

- 1) Determine and/or Compute  $\phi$ ,  $\lambda$ ,  $\gamma$ ,  $N$ ,  $E$ ,  $k$  ... for all known points
- 2) Zenith Angle Correction: 
$$ZA = Z\angle + \text{asin} \left( \frac{[(HT - HR) - (HI - HM)] \cdot \sin(Z\angle)}{SD} \right)$$
- 3) Curvature and Refraction: 
$$Q = \frac{ZA + ZB - 180^\circ}{2} \quad C + R = \frac{3600 \cdot Q}{SD \cdot \sin(ZA)}$$

$(C + R)$  should be between 0.013" and 0.017" per meter and must be estimated!

Plane Zenith (both ends): 
$$PZ = ZA - Q \quad \text{or} \quad PZ = \frac{ZA - ZB + 180^\circ}{2}$$

Plane Zenith (one end): 
$$PZ = ZA - \frac{(C + R) \cdot SD \cdot \sin(ZA)}{3600}$$
- 4) Horizontal Distance (at mean elevation): 
$$HD = SD \cdot \sin(PZ)$$

Vertical Difference: 
$$VD = SD \cdot \cos(PZ)$$

Change in Elevation: 
$$\Delta E = \frac{HM_A + HR_B}{2} + VD - \frac{HM_B + HR_A}{2}$$
- 5) Traverse and Determine Preliminary  $N$ ,  $E$ ,  $\phi$ ,  $k$
- 6) Scale Factor (8 places): 
$$\frac{k_1 + k_2}{2} \quad \text{or} \quad \frac{k_1 + 4 \cdot k_m + k_2}{6}$$

Must use correction to natural scale radius if latitudes differ by 4' or more.

Elevation Factor (8 places): 
$$\frac{R}{R + E + h}$$

$R$  (mean radius of earth) = 6,371,000 meters  
 $E$  (point elevation or mean elevation of line)  
 $h$  (geoid separation)

Grid Factor (8 places): 
$$GF = \frac{k \cdot R}{R + E + h} \quad (\text{Note: } GF = SF \cdot SLF)$$

Grid Distance: 
$$GD = HD \cdot GF$$
- 7) Second Term (2 places): 
$$\delta = A \cdot (E_2 - E_1) \cdot \left( N_1 - N_0 + \frac{N_2 - N_1}{3} \right) \quad \underline{\text{seconds!}}$$

$A = 25.4 \cdot 10^{-10}$  for all NAD83 zones  
 ( Note:  $Grid.AZI = Geod.AZI - \gamma + \delta$  )

Grid Angle: 
$$\beta = \alpha - \delta_{BS} + \delta_{FS}$$

$\alpha$  (geodetic angle)  
 $\beta$  (grid angle)
- 8) Balance Angles, Traverse and Compass Rule Adjust