$$\mathbf{F} = \frac{\partial \mathbf{f}(t, \mathbf{x}(t), \mathbf{p})}{\partial \mathbf{x}(t)} = \begin{bmatrix} \frac{\partial \mathbf{v}}{\partial \mathbf{r}} & \frac{\partial \mathbf{v}}{\partial \mathbf{v}} \\ \frac{\partial \mathbf{a}}{\partial \mathbf{r}} & \frac{\partial \mathbf{a}}{\partial \mathbf{v}} \end{bmatrix} = \begin{bmatrix} \mathbf{0}_{3\times3} & \mathbf{I}_{3\times3} \\ \frac{\partial \mathbf{a}}{\partial \mathbf{r}} & \frac{\partial \mathbf{a}}{\partial \mathbf{v}} \end{bmatrix}$$

$$\mathbf{a} = \mathbf{a}_{\text{grav}} + \mathbf{a}_{\text{rot}} = -\frac{\mu}{r^3}\mathbf{r} - \mathbf{\Omega}^2\mathbf{r} - 2\mathbf{\Omega}\mathbf{v}$$

$$\mathbf{F} = \begin{bmatrix} \mathbf{0}_{3\times3} & \mathbf{I}_{3\times3} \\ \frac{\mu}{r^5}(3\mathbf{r}\mathbf{r}^T - r^2\mathbf{I}_{3\times3}) - \mathbf{\Omega}^2 & -2\mathbf{\Omega} \end{bmatrix}$$

$$\mathbf{\Omega} = \begin{bmatrix} 0 & -\omega_E & 0 \\ \omega_E & 0 & 0 \end{bmatrix}$$

$$\mathbf{\Phi}(t_k, t_k) = \frac{\partial \mathbf{x}(t_k)}{\partial \mathbf{x}(t_k)} = \mathbf{I}_{6\times6}$$