$$\vec{q}(t) = \begin{bmatrix} v_y(t) & (1) \\ v_z(t) & (2) \\ y(t) & (3) \\ z(t) & (4) \\ \omega_x(t) & (5) \\ \vec{\vec{R}}_1(t) & (6) \\ \vec{\vec{R}}_2(t) & (7) \\ \vec{\vec{R}}_3(t) & (8) \\ \vec{\vec{R}}_4(t) & (9) \\ m(t) & (10) \end{bmatrix} \tag{1}$$

$$\vec{q}(0) = \begin{bmatrix} v_y(0) \\ v_z(0) \\ y(0) \\ z(0) \\ \omega_x(0) \\ \vec{\vec{R}}_1(0) \\ \vec{\vec{R}}_2(0) \\ \vec{\vec{R}}_3(0) \\ \vec{\vec{R}}_4(0) \\ m(0) \end{bmatrix} = \begin{bmatrix} 0 & \frac{m}{s} \\ 0 & \frac{m}{s} \\ 0 & m \\ R_T + d & m \\ 0 & \frac{rad}{s} \\ \cos(\frac{\beta}{2}) & \\ \sin(\frac{\beta}{2}) & \\ 0 & \\ 0 & \\ M_i & kg \end{bmatrix} = \begin{bmatrix} 0 & \frac{m}{s} \\ 0 & \frac{m}{s} \\ 0 & m \\ 6371025 & m \\ 0 & \frac{rad}{s} \\ 1 & \\ 0 & \\ 0 & \\ 0 & \\ 320000 & kg \end{bmatrix} \tag{2}$$

$$\vec{g}(t) = \begin{bmatrix} \frac{v_y(t)}{dt} \\ \frac{v_z(t)}{dt} \\ \frac{y(t)}{dt} \\ \frac{z(t)}{dt} \\ \frac{\omega_x(t)}{dt} \\ \frac{\vec{\vec{R}}_1(t)}{dt} \\ \frac{\vec{\vec{R}}_2(t)}{dt} \\ \frac{\vec{\vec{R}}_3(t)}{dt} \\ \frac{\vec{\vec{R}}_4(t)}{dt} \\ \frac{m(t)}{dt} \end{bmatrix} = \begin{bmatrix} a_y \\ a_x \\ v_y \\ v_z \\ \alpha_x \\ \frac{\vec{\vec{R}}(t)\vec{\vec{\omega}}(t)}{2}_1 \\ \frac{\vec{\vec{R}}(t)\vec{\vec{\omega}}(t)}{2}_2 \\ \frac{\vec{\vec{R}}(t)\vec{\vec{\omega}}(t)}{2}_3 \\ \frac{\vec{\vec{R}}(t)\vec{\vec{\omega}}(t)}{2}_4 \\ \begin{cases} -\mu \text{ si m } > M_i - M_{carburant} \\ 0 \text{ si m } <= M_i - M_{carburant} \end{cases} \end{bmatrix} \tag{3}$$

Acceleration:

$$\begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix} = \begin{bmatrix} \frac{F_x}{m} \\ \frac{F_y}{m} \\ \frac{F_z}{m} \end{bmatrix} \tag{4}$$

Acceleration angulaire:

$$\begin{bmatrix} \alpha_x \\ \alpha_y \\ \alpha_z \end{bmatrix} = \begin{bmatrix} (\boldsymbol{I}^{-1}[\vec{\tau} - (\tilde{\boldsymbol{\omega}}\boldsymbol{I}\vec{\omega})])_x \\ (\boldsymbol{I}^{-1}[\vec{\tau} - (\tilde{\boldsymbol{\omega}}\boldsymbol{I}\vec{\omega})])_y \\ (\boldsymbol{I}^{-1}[\vec{\tau} - (\tilde{\boldsymbol{\omega}}\boldsymbol{I}\vec{\omega})])_z \end{bmatrix} \tag{5}$$

$$\vec{v} = \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix} \implies \vec{\vec{v}} = \begin{bmatrix} 0 \\ v_x \\ v_y \\ v_z \end{bmatrix}, \vec{\vec{R}} = \begin{bmatrix} \cos(\frac{\theta}{2}) \\ \sin(\frac{\theta}{2})\hat{u}_x \\ \sin(\frac{\theta}{2})\hat{u}_y \\ \sin(\frac{\theta}{2})\hat{u}_z \end{bmatrix}, \vec{\vec{R}}^* = \begin{bmatrix} \cos(\frac{\theta}{2}) \\ -\sin(\frac{\theta}{2})\hat{u}_x \\ -\sin(\frac{\theta}{2})\hat{u}_y \\ -\sin(\frac{\theta}{2})\hat{u}_z \end{bmatrix} \tag{6}$$

$$\vec{\vec{v}}' = \vec{\vec{R}}\vec{\vec{v}}\vec{\vec{R}}^* = \begin{bmatrix} v'_1 \\ v'_2 \\ v'_3 \\ v'_4 \end{bmatrix} \implies \vec{v}' = \begin{bmatrix} v'_2 \\ v'_3 \\ v'_4 \end{bmatrix} \tag{7}$$