# Error Ellipse of a Survey Point

Semi-axes and orientation of the standard error ellipse of a point from its northing and easting standard errors and covariance, with the 95 % ellipse.

**Method:** Error ellipses from least-squares covariance

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Standard error of northing | 12.000 | mm |
| Standard error of easting | 8.0000 | mm |
| Covariance of N and E (m²) | 4.0000e-05 | |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Semi-major axis (standard) | 12.672 | mm |
| Semi-minor axis (standard) | 6.8870 | mm |
| Azimuth of the semi-major axis | 22.500 | ° |
| Semi-major axis, 95 % | 31.017 | mm |
| Semi-minor axis, 95 % | 16.858 | mm |
| Correlation coefficient | 0.41667 | |

### Notes for this case

• The covariance matrix [σ_N², σ_NE; σ_NE, σ_E²] has eigenvalues S_u² and S_v² = (σ_N² + σ_E²)/2 ± √[((σ_N² − σ_E²)/2)² + σ_NE²], the squared semi-axes, and the major axis lies at azimuth t = ½·atan2(2σ_NE, σ_N² − σ_E²). The standard ellipse holds the true point with about 39 % probability; multiplying by √(−2 ln 0.05) = 2.448 gives the 95 % ellipse. Values come from a least-squares adjustment.

## Formula and method

$$S_{u,v}^2 = \frac{\sigma_N^2 + \sigma_E^2}{2} \pm \sqrt{\left(\frac{\sigma_N^2 - \sigma_E^2}{2}\right)^2 + \sigma_{NE}^2}, \quad t = \frac{1}{2}\operatorname{atan2}(2\sigma_{NE}, \sigma_N^2 - \sigma_E^2)$$

### Variables

| | | |
|---|---|---|
| $\sigma_N$ | Standard error of northing | m |
| $\sigma_E$ | Standard error of easting | m |
| $\sigma_{NE}$ | Covariance of N and E (m²) | - |
| $S_u$ | Semi-major axis (standard) | m |
| $S_v$ | Semi-minor axis (standard) | m |
| $t$ | Azimuth of the semi-major axis | rad |
| $S_{u,95}$ | Semi-major axis, 95 % | m |
| $S_{v,95}$ | Semi-minor axis, 95 % | m |
| $\rho$ | Correlation coefficient | - |

### Method and standards

Error ellipse.

### Assumptions and limits

- Normally distributed errors; two-dimensional.

## References

Error ellipses from least-squares covariance

## Report details

| | |
|---|---|
| Report reference | FCC-JVKN-G871 (the same inputs always give the same reference) |
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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/civil/surveying/survey-error-ellipse

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.