



Further information and useful addresses

The Survey Association

<http://www.tsa-uk.org.uk/>

Newcastle University

<http://www.ceg.ncl.ac.uk/geomatics>

Ordnance Survey

<http://www.ordnancesurvey.co.uk/oswebsite/gps/>

Leica Geosystems

<http://smartnet.leica-geosystems.co.uk/SpiderWeb/frmlIndex.aspx>

Trimble

<http://www.trimble.com/vrsnow.shtml>

RICS

<http://www.rics.org/>

Guidelines for the use of GPS in surveying and mapping, RICS Guidance Note (2003), ISBN 1-84219-093-8.

An examination of commercial network RTK services in Great Britain, Newcastle University (2008), Report for TSA, download at <http://www.tsa-uk.org.uk/>

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THE SURVEY
ASSOCIATION



Best Practice Guidance Notes for Network RTK Surveying in Great Britain



Introduction

This leaflet has been produced as part of a drive to provide surveyors, engineers and their clients with guidelines for the use of network RTK GPS in land and engineering surveys. It has been produced by a joint working group comprising: The Survey Association (TSA), Ordnance Survey, Newcastle University, Leica Geosystems, Trimble, and the Royal Institution of Chartered Surveyors (RICS).

The primary goal of this leaflet is to provide best practice guidance for those using the various commercial network RTK solutions available in Great Britain. Previous guidance notes such as the RICS Guidelines for the use of GPS in surveying and mapping (2003) have covered many aspects of GPS use. However, with the rapidly advancing technology in GPS surveying, not all current aspects are covered by these. This leaflet extends current guidance; however, many aspects of the RICS guidelines still apply.

Background

The guidelines presented in this leaflet have been established through a series of experiments undertaken at known points throughout England and Wales. A total of seven test locations were chosen to provide a range of representative situations that users of network RTK might face. Selection criteria included factors such as the distances and elevation differences to nearby Ordnance Survey OS Net base stations, the aspect (open or urban), proximity to edges of the network, and susceptibility to ocean tide loading effects (OTL). At each site approximately 6 hours of data were collected from each of the two current (2008) commercial providers of network RTK solutions using proprietary equipment and firmware configurations.

Improving solution robustness

- For topographic survey, the use of a 5 second single window average will reduce the effect of individual coordinate solution variations.
- For precise work where the height component is important e.g. control station establishment, the process of double window averaging should be undertaken. You should observe an averaged window of around 3 minutes followed by another averaged window of the same length separated from the first by at least 20 minutes.
- On average, a time separation of 20 minutes will yield a 10 - 20% improvement in coordinate accuracy and a 45 minute separation will yield improved accuracies at the 15 - 30% level compared to a single epoch solution. Window separations of greater than 45 minutes do not typically provide appreciable further improvement to the determined coordinates, except for the mitigation of ocean tide loading effects (see below).

Ocean tide loading

- Ocean tide loading (OTL) is the time-varying displacement of the Earth's surface due to the weight of the ocean tides, and can reach ± 60 mm in height and ± 20 mm in plan near the tip of the South-West Peninsula and Western Isles. In mainland Britain it decreases to slightly less than half of this magnitude east of a line roughly joining Southampton to Aberystwith. Instantaneous differences in OTL between a rover and base station can cause errors in the measured coordinates.
- Network RTK reduces OTL error to current system noise levels throughout most of mainland Britain. In areas where OTL remains a concern, its effect can be almost completely removed by taking the mean of two sets of coordinates collected with 6 - 6½ hour separation.
- To assess the potential OTL error in a locality on a given day, an upper bound Σ on the height error due to OTL can be estimated by

$$\Sigma = \sqrt{\frac{1}{2}H_1^2 + H_2^2 + \frac{1}{2}H_3^2 - H_1H_2 - H_2H_3}$$

where H_1 , H_2 , and H_3 are the height components determined from windows separated by 3 - 3¼ hours. If Σ is less than the survey tolerance, the above averaging procedure may be omitted.

Guidance

Important Note: Users should note the guidance set out in this leaflet is based in the main on GPS based network RTK solutions only. Testing of augmented solutions using e.g. GLONASS was limited due to current geographic coverage of combined (GPS and GLONASS) corrections.

General

Whilst this leaflet addresses best practice for network RTK surveying in Great Britain it does not address, but assumes the user adopts, general best practice for GPS RTK surveying. The use of local base station RTK remains a viable option for land and engineering surveying in Great Britain although its attendant overheads of cost, security and efficiency make it less attractive in many situations.

Accuracy

- Accuracy is a measure of the difference between a particular measured coordinate and its true value, often quoted as the root mean square error (rms). If the measurement is unbiased and has normally distributed errors, then for each coordinate component roughly 68% of individual solutions will have errors smaller than the rms, and 95% will have errors smaller than twice the rms. However, systematic errors (biases) will reduce these percentages.
- Typically, commercial network RTK solutions within Great Britain provide instantaneous results (i.e. single epoch coordinate solutions) that achieve rms accuracies around 10 - 20 mm in plan and 15 - 30 mm in height, with relatively small biases.

Surveying at the limits of the network

- Limited testing of network RTK performance at the network extents (e.g. some parts of the coastal zone) shows greater frequency of excursion from the expected system performance. To aid planning, Figure 2 shows the mean distance to the nearest four OS Net sites. If you frequently work in areas where this mean distance is large, or where you are outside the polygon formed by the nearest OS Net sites, you should consider making greater use of single window averaging (see page 6) for normal topographic survey and double window averaging for control station establishment.

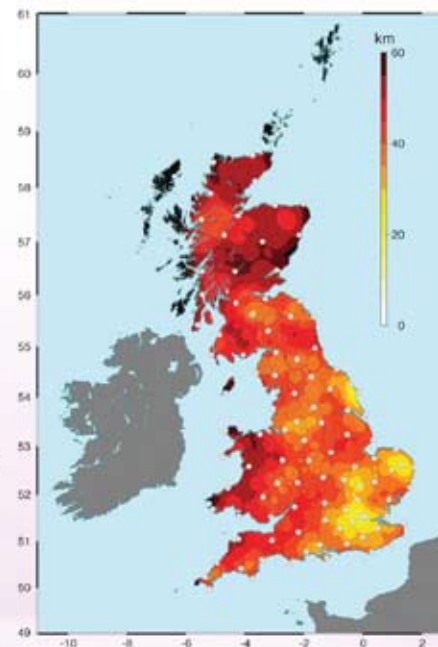


Figure 2 Mean distance from nearest four OS Net sites

Additional satellite constellations

- When surveying in challenging satellite visibility environments (e.g. urban canyons), the use of satellites from other global navigation constellations (e.g. GLONASS) can improve overall satellite visibility and hence allow surveying to proceed with less downtime, but may not necessarily lead to an improvement in accuracy.
- If satellite availability is significantly diminished (e.g. under a tree or close to an overhang), use standard terrestrial survey techniques to radiate from a nearby unobstructed point. Do not attempt to use network RTK.

Equipment configuration

- Always ensure your network RTK rover firmware and antenna settings are configured according to manufacturer guidelines. Significant variations from recommended settings may lead to unacceptable variations in determined coordinates.
- Geometric Dilution of Precision (GDOP) is a measure of the worsening of a GNSS (Global Navigation Satellite System) solution caused by the geometric arrangement of visible satellites. Often a maximum GDOP of 5 is imposed. Reducing the GDOP limit to 3 will increase the robustness of determined coordinates under challenging conditions (e.g. urban canyons) but does not reduce productivity in open/benign environments where GDOP values between 2 and 3 predominate. The imposition of such a filter on average provides the user with over 95% of possible coordinate solutions.

Quality indicators

- Always ensure your rover unit is set to display all available coordinate quality indicators for your position fix and pay close attention to them. In most situations these indicators reflect well the actual performance of your system.
- Coordinate solutions where the reported quality is worse than 100 mm generally result from problems with satellite lock or ambiguity resolution, and should always be discarded.
- In the most challenging environments (e.g. restricted satellite visibility, large distances or height differences to surrounding OS Net sites, or high multipath), reported coordinate quality may be over-optimistic by a factor of 3 – 5 especially in the height component. This can be mitigated as described on page 6.

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Height effects

- For the majority of England and Wales, the errors caused by tropospheric effects and height variations between OS Net sites and your network RTK rover position are generally well modelled by network RTK providers. However, where these height differences increase (e.g. Snowdonia, Lake District and Scottish Highlands), it is recommended that the procedures as for surveying at the limits of the network be adopted to reduce heighting error. To aid planning, height difference from the nearest four OS Net sites is shown in Figure 1. Note that it is possible to be significantly below the nearby OS Net sites.

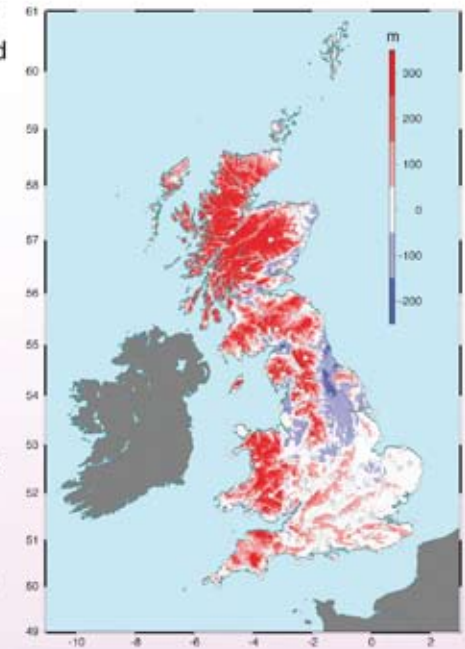


Figure 1 Mean height difference from nearest four OS Net sites

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