$$\dot{p} = Rv \tag{1}$$

$$\dot{v} = \omega_\times v + gR^\top e_3 + \frac{1}{m}F \tag{2}$$

$$\dot{R} = R\omega_\times \tag{3}$$

$$\dot{\omega} = J^{-1}\omega_\times J\omega + J^{-1}M, \tag{4}$$