Optimal Control Problem, Re-Formulated

$$\underset{u_p(t),u_b(t)}{\text{minimize}}\ J = \Phi + \int_0^{t_f} P_{motor}(v(t), F_{tire}(t))dt \tag{1}$$

$$\tag{2}$$

$$\text{subject to } \frac{ds(t)}{dt} = v(t) \tag{3}$$

$$\dot{v}(t) = \frac{F_m(t)}{m} + \frac{F_b(t)}{m} - \frac{\rho C_d A_F}{2m} v^2(t) - g(C_r \cos\alpha(s(t)) + \sin\alpha(s(t)) \tag{4}$$

$$= \frac{F_m(t)}{m} + \frac{F_b(t)}{m} - \frac{F_{air}}{m} - \frac{F_\alpha(t)}{m} \tag{5}$$

$$v(0) = 0[m/s] \tag{6}$$

$$v(t_f) = \text{free} \tag{7}$$

$$s(0) = -50[m] \tag{8}$$

$$s(t_f) = \text{free} \tag{9}$$

$$u_{p,min}(v(t), t) \leq u_p(t) \leq u_{p,max}(v(t), t) \tag{10}$$

$$0 \leq u_b(t) \leq u_{b,max} \tag{11}$$

$$v_{min} \leq v(t) \leq v_{max} \tag{12}$$

$$F_{m,min}(v(t)) \leq F_m(t) \leq F_{m,max}(v(t)) \tag{13}$$

$$F_{b,min} \leq F_b(t) \leq F_{b,max} \tag{14}$$

$$F_m(t)F_b(t) \geq 0 \tag{15}$$

$$s(t) \leq s_f(t) - 20[m] \tag{16}$$