$$\begin{pmatrix} \mathrm{u_o} \\ \mathrm{u'_o} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_2 & 1 \end{pmatrix} \begin{pmatrix} \cos\theta & \mathrm{R}\sin\theta \\ -\frac{1}{\mathrm{R}}\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_1 & 1 \end{pmatrix} \begin{pmatrix} \mathrm{u_i} \\ \mathrm{u'_i} \end{pmatrix} \tag{1}$$

$$= \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_2 & 1 \end{pmatrix} \begin{pmatrix} \mathrm{u} \\ \mathrm{u'} \end{pmatrix} \tag{2}$$

$$\begin{pmatrix} \mathrm{u} \\ \mathrm{u'} \end{pmatrix} = \begin{pmatrix} \cos\theta & \mathrm{R}\sin\theta \\ -\frac{1}{\mathrm{R}}\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_1 & 1 \end{pmatrix} \begin{pmatrix} \mathrm{u_i} \\ \mathrm{u'_i} \end{pmatrix} \tag{3}$$

$$\begin{pmatrix} \mathrm{u} \\ \mathrm{u'} \end{pmatrix} = \begin{pmatrix} \cos\theta & \mathrm{R}\sin\theta \\ -\frac{1}{\mathrm{R}}\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_1 & 1 \end{pmatrix} \begin{pmatrix} \mathrm{u_i} \\ \mathrm{u'_i} \end{pmatrix} + \begin{pmatrix} \Delta\mathrm{u} \\ \Delta\mathrm{u'} \end{pmatrix} \tag{4}$$

$$\begin{pmatrix} \mathrm{u_o} \\ \mathrm{u'_o} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \frac{1}{\mathrm{R}}\tan\beta_2 & 1 \end{pmatrix} \begin{pmatrix} \mathrm{u} \\ \mathrm{u'} \end{pmatrix} \begin{pmatrix} \Delta u \\ \Delta u' \end{pmatrix} \tag{5}$$

$$\begin{pmatrix} z_o \\ z'_o \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \frac{-1}{R}\tan\beta_2 & 1 \end{pmatrix} \begin{pmatrix} 1 & L \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{-1}{R}\tan\beta_1 & 1 \end{pmatrix} \begin{pmatrix} z_i \\ z'_i \end{pmatrix} \tag{6}$$

$$\begin{pmatrix} z \\ z' \end{pmatrix} = \begin{pmatrix} 1 & L \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{-1}{R}\tan\beta_1 & 1 \end{pmatrix} \begin{pmatrix} z_i \\ z'_i \end{pmatrix} \tag{7}$$

$$\mathrm{u} = \mathrm{u(s)} \tag{8}$$

$$\mathrm{z} = \mathrm{z(s)} \tag{9}$$

$$\mathrm{u'} = \frac{\mathrm{du}}{\mathrm{ds}} \tag{10}$$

$$\mathrm{z'} = \frac{\mathrm{dz}}{\mathrm{ds}} \tag{11}$$

$$\begin{pmatrix} \Delta\mathrm{u} \\ \Delta\mathrm{u'} \end{pmatrix} = \begin{pmatrix} \sqrt{2\mathrm{a}^2\cos^2\theta + 2\mathrm{a}\cos\theta\sqrt{\mathrm{R}^2 - 2\mathrm{aR} + \mathrm{a}^2\cos^2\theta} + \mathrm{R}^2 - 2\alpha\mathrm{R}} - \mathrm{R} \\ \frac{-4\mathrm{a}^2\cos\theta\sin\theta - 2\mathrm{a}\sin\theta\sqrt{\mathrm{R}^2-2\mathrm{aR}+\mathrm{a}^2\cos^2\theta} - \frac{2\mathrm{a}^3\cos^2\theta\sin\theta}{\sqrt{\mathrm{R}^2-2\mathrm{aR}+\mathrm{a}^2\cos^2\theta}}}{2\mathrm{R}\sqrt{2\mathrm{a}^2\cos^2\theta+2\mathrm{a}\cos\theta\sqrt{\mathrm{R}^2-2\mathrm{aR}+\mathrm{a}^2\cos^2\theta}+\mathrm{R}^2-2\mathrm{aR}}} \end{pmatrix} \tag{12}$$

$$\Delta\mathrm{u} = \sqrt{2\mathrm{a}^2\cos^2\theta + 2\mathrm{a}\cos\theta\sqrt{\mathrm{R}^2 - 2\mathrm{aR} + \mathrm{a}^2\cos^2\theta} + \mathrm{R}^2 - 2\mathrm{aR}} - \mathrm{R} \tag{13}$$

$$\Delta\mathrm{u'} = \frac{-4\mathrm{a}^2\cos\theta\sin\theta - 2\mathrm{a}\sin\theta\sqrt{\mathrm{R}^2 - 2\mathrm{aR} + \mathrm{a}^2\cos^2\theta} - \frac{2\mathrm{a}^3\cos^2\theta\sin\theta}{\sqrt{\mathrm{R}^2-2\mathrm{aR}+\mathrm{a}^2\cos^2\theta}}}{2\mathrm{R}\sqrt{2\mathrm{a}^2\cos^2\theta + 2\mathrm{a}\cos\theta\sqrt{\mathrm{R}^2 - 2\mathrm{aR} + \mathrm{a}^2\cos^2\theta} + \mathrm{R}^2 - 2\mathrm{aR}}} \tag{14}$$

$$\mathrm{a} = \mathrm{R}\sqrt{\frac{\mathrm{E} - \Delta\mathrm{E}}{\mathrm{E}}} \tag{15}$$