$$x_m = \begin{bmatrix} p_x \\ p_y \\ \varphi \\ s_x \\ s_y \\ b \end{bmatrix} \quad v = \begin{bmatrix} v_d \\ v_r \\ v_b \end{bmatrix} \; z = \begin{bmatrix} z_a \\ z_b \\ z_c \\ z_g \\ z_n \end{bmatrix} \; w = \begin{bmatrix} w_a \\ w_b \\ w_c \\ w_g \\ w_n \end{bmatrix}$$

$$\dot{x}_m = \begin{bmatrix} \dot{p}_x \\ \dot{p}_y \\ \dot{\varphi} \\ \dot{s}_x \\ \dot{s}_y \\ \dot{b} \end{bmatrix} = \begin{bmatrix} s_x \\ s_y \\ C_r u_r (1 + v_r) \\ \cos\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)(1 + v_d)\right] \\ \sin\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)(1 + v_d)\right] \\ v_b \end{bmatrix}$$

$$actuate = [u_t \quad u_r]$$

$$\dot{\hat{x}} = q(\hat{x}(t), 0, t) = \begin{bmatrix} s_x \\ s_y \\ C_r u_r \\ \cos\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)\right] \\ \sin\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)\right] \\ 0 \end{bmatrix}$$

$$A(t) = \frac{\partial q(\hat{x}(t), 0, t)}{\partial x} = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\sin\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)\right] & -2C_d s_x \cos\varphi & -2C_d s_y \cos\varphi & 0 \\ 0 & 0 & \cos\varphi \left[\tanh u_t - C_d\left(s_x^2 + s_y^2\right)\right] & -2C_d s_x \sin\varphi & -2C_d s_y \sin\varphi & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$L(t) = \frac{\partial q(\hat{x}(t), 0, t)}{\partial v} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & C_r u_r & 0 \\ -\cos\varphi \, C_d\left(s_x^2 + s_y^2\right) & 0 & 0 \\ -\sin\varphi \, C_d\left(s_x^2 + s_y^2\right) & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$Q_c = \begin{bmatrix} Q_d & & \\ & Q_r & \\ & & Q_b \end{bmatrix} \; R = \begin{bmatrix} \sigma_a^2 & & & & \\ & \sigma_b^2 & & & \\ & & \sigma_c^2 & & \\ & & & \sigma_g^2 & \\ & & & & \sigma_n^2 \end{bmatrix}$$

$$H[k] = \frac{\partial h_k\left(\hat{x}_p[k], 0\right)}{\partial x} = \begin{bmatrix} \frac{p_x[k] - x_a}{\sqrt{(p_x[k] - x_a)^2 + \left(p_y[k] - y_a\right)^2}} & \frac{p_y[k] - y_a}{\sqrt{(p_x[k] - x_a)^2 + \left(p_y[k] - y_a\right)^2}} & 0 & 0 & 0 & 0 \\ \frac{p_x[k] - x_b}{\sqrt{(p_x[k] - x_b)^2 + \left(p_y[k] - y_b\right)^2}} & \frac{p_y[k] - y_b}{\sqrt{(p_x[k] - x_b)^2 + \left(p_y[k] - y_b\right)^2}} & 0 & 0 & 0 & 0 \\ \frac{p_x[k] - x_c}{\sqrt{(p_x[k] - x_c)^2 + \left(p_y[k] - y_c\right)^2}} & \frac{p_y[k] - y_c}{\sqrt{(p_x[k] - x_c)^2 + \left(p_y[k] - y_c\right)^2}} & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

$$M[k] = \frac{\partial h_k\left(\hat{x}_p[k], 0\right)}{\partial w} = \begin{bmatrix} 1 & & & & \\ & 1 & & & \\ & & 1 & & \\ & & & 1 & \\ & & & & 1 \end{bmatrix}$$