Aerodynamics and Fluid Mechanics 3: Delta wing aerodynamics laboratory

CAUTION:

Take care in the wind tunnel working section. It is a precision, scientific instrument and should be treated with the utmost care.

PAY ATTENTION TO THE DEMONSTRATORS.
MOVE AROUND WITH CARE INSIDE THE WIND TUNNEL.
TAKE CARE OF WHERE YOU ARE IN THE WIND TUNNEL, AND DO NOT TOUCH ANY SENSORS OR PROBES.
DO NOT TREAD ON ANY CABLES OR TUBES.
DO NOT LEAN ON OR TREAD ON THE WIND TUNNEL MODEL.
IF YOU NEED TO TOUCH THE WIND TUNNEL MODEL SURFACE, DO SO GENTLY.
WALK CAREFULLY AROUND THE TRAVERSE SYSTEM.
DO NOT TOUCH THE PROBE ON THE TRAVERSE SYSTEM.
TAKE NOTES DURING THE LABORATORY. YOU MAY TAKE PHOTOGRAPHS, BUT BE CAREFUL TO ANNOTATE THESE IF YOU WANT TO USE THEM FOR THE LABORATORY REPORT.

1 Introduction

This laboratory is run at the Acre Road facility. You need to make your own way out to the laboratory, post-code is G20 0TL

The purpose of the experiment is to establish the aerodynamic performance of a finite wing in terms of the expression $C_D = C_{D_o} + kC_L^2$, and to take measurements of the wake of the wing to determine the characteristics of the trailing vortex system and to evaluate the drag at a wing section location. Thus the finite wing drag C_D may be compared with the wing section (2-D) drag $C_d(z)$ at a given spanwise location, and the wing tip vortex properties may be related to wing lift and drag.

2 Description of experiment

A Delta wing model is installed in the deHavilland wind tunnel at Acre Road as shown in figure 1. The wind tunnel is a low-speed, closed-return type with a 2.66m wide by 2.06m high by 5.40m long working section. The wind tunnel model is a 60^o leading edge Delta wing with flat upper and lower surfaces and sharp leading edges with 20^o bevel angle. The model is mounted on a six-component balance, in turn is mounted at the end of a sting attached to an arc-sector on a turntable for yaw, pitch, roll angle adjustment as indicated. The turntable is controlled by precision servo motors and the yaw angle can be set to an accuracy of 0.01^o. The balance forces relevant to this laboratory are shown in the figure, and note that the pitching moment is in the conventional right hand sense measured at the balance centre.You will have to do an axis transformation to convert balance F_x and F_z forces into aerodynamic lift and drag, and pitching moment line of action needs to be compensated for to find the wing centre of pressure and aerodynamic centre. A traverse system is installed in the wind tunnel just downstream of the model, and this is used to move a probe around the wing wake. The probe is a seven hole pressure probe that can provide (u, v, w) velocities and local stagnation and static pressure at the probe location, see figure 2 for the senses of the probe velocity components. The traverse is driven by stepper motors that can position the probe to an accuracy of 0.01mm, and the stepper motors are driven by a stepper motor controller operated by a matlab interface. The seven hole probe is connected to a pressure scanner that is able to resolve pressure to 0.1Pa accuracy. The pressure scanner is operated through a matlab interface, and also records the wind tunnel dynamic pressure and wind tunnel static pressure at three reference locations. The seven hole probe has been calibrated, and the measured velocities are plotted as the traverse is moved through the flow field and the probe pressures are measured.

3 Methodology

The laboratory session will start with a brief tour of the wind tunnel working section and model. Pay attention to what the demonstrators say. All the systems are computer controlled, you will be asked by the demonstrator to help operate the wind tunnel instruments. Some of them can be set to run automatically.

1. Take measurements of the wing root chord, apex angle or trailing edge width, and distance from the model apex to the balance centre.
2. There may be the possibility of visualising the leading edge vortex system using a smoke flow visualisation wand. The wind tunnel needs to be run at very low speed for this, and the wand needs to be supported inside the wind tunnel and placed at an appropriate location. Observe the flow with the model at a moderate, positive angle of attack.
3. To measure the aerodynamic loads, the wind tunnel needs to be set to zero speed firstly, and the model angle of attack set to each value to be measured and a loads tare recorded. The turntable control system will take care of this. After this, and the model set to the first angle of attack to be measured, the hardware and software instrument zeroes should be reset, and the wind tunnel can then be set to the operating speed of 20ms^{-1}. When the wind tunnel

speed has settled to the requires test speed, the measurements can begin. The turntable system takes care of the angles of attack to be set and the loads measurements.

4. For the wake measurement with the probe, you need to understand where the wake vortex is in the traverse axis system. Firstly the wind tunnel must be at zero speed. The test to measure the wake vortex needs to be done at a small, positive angle of attack, set the model to this angle. Look at where the probe is relative to where the wing tip is, and use the matlab based traverse control system to move it to a more suitable position if necessary, and set this to the 'home' or origin position. Ensure that the pressure scanner is zeroed, and then run the tunnel to 20ms^{-1}. Record the pressure readings, and traverse the probe in small steps to develop a picture of what the wake flow looks like; what do you expect the wake vortex flow field to look like? Continue traversing the probe and recording data until you have a good measurement of the wake vortex velocity field and flow inboard of the tip. Stop the wind tunnel when you are finished and review the data recorded. *For the lab walk through a single wake traverse matrix was recorded, this contains the vortex flow.*

5. The probe survey data were recorded at 15 degree angle of attack. The leading edge origin is at traverse coordinate (130,130)mm relative to the probe origin.

4 Figures

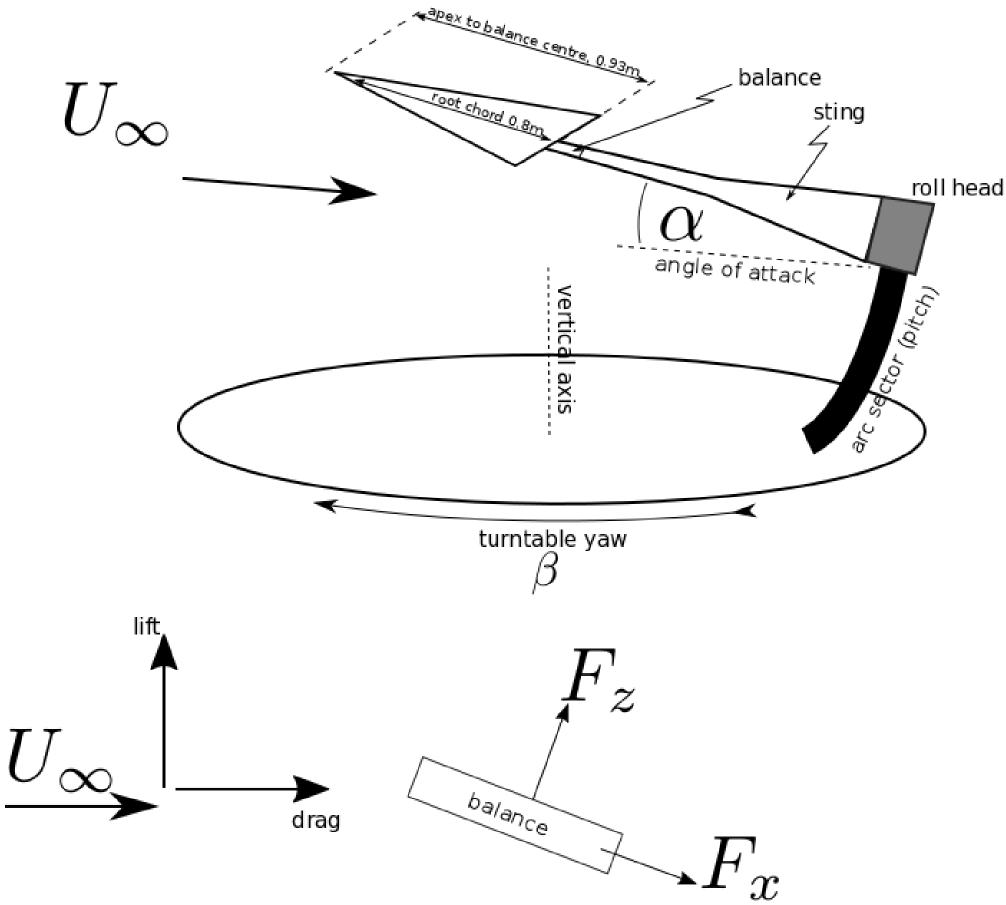

Figure 1: Schematic diagram of Delta wing model in the wind tunnel showing balance force directions

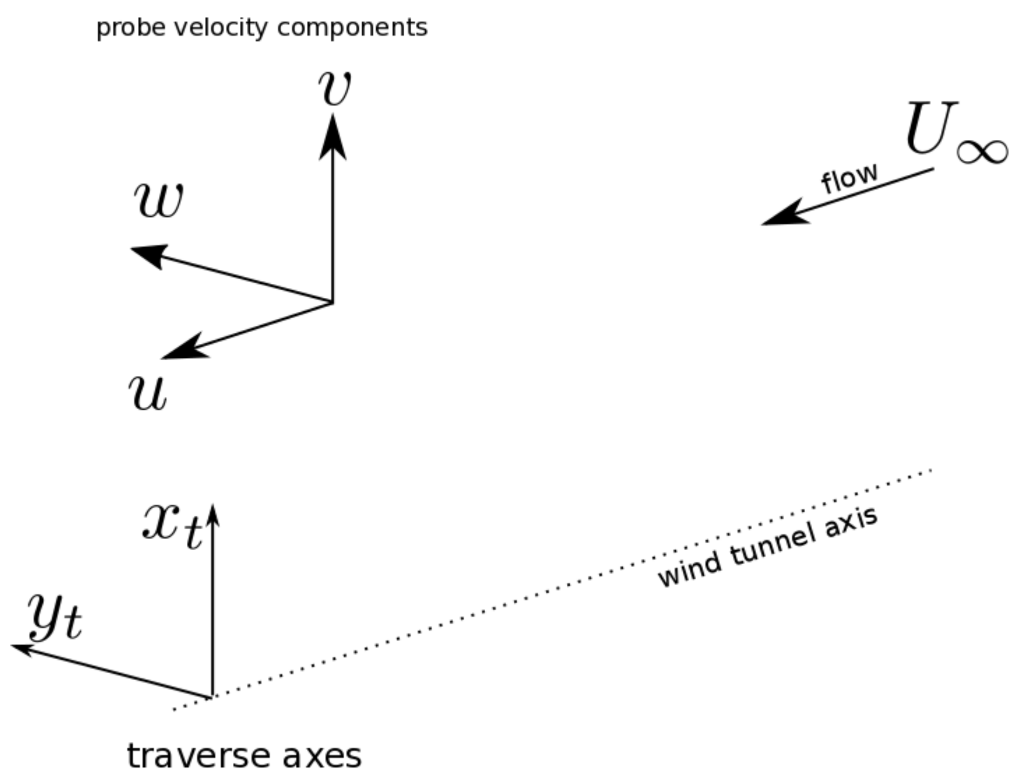

Figure 2: 7 hole probe (u, v, w) velocity components and axis system