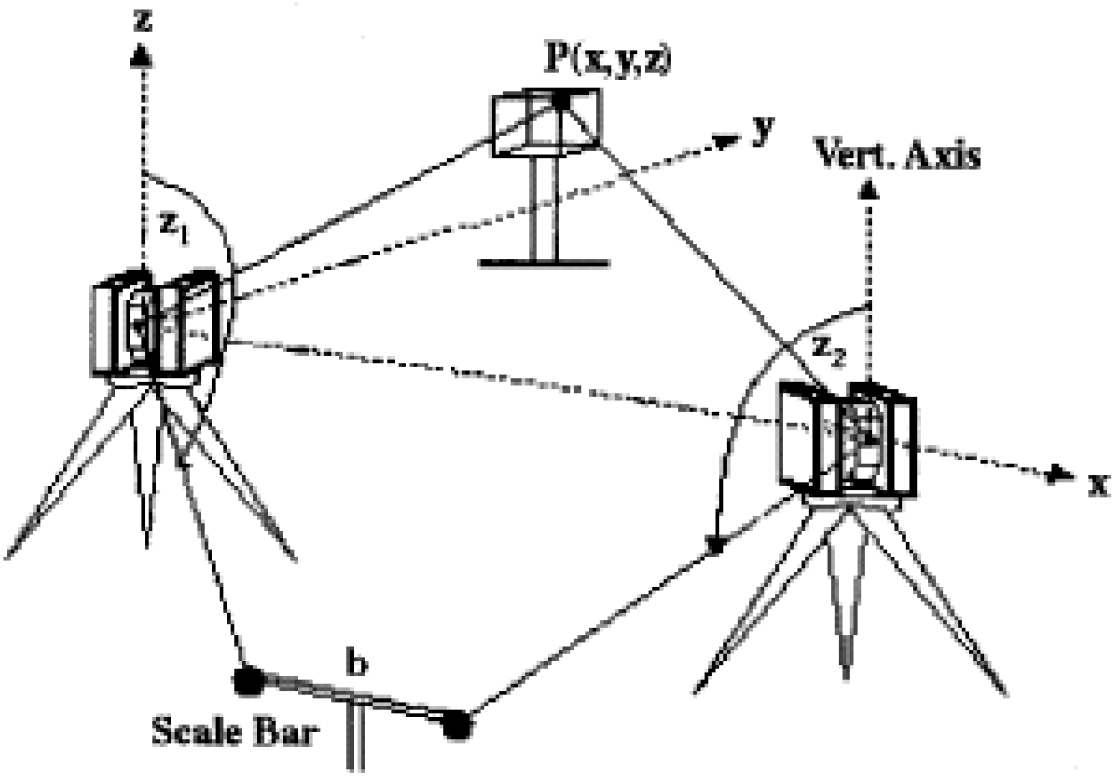
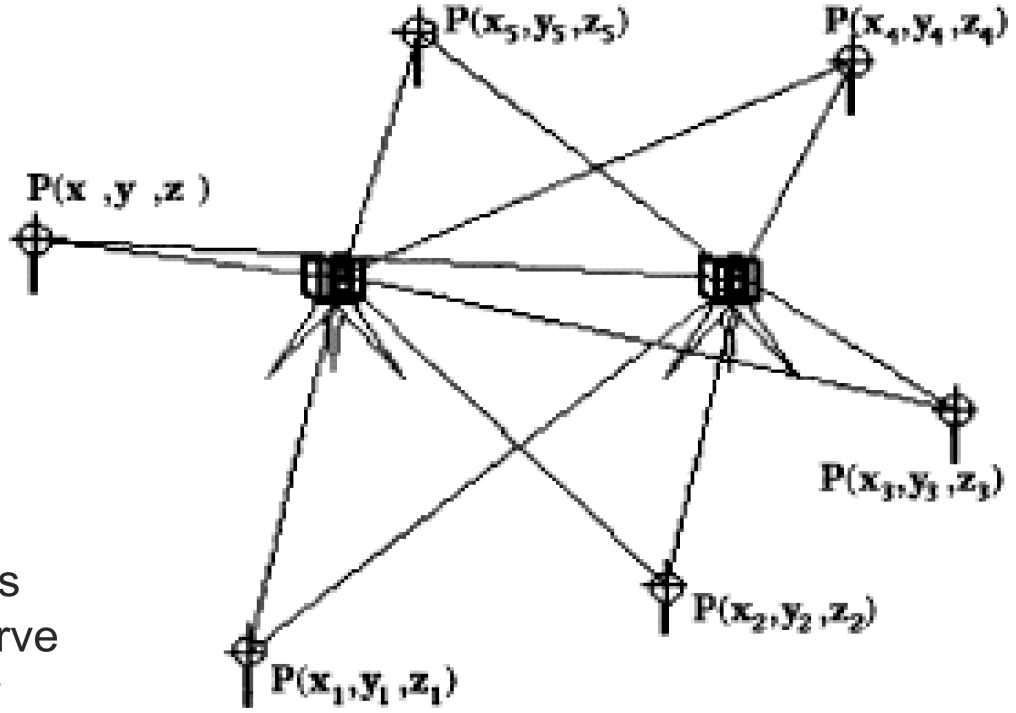
angles

- What are some considerations for 3D angles?
  - Principles involves measuring horizontal and zenith angles; no EDM measurements, vertical axes set by compensators. Can typically give < 1mm accurate for lines < 30m.
    - The common method is either by:
      - Reciprocal observations (if instruments can accurately observe to each other)
      - Measurements to a scale bar



      - Measurements to control points with known coordinates (resections)



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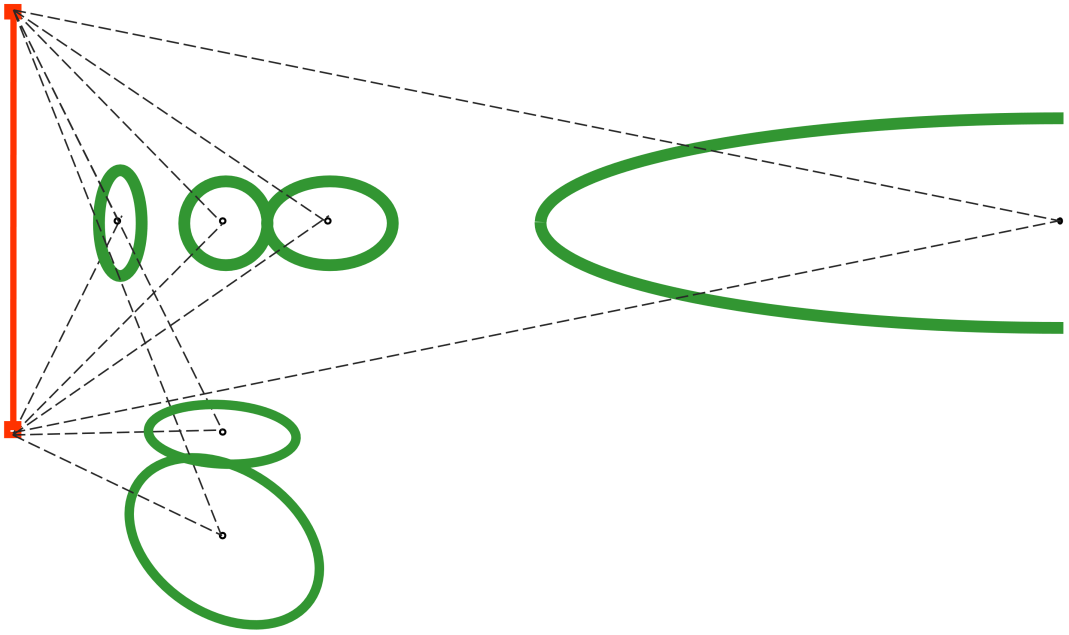
- Redundancy of
  - 3D intersections: 4 obs, 3 coords ENH = 4 residual
    - Computer link = real time coordinates and residuals / errors
  - 2D intersections: 2 obs, 2 coords EN = no residuals
- Errors could include:
  - Sighting to other instruments? (1" at 5m = 0.025mm)
  - Change of focus, line of sight instability?
    - Hidden point poles w/ 2 prisms. High precision, but not sub-mm.
  - Error ellipses depend on position of instruments.



- e.g Arch Bridge case study using **spatial intersections**; subtense method, no EDMs, use of a scale bar
  - Use of specialised targets (lining up with the crosshairs/circular graticule)

    - Measuring to control points and arch targets, assuming the targets are stable
        - If sighting back to the control point had different measurements, then the targets must have moved.
    - One large LS adjustment in FIXIT.
- What affects angle measurements?
    - **Atmospheric**
        - Due to refraction affects (ground proximity/grazing rays most affected) and atmospheric delays (humidity affects GPS signals - tellurometers)
        - HA during sunrise and sunset, zenith angles during midday (rapid changes in k at sunrise and sunset).
    - **Earth Curvature**
        - To gain heights using ZA obs, do **reciprocal** observations (forward and reverse) and mean ΔH, Earth curvature cancels.
        - This is usually a larger issue than atmospheric.
- What is the Local Scale Parameter Method?
    - Rather than directly measuring the atmosphere, the effects are observed and then corrected for those observations.
        - First, reference marks are assumed to not move
        - Calculate slope distance, bearing and ZA from coordinates
        - Observe to fixed reference points/coords and compared with obs
        - Calculate scale factor correction, ZA correction, and orientation for EACH line.
            - Remember, distance is 3D distance! Take height into account.
            - C has units ("/km, calculate correction like ppm, error is inversely proportion to distance)

$$F = \frac{d_{coords}}{d_{msd}}$$

$$\Omega = Bearing_{coords} - Direction_{obs}$$

$$C = (ZA_{coords} - ZA_{msd}) / d$$

        - Calculate the **mean** of the corrections/factor and apply to obs to NON-reference points.
    - This method is typically used for monitoring open-cut mines for stability and deformation, of dam surveillance surveys. Need to consider
        - Observing conditions (mist, dust, line of sight obstructed)

- Types of targets