# Approval Sheet

The project report attached here to, entitle "Modelling and Fabricating Subsonic Wing" prepared and submitted by Khairul Amin bin Othman in partial fulfillment of the requirement for Bachelor of Engineering with Honours in Mechanical Engineering and Manufacturing System in hereby read and approved by:

M. Shahril

Dr. Mohd. Shahril bin Osman
Supervisor

24/5/2005

Date
MEI 2005

# MODELLING AND FABRICATING SUBSONIC WING

**KHAIRUL AMIN BIN OTHMAN**

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing Systems)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

For my Father and Mother
And
My beloved family

# ACKNOWLEDGEMENTS

Alhamdulillah, Thank God for all His blessing and permission I was able to complete this Final Year Project. First and foremost I would like to take this opportunity to thank my supervisor, Dr. Mohd. Shahril Osman for his valuable advices, his patience and willingness to assist me completes this report. Without his support, the work is never have been finished. I would like to mention my special thanks to my mother and my father, my parents for their continuous encouragement and support in my life. I am forever grateful to them for that.

I would like to thank Mr Masri and Mr Rhyier and other lab technicians for their willing to work overtime n enabling me to collect necessary data and prepare the tools and machines that needed in this project. They have always been exceptionally helpful whenever I faced any problem in developing the experimental set up.

I am grateful to all my supportive friends and mechanical lecturers, without their help I would be still taking data. Last but no the least, I want to expressed my thank to my roommate, Nizam and my friends, Zulkurnain, Dahri especially Elizah for just being there in my difficult times.

# ABSTRACT

Aerodynamics is the study of forces and the resulting motion of objects through the fluid. Aerodynamics affects the motion of a large airliner, a model rocket, or a kite flying high overhead. The purpose of this study is to determine the best subsonic wing profile. The airfoil of the wing is developed and fabricated for test. The aerodynamics characteristics such as lift force and drag force, lift and drag coefficient, lift drag ratio and other properties is measured and analysed. Several experiments have been carried out in open subsonic wind tunnel using the four models of NACA 4- digit airfoil. According to experiment, the maximum model NACA 1221 has a high lift coefficient which is 1.86882 and NACA 2317 airfoil has the lowest drag coefficient of 0.01127. In addition, the result is compared with other experimental past data. From the lift over drag ratio results, we can conclude that NACA 2317 airfoil model is the effective airfoil compare to the other three tested airfoil.

# ABSTRAK

Aerodinamik merupakan kajian tentang daya dan akibat dari pergerakan objek melalui cecair dan gas. Aerodinamik memberi amat penting kepada kapal terbang, model roket mahupun pergerakan layang-layang diudara. Kajian ini bertujuan untuk menentukan dan mencari sayap terbang 'subsonic' yang terbaik. Dengan itu, 'airfoil' telah direka dan dibentuk untuk digunakan dalam pengkajian ini. Sifat aerodinamik seperti daya terbang dan daya seretan, koefisien terbang dan seretan dan juga lain- lain ciri aerodinamik telah diukur dan dianalisis. Beberapa siri eksperimen telah dibuat dalam terowong udara 'subsonic' terbuka menggunakan 'airfoil' 4- digit NACA yang telah dibuat pada awalnya. Daripada eksperimen itu, 'airfoil' NACA 1221 mempunyai koefisien terbang paling tinggi iaitu 1.86882 dan 'airfoil' NACA 2317 mempunyai koefisien seretan paling rendah 0.01127. Sebagai tambahan, keputusan eksperimen dibandingkan dengan data dari eksperimen lain. Dari keputusan bandingan terbang terhadap seretan, dapat disimpulkan bahawa 'airfoil' NACA 2317 merupakan model yang paling effektif dibandingkan dengan tiga 'airfoil' yang lainnya.

# CONTENTS

| Contents | Page Number |
|---|---|

## CHAPTER 5: CONCLUSION

# LIST OF FIGURE

**FIGURE** **PAGE NUMBER**

# LIST OF TABLE

**TABLE** **PAGE NUMBER**

# NOMENCLATURES

$\alpha$ : Angle of attack

$\rho$ : Mass density

$\rho_a$ : Local air density

$\gamma$ : Ratio of specific heat

$\nu$ : Kinematics viscosity

$\Delta P_1$ : Dynamic pressure

a : Speed of sound

A : Airfoil area

$A_p$ : Planform area

AR : Aspect ratio

c : Chord

$C_D$ : Total drag coefficient

$C_{Di}$ : Induced drag coefficient

$C_{D\infty}$ : Drag of infinite span airfoil

$C_L$ : Lift coefficient

D : Drag force

h /c : maximum chamber

L : Lift force

L : Length of the airfoil

L / D : Lift drag ratio

Ma : Mach number

$P_a$ : Ambient atmospheric pressure

R : Gas constant

Ra : Average roughness

Re : Reynolds number

s : Span

T : Temperature

$T_a$ : Ambient temperature

U : External velocity

V : Velocity of wind relative to the body

# Chapter 1

# INTRODUCTION

## 1.0 General Overview of Aerodynamic

Aerodynamics is the study of fluids in motion. Anderson (2001), states that aerodynamics is an applied science with many practical applications in engineering. No matter how sophisticated an aerodynamic experiment may be, the efforts are usually at one or more of the following practical objectives:

a. The prediction of forces and moments on, and the heat transfer to, bodies moving through the fluid (usually air).
b. Determination of flows moving internally through the duct.

The application in first item come heading of external aerodynamic since they deal with external flows over the body. In contrast, the application in second item is involve internal aerodynamics because they deal with flow internally within ducts. This project consider to the external aerodynamics of the airplane wing and much more focusing on the airfoil shape design that will best suit for the subsonic airplane.

## 1.1 Overview of airplane

Airplanes come in many different shapes and sizes. The wings generate most of the lift to hold the plane in the air. To generate lift, the airplane must be pushed through the air by the jet engines to provide the thrust to push airplane forward. This moving will cause the oppose force due to air resistant called drag.

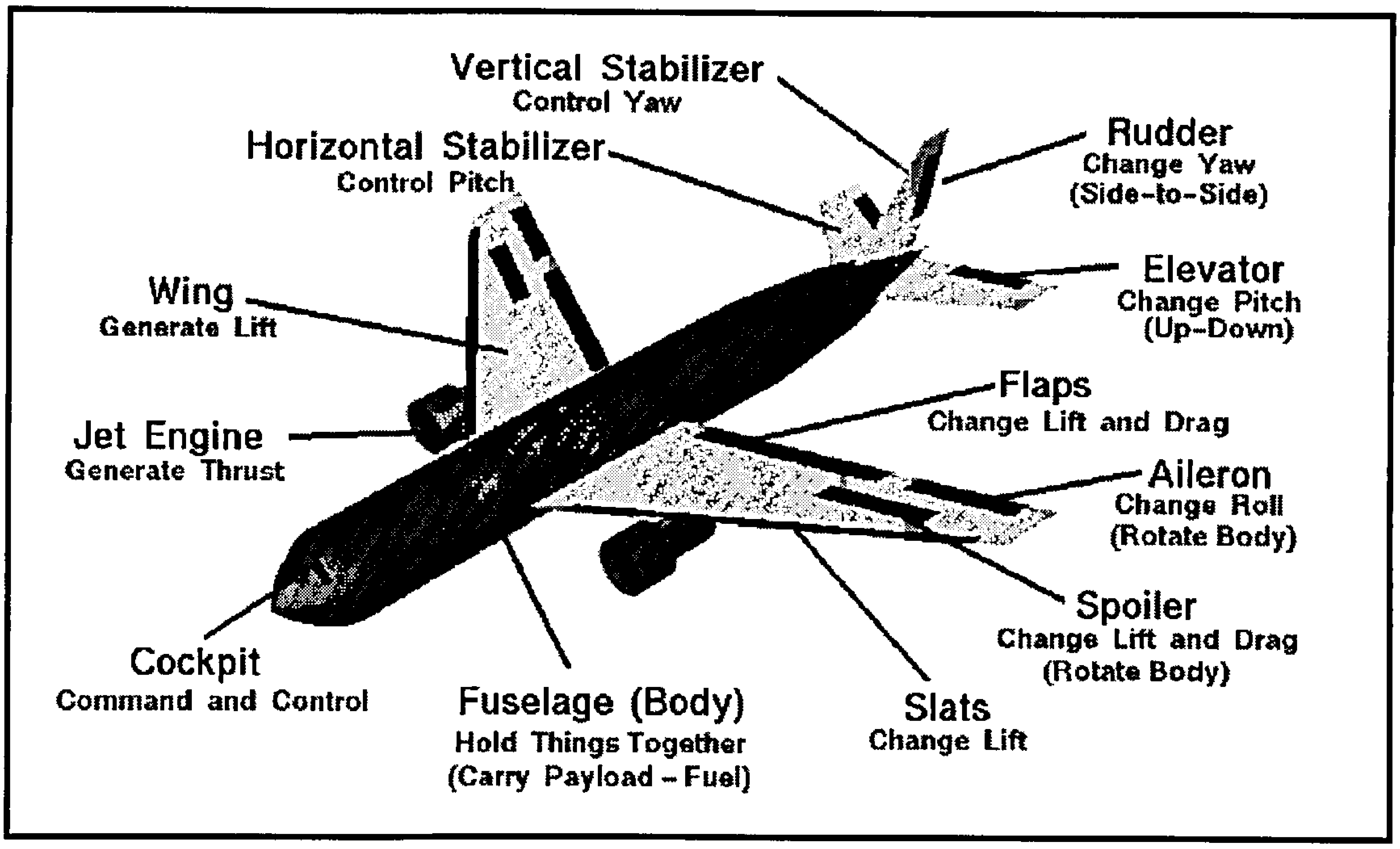


**Figure 1.1:** Airplane configuration (Courtesy from Bensen,2004)

Figure 1.1 shows the generally airplane parts. wing is located at the centre of the fuselage. Vertical stabilizer and horizontal stabilizer located at the airplane tail to provide stability for the airplane, to keep it fly straight. the function of the vertical stabilizer is to avoid airplane nose from swinging side to side,while horizontal stabilizer prevent up and down nose motion.Rudder is the hinged part of the vertical stabilizer, used to deflect the tail to the left and right. The hinged part at the horizontal called elevator; to deflect the tail up and down as shown in the Figure 1.0.

Aileron and spoiler at the wing used to rotate the body of the airplane; aileron change the roll and spoiler decrease the lift force when it is deployed.

The wings have additional hinged, rear sections near the body that are called flaps. Flaps are deployed downward on takeoff and landing to increase the amount of force produced by the wing. Slat, the front part of the wing will also deflect at takeoff and landing to produce additional force. The spoilers are also used during landing to slow the plane down and to counteract the flaps when the airplane is on the ground.

### 1.1.1 Wing Geometry

**Top View**

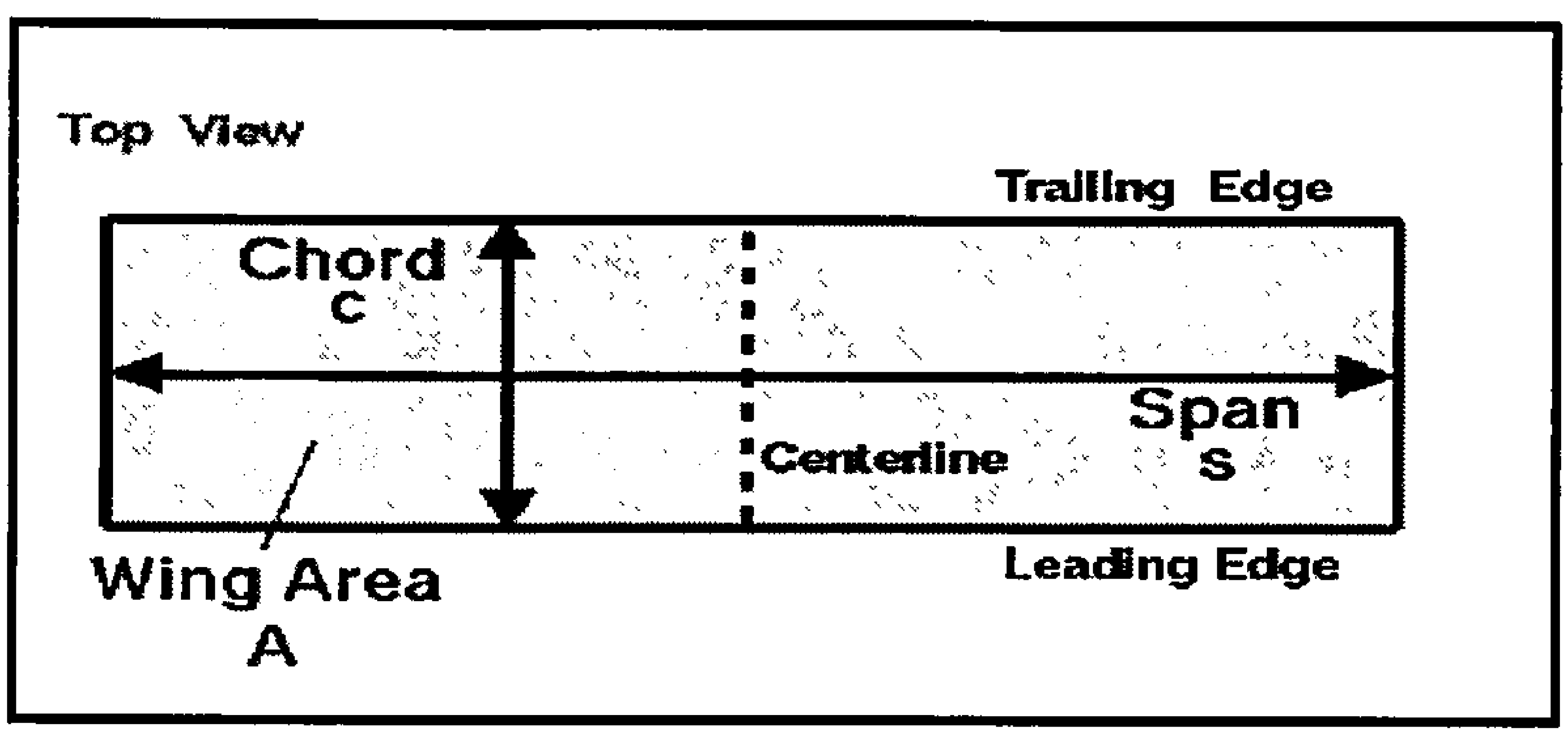


**Figure 1.2:** Airplane geometry top view (Courtesy from Bensen, 2004)

The Figure 1.2 shows a simple wing geometry in the top view. The front of the wing is called the leading edge; the back of the wing is called the trailing edge. The distance from the leading edge to the trailing edge is called the chord, denoted by the symbol, *c*. The ends of the wing are called the wing tips, and the distance from one wing tip to the other is called the span, given the symbol, *s*. The shape of the wing, when viewed from above looking down onto the wing, is called a planform. The wing area, $A$, is the projected area of the planform and is bounded by the leading and trailing edges and the wing tips.

**Front View**

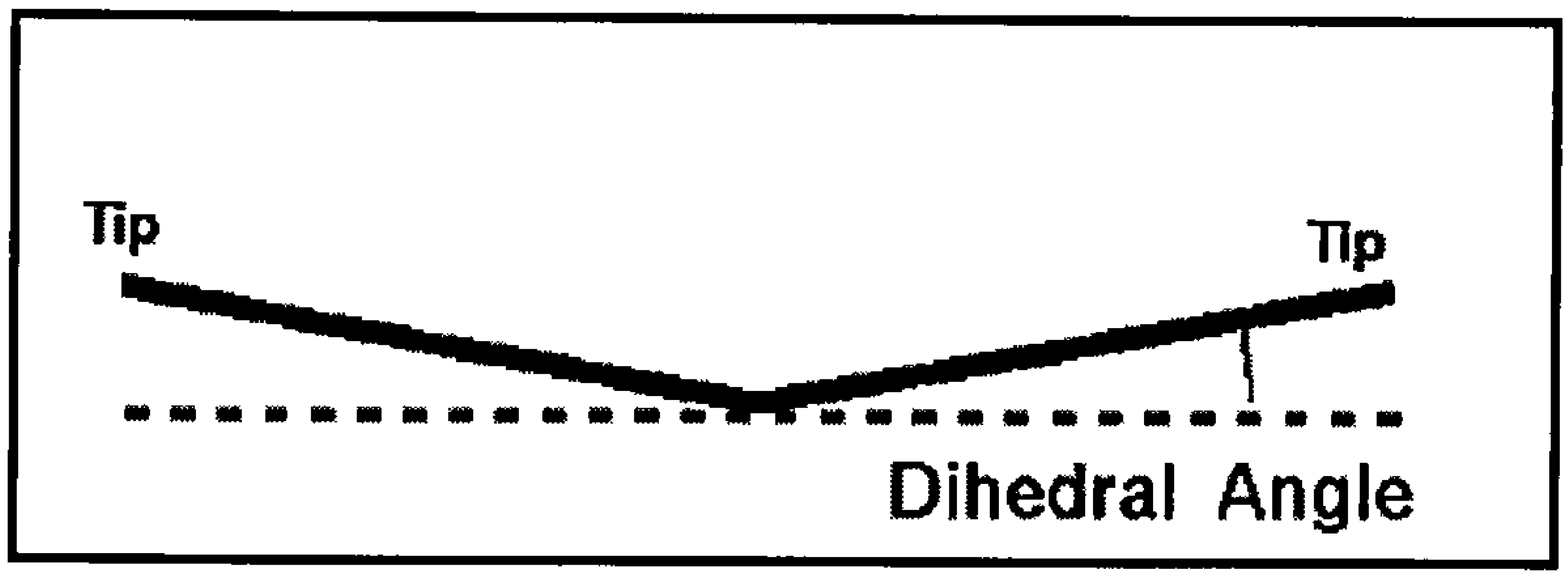


**Figure 1.3:** Airplane geometry front view (Courtesy from Bensen, 2004)

According to Bensen (2004), the front view of this wing shows that the left and right wing do not lie in the same plane but meet at an angle. The angle that the wing makes with the local horizontal is called the dihedral angle. Dihedral is added to the wings for roll stability; a wing with some dihedral will naturally return to its original position if it encounters a slight roll displacement. The wing tips are farther off the ground than the wing root. A negative dihedral angle is called anhedral.

**Side View**

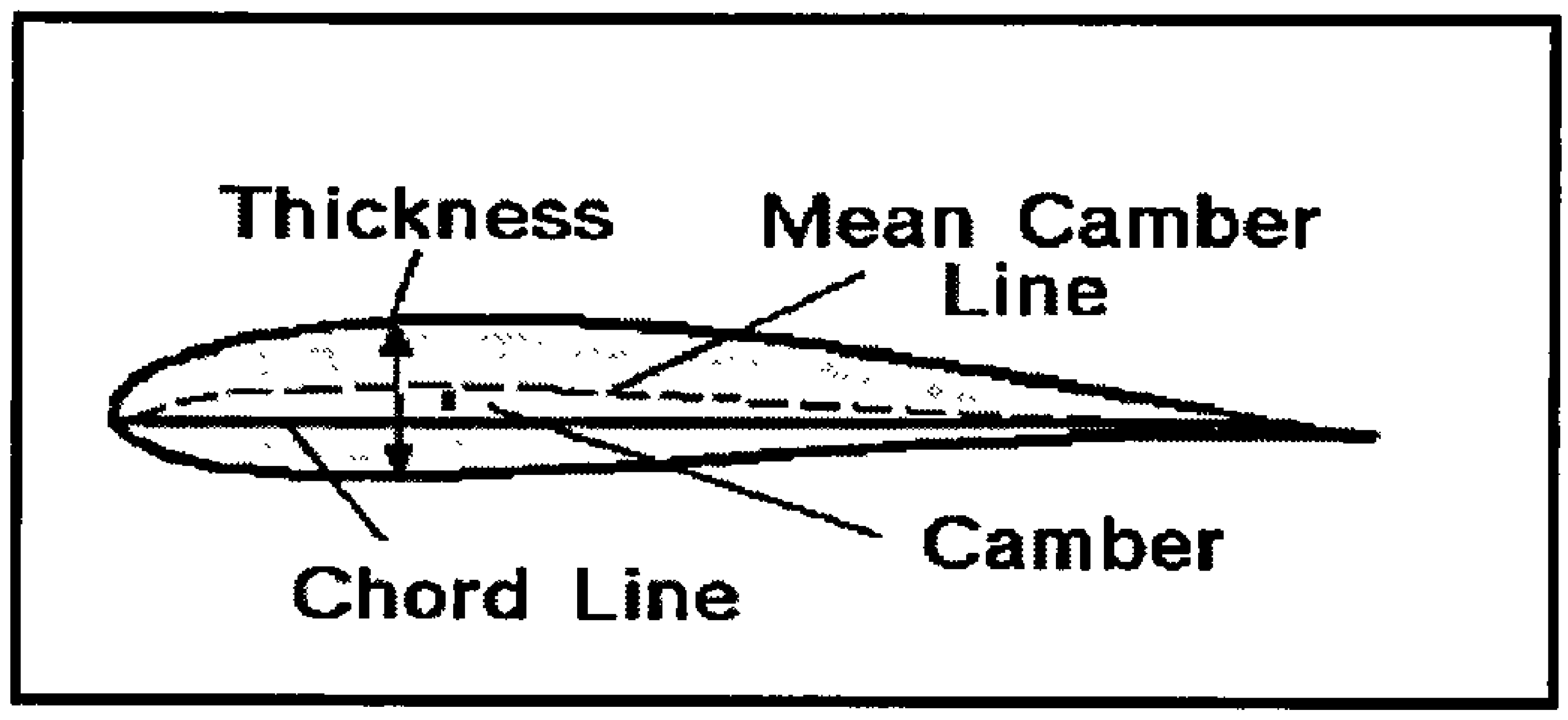


**Figure 1.4:** Airplane geometry side view (Courtesy from Bensen,2004)

A cut through the wing perpendicular to the leading and trailing edges will show the cross-section of the wing called an airfoil. The straight line drawn from the leading to trailing edges of the airfoil is called the chord line. The chord line cuts the airfoil into an upper surface and a lower surface. Plotting the points that lie halfway between the upper and lower surfaces, will obtain a curve called the mean camber line. For a symmetric airfoil (upper surface the same shape as the lower surface) the mean camber line will fall on top of the chord line. But in most cases, these are two separate lines. The maximum distance between the two lines is called the camber. The maximum distance between the upper and lower surfaces is called the thickness. (Bensen, 2001).

## 1.2 Overview of the Project

The project is to fabricate and airplane model and to design the airfoil shape. So, the part that will consider in this project is the airfoil of the wing. This project starts with the designing of the airfoil. The reference model to be compared is NACA four digit series which is model 2412. There are four airfoil model used in this project which is

- **Model 1** – The span length is 0.255 m with the chord length is 0.098 m. Maximum chamber thickness is 0.002 m located 0.004 m from the leading edge. The maximum thickness is 0.0126 m. By using the NACA four digit systems, the airfoil can be name as 2413 airfoil.
- **Model 2** – The span length is 0.292 m with the chord length is 0.100 m. Maximum chamber thickness is 0.002 m located 0.006 m from the leading edge. The maximum thickness is 0.0170 m. By using the NACA four digit systems, the airfoil can be name as 2617airfoil.
- **Model 3** – The span length is 0.285 m with the chord length is 0.098 m. Maximum chamber thickness is 0.00275 m located 0.0046 m from the leading edge. The maximum thickness is 0.0170 m. the airfoil can be name as 2417 airfoil using the NACA four digit systems.
- **Model 4** – The span length is 0.290 m with the chord length is 0.099 m. Maximum chamber thickness is 0.0015 m located 0.0017 m from the leading edge. The maximum thickness is 0.021 m. Using the NACA four digit systems, the airfoil can be name as 1221 airfoil.