Wind Tunnel Testing of full-scale Yardstik aircraft : Part 2: Lateral motion derivatives

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1 Positive conventions

The positive convention of the sideslip angle β and rudder deflection δ_r are shown in figure 1.

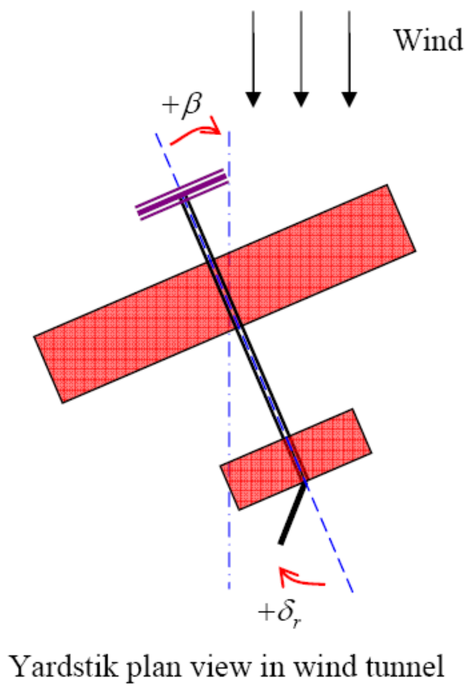

Figure 1: Positive convention of β and δ_r

2 Side force, drag and moments calculation

2.1 Lift and drag forces

From the measured transverse and axial forces, the side force and drag forces can be calculated by resolving these 2 forces along the body axis at various sideslip angles β that the aircraft holds. Figure 2 shows the relationship between the side force and drag forces with the measured transverse and axial forces.

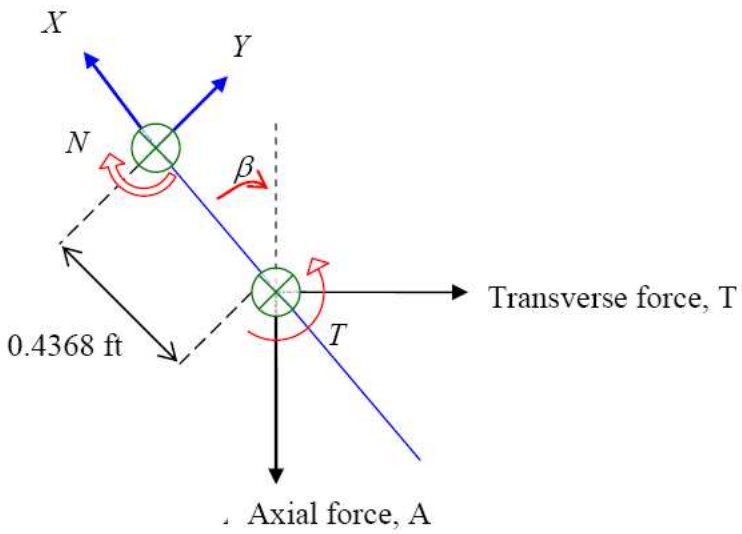

Figure 2: Relationship between the side and drag forces with the measured transverse and axial forces

The side force, Y, is given by:

$$Y = Tcos\beta - Asin\beta \tag{1}$$

With the side force calculated, the coefficient is given by:

$$C_Y = \frac{Y}{\frac{1}{2}\rho V^2 S} \tag{2}$$

The drag force is given by:

$$D = Acos\beta + Tsin\beta \tag{3}$$

2.2 Yaw moment calculation

To calculate the yaw moment at the quarter chord point of the wing ($N_{1/4}$), we need to determine the moment arms from the measurement point to the quarter chord point of the wing. A calibration test using known load was done to determine this moment arm. The yaw moment about the quarter chord is given by:

$$N_{1/4} = -\frac{N_m}{12} + 0.4368Asin\beta - 0.4368Tcos\beta \tag{4}$$

With $N_{1/4}$ calculated, the moment coefficient at quarter chord is given by:

$$C_{n_{1/4}} = \frac{N_{1/4}}{\frac{1}{2}\rho V^2 Sb} \tag{5}$$

2.3 Roll moment calculation

The roll moment is calculated by:

$$L_{1/4} = -\frac{L_m cos\beta}{12} + 0.328Asin\beta - 0.328Tcos\beta \tag{6}$$

With $L_{1/4}$ calculated, the moment coefficient at quarter chord is given by:

$$C_{l_{1/4}} = \frac{L_{1/4}}{\frac{1}{2}\rho V^2 Sb} \tag{7}$$

3 Experimental data and result

3.1 Side Forces

Figure 3 shows the plot of C_Y vs β and figure 4 shows the plot of C_Y vs δ_r. From the graph, we can deduce the following data:

1. C_{Y_β} = -0.321 /rad
2. $C_{Y_{\delta_r}}$ = 0.113 /rad

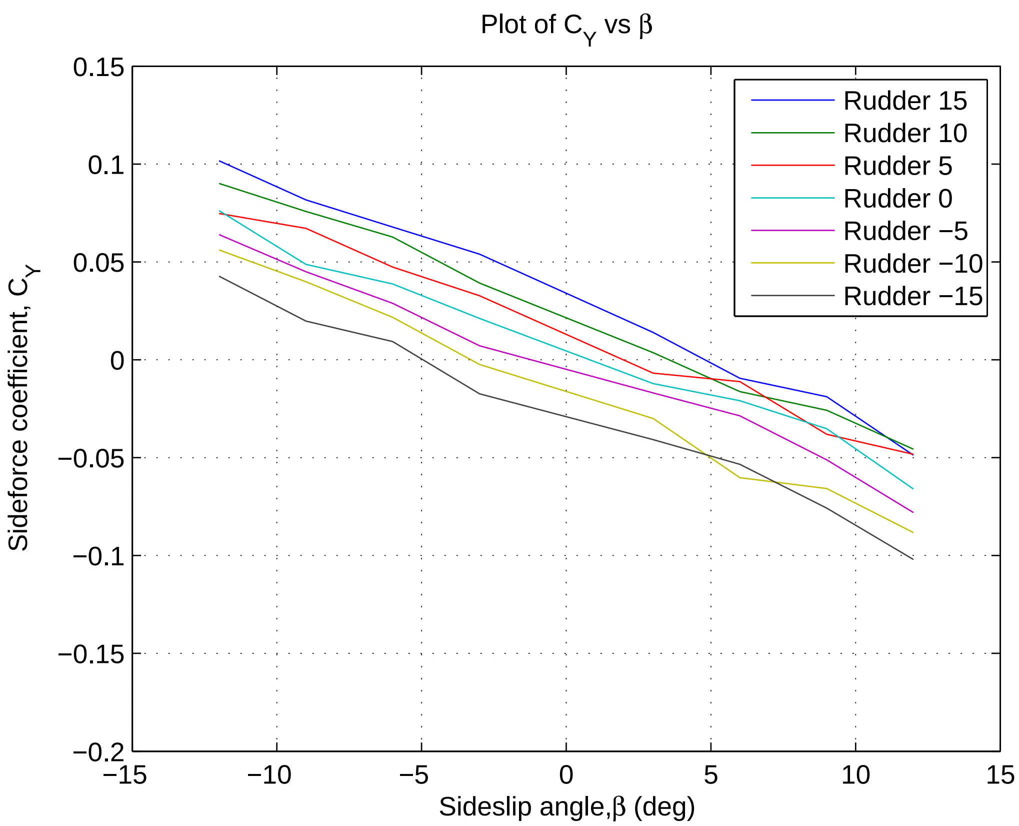

Figure 3: Plot of C_Y vs β for V = 6 m/s

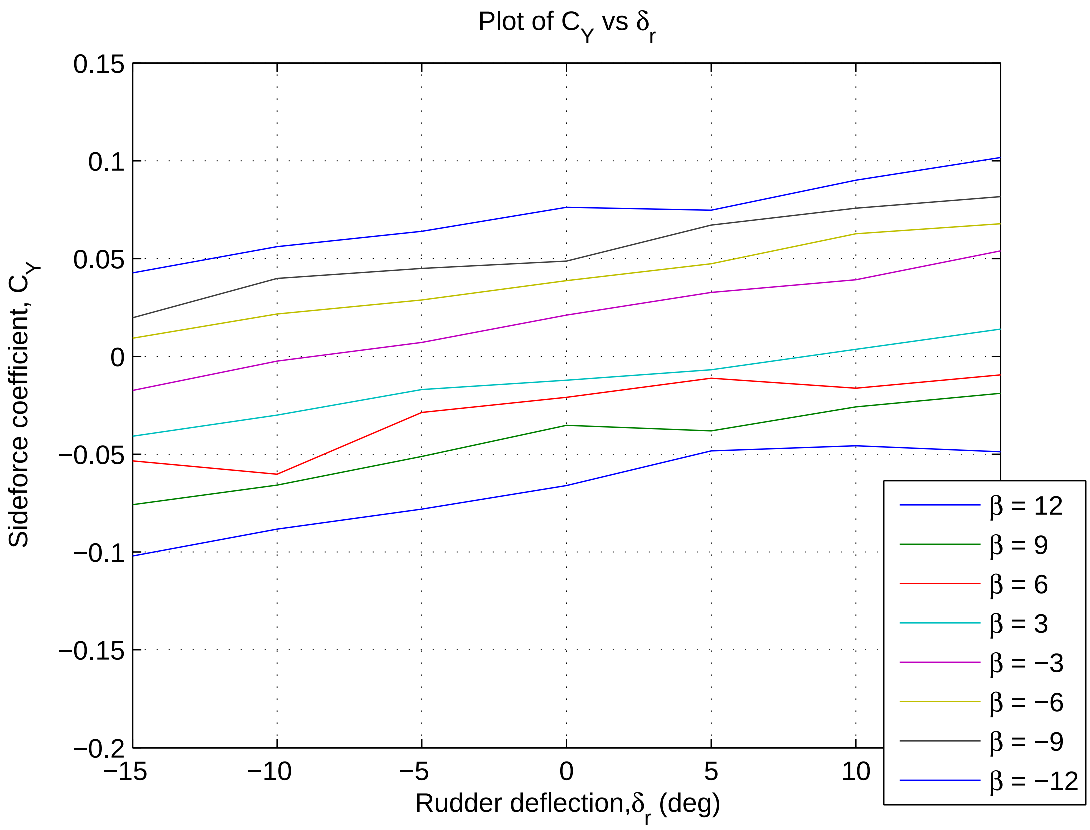

Figure 4: Plot of C_Y vs δ_r for V = 6 m/s

3.2 Yaw Moment

Figure 5 shows the plot of C_n vs β and figure 6 shows the plot of C_n vs δ_r. From the graph, we can deduce the following data:

1. C_{n_β} = 0.252 /rad
2. $C_{n_{\delta_r}}$ = -0.223 /rad

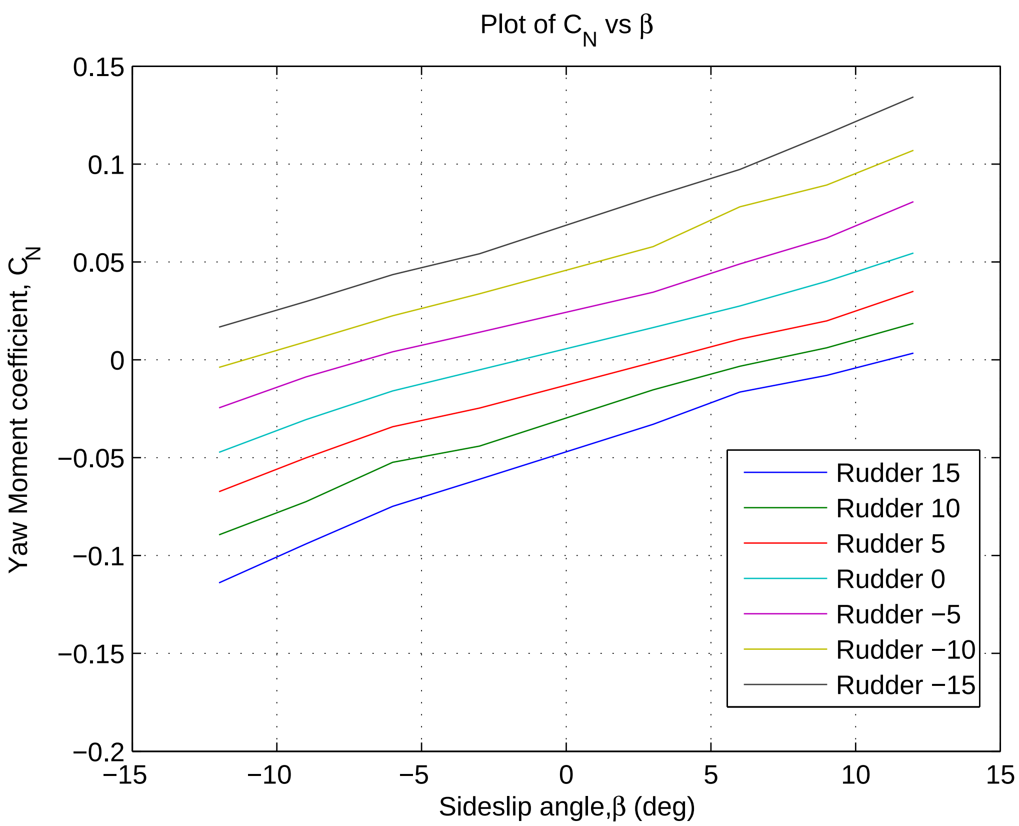

Figure 5: Plot of C_n vs β for V = 6 m/s

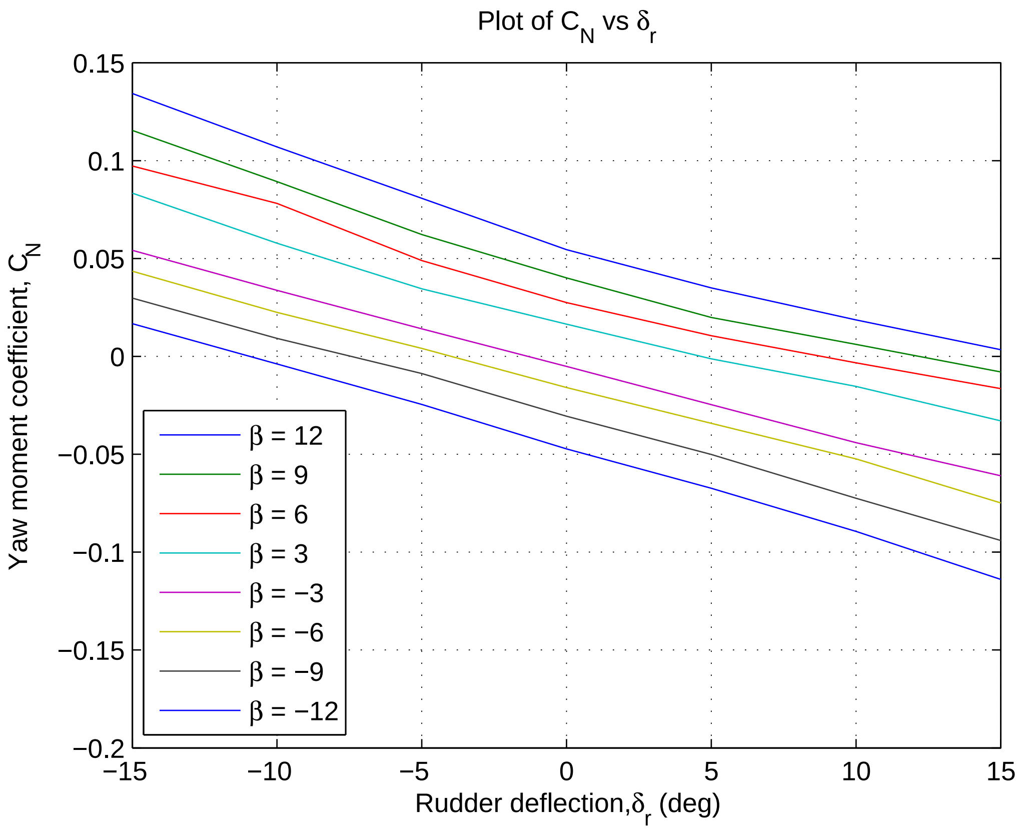

Figure 6: Plot of C_n vs δ_r for V = 6 m/s

3.3 Roll Moment

Figure 7 shows the plot of C_l vs β and figure 8 shows the plot of C_l vs δ_r. From the graph, we can deduce the following data:

1. C_{l_β} = -0.688 /rad
2. $C_{l_{\delta_r}} = 0.0573$ /rad

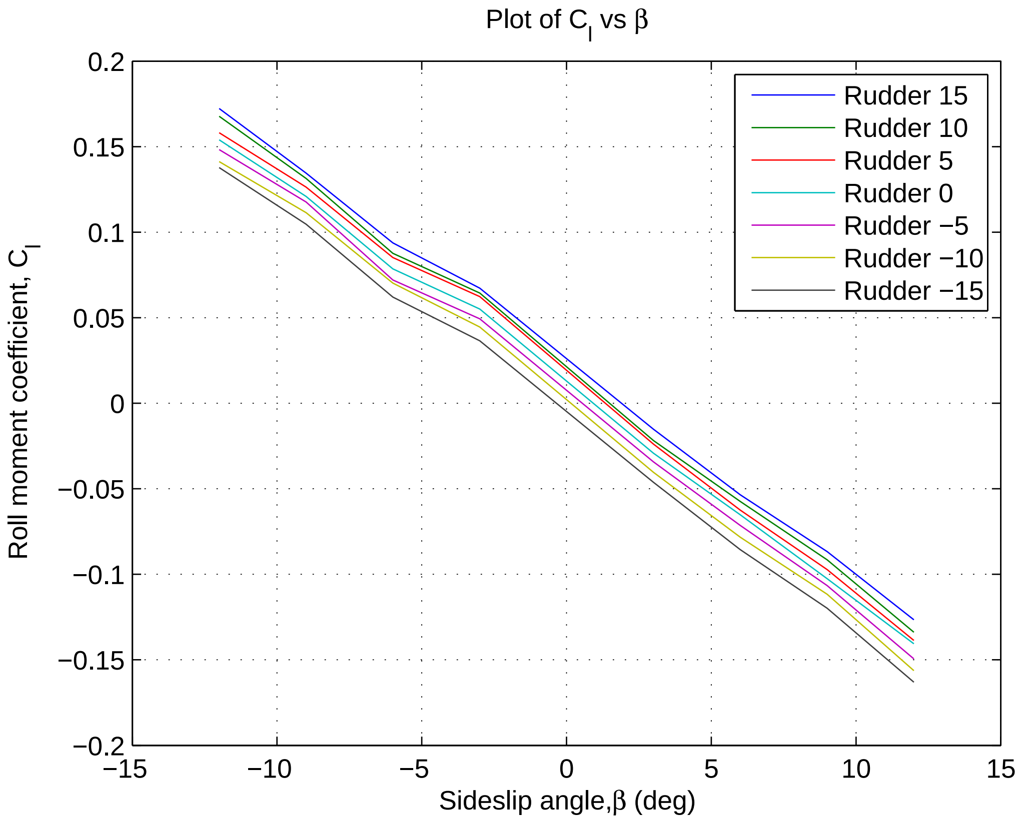

Figure 7: Plot of C_l vs β for V = 6 m/s

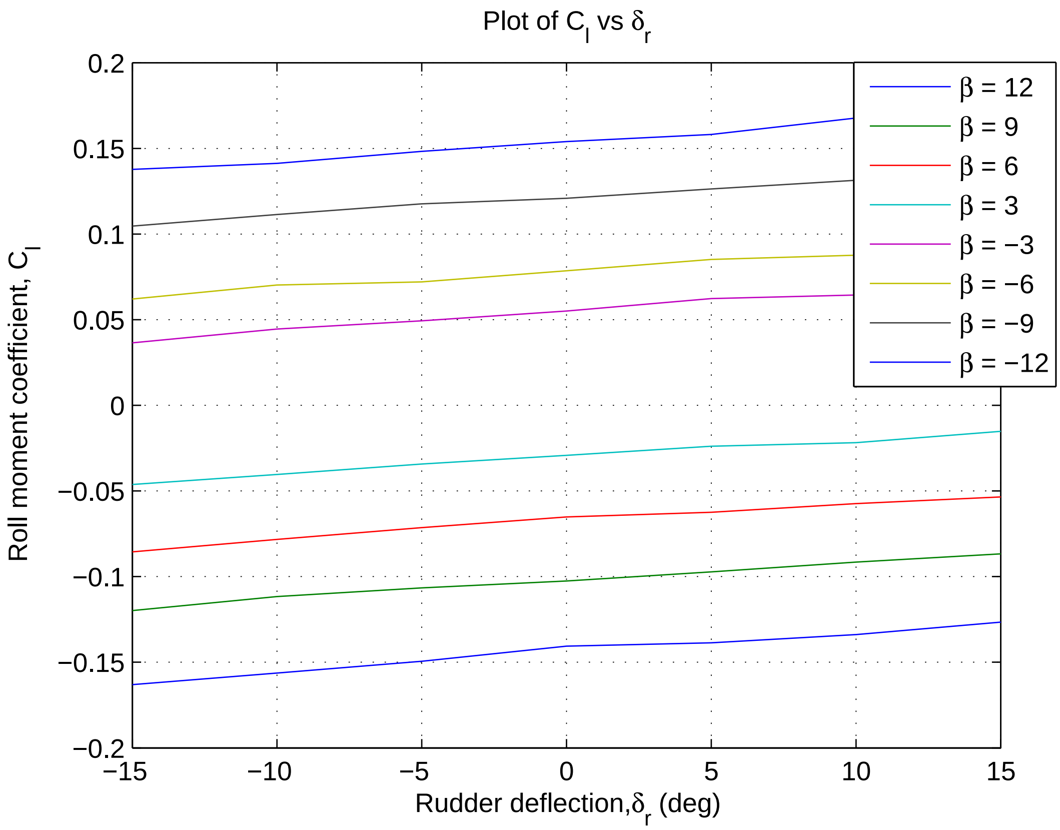

Figure 8: Plot of C_l vs δ_r for V = 6 m/s