$$\Delta s_N = s_N - \bar{s}_N \qquad \Delta \bar{s}_k = \bar{s}_k - s^*$$

$$\Delta \bar{s}_N = \bar{s}_N - s^*$$

$$\Delta s_k = s_k - \bar{s}_k$$

$$c(\Delta s_k, \Delta u_k)$$

$$c_k = \frac{1}{2}(\Delta \bar{s}_N + \Delta s_N)^T Q_N (\Delta \bar{s}_N + \Delta s_N)$$

$$+ \frac{1}{2}\sum_{k=0}^{N-1} \Big((\Delta \bar{s}_k + \Delta s_k)^T Q (\Delta \bar{s}_k + \Delta s_k)$$

$$\cancel{+ u_k^T R u_k)}$$

$$\cancel{+ \Delta u_k^T R \Delta u_k)}$$

$$+ (u_k + \Delta u_k)^T R (u_k + \Delta u_k) \Big)$$

$$q_k = c_{s,k}^T$$

$$c_{s,k} = \frac{\partial c}{\partial s}(\bar{s}_k, \bar{u}_k)$$

$$= Q(\Delta \bar{s}_k + \Delta s_k)$$

$$c_{s,k}^T = \big(Q(\Delta \bar{s}_k + \Delta s_k)\big)^T$$

$$= (\Delta \bar{s}_k + \Delta s_k)^T Q$$

$$q_k = (\Delta \bar{s}_k + \Delta s_k)^T Q \quad \rightarrow (1)$$

$$q_N = \frac{\partial c}{\partial s}(\bar{s}_N, \bar{u}_N) \quad \rightarrow (2)$$

$$= Q_f (\Delta \bar{s}_N + \Delta s_N)$$

$$r_k = c_{u,k}^T$$

$$c_{u,k} = \frac{\partial c}{\partial u}(\bar{s}_k, \bar{u}_k) = R \cancel{u_k} \cancel{\Delta u_k}$$

$$r_k = \cancel{\Delta u_k^T R} \qquad \cancel{\rightarrow (3)}$$

$$= R(u_k + \Delta u_k)$$