2.4 Predict the Transfer Orbit Parameters (Continued)

$$A^2 \cos^2 \theta_t + C^2 - 2AC \cos \theta_t = B^2(1 - \cos^2 \theta_t)$$

$$(A^2 + B^2) \cos^2 \theta_t - 2AC \cos \theta_t + C^2 - B^2 = 0$$

$$\cos \theta_t = \frac{2AC \pm \sqrt{4A^2C^2 - 4(C^2-B^2)}}{2(A^2+B^2)}$$

$$\cos \theta_t = \frac{AC \pm \sqrt{A^2C^2-C^2+B^2}}{A^2 + B^2} ; \quad \begin{aligned} A &= P_f e_t - P_t e_f \cos \Psi \\ B &= P_t e_f \sin \Psi \\ C &= P_t - P_f \end{aligned}$$

The elements of the final orbit are known, and the radius of perigee of the transfer orbit is set equal to the semi-major axis of the circular waiting orbit.

$$r_{pt} = a_w$$

This allows solving for the radius of apogee of the transfer orbit and the radius of intersection.

$$\frac{r_{at}\ r_{pt}}{r_{at} + r_{pt}} \left[1 + \frac{r_{af} - r_{pf}}{r_{af} + r_{pf}} \cos (\theta_t - \Psi) \right]$$

$$= \frac{r_{af}\ r_{pf}}{r_{af}+r_{pf}} \left[1 + \frac{r_{at} - r_{pt}}{r_{at} + r_{pt}} \cos (\theta_t) \right]$$

$$\frac{r_{af}+r_{pf}}{r_{af}\ r_{pf}} \left[1 + \frac{r_{af} - r_{pf}}{r_{af} + r_{pf}} \cos (\theta_t - \Psi) \right]$$

$$= \frac{r_{at}+r_{pt}}{r_{at}\ r_{pt}} \left[1 + \frac{r_{at} - r_{pt}}{r_{at} + r_{pt}} \cos (\theta_t) \right]$$