Project 1 – Lift and drag

1.1 Context and objectives

The objective of this first project is to study the speed limits of a conventional aircraft in normal flight.

You are working for an aircraft manufacturer which is developing a business jet intended to compete with two existing products. Wind tunnel experiments have yielded preliminary data regarding the lift, drag and thrust characteristics of the proposed airplane. Based on this data, you are asked to study the flight performance of the proposed aircraft, and help design it into a commercially viable airplane.

Based on your analysis of the aerodynamic data,

- Select both an area and an angle setting relative to the fuselage for the wing;
- Calculate the range of speeds at which the aircraft will be able to remain in flight at low altitude;
- Calculate the aircraft's finesse and the power required to maintain steady flight.

Your mark will be based on the clarity of your work as well as on the validity of your calculations. You may use any tool you wish (ex. software, books), but you are required to quote all of your sources.

Groups handing in written reports must hand in one single printed or PDF (A4-size) document, no longer than 8 pages.

Groups making an oral presentation must aim for less than 15 minutes (all members participating), and then answer questions from the class. Please hand in your slides as a print-out or PDF file.

1.2 Aircraft specifications

The aircraft you are working on is to compete with the *Eclipse 500* and the *Cessna Citation Mustang* (figure 1.1). It is designed as an entry-market, twin-engined pressurized business jet priced below $3m, able to carry 6 passengers comfortably.

The wing area of the aircraft is not yet determined. Preliminary specifications are given in table 1.1 ; it is assumed that aircraft weights are approximately independent of wing area.

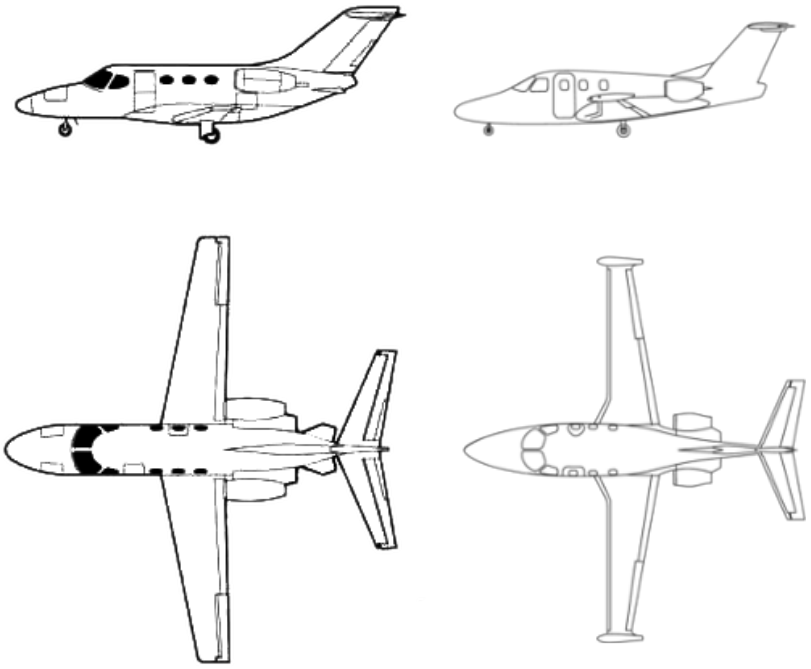

Figure 1.1: Three-view plans of the Cessna Citation Mustang (left) and Eclipse 500 (right), drawn approximately to scale.

Crew	1 or 2
Capacity	5 to 6 pax
Length	12 m
Wingspan	12 m
OWE	1 950 kg
MTOW	3 250 kg
Powerplant	2 × P&WC PW600, (4,5 kN) each

Table 1.1: Specifications of the new aircraft

1.3 Engine data

The aircraft is powered by two Pratt & Whitney Canada PW600 turbofans. Each has a maximum thrust at sea level, $T_{max,SL}$, of 4,5 kN.

1.4 Aircraft design requirements

In order to be able to land at restricted airports, the aircraft must have a landing speed no higher than 120 km/h.

In order to reduce drag during cruise, the aircraft fuselage should have an angle relative to horizontal no lower than −2° during cruise flight.

1.5 Aircraft aerodynamics

Wind tunnel measurements on a small model yield the values for aircraft lift coefficient (C_L) plotted in figure 1.2.

Wind tunnel measurements also allowed aerodynamicists to model the drag coefficient as follows:

In clean wing configuration:

$$C_D = 0{,}024 + 0{,}044\ C_L^2 \tag{1/1}$$

In landing configuration:

$$C_D = 0{,}056 + 0{,}05\ C_L^2 \tag{1/2}$$

1.6 Atmospheric data

In this project we will evaluate flight performance at sea level, where $T_{SL} = 288{,}15\,\mathrm{K}$ and $\rho_{SL} = 1{,}225\,\mathrm{kg\,m^{-3}}$.

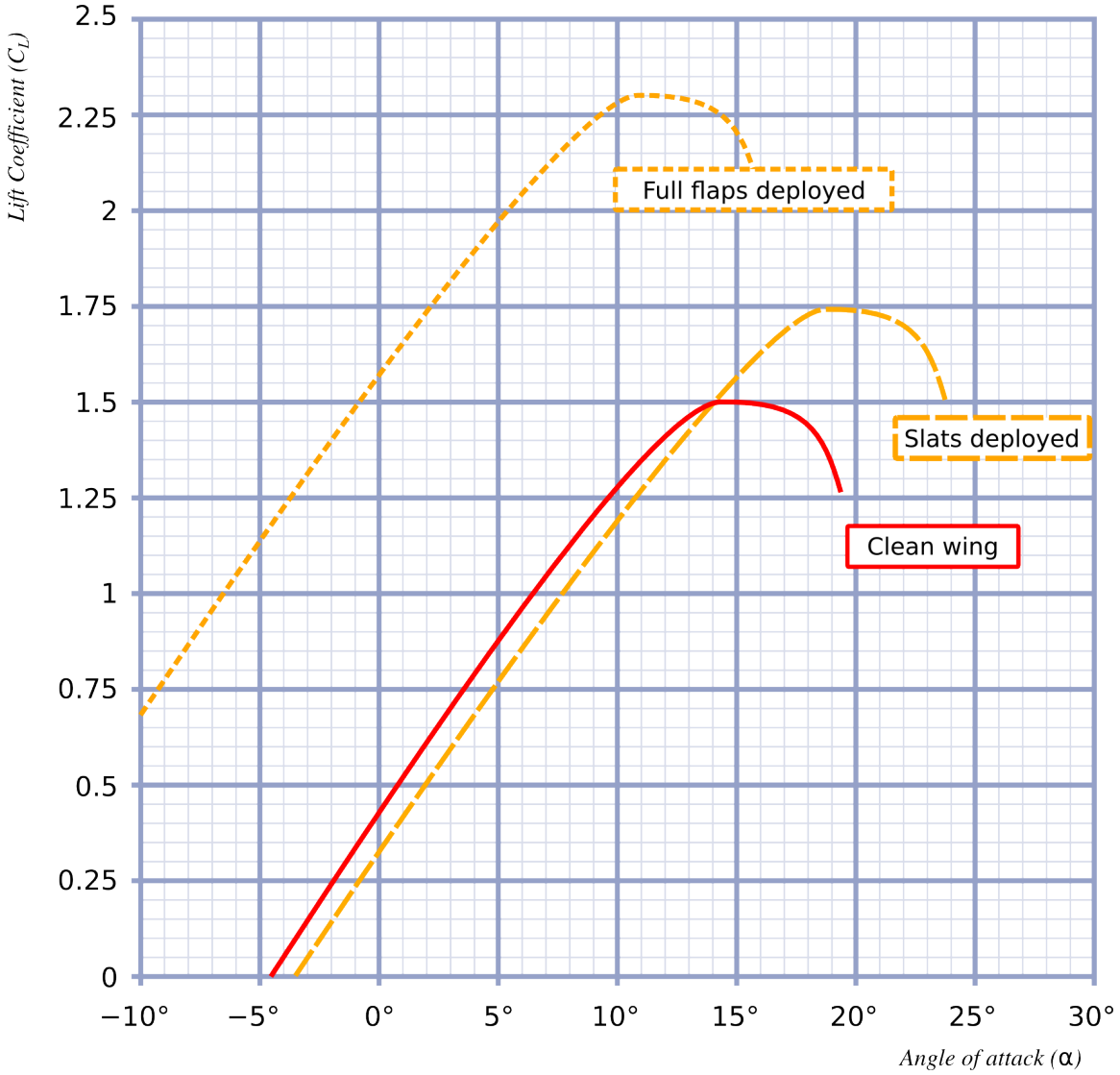

Figure 1.2: Lift coefficient as a function of angle of attack for the aircraft, as measured on a representative wind tunnel model.