

What are scale factors?

By Halmat Atta Ali

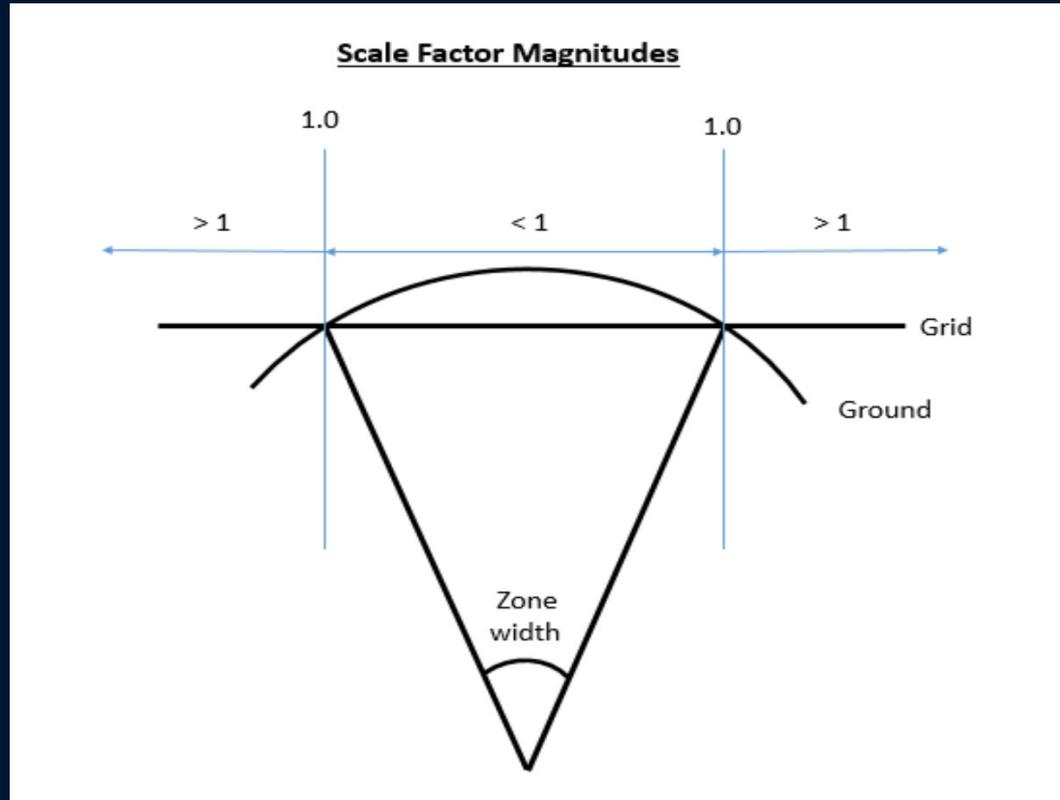




What are scale factors?

A scale factor accounts for the difference between a distance on a curved surface (Earth), and that same distance when projected onto a mapping plane or grid. A point scale factor gives the distortion at a specific location for a specified map projection. In the example below, the scale factor is 1 at the intersection of the ground with the grid, meaning the ground measurement equals the grid measurement. Between the intersections, the ground distance is greater than the grid distance so the scale factors are less than 1. Outside the intersections, the ground distances are shorter than the grid distances, so the scale factors are greater than 1. The smaller the zone width, the smaller the magnitude of scale factors. For this reason, surveyors often prefer working with the Modified Transverse Mercator (MTM) 30 Projection over the Universal Transverse Mercator (UTM) 60 Projection since survey plans designed on the grid more closely reflect ground measurements.

What are scale factors?





What is the difference between grid scale factor, elevation scale factor and combined scale factor?

The reduction of horizontal distances to grid distances is a two-step process:

1.) Reduction from horizontal distance to ellipsoidal distance using the Elevation Scale Factor (ESF)

Elevation Scale Factor (approx.)

$$\text{ellipsoid distance} = \text{horizontal distance} * \left(\frac{R}{R + h} \right)$$

R = radius of Earth,
 h = ellipsoid height,

2.) Reduction from ellipsoidal distance to grid distance using the Grid Scale Factor (GSF)

$$\text{grid distance} = \text{ellipsoid distance} * \text{grid scale factor}$$



Often these scale factors are combined in what is known as a Combined Scale Factor (CSF) which allows grid distance to be calculated from ground distance in one step

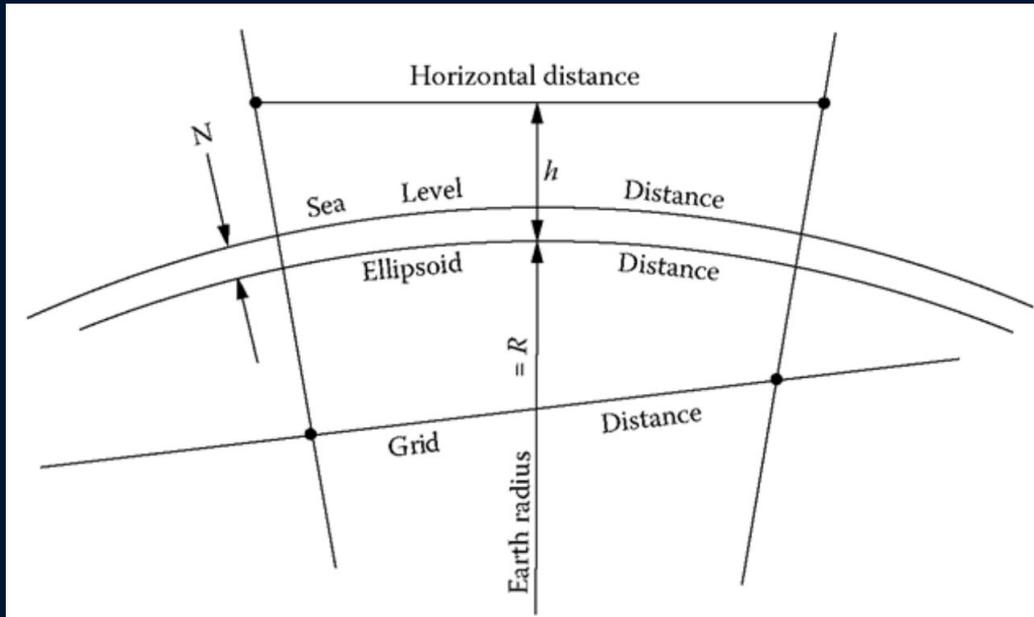
*Grid distance = ground distance * combined scale factor*

$$CSF = ESF \times GSF$$

It can be seen from the formula for calculating ellipsoid distance that unless there is significant ellipsoidal height, the elevation scale factor is very close to 1. For this reason, the GSF is often used as a close approximation of the CSF. It is up to the user to determine if the ESF can be neglected. In Nova Scotia, a typical ellipsoidal height is -20 m. The table below illustrates the impact of ellipsoidal height on the elevation scale factor and also the impact that this has on a 1000.000 m horizontal distance reduction.



h (m)	ESF	Ellipsoidal Distance based on 1000.000 m Horizontal Distance	Impact of Neglecting ESF (m)
10000	0.998435	998.435	1.565
1000	0.999843	999.843	0.157
100	0.999984	999.984	0.016
10	0.999998	999.998	0.002





What is a point scale factor and line scale factor?

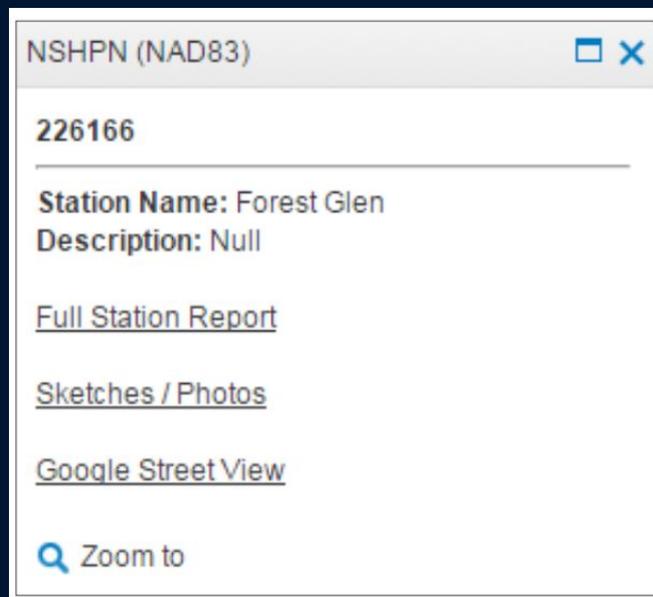
The term point scale factor refers to the grid scale factor at a specified location or point. A line scale factor refers to a calculated grid scale factor for a particular distance between two points. There are different methods of calculating a grid scale factor depending on the length of the line as summarized in the table below.

Distance	Methodology
< 1 km	Use point scale factor for any point along the measured line
< 4 km	Use average point scale factor
>= 4 km	Use Simpson 1/6 Rule



Where do I find the value of a scale factor?

Grid scale factor/ point scale factor can be found in the Full Station Report for NSCOMs in the NSCRS Viewer. For NSHPN monuments, the combined scale factor is also published in the Full Station Report.



Horizontal Data



Horizontal Reference Frame: **NAD83 (CSRS) 2010.0** ▾ **NEW**

MTM

UTM

Geographic

Cartesian

Real Zone 5

Northing

4921952.971

Easting

25445005.487

Northing (Standard Deviation)

0.0000

Easting (Standard Deviation)

0.0000

Semi Major Axis A

0.0000

Semi Minor Axis B

0.0000

Orientation

0.000000

Convergence (decimal degrees)

0.4836

Scale Factor

0.999937

Combined Scale Factor

0.999918

Coordinate Status

Adopted (Published) Values

Adjustment ID

NAD831997_V1p0_AF

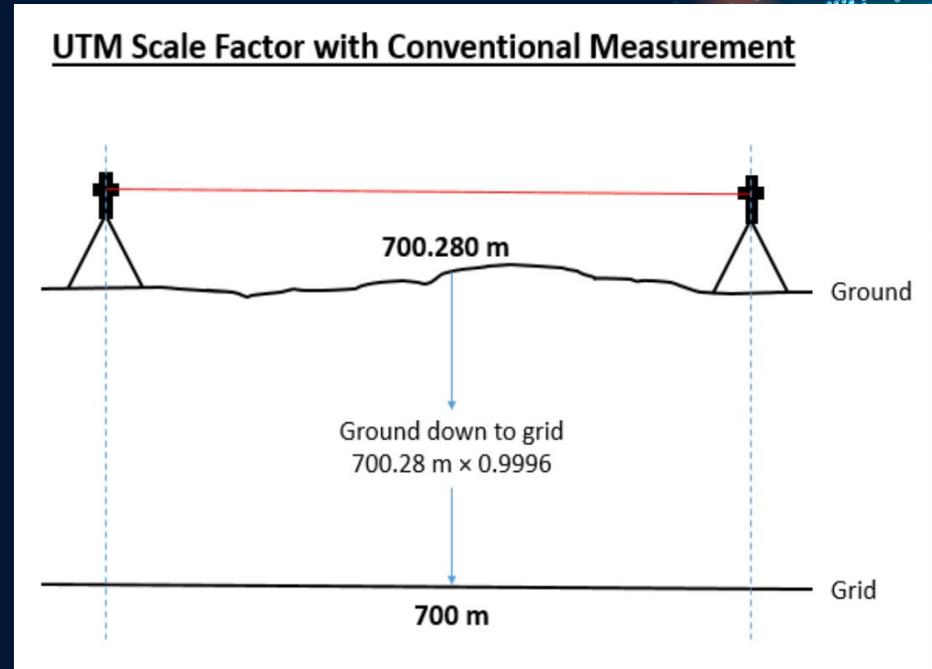
Coordinate Date (YYYYMMDD)

2014-09-11

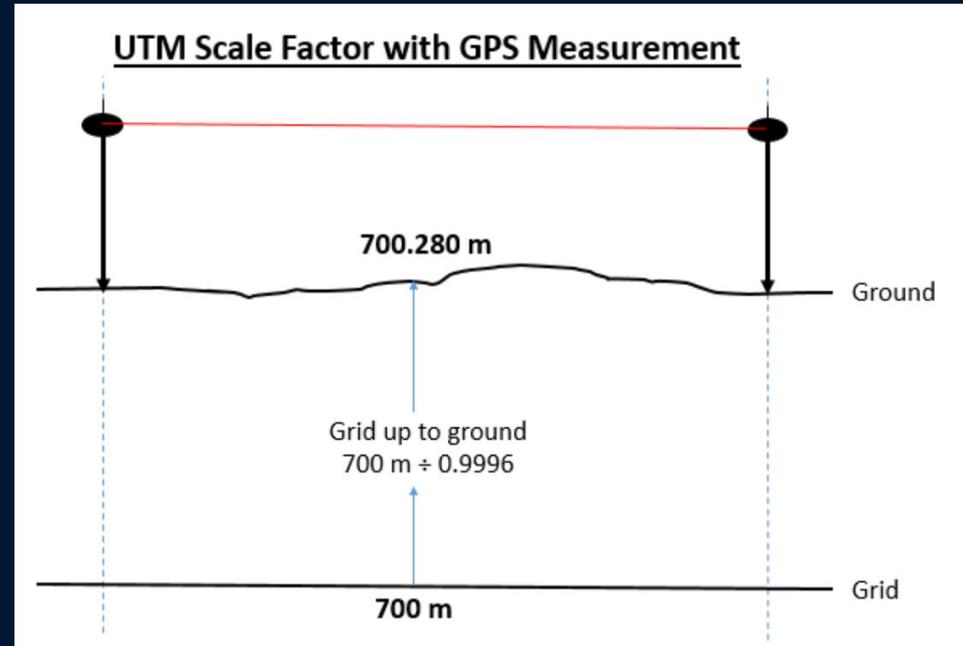


Where do I How much does scale factor effect survey measurements? the value of a scale factor?

If a measurement was taken between two points along the central meridian while using the Universal Transverse Mercator (UTM) projection, the scale factor would be 0.9996. If a ground distance of 700.280 m was measured with an Electronic Distance Measurement (EDM) device, it would correctly be shown as 700 m on the grid (700.28×0.9996).

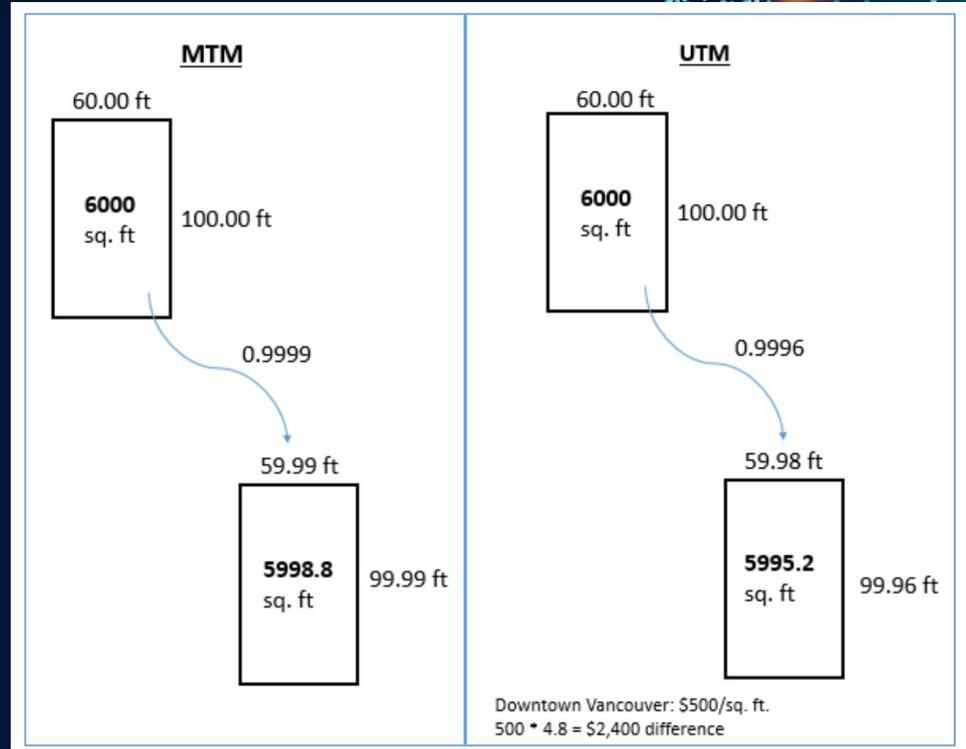


If a GNSS distance was measured between the same 2 points above, then its distance would likely display 700.000 m. This is because GNSS controllers generally display grid measurements (although some controllers can display ground distances). If a property owner was interested in using a tape to verify this measurement, he or she would measure 700.280 m on the ground ($700.000 \text{ m} \div 0.9996$). Survey plans should always indicate whether ground or grid distances are being displayed.



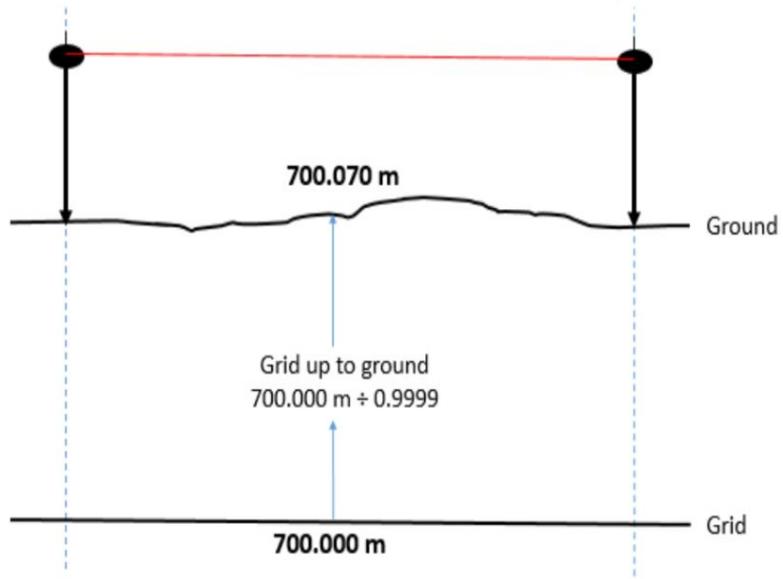


The effect of a scale factor is at times negligible, but the user should always verify. In extreme cases such as in urban areas where property value is high, the impact of neglecting to account for scale factors can have a significant financial impact on owners of property rights. The example below illustrates the impact of staking out a subdivision lot that was designed with grid coordinates and laid out using a total station without applying appropriate scale factors. It can be seen that the MTM Projection is more forgiving in such a situation.

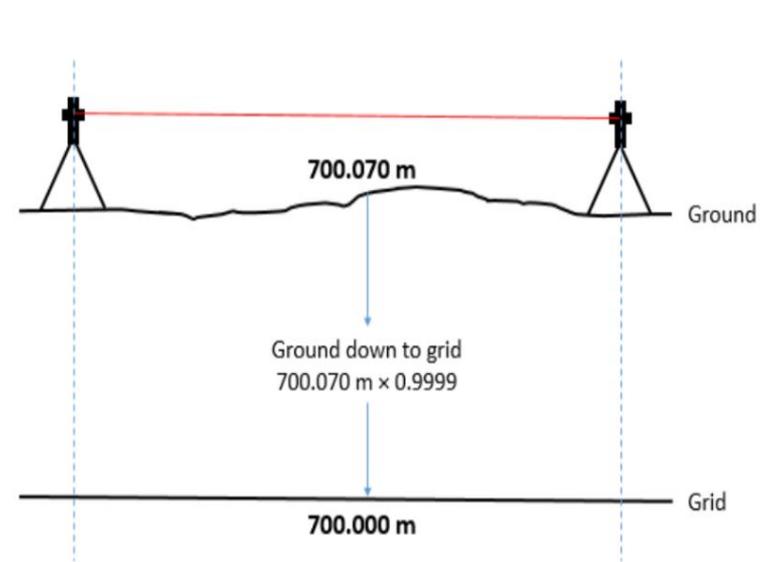




MTM Scale Factor with GPS Measurement



MTM Scale Factor with Conventional Measurement



Thank you for Your Participation

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