Traverse Adjustments

Learning Objectives for this Lecture

1. Know the process for traverse computations and adjustment
2. Know the computations for departure and latitude
3. Know the quadrant signs for departure and latitude
4. Be able to compute coordinates from unadjusted departures and latitudes
5. Be able to compute traverse closure
6. Be able to compute linear error
7. Be able to compute relative error
8. Be able to compute relative error on an equivalent scale basis
9. Know the 4 methods of adjusting traverses
10. Be able to adjust traverses by the compass rule
11. Be able to compute latitude and departure corrections
12. Be able to compute adjusted latitude and departure
13. Be able to compute adjusted coordinates

We have already established that all measurements have error. The next step in the traverse is to identify and adjust errors in distance and direction.

IMPORTANT! WE ARE NOT ADJUSTING MISTAKES, ONLY ERRORS

The steps in the traverse adjustment process for a closed traverse are:

1. Compute the departures and latitudes of each line segment (course)
2. Compute unadjusted coordinates for each survey position (station)
3. Compute the sums of departure and sums of latitude
4. Compute the adjustment for each station by the appropriate rule
5. Compute the adjusted departure and adjusted latitude
6. Compute the adjusted coordinates

Departures and Latitudes

Defined as the X and Y components of a survey line, superimposed onto a horizontal plane with a directional reference system.

Mathematically they are the legs of a right triangle, the hypotenuse being the survey line itself.
X Departure

Y Departure

X = L sin Z

Y = L cos Z

Where: L = the length of the line
       Z = the azimuth or bearing of the line

Coordinates of X and Y at any station are calculated from the previous station coordinates plus the departure and latitude to the current station

(WATCH SIGNS!)
Rules on the signs in the four quadrants:

**Latitude:** Positive in the northerly direction  
Negative in the southerly direction

**Departure:** Positive in the easterly direction  
Negative in the westerly direction

Example:

\[ \begin{align*} 
\alpha &= 37^\circ \\
\Delta X &= L \sin Z \\
\Delta Y &= L \cos Z \\
\Delta X &= 212.57' \sin 37^\circ \\
\Delta Y &= 212.57' \cos 37^\circ \\
\Delta X &= (212.57') \cdot 0.601815 \\
\Delta Y &= (212.57') \cdot 0.798636 \\
\Delta X &= 127.93' \\
\Delta Y &= 169.77' \\
X_B &= 125000.00 + 127.93 = 125127.93 \\
Y_B &= 46750.00 + 169.77 = 46919.77 
\end{align*} \]
Angle = 217°

\[ \Delta X = L \sin Z \quad \Delta Y = L \cos Z \]
\[ \Delta X = 212.57' \sin 217 \quad \Delta Y = 212.57 \cos 217 \]
\[ \Delta X = 212.57' (-.6018...) \quad \Delta Y = 212.57 (-.7986...) \]
\[ \Delta X = -127.93 \quad \Delta Y = -169.77 \]

\[ X_B = 125127.93 - 127.93 = 125000.00 \]
\[ Y_B = 46919.77 - 169.77 = 46750.00 \]
Traverse Closure

In a closed-loop survey the sums of the departures and latitudes should equal zero.

The total or linear error of closure = the hypotenuse of the triangle formed by the errors in latitude and departure.

\[ E_T = \sqrt{E_d^2 + E_i^2} \]

The relative error of closure (or precision of the traverse) = the total error divided by the perimeter. Usually expressed as a ratio.

Example:

The error in departure on a traverse = 0.13’
The error in latitude on a traverse = 0.09’
The total length of the traverse is 1950.23’

\[ E_T = \sqrt{(0.13^2 + 0.09^2)} \]

\[ E_T = \sqrt{0.250} \]

\[ E_T = 0.158 \]

\[ E_R = \frac{0.158}{1950.23} \]

\[ E_R = 0.000081 \]

\[ E_R = 1:12300 \]
Example:

<table>
<thead>
<tr>
<th>Sta</th>
<th>SD</th>
<th>%</th>
<th>HD</th>
<th>AHD</th>
<th>LAT</th>
<th>DEP</th>
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<td>-0.25</td>
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$$\text{Linear error of closure} = \sqrt{(0.46^2) + (0.25^2)} = 0.52'$$

$$\text{Relative error of closure} = \frac{0.52'}{2915.80} = 1:5607$$

Equivalent error can be calculated from the relative error by understanding that the relative error is unitless. For example in the above we can read the relative error of 1:5607 as:

1 foot in 5607 feet or 1 meter in 5607 meters

Typical is to express relative error on a per mile basis, therefore:

$$\frac{1'}{5607'} = \frac{x'}{5280'} = \frac{0.94'}{\text{mile}}$$
**Traverse Adjustments**

Methods of adjusting traverses:

1. Compass (or Bowditch rule)
2. Transit rule
3. Least Squares
4. Crandall method

Assumptions:

Compass rule: Distances and directions are measured with consistent precision. This means there is an equal chance of error from either measurement.

Transit rule: Directions are measured with higher precision than the distances. After adjustments, directions are disrupted less than distances.

Least Square rule: Theoretically results in the least disturbance to the original measurements. This method minimizes the overall adjustments.

Crandall method: A weighted least squares method. Higher weight is given to the directions, similar to the transit rule.

**Compass Rule**

Departures and latitudes are adjusted in proportion to their lengths.

Correction in departure for \( XY = \frac{-\text{(total departure misclosure)}}{\text{Traverse perimeter}} \times \text{length of XY} \)

Correction in latitude for \( XY = \frac{-\text{(total latitude misclosure)}}{\text{Traverse perimeter}} \times \text{length of XY} \)

**NOTE:** Pay particular attention to the signs of the correction
Example:

<table>
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<th>DEP</th>
<th>LAT_{corr}</th>
<th>DEP_{corr}</th>
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<td>-0.46</td>
<td>+0.25</td>
<td>0.00</td>
<td>0.00</td>
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</tbody>
</table>

Coordinate computations

Coordinate computations are made by simply adding the adjusted departures and latitudes to the previous coordinates.

In a closed traverse these coordinates should agree in balance back at the first.
Example:

Coordinates of A

<table>
<thead>
<tr>
<th>Sta</th>
<th>LAT&lt;sub&gt;adj&lt;/sub&gt;</th>
<th>DEP&lt;sub&gt;adj&lt;/sub&gt;</th>
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<th>Easting</th>
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