

$$\dot{\mathbf{r}} = +\omega_{\mathbf{k}} = \mathbf{u} + \frac{\bar{\omega}_{\mathbf{k}}}{k} \mathbf{k},$$

$$\dot{\mathbf{k}} = -\omega_{\mathbf{r}} = \zeta \hat{\mathbf{z}} \times \mathbf{k} - (\mathbf{k} \cdot \nabla) \mathbf{u}$$