Contents

1 the equations:

if $\psi = 0$:

$$\boldsymbol{\xi}_{bxy} = \begin{bmatrix} \phi_{sp} \\ \theta_{sp} \\ 0 \end{bmatrix} = \begin{bmatrix} y_{cmd} \\ -x_{cmd} \\ 0 \end{bmatrix} \tag{1}$$

$$\left.\begin{aligned} \boldsymbol{q}_{ned}^{bxy} &= \cos\frac{\sigma}{2} + \overrightarrow{\boldsymbol{q}}_{ned}^{bxy} \sin\frac{\sigma}{2} \\ \overrightarrow{\boldsymbol{q}}_{ned}^{bxy} &= \frac{\boldsymbol{\xi}_{bxy}}{\|\boldsymbol{\xi}_{bxy}\|} \end{aligned}\right\} \tag{2}$$

$$[\boldsymbol{x}_{bxy}]_{ned} = \left(\boldsymbol{C}_{ned}^{bxy}\right)^T \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}_{bxy} \quad [\boldsymbol{z}_{bxy}]_{ned} = \left(\boldsymbol{C}_{ned}^{bxy}\right)^T \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}_{bxy} \tag{3}$$

$$[\boldsymbol{p}]_{ned} = \begin{bmatrix} \cos\psi_{ned} \\ \sin\psi_{ned} \\ 0 \end{bmatrix}_{ned} \tag{4}$$

$$\boldsymbol{x}_{body} \cdot \boldsymbol{z}_{body} = \boldsymbol{x}_{body} \cdot \boldsymbol{z}_{bxy} = 0 \tag{5}$$

$\boldsymbol{x}_{body}$:

$$[\boldsymbol{x}_{body}]_{ned} = \begin{bmatrix} \cos\psi_{ned} \\ \sin\psi_{ned} \\ -[\boldsymbol{p}]_{ned} \cdot [\boldsymbol{z}_{bxy}]_{ned}/z_3 \end{bmatrix}_{ned} \tag{6}$$

$$\psi_{body} = \arctan\left(\frac{\|[\boldsymbol{x}_{bxy}]_{ned} \times [\boldsymbol{x}_{body}]_{ned}\|}{[\boldsymbol{x}_{bxy}]_{ned} \cdot [\boldsymbol{x}_{body}]_{ned}} \operatorname{sgn}\big([\boldsymbol{x}_{bxy}]_{ned} \times [\boldsymbol{x}_{body}]_{ned} \cdot [\boldsymbol{z}_{body}]_{ned}\big) \right) \tag{7}$$

$$\boldsymbol{q}_{bxy}^{body} = \begin{bmatrix} \cos(\psi_{body}/2) \\ \begin{bmatrix} 0 \\ 0 \\ \sin(\psi_{body}/2) \end{bmatrix} \end{bmatrix} \tag{8}$$

$$\boldsymbol{q}_{ned}^{body} = \boldsymbol{q}_{ned}^{bxy} \otimes \boldsymbol{q}_{bxy}^{body} \tag{9}$$