AENG 411: Aerospace Laboratory

Wind Tunnel Testing of a Complete Aircraft

by

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# Summary

# Nomenclature

*B* Test Section Width

*(Value)w* Wing Coefficient, Value, or Parameter

*(Value)tail* Tail Coefficient, Value, or Parameter

*(Coefficient)u* Uncorrected Coefficient

*(Coefficient)c* Corrected Coefficient

*b* Geometric Span

*be* Effective Span

*C* Test Section Cross Sectional Area

*d* Maximum Diameter of Fuselage

*H* Test Section Height

*k* Ratio of Effective Span to Tunnel Width

*K1* Body Shape Factor for Blockage

*K2* Fuselage Shape Factor for Blockage

*l* Length of Body

*lt* Distance from CG to ¼ MAC of Tail

*q* Freestream Dynamic Pressure

*qc* Corrected Freestream Dynamic Pressure

*Re* Reynolds Number

*S*Area

*αg* Geometric Angle of Attack

*αc* Corrected Angle of Attack

*δ* Boundary Correction Factor

*εT* Total Solid Blockage Correction Factor

*εsbB* Body Solid Blockage Correction Factor

*εsbW* Wing Solid Blockage Correction Factor

*εstuts,windshields* Strut and Windshields Solid Blockage Correction Factor

*τ1* Tunnel Correction Factor for Blockage

*τ2* Downwash Correction Factor

*c­t* Tip Chord

*cr* Root Chord

*λ* Taper Ratio

*MAC* Mean Aerodynamic Chord

*CM* Moment Coefficient about ¼ Chord of MACwing

*CD* Coefficient of Drag

*CL* Coefficient of Lift

*L* Lift

*D* Drag

*M* Moment about ¼ Chord of MACwing

*AR* Aspect Ratio

Mean Aerodynamic Chord

*V* Freestream Velocity

*CG* Center of Gravity

**Nomenclature (Cont)**

*CLW* Wing-Only Lift Coefficient

Variation in Pitching Moment Coefficient with Horizontal Tail Incidence Angle

*a* 2-D Lift Curve Slope

Horizontal Tail Velocity Coefficient

*FA* Strut Frontal Area

*tstrut* Strut Thickness

*hstrut* Strut Height

*P* Ambient Pressure

*T* Ambient Temperature

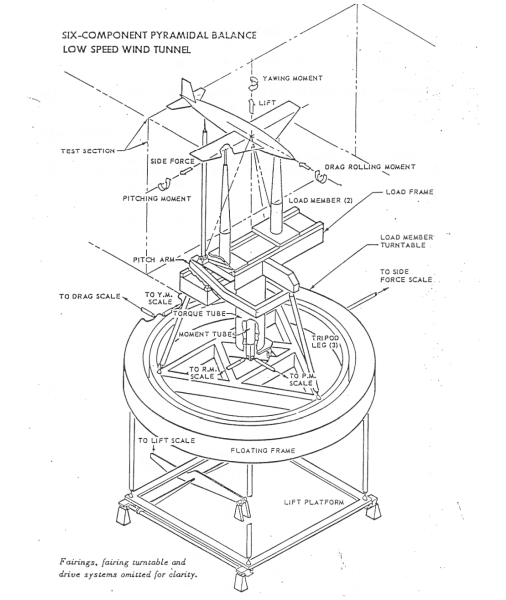
*ρ* Ambient Density

Volume

# Introduction

­­­There exist two standard methods of calculating the flight characteristics associated with a given aircraft: flight simulation of the whole aircraft through the use of potential flow theory and computational fluid dynamics and wind tunnel testing on a model representation of a given aircraft, where the flow characteristics are scaled up to the full size aircraft through the use of dimensional analysis. Each method has its advantages and disadvantages, with the former offering a quick, oftentimes highly accurate, representation all of the characteristics associated with an aircraft’s lift, drag, and moment coefficients for a wide range of angle of attacks. The accuracy of this method, though substantial and improving all the time, is highly reliant on the proper running of and collection of data from real-life wind tunnel testing. This report serves as documentation for one particular wind tunnel test that was run within the Low-Speed Tunnel within Oliver Hall on the campus of Saint Louis University.

For any given wind tunnel test, the main method of calculating the lift, drag, and moments associated with an aircraft is through the use of Six-Component-Pyramidal balance, an example of which is shown in Figure 3-1 below. Through the use of stain gauges, this device is able to calculate the force and moments that an aircraft attached to its struts experiences in all six flight directions (yaw, pitch, roll, lift, drag, thrust).



**Figure 3-1. Six-Component-Pyramidal Wind Tunnel Balance Drawing[[1]](#footnote-1)**

Though most tunnel balances are fairly precise, no tunnel balance in existence can be considered perfectly calibrated. The reason for this rests in the generally small forces associated with lift, drag, etc. for a given aircraft versus the inherent instability of the balance itself, due to its large mass and inverted pendulum configuration. Thus, small errors in the motion of the balance in any direction due to instabilities leads to noticeable differences between the force values that the balance outputs versus the ones that the test aircraft actually experienced. In order to account for this difference, it is necessary to run wind tunnel tests both with no wind and the model just sitting on the balance and with full speed wind and no model sitting on the balance whatsoever. Based on the results obtained from this process, the data collected during testing can be corrected through the use of the following relation:

(1,2)

Where the coefficients with no u subscript are the raw coefficients calculated directly from the information recorded by the balance for a given test run and the coefficients with No Model and No Wind tare run being those collected when the tunnel is run at full speed with no model for the former and when the tunnel is run with no speed with the model on the balance.

1. Image Obtained from Parks College of Engineering, Aviation and Technology Aerodynamics Laboratory Manual [↑](#footnote-ref-1)