$$\mathbf{x} = \begin{bmatrix} p \\ q \\ r \\ \phi \\ \theta \\ \psi \\ \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix}$$

$$\boldsymbol{\omega} = \begin{bmatrix} p \\ q \\ r \end{bmatrix}$$

$$\dot{\boldsymbol{\omega}} = \mathbf{I}_b^{-1}\Big(\mathbf{T}_{\text{ext}} + \mathbf{T}_{\text{CMG}} - \boldsymbol{\omega} \times (\mathbf{I}_b\,\boldsymbol{\omega})\Big)$$

$$\mathbf{T}_{\text{ext}} = 3\left(\sqrt{\frac{\mu}{r^3}}\right)^2 \begin{bmatrix} (I_{yy} - I_{zz})\,\sin(\theta)\,\cos(\theta) \\ (I_{zz} - I_{xx})\,\sin(\phi)\,\cos(\phi) \\ (I_{xx} - I_{yy})\,\sin(\phi)\,\sin(\theta) \end{bmatrix}$$

$$\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} 1 & \sin(\phi)\,\tan(\theta) & \cos(\phi)\,\tan(\theta) \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \dfrac{\sin(\phi)}{\cos(\theta)} & \dfrac{\cos(\phi)}{\cos(\theta)} \end{bmatrix} \begin{bmatrix} p \\ q \\ r \end{bmatrix}$$

$$\dot{\mathbf{x}} = \begin{bmatrix} \dot{p} \\ \dot{q} \\ \dot{r} \\ \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \\ \dot{\delta}_1 \\ \dot{\delta}_2 \\ \dot{\delta}_3 \\ \dot{\delta}_4 \end{bmatrix}$$

$$\mathbf{x}_{n+1} = \mathbf{x}_n + \frac{\Delta t}{6}\Big(\mathbf{k}_1 + 2\,\mathbf{k}_2 + 2\,\mathbf{k}_3 + \mathbf{k}_4\Big)$$

$$\mathbf{k}_1 = f(t_n, \mathbf{x}_n), \quad \mathbf{k}_2 = f\Big(t_n{+}\tfrac{\Delta t}{2},\, \mathbf{x}_n{+}\tfrac{\Delta t}{2}\,\mathbf{k}_1\Big), \quad \mathbf{k}_3 = f\Big(t_n{+}\tfrac{\Delta t}{2},\, \mathbf{x}_n{+}\tfrac{\Delta t}{2}\,\mathbf{k}_2\Big), \quad \mathbf{k}_4 = f\Big(t_n{+}\Delta t,\, \mathbf{x}_n{+}$$