0.1 Assumtions

Assumptions were made to simplify the dynamics model:

- Basic lift/drag equations hold
- Constant C_L and C_D
- Lift and drag relative to the orientation of the plane rather than direction of air flow
- Velocity of airflow is equal to the relative velocity of the plane and in the direction of the airfoil

0.2 State Space

The states space is given by a 6 by 1 matrix in where x, y and z refer to world coordinates.

$$\begin{pmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix}$$

0.3 Transition

At each time step of Δt the transition is done using a first order Euler Method:

$$\begin{pmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix}' = \begin{pmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix} + \Delta t \begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{pmatrix}$$

0.4 Calculating Accelerations

The accelerations were calculated as follows:

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix} = g_{Mars} \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix} + R \begin{pmatrix} T - D \\ 0 \\ -L \end{pmatrix}$$

Where g_{mars} is the gravitational acceleration on Mars, R is the rotation matrix to transform plane coordinates to world coordinates, T is the thrust, D is the drag and L is the lift.

For level flight along the world's x axis the rotation matrix, R, would be:

$$R = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

0.5 Calculating Lift and Drag

Given aerodynamic constants from the atmospheric conditions on Mars and the aerofoil design, the basic lift equations were used.

$$L = \frac{1}{2} C_L \rho S v^2$$

$$D = \frac{1}{2} C_D \rho S v^2$$

Where C_L and C_D are the respective lift and drag coefficients, ρ is air density, S is the surface area of the wing, and v is the relative air velocity which was calculated as:

$$v = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2}$$