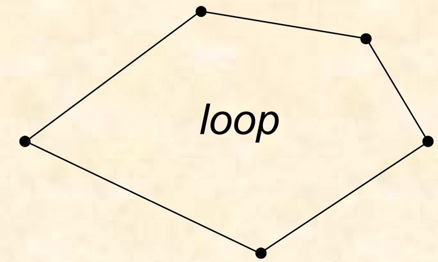
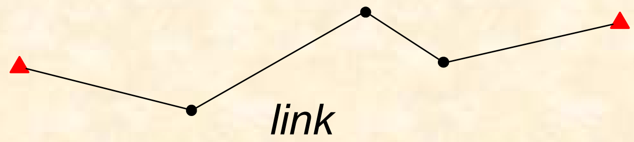
Traverses

A. Traverse: A series of lines whose lengths and angular relationships have been measured.

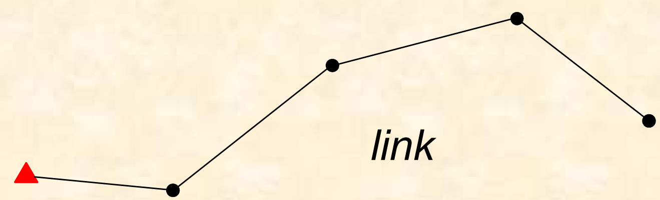
B. Types – *Mathematically* defined

Closed - starts and ends on the same point, or, starts at one *known* point and ends at a second *known* point.





Open - starts at a known or unknown point and ends at an *unknown* point.



▲ Control point
● Unknown point

C. Horizontal angles

1. Types

a. Interior/Exterior

b. Angle to Right/Left

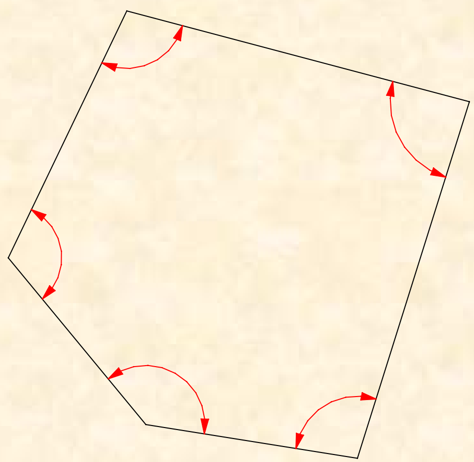
c. Deflection Angle

2. Angle closure condition - Loop traverse

interior angles

$$\Sigma(\text{interior angles}) = (n-2) \times 180^\circ$$

$$n = \text{number of angles}$$

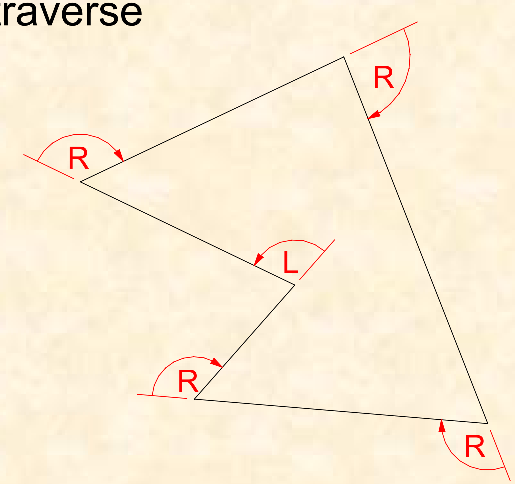


C. Horizontal angles

2. Angle closure condition - Loop traverse

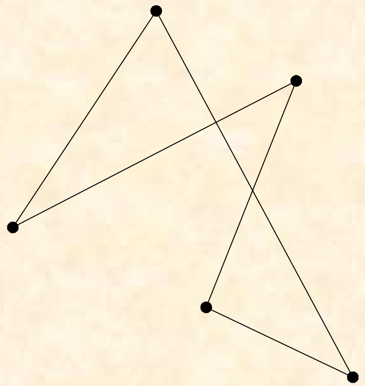
deflection angles

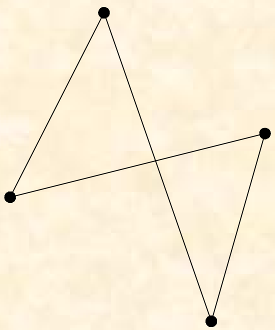
Defl R is +
Defl L is –



even crossings Σ(defl angles)= $\pm$ **360°**

odd crossings Σ(defl angles)= **0°**





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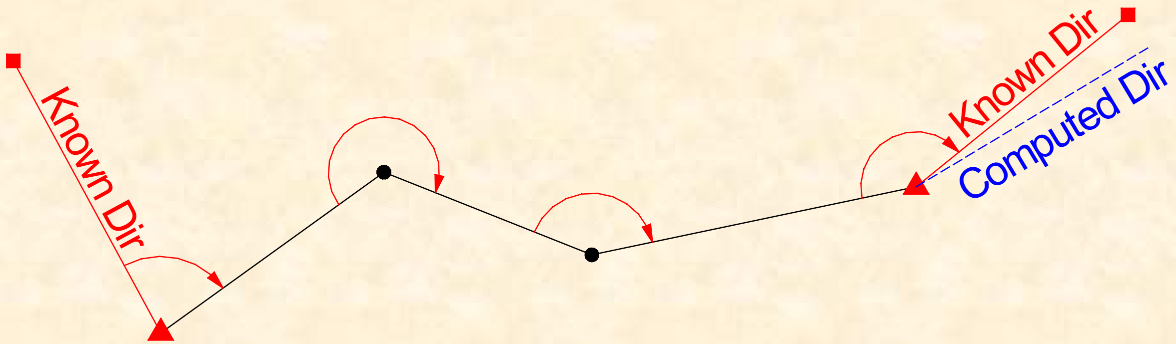
C. Horizontal angles

2. Angle closure condition - Link traverse

Must have beginning and ending directions



Angular misclosure is the difference between the known and computed directions at the end of the traverse.

This method can also be used for a loop traverse.

C. Horizontal angles

3. Expected misclosure: *random error*

$$c = k\sqrt{n}$$ *error of a series*

a. Formal Standards: (FGCS)

Order	*Class*	*k*
First	--	1.7”
Second	I	3”
	II	4.5”
Third	I	10”
	II	12”

C. Horizontal angles

3. Expected misclosure: *random error*

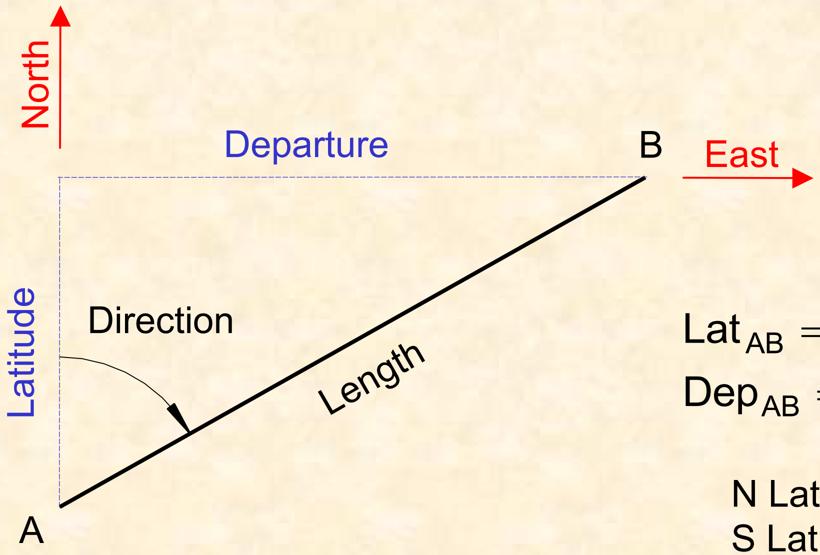
$$c = k\sqrt{n}$$

b. Informal standards

example: A survey crew can measure angles with a consistent accuracy of ±00°00’15”. What is their expected misclosure on a 9-sided traverse?

$$\begin{aligned} c &= k\sqrt{n} \\ &= \pm 0^\circ 00'15''\sqrt{9} \\ &= \pm 0^\circ 00'45'' \end{aligned}$$

D. Latitudes and Departures



$$Lat_{AB} = L_{AB} \times Cos(Dir_{AB})$$
$$Dep_{AB} = L_{AB} \times Sin(Dir_{AB})$$

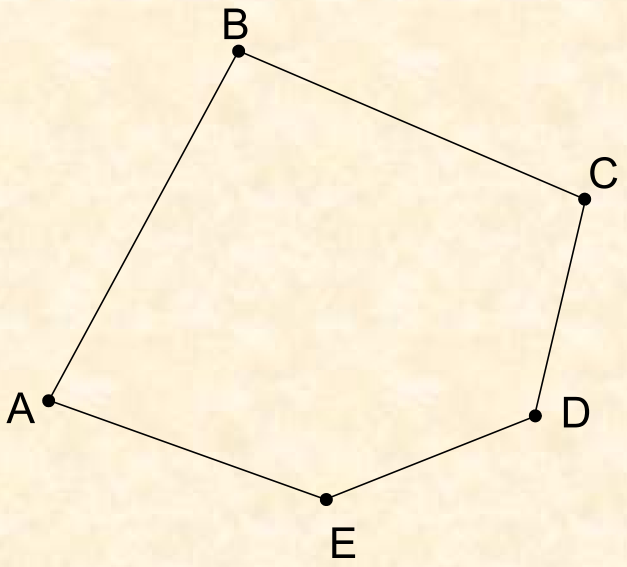
N Lat is (+) E Dep is (+)
S Lat is (–) W Dep is (–)

Bearings:
Sin() and Cos() of the bearing angle (0˚ to 90˚) will always be positive.
Assign correct signs to Lats and Deps based on bearing quadrant.

Azimuths:
Sin() and Cos() of the azimuth angle (0˚ to 360˚) will return correct sign on Lats and Deps.

E. Traverse Closure

Loop traverse



$$\text{Lat err} = \sum_{i=1}^{n} \left(\text{Lats}_i\right)$$

$$\text{Dep err} = \sum_{i=1}^{n} \left(\text{Dep}_i\right)$$

$$\text{LC} = \sqrt{\left(\text{Lat err}\right)^2 + \left(\text{Dep err}\right)^2}$$

$$\text{precision} = \frac{\text{LC}}{\text{Total distance}} = \frac{1}{P}$$

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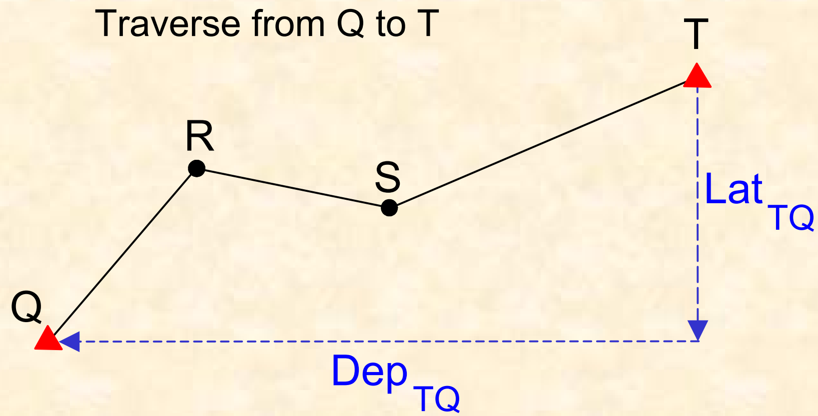
E. Traverse Closure

Link traverse



$$\text{Lat err} = \left[\sum_{i=1}^{n}\left(\text{Lats}_i\right)\right] + \text{Lat}_{n1}$$

$$\text{Dep err} = \left[\sum_{i=1}^{n}\left(\text{Dep}_i\right)\right] + \text{Dep}_{n1}$$

$$LC = \sqrt{\left(\text{Lat err}\right)^2 + \left(\text{Dep err}\right)^2}$$

$$\text{precision} = \frac{LC}{\text{Total distance}} = \frac{1}{P}$$

Lat_{n1} is the computed latitude from the closing control point to the beginning control point.

Dep_{n1} is the computed departure from the closing control point to the beginning control point.

E. Traverse Closure

Closure standards

Formal closure standards - FGCS

Order	*Class*	*precision*
First	--	1/100,000
Second	I	1/50,000
	II	1/20,000
Third	I	1/10,000
	II	1/5,000

F. Traverse Adjustment

What

Adjustment of traverse closure. Traverse closure is propagated random error.

Closure error is distributed back into measurements.

Method used should approximate how error accumulated.

Methods

Arbitrary - no adjustment or all errors placed into various measurements

Transit Rule - angles measure with higher accuracy than angles.

Compass Rule (Bowditch Rule) - angles and distances measured with comparable accuracies.

Crandall Method - least squares applied to distances only.

Least Squares - angles and distances adjusted statistically.

F. Traverse Adjustment

Compass Rule (Bowditch Rule): Common manual method

$$\text{Lat corr'n}_{AB} = \left(\frac{-(\text{Lat err})}{\text{Traverse dist}}\right) \times L_{AB}$$

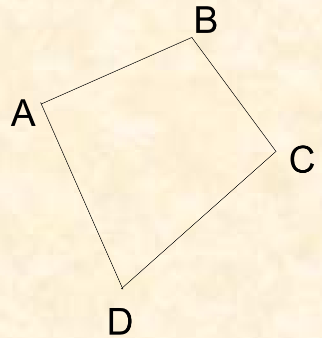
$$\text{Dep corr'n}_{AB} = \left(\frac{-(\text{Dep err})}{\text{Traverse dist}}\right) \times L_{AB}$$

$$\text{Adj Lat}_{AB} = \text{Lat}_{AB} + \text{Lat corr'n}_{AB}$$

$$\text{Adj Dep}_{AB} = \text{Dep}_{AB} + \text{Dep corr'n}_{AB}$$

F. Traverse Adjustment

Example traverse Computation and adjustment



from	to	Azimuth	Dist	Unadjusted Lat	Unadjusted Dep	Adjusted Lat	Adjusted Dep
A	B	66°25'30"	367.25	146.881	336.598	146.838	336.614
B	C	143°41'15"	314.83	-253.690	186.439	-253.727	186.452
C	D	227°57'25"	462.54	-309.758	-343.502	-309.813	-343.482
D	A	336°41'10"	453.81	416.757	-179.604	416.703	-179.584
		sums:	1598.43	0.190	-0.068	**0.000**	**0.000**

Math Check

Linear Closure

Length 0.202
Azimuth 160°22'25"
Bearing S 19°37'35"E
Prec: 1/7910

$$\text{Adj Lat}_{AB} = \text{Lat}_{AB} + \left(\frac{-(0.190)}{1598.43}\right) \times L_{AB}$$

$$\text{Adj Dep}_{AB} = \text{Dep}_{AB} + \left(\frac{-(-0.068)}{1598.43}\right) \times L_{AB}$$

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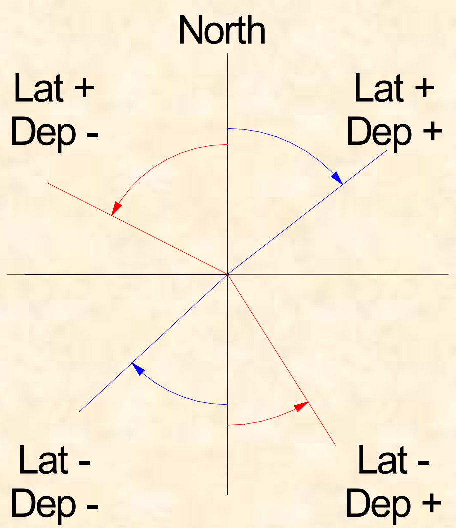
G. Length and Direction Computation

$$L_{AB} = \sqrt{(Lat_{AB})^2 + (Dep_{AB})^2}$$

$$\alpha = \tan^{-1}\left[\frac{Dep_{AB}}{Lat_{AB}}\right]$$

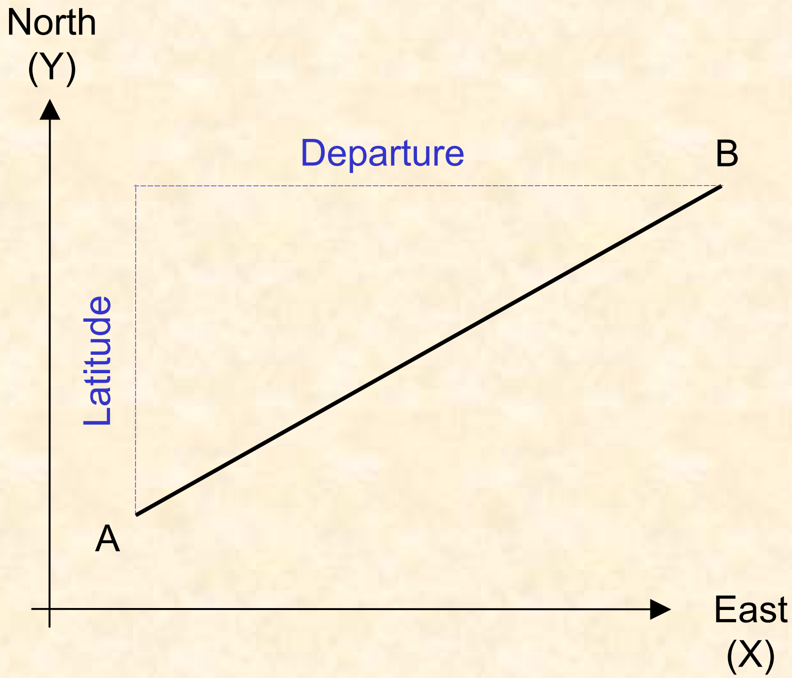
Using *adjusted* Lat and Dep will give the Length and Direction based on the traverse adjustment.

α will always be 0 to ±90º and referenced to the meridian.



sign(Lat)	sign(Dep)	sign(α)	bearing	azimuth
+	+	+	N α E	α
+	–	–	N |α | W	180˚+ α
–	+	–	S |α | E	180˚+ α
–	–	+	S α W	360˚+ α

H. Coordinates



$$N_B = N_A + Lat_{AB}$$

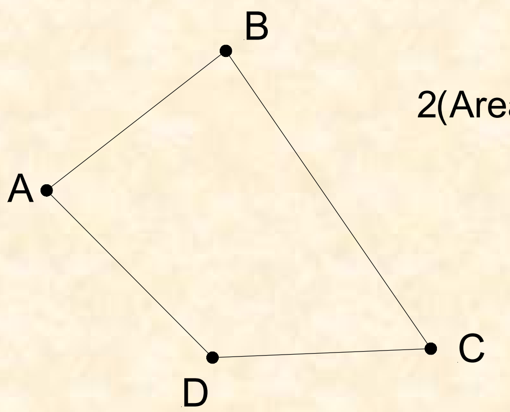
$$E_B = E_A + Dep_{AB}$$

$$Y_B = Y_A + Lat_{AB}$$

$$X_B = X_A + Dep_{AB}$$

I. Area Computation

By coordinates



$$2(\text{Area}) = X_B Y_A + X_C Y_B + X_D Y_C + X_A Y_D - X_A Y_B - X_B Y_C - X_C Y_D - X_D Y_A$$

Coordinates		Cross multiplication ($\nearrow$)	($\searrow$)
X_A	Y_A	$X_B Y_A$	
X_B	Y_B	$X_C Y_B$	$X_A Y_B$
X_C	Y_C	$X_D Y_C$	$X_B Y_C$
X_D	Y_D	$X_A Y_D$	$X_C Y_D$
X_A	Y_A		$X_D Y_A$
	Sums:	$\Sigma(\nearrow)$	$\Sigma(\searrow)$

$$\text{Area} = \left| \frac{\Sigma(\nearrow) - \Sigma(\searrow)}{2} \right|$$

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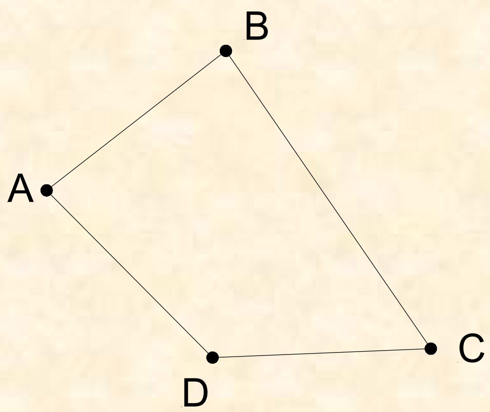
I. Area Computation

By DMDs (Double Meridian Distances)



Line	Lat	Dep	DMD	Lat x DMD
AB	Lat_{AB}	Dep_{AB}	$DMD_{AB}=Dep_{AB}$	Lat_{AB} x Dep_{AB}
BC	Lat_{BC}	Dep_{BC}	$DMD_{BC}=DMD_{AB}+Dep_{AB}+Dep_{BC}$	Lat_{BC} x Dep_{BC}
CD	Lat_{CD}	Dep_{CD}	$DMD_{CD}=DMD_{BC}+Dep_{BC}+Dep_{CD}$	Lat_{CD} x Dep_{CD}
DA	Lat_{DA}	Dep_{DA}	$DMD_{DA}=DMD_{CD}+Dep_{CD}+Dep_{DA}$	Lat_{DA} x Dep_{DA}
			Sum:	Σ(Lat x DMD)

Math check: $DMD_{DA} = -(Dep_{DA})$

$$\text{Area} = \left| \frac{\Sigma(\text{Lat x DMD})}{2} \right|$$

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