Linearlization:

Lateral dynamic:

$$\begin{cases} \ddot{y} = -\dot{\psi}\dot{x} + \frac{1}{m}(F_{yf}\cos\delta + F_{yr}) \\ F_{yf} = 2C_\alpha\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right) \\ F_{yr} = 2C_\alpha\left(-\frac{\dot{y}-l_r\dot{\psi}}{\dot{x}}\right) \end{cases}$$

$$\ddot{y} = -\dot{\psi}\dot{x} + \frac{2C_\alpha}{m}\left(\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right)\cos\delta\right) - \frac{2C_\alpha}{m}\left(\frac{\dot{y}}{\dot{x}} + \frac{l_r\dot{\psi}}{\dot{x}}\right)$$

$$= -\dot{\psi}\dot{x} + \frac{2C_\alpha}{m}\delta - \frac{2C_\alpha\dot{y}}{m\dot{x}} + \frac{2C_\alpha l_f\dot{\psi}}{m\dot{x}} - \frac{2C_\alpha\dot{y}}{m\dot{x}} - \frac{2C_\alpha l_r\dot{\psi}}{m\dot{x}}$$

$$= \dot{\psi}\left(-\dot{x} + \frac{-2C_\alpha l_r}{m\dot{x}} + \frac{2C_\alpha l_f}{m\dot{x}}\right) + \delta\left(\frac{2C_\alpha}{m}\right) + \dot{y}\left(-\frac{4C_\alpha}{m\dot{x}}\right)$$

$$\ddot{\psi} I_z = l_f F_{yf} - l_r F_{yr}.$$

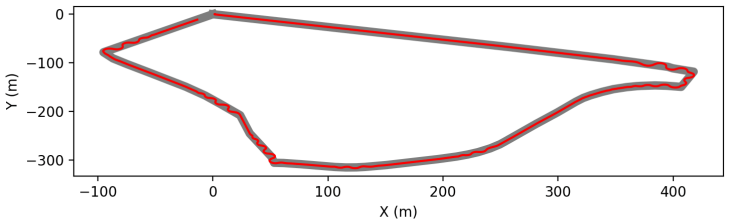
$$\ddot{\psi} = \frac{l_f F_{yf}}{I_z} - \frac{l_r F_{yr}}{I_z}$$

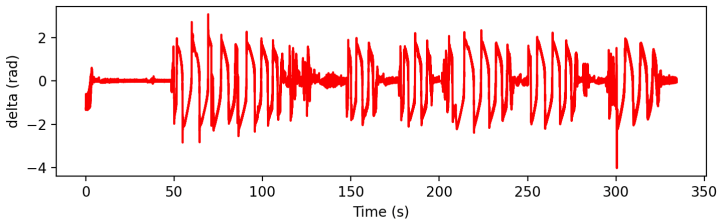
$$= \dot{\psi}\left(-\frac{2l_f^2 C_\alpha + 2l_r^2 C_\alpha}{I_z\dot{x}}\right) + \delta\left(2\frac{l_f C_\alpha}{I_z}\right) + \dot{y}\left(\frac{2l_r C_\alpha - 2l_f C_\alpha}{I_z\dot{x}}\right)$$

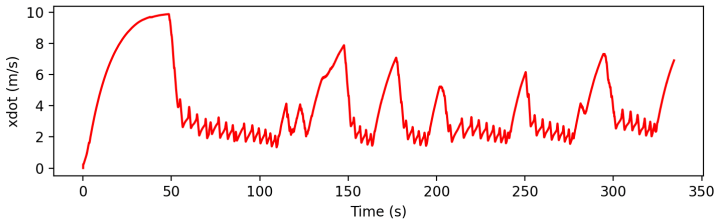
$$\dot{S}_1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{-4C_\alpha}{m\dot{x}} & 0 & -\dot{x} + \frac{2C_\alpha(l_r - l_f)}{m\dot{x}} \\ 0 & 0 & 0 & 1 \\ 0 & \frac{2C_\alpha(l_r - l_f)}{I_z\dot{x}} & 0 & -\frac{2C_\alpha(l_r^2 + l_f^2)}{I_z\dot{x}} \end{bmatrix} \begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{2C_\alpha}{m} & 0 \\ 0 & 0 \\ \frac{2l_f C_\alpha}{I_z} & 0 \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix}$$

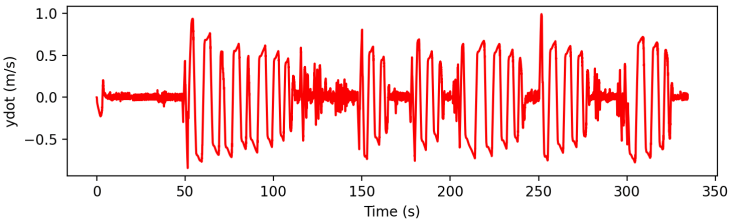
$$\dot{S}_2 = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ \dot{x} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{m} \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix} + \dot{\psi}\dot{y} - Fg.$$

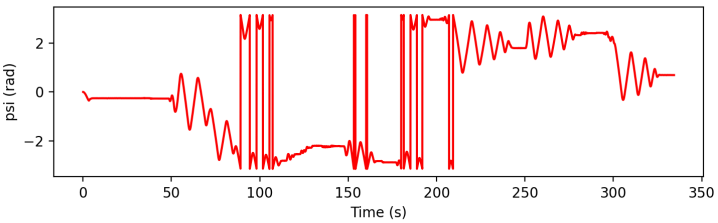
$$\ddot{x} = \dot{\psi}\dot{y} + \frac{F}{m} - fg$$

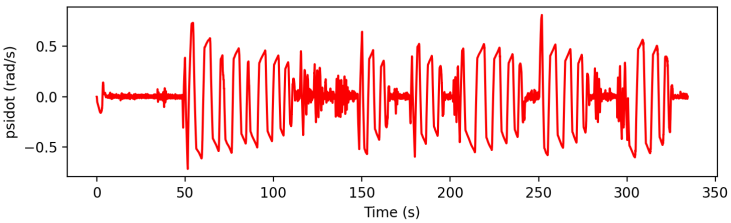

Y (m)
X (m)

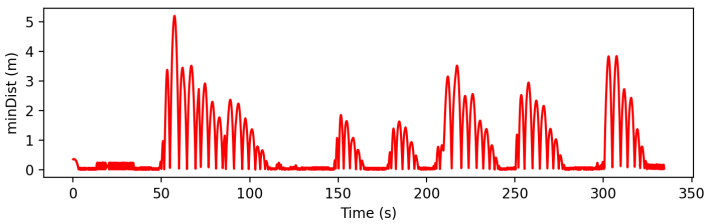

delta (rad)
Time (s)

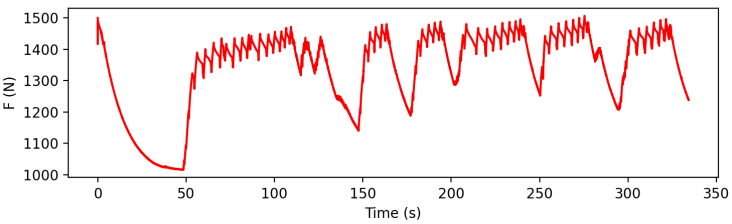

xdot (m/s)
Time (s)


ydot (m/s)
Time (s)


psi (rad)
Time (s)


psidot (rad/s)
Time (s)


minDist (m)
Time (s)


F (N)
Time (s)