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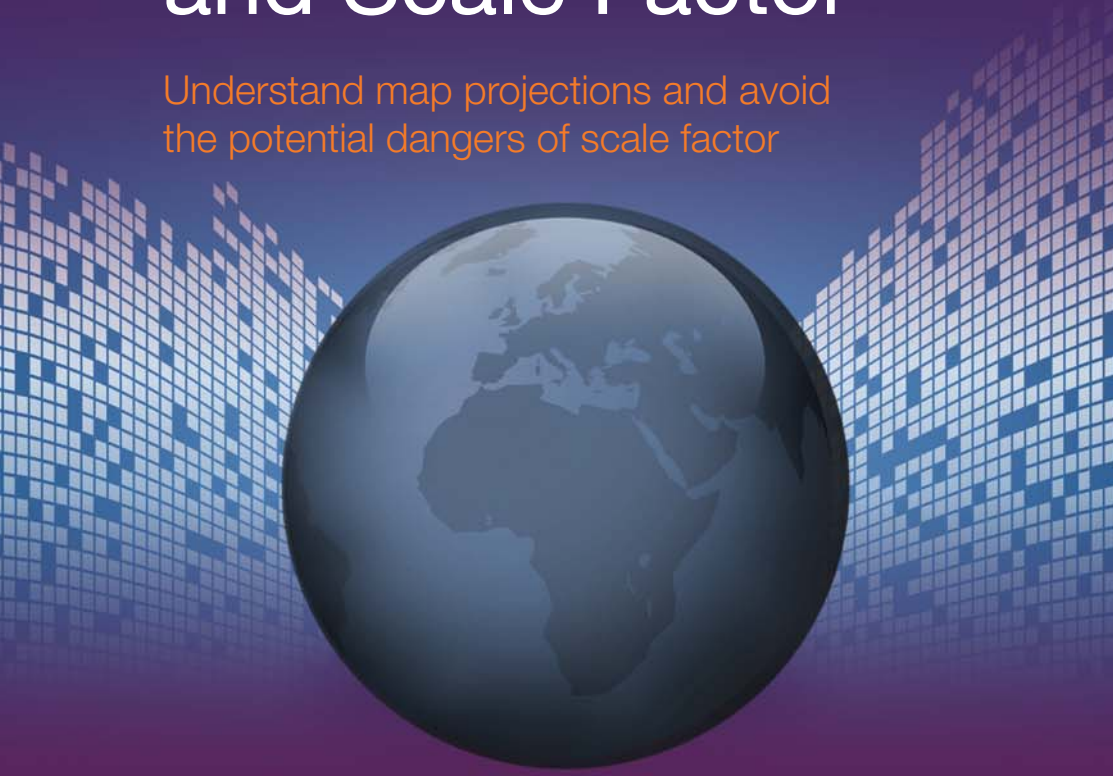
Geomatics Client Guides

Map Projections and Scale Factor

Understand map projections and avoid the potential dangers of scale factor



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Are you an architect, engineer, developer or builder?

If you use large-scale topographic survey information or mapping, it is essential to understand the effects that one particular function of map projections – scale factor – can have upon distances and dimensions.

Map projections are used throughout the world, so the principles discussed here are generally applicable worldwide. This client guide features an example from the Republic of Ireland, where the need for a wider community of users to understand the issue of scale factor distortion has become more critical in recent years.

Why is the distance that I measure on the ground not the same as the distance that I measure off my map?

The most likely cause is that the difference is due to the effect of the projection scale factor.

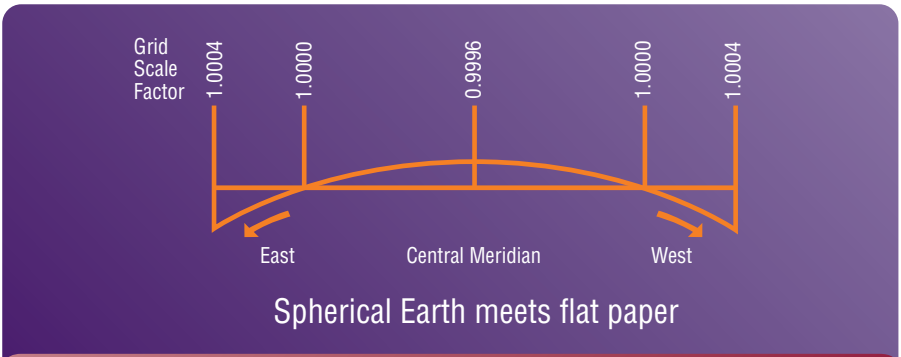

Diagram 1: This basic survey diagram shows the age-old problem of how to mathematically reconcile a spherical surface (Earth) with a flat sheet of paper (Map). This is the central dichotomy at the heart of scale-factor issues.

Map Projections and Scale Factor

Depicting a curved surface (such as the Earth) on a flat surface (such as on paper or in a digital representation of it), is a problem that surveyors solve using map projections. Map projections are not new and have been in common use for centuries. However, what is new is the increasingly widespread use of 'projected' survey information. This has come about for two key reasons:

Firstly, professionals are making increasing use of large-scale digital mapping data supplied by national mapping agencies. For example, in the Republic of Ireland, Ordnance Survey Ireland (www.osi.ie) provides geodata referenced to a map projection known as Irish Transverse Mercator (ITM). In most places, there will be a difference between a distance measured on the ground. This difference is known as scale-error or scale factor distortion. It is variable depending upon location in the country, and can affect measurements by an amount ranging between zero and 4cms every 100m.

Used less, but still supported by OSi, is the older map projection known as Irish Grid (IG) 1975. Irish Grid is subject to distortions which result in an inevitable loss of accuracy when converting between GPS-derived coordinates and IG. ITM, on the other hand, is 100% GPS-compatible so there is no loss of accuracy when converting between GPS-derived coordinates and ITM. Accordingly, ITM is the preferred option when choosing between IG and ITM. Note that all coordinate conversions should be carried-out using the GridInquest software available from the OSi website (www.osi.ie). Over time it is expected that most users will migrate to ITM. Currently Property Registration Authority Ireland and Ordnance Survey Ireland have all 26 counties fully migrated to ITM projection.

Secondly, until recently, it was very costly to produce maps in the Irish Grid – so almost all surveys for private clients were drawn on local 'flat earth' grids. Local grids are specifically designed to ensure that ground and map distances agree. This is common practice when the survey is for a small local area, and is used as the basis for design or setting-out.

Due to the increasing use of technology such as GPS, it has become easier and cheaper to provide surveys in the Irish Transverse Mercator Grid; and this is becoming more common.

If you don't understand the issue of scale-error and the role of the scale factor you could face some serious difficulties. This could result in expensive and time-consuming mistakes such as incorrect boundaries or construction in the wrong place!

For impartial expert advice contact a Chartered Geomatics Surveyor in your area by visiting: visiting http://www.scsi.ie/surveyors/surveyors_search

So why don't we continue surveying using local grids?

Design and construction drawings are usually based on a local grid system aligned to the orientation of new construction works; this eases design and construction.

However it is awkward to determine an accurate orientation to grid north, and if the survey control points (that are vital for setting-out new construction works) are destroyed it can be difficult and an inaccurate process to re-install them.

It's also more difficult to relate the survey to other features relevant to the site – for example: utilities, neighbouring buildings and infrastructure. This is increasingly important, as the integration of data from different sources using geographical information technology becomes commonplace.

If the site is large (more than a kilometre or so), scale differences across the site may start to become a problem on a 'flat earth' grid.

Can we design a site on the Irish Transverse Mercator Grid?

Yes we could. Also, if we did, there would be advantages as the site would be directly related to its neighbours and local infrastructure, and would be orientated accurately to (grid) north. It would also:

- occupy a unique co-ordinated position in the Republic of Ireland
- be easier to revise and update, and
- be easier to re-establish survey control points if they were destroyed.

However, it would be more awkward to use in practice. You would have to continually take into account potential scale factor distortions between design dimensions, setting out and final as-built surveys; thereby increasing the probability of error.

Can we have the best of both worlds?

We need to decide, what is the acceptable difference between distance measured on the ground and distance measured on the map?

Local ‘flat earth’ grids only work over a very small area. If your work area extends beyond a kilometre you can no longer use a localised flat earth grid. However, you could define your own local map projection with a small (negligible, but acceptable) scale factor. It is relatively easy to convert data between your local projection and the national grid.

If you are designing a long linear feature, it will usually have its own reference system – chainage (i.e. distance from a known starting point), along the feature and offset perpendicular to the feature. You could introduce a variable scale factor, so that chainage corresponds with what you measure on the ground. An even neater solution would be to use what is commonly known as ‘snake’ projection – this dynamically converts between chainage and grid co-ordinates on large, generally linear projects.

Whatever you do, make sure your local grid co-ordinates cannot be confused with national grid co-ordinates.

It’s important to get your grids right. If in doubt ask a Chartered Geomatic Surveyor. Ordnance Survey Ireland published several papers related to ITM and IG. They can be found at: http://www.osi.ie/Services/GPS-Services/Publications-Papers.aspx. Also RICS’ Geomatics World journal published more in-depth articles on datums, map projections and snake projections. More information can be found at: www.pvpubs.com/magazines.asp

This client guide is one of a series from the SCSI Geomatics Committee, the full series and professional guidance can be downloaded from: www.scsi.ie

For impartial expert advice contact a Chartered Geomatics Surveyor in your area by visiting http://www.scsi.ie/surveyors/surveyors_search

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Dating back to 1895, the Society of Chartered Surveyors Ireland is the independent professional body for Chartered Surveyors working and practicing in Ireland.

Working in **partnership with RICS**, the pre-eminent Chartered professional body for the **construction, land** and **property** sectors around the world, the Society and RICS act in the public interest: setting and maintaining the **highest standards of competence and integrity** among the profession; and providing **impartial, authoritative** advice on key issues for business, society and governments worldwide.

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Members of the profession are typically employed in the construction, land and property markets through private practice, in central and local government, in state agencies, in academic institutions, in business organisations and in non-governmental organisations.

Members' services are diverse and can include offering strategic advice on the economics, valuation, law, technology, finance and management in all aspects of the construction, land and property industry.

All aspects of the profession, from **education** through to **qualification** and the continuing **maintenance of the highest professional standards** are **regulated** and overseen through the partnership of the Society of Chartered Surveyors Ireland and RICS, in the public interest.

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