : Important arrangements for the horizontal tail are the conventional tail, T-tail and cruciform tail. In conventional tail arrangement the horizontal tail is behind the wing and located on the fuselage (Fig.1.2 f & j). In T-tail configuration the horizontal tail is located on top of the vertical tail (Fig.1.1a). Whereas in a cruciform tail the horizontal tail is located midway on the vertical tail (Fig.A2.2.2). See Ref.1.18, chapter 4 for other arrangements of tails.
- **Types of power plant** : piston engine-propeller combination, turboprop, turbofan and turbojet.
- **Types of vertical tail:** Generally airplanes have single vertical tail (Fig.1.7, 1.8 a, 1.8 b and 1.9).



Fig.A2.2.2 Airplane with cruciform horizontal tail

(Source : www.upload.wikimedia.org)

In supersonic airplanes there may be two vertical tails located near the tips of the horizontal tail (Fig.1.12). In an airplane with pod and boom configuration,

there are two vertical tails located on top of booms (Fig.1.2i). The horizontal tail would be in between the two booms.

- **Twist(ϵ)**: Variation in angle of incidence along the wing span (Fig.A2.1.1).
- **Useful load** : It is the difference between operational empty weight (OEW) and maximum take-off weight (MTOW) (Ref.1.2).
- **Wheel base** : Distance in side elevation between wheel centers of nose and main landing gears.
- **Wheel tread**: Lateral spacing between the left and the right main landing gears.
- **Wing loading (W/S)**: Gross weight or MTOW divided by wing area.