Grid–Ground Distance: Elevation, Grid and Combined Factors

Elevation factor, combined scale factor and the grid distance from a ground distance (or the reverse) for state plane, UTM or other projected coordinates.

Method: Reduction of distances to a map projection grid

Input parameters

Unit system: SI

Parameter	Value	Unit
Ground (horizontal) distance	1,500.0	m
Mean orthometric height of the line	450.00	m
Geoid undulation	-30.000	m
Grid scale factor of the projection	0.99984	
Earth radius (mean or R_α)	6,371.0	km

Calculated results

Parameter	Value	Unit
Elevation factor	0.99993	
Combined factor	0.99977	
Grid distance	1,499.7	m
Grid minus ground	-338.86	mm
Combined factor in ppm	-225.91	

Notes for this case

• Ground distances are first reduced to the ellipsoid by the elevation factor R/(R + h), with ellipsoid height h = H + N, then scaled to the map projection by its grid scale factor k at the line. Combined factor = EF × k; grid = ground × CF, ground = grid / CF. Mixing ground and grid distances in one traverse causes misclosures of tens of ppm; low-distortion projections are designed to keep CF near 1 over a project.

Formula and method

$$EF = \frac{R}{R + H + N}, \quad CF = EF \cdot k, \quad L_{grid} = L_g \cdot CF$$

Variables

L_g	Ground (horizontal) distance	m
H	Mean orthometric height of the line	m
N	Geoid undulation	m
k	Grid scale factor of the projection	-
R	Earth radius (mean or R_α)	m
EF	Elevation factor	-
CF	Combined factor	-
L_{grid}	Grid distance	m
$L_{grid} - L_g$	Grid minus ground	m
$(CF-1)10^6$	Combined factor in ppm	-

Method and standards

Combined factor.

Assumptions and limits

- Spherical earth radius; mean factors along the line.

References

Reduction of distances to a map projection grid

Report details

Report reference	FCC-10F0-MKW5 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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/grid-ground-combined-factor

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.