Section 8: Ordnance Survey – Current Issues

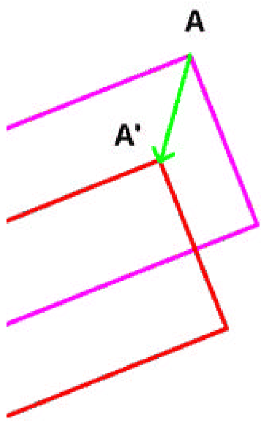
Introduction

This section looks at a few of the issues currently affecting Ordnance Survey which may be relevant to RoS and which are topical at the time of writing. By definition these issues will change over time.

The issues described below - Positional Accuracy Improvement (PAI), Land-Line Pre-Build data, and GPS are technical ones, rather than organisational, commercial, or political ones, and are chosen because they are all likely to be relevant for some time and all have significant impact for users of Ordnance Survey data.

1. Positional Accuracy Improvement[1]

From the very first section of this Reference Guide the problems resulting from the conversion of mapping from the 1:2500 County Series to National Grid has been a recurring subject. Until the late 1940s, the County Series maps of the UK existed on their own local Cassini projections. When these maps were reconciled to match the National Grid, relative accuracy was maintained, as far as possible, but the fairly crude way in which the overhaul took place meant that the absolute accuracy of the data was not very good. When using the mapping on a local basis, this has not been so much of a problem for users, but the increasingly widespread use of GPS positioning in surveying and navigation (along with the use of orthophotographs created from independently collected GPS points) has highlighted the inaccuracies.



Because of these newer surveying techniques, the absolute positional accuracy of map data with respect to a global reference system is more important than ever. This is not a situation unique to the UK, however. Many other countries, e.g. USA and Germany, are undergoing projection refinements, improvements and datum changes that will result in positional accuracy differences in their published data. With modern GIS applications increasingly making use of digital map data derived

[1] Excellent references for this section can be found at :
www.ordnancesurvey.co.uk/positional and
www.ginews.co.uk/0203_52.html

from national mapping organisations, and other digital data being more widely shared between a number of organisations, these positional differences have become a significant issue.

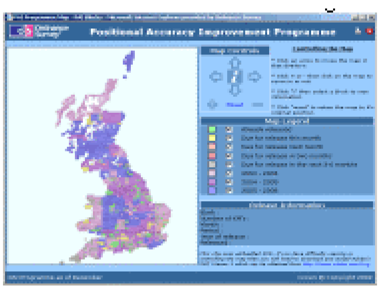
To address these problems Ordnance Survey started it's Positional Accuracy Improvement (PAI) programme in April 2001 with the aim of bringing all 1:2500 scale data within a uniform resurvey specification within five years.

The PAI programme deals with improving the absolute accuracy from current 1:2500 scale overhaul accuracies to either:

- 1:1250 scale resurvey standards; ±0.4m rmse - for the built up areas of defined rural towns, or
- 1:2500 scale resurvey standards; ±1.1m - for the remaining areas.

This programme entails the manual editing of detail on Ordnance Survey maps; in some cases blocks of detail are shifted and rotated by several metres. In consultation papers, Ordnance Survey undertook to liaise closely with customers throughout the programme and advised that the overall timescale of the programme would be tailored to the needs of major users. The PAI programme was split into two parts - Rural Towns and Other Rural Areas.

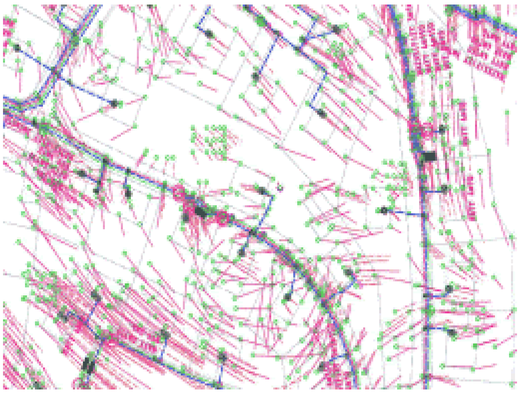
The Rural Towns programme covers some 2,300 x 1:2500 map tiles, while the Other Rural Areas account for some 155,000 x 1:2500 map tiles. PAI in these latter areas is being achieved by methods that involve resurveying or photogrammetric interpretation. The resulting data should have an absolute accuracy of ± 1.1 metres rmse. Priority has been placed on those areas requiring the most urgent rural revision update. The full programme is planned to be completed in five years, coinciding with the rural revision cycle that also began in April 2001.In recognition of the problem, Ordnance Survey has set up a number of support actions to help users understand and overcome the problems associated with PAI including:



- A specific section in the OS Website
- Link files (general description of shift—vector field)
- Development of case-studies / best practise
- Data audit matrix and planning guidance
- Step by step guide
- Development of options toolbox (methodology)
- Seminars (e.g. AGI)
- Business case arguments

- Researching international experience

To help users process their own data to fit the PAI data, Ordnance Survey has published a “link file” for each PAI map sheet. The link file is a set of control points that indicate the position of certain features before and after the PAI. The first set of PAI data (with corresponding link files) was introduced into the National Topographic Database (NTD) in November 2001. However, this initial release caused some concern among the user community. Many discovered the scale of the problem facing them and potential problems in the quality and density of the link files provided. Following consultation with customers, Ordnance Survey decided to postpone the data banking of PAI data until further analysis. Ordnance Survey has now revised the specification for link files to include significantly more points per tile (especially in rural areas) and fewer 'rogue' links. The first set of improved data was released in September 2002, and a new programme timetable for the next few months has been announced.



Judging by the link file data released so far, the accuracy variations caused by the overhaul of the County Series mapping to the National Grid are not systematic - no large areas of constant shift can be identified. The situation is complex, with several revisions having taken place on each map sheet, some selected revision by local survey (perhaps using RTK) and some by complete map overhaul.

Systematic shifts may be apparent in suburban areas where development has been surveyed using local control, but it does not seem feasible to identify and model these in any practical way. Therefore, it is highly likely that most users will have to use complex local transformations to adjust their data to match PAI data satisfactorily.

Given the positional accuracy problem with Ordnance Survey 1:2,500 data (Land-Line or OS MasterMap), users need to examine what effect the PAI programme has on their data, how serious the problems are and what options are available to help resolve them. There is a range of possible solutions available to those affected by the Ordnance Survey PAI programme, with different costs and other implications. In organisations managing a number of datasets, no one option may be suitable for all their different data. Options include:

- Do nothing – the cheapest option, but unsuitable for many large-scale map users unless absolute accuracy and good map representation is unimportant, or where all data has been fixed by absolute methods only. A variation of this solution is to 'do nothing for a while' and wait until the PAI programme is finished, at least in a certain area. However, this may mean freezing the background base mapping for five years or more, and not introducing any customer data captured by absolute means. Most businesses need to update their base map data much more regularly, and many businesses are using GPS and ground survey more and more, so this may also be an option for only a small number of users.
- Re-capture or edit users' data manually – an expensive option, especially for organisations with large volumes of data that have been captured over many years. Despite the cost and time needed to re-digitise or edit large volumes of data, this may be the best way to guarantee the highest possible quality result. Indeed, it may provide a valuable opportunity to re-evaluate the accuracy, attribution, content and metadata of existing digital data, and to use the PAI programme as an opportunity to re-engineer or enhance information. It may be impractical however, or difficult to justify the cost.
- Use link files to perform an automated transformation - the link files supplied by Ordnance Survey could provide the basis for a mathematical transformation of users' data to match the PAI large-scale Ordnance Survey data. However, whatever specific transformation algorithm is used, the quality of the result is directly related to the quality of the input points (the link file data).
- A mixture of the above - a common solution to the issues raised by the PAI programme may be to transform users' data automatically using the link files and then to post-process the data to resolve any residual problems. Although some software packages offer the ability to snap users' data automatically to Ordnance Survey PAI data after it has been transformed, any completely automated solution is unlikely to be entirely successful. Some manual intervention and quality control will probably still be needed.

How will this affect RoS?

PAI is a huge, and potentially very expensive, issue for Ordnance Survey and all current users of 1:2500 Ordnance Survey data. The PAI programme, coinciding with the release of a major rural revision and the release of OS MasterMap, is undoubtedly necessary to improve the quality of Ordnance Survey data, but to deal with it users will have to develop strategies that best suit their data and businesses. In Scotland, Ordnance Survey will deliver

- 36 rural towns to an absolute accuracy of ±0.4m rmse affecting 360 map tiles containing some 40,000 registrations;

- all other 1:2500 rural areas including villages to an overall absolute accuracy of ±1.1m rmse affecting approximately 36,500 map tiles and 160,000 registrations.

During and following the PAI programme, data provided to RoS by Ordnance Survey will be as a result of one of three changes, either:

- Positional Accuracy changes, e.g. shift of existing features owing to PAI;
- Real World update changes, e.g. a new house/boundary since the last survey;
- Surveyed changes, those that are made because of original survey error - changes/errors in OS spec i.e. building juts/internal divisions should have been shown.

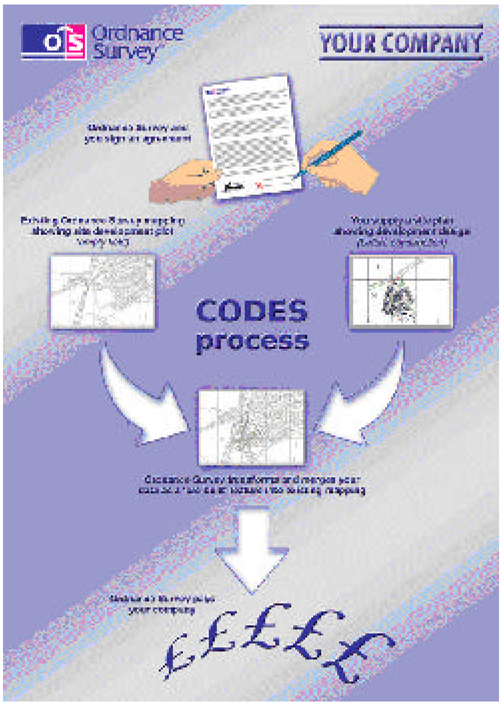
On receipt of this new data RoS will compare the information against the existing Index Map of Registered Titles and complete any necessary remedial work to match the new re-surveyed data. This work will be given a high level of priority in the Agency, as an up to date mapbase is essential for the provision of accurate information from the register. The diverse nature of the newly supplied data makes the update process more difficult and time consuming for our staff.

The Agency is currently (Spring 2004) about to start work in the Counties of East Lothian and Berwick with further releases of data in the counties of Aberdeen and Kincardine to follow.

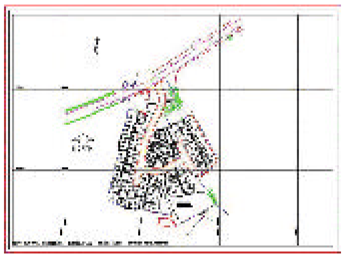
It is widely understood that the Ordnance Survey PAI programme for rural areas will significantly shift boundary, building and other features to more accurate positions and it is anticipated that there will be a severe impact on the Mapbase Maintenance Section.

In many cases the shift will be significant, such that the polygon for a property may now straddle or completely overlay the geometry for another property. This is where the responsibility of compare/remedial work of such new data falls within the remit of Mapbase Maintenance section to complete prior to releasing to Production. A significant investment in staff resource will be required to undertake and resolve mapping discrepancies from the 36 towns affected by PAI. This does not take into account the rural areas - although it is not anticipated that these tiles will incur much considerative work and would be treated similarly to other tiles received through the Maintenance Contract.

2. CODES and Land Line pre-build



CODES (Collection Of Data from External Sources) is the process by which Ordnance Survey uses data collected by builders and developers to add to the National Topographic Database – typically from the builder's plans in advance of the building taking place. For data from these site plans Ordnance Survey pays £8 for a design of a new house or ground floor flat (minimum supply five units) or £75 per hectare for industrial, commercial or government sites, plus money for major roads and rail designs. The data then becomes available to users as Land-Line® Pre-Build data. Pre-Build data is therefore derived from plans of sites under development that are supplied to Ordnance Survey by external sources such as architects and construction engineers.



The finalised plans must have been approved by the local authority planning office, so that when they are received by Ordnance Survey confidence is high that the data represents what the developers will actually build, usually within the following three months. On receipt, the data is edited, transformed to National Grid position and brought in line with Land-Line specification.

Pre-Build data is available in the usual Ordnance Survey basic scales of mapping according to location, i.e 1:1250 (urban); 1:2500 (rural); and 1:10 000 (mountains and moorland).

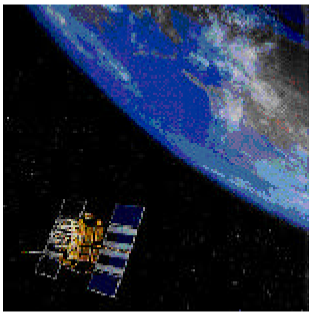
The contribution of this type of data capture is growing steadily. Ordnance Survey estimate that approximately 67,000 house units – which is around 15% of changed detail is now captured this way annually, including over 60% of the new houses built and bought in GB each year. Pre-Build data has been specifically designed to be used in conjunction with existing Land-Line data but in the near future Ordnance Survey intend it to become an integral part of OS MasterMap™.

In its information to customers Ordnance Survey is keen to point out that Pre-Build data is NOT derived from surveys carried out by Ordnance Survey.

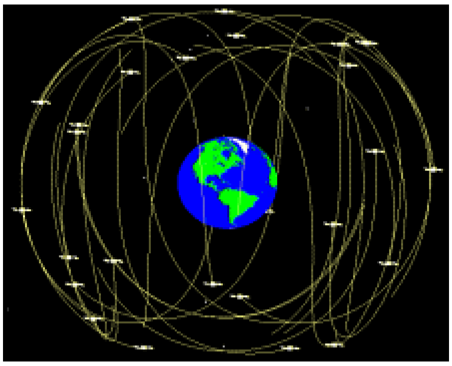
"The data originates from external sources and is unverified. The representation of detail in the data is no guarantee that it will come into existence, in part or in whole, or in the exact position indicated in the plan. Pre-Build data is not a national dataset and so the data available will vary from site to site, according to the agreements in existence between Ordnance Survey and the data providers."[2]

3. GPS

To begin this section it might be a good idea to make a general introduction to GPS and then to recap on past and present GB co-ordinate systems. Then the discussion will broaden out into the current developments underway at Ordnance Survey. The subject can become very complex and, as with any specialist subject, is full of jargon. This section will try to describe the issues in a "non-specialist" manner, but more detailed information and explanations can be found on the references that are given.



What is GPS?



GPS (Global Positioning System) is a satellite-based positioning and navigation system owned and operated by US Department of Defense. Access is free for all users and the service is available 24 hours a day, 365 days a year. It is an all weather system that works anywhere in the world. There are other satellite based navigation systems – the Russian GLONASS is already in operation, and the new EU version is called Galileo.

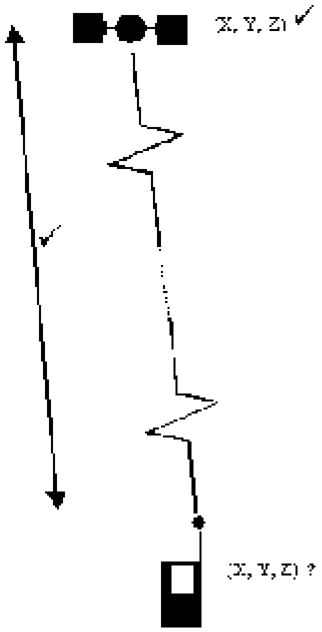
The GLONASS system has operated for some years now, and is still being developed. Galileo is still in the start-up phase and will not be available to users until 2008.

GPS can give an instantaneous, real-time position to within approximately 10m using a single handheld receiver. This type of receiver is becoming used commonly for many leisure activities (e.g. sailing, walking) but higher accuracies are leading to

[2] http://www.ordnancesurvey.co.uk/oswebsite/products/prebuild/

more and more business and commercial uses, including for example surveying and in-car navigation.

How does GPS work? – The x, y, z position of each of the 20+ satellites is known, and this information is transmitted by all the satellites. If enough satellites are measured to (in GPS jargon – the *range* is calculated), a position for the receiver can be computed. Each satellite contains a very accurate clock (actually four very accurate atomic clocks) and the clock is used to generate a unique coded signal for each satellite.
The receiver on the ground generates the same coded signal at the same time and compares the received code with the one being generated.
The time difference between the two codes gives the time of signal travel between the satellite and receiver and:



range to satellite (D) = signal travel time (dt) x speed of light

A range measured in this way is often called a p*seudorange* - pseudo because not all the errors in the measurement are taken into account and therefore the range measured is not the true one.

Positional accuracy with a single receiver, to civilian users, approximately equals 5m to 10m, 95% of the time, and the height accuracy is generally 15m to 20m 95% of the time. Until May 2000, the accuracy was a lot worse (100m, 95%) before the US DoD turned off Selective Availability (SA). SA was the deliberate degradation of the GPS signal to limit its real-time accuracy to civilian users. The US DoD now have other ways of doing this if necessary (for example, in time of conflict). Military users have access to a more accurate coded signal from the satellites and the accuracy of this can only be guessed.

The positional accuracy is affected by GPS satellite orbit errors, the atmosphere and receiver clock errors. The real-time positional accuracy of a single receiver can be greatly improved by using a technique known as **differential GPS** (DGPS). DGPS involves the computation of corrections to the GPS signals. The corrections counteract the effect of the remaining errors in the GPS position (orbit and atmosphere). The corrections are combined with GPS signals at the receiver to improve the computed position. The corrections are computed using another GPS receiver at a known co-ordinated point. The receiver at the known point compares it's computed and known positions and uses the differences to compute the corrections to the GPS signal. The corrections are then transmitted to other receivers in the area.

Surveying with GPS

GPS can be used as a surveying tool as well as a positioning tool. When surveying with GPS, rather than the absolute positions of the points being measured, a baseline (three-dimensional distance) between two points is computed instead. The answer is generally not instantaneous however. GPS data has to be simultaneously collected at both points and used later in computations to determine the baseline. This is generally known as **Static GPS**.

Some systems compute the baseline in real time to give an almost instantaneous answer. This technique is generally known as **RTK (Real-Time Kinematic) GPS**. The measurement of the baseline between the two points can be very accurate (cm level and better). This relative positioning of points with respect to each other is much more accurate than instant absolute positioning using one receiver – i.e at least two receivers are required.

To get accurate absolute positions one receiver has to be on a known point. The Ordnance Survey active GPS Network provides a network of GPS receivers on known points that can be used for surveying with GPS. Centimetre accuracy is possible with small amounts of data, standard equipment and software.

What are the GB national coordinate systems?

Many coordinate reference systems (datums) are used by geodesists, surveyors and engineers for many different purposes. As the government agency responsible for national standards in spatial positioning in Great Britain, Ordnance Survey maintains three national coordinate systems, for which it undertakes to provide national positioning infrastructure available to everybody in Great Britain. The national coordinate systems are:

ETRS89 (European Terrestrial Reference System 1989)	This is the national coordinate system for 3D GPS positioning. It is a much more exacting definition of the GPS coordinate system than the better known WGS84 standard. Consequently, ETRS89 coordinates are also WGS84 coordinates, but users should be aware that general WGS84 coordinates do not necessarily meet the ETRS89 standard. ETRS89 is the GPS coordinate system standard used for high-quality GPS surveys throughout Europe.
OSGB36 National Grid (Ordnance Survey Great Britain 1936)	This is the national coordinate system for topographic mapping. It is used for Ordnance Survey mapping at all scales, and for many private topographic surveys. The OSGB36 part of the name refers to the geodetic datum (system of latitude and longitude) used, and the National Grid part refers to the map projection and grid referencing convention for eastings and northings.
ODN (Ordnance Datum Newlyn)	This is the national coordinate system for heights above mean sea level (orthometric heights). It was originally based on tide gauge readings at Newlyn, Cornwall. ODN is the usual definition of height above mean sea level in mainland Britain and some islands.

Additional technical information on the national coordinate systems is available from the Ordnance Survey web site[3].

Ordnance Survey has fully adopted GPS positioning as the basis of all three national coordinate systems listed above. OSGB36 National Grid is no longer realised by triangulation stations but by the ETRS89 positions of the National GPS Network stations in conjunction with the definitive transformation model OSTN02. This sounds complicated but in essence it means that many of the old triangulation points, and a number of new control stations, have been fixed within a new framework, which has been defined in both ETRS89 and National Grid co-ordinates. Likewise orthometric heights (defined by ODN on mainland UK) will not be realised by levelled bench marks but by GPS positioning in conjunction with the Geoid model OSGM02. All surveyors who want to take advantage of the new infrastructure will therefore need access to survey-grade GPS equipment. There are three major components of the new GPS-based national positioning infrastructure:

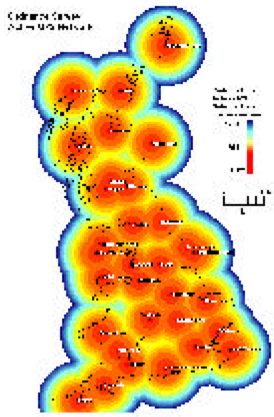
[3] http://www.gps.gov.uk/guidecontents.asp

The National GPS Network	The original OS GPS network dates from 1992. Since then, the National GPS Network has been radically upgraded with about 30 active reference stations and about 900 passive reference stations (these phrases are explained below). Using this reference network, precise ETRS89 positions are obtained from user's GPS equipment.
National Grid Transformation OSTN02	The definitive transformation between ETRS89 and OSGB36 National Grid. The National GPS Network in conjunction with OSTN02 provide the standard method of obtaining locally consistent National Grid coordinates for GPS surveyors. Occupying triangulation stations with GPS is no longer necessary.
National Geoid Model OSGM02	The national standard precise geoid model, converting precise ETRS89 ellipsoid heights to heights above mean sea level (ODN orthometric heights for the mainland UK). With high accuracy GPS positioning using the National GPS Network, surveyors can use OSGM02 to install their own bench marks relative to the MSL datum without levelling to Ordnance Survey bench marks.

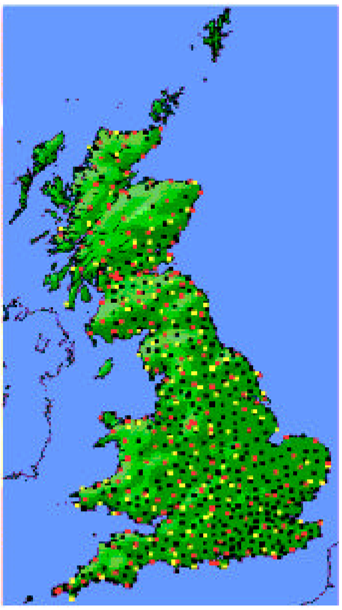
What are active and passive GPS reference stations ?

During 1999 and early 2000, Ordnance Survey established a national network of permanently installed, continuously observing, automatically communicating GPS stations in all parts of Great Britain - the **active stations** of the National GPS Network. The completed network includes 30 active stations, of which about two-thirds are owned by OS, and the remainder operated by other government agencies working in partnership with OS. The active stations are deployed such that any point in Great Britain, including all the islands, will be within 100 km of the nearest active station. The active stations all use dual-frequency geodetic quality receivers, mostly with "choke-ring" antennae. They communicate automatically via ISDN lines with a control centre at OSHQ in Southampton. A central computer is used to download data from each station every hour and monitor the health of the system. Daily precise ETRS89 coordinates of all active stations are computed weekly by Ordnance Survey and used to monitor the positional stability and data quality of each station.

The advantages of using the National GPS Network active stations are that users need as a minimum only one dual-frequency GPS receiver, and they don't have to leave their survey site to obtain ETRS89 coordinates for the stations. With ETRS89 coordinates of the primary stations determined in this way, users can then use RTK GPS survey methods to determine ETRS89 coordinates of a large number of points relative to the primary stations. These points might be lower-order control, setting-out points, detail survey points, utility assets, vehicle trajectories, hydrographic shot points, and so on.



National GPS network **passive stations** are publicly accessible geodetic quality survey marks which have been precisely coordinated in ETRS89 by Ordnance Survey. Each passive station is repositioned by Ordnance Survey at least every five years, to ensure the coordinates available are up to date. There are currently about 900 passive stations, covering Great Britain such that most places are within 20-30 km of a passive station (more in the Highlands and Islands of Scotland).



This map shows the locations of about 900 passive GPS stations in Great Britain which were available from 2000 onwards. The red dots are passive stations which are co-located with OS fundamental bench marks, and the yellow dots are passive stations which are co-located with OS triangulation monuments. The black dots are purpose-made GPS monuments. Some passive stations are re-used triangulation pillars or fundamental benchmarks; others are purpose-built GPS marks such as buried concrete blocks or "Berntsen" markers. All these types of passive station have GPS coordinates of the same high quality, and are equally good for the purpose of controlling GPS surveys in the ETRS89 coordinate system.

The ETRS89 coordinates and full information on all passive stations is available on the OS National GPS Network web site.

To use National GPS Network passive stations, one or more of these stations is occupied by survey-grade receivers while another receiver occupies a primary survey station.
The data recorded is post-processed using GPS software and the station coordinates supplied by Ordnance Survey, producing ETRS89 coordinates of the user's primary survey station. It is also possible to use passive stations as reference stations for real-time GPS surveys, if their location is appropriate for the survey.

The advantage of Ordnance Survey passive GPS stations is their high density in many parts of the country, meaning that in many cases users will be surveying within 20 km of more than one passive station. This allows users to keep observation times to a minimum and obtain good results even with basic analysis software. It is also possible to use less expensive single-frequency GPS receivers to obtain ETRS89 coordinates from National GPS Network passive stations.

GPS in Ordnance Survey

To begin with, Ordnance Survey used GPS to update rural maps (1:2500 and some 1:10,000). With the removal of the selective availability, improvements in technology, and the development of differential GPS, Ordnance Survey began a project in 2000 called GPSi which is still ongoing, and which is developing GPS as a tool for data capture for all Ordnance Survey large scales.

The pilot project, ran from Nov 2000 to Jul 2001 evaluating the overall operational efficiencies that could be obtained, developing standard operational methodologies, assessing health and safety issues, and establishing a plan for a more widespread implementation project. This implementation project rolled out from Jan 2002 to Feb 2003 and involved an investment of over £3.5Mill.

Some other statistics:

- 68 Ordnance Survey survey offices are now using GPS;
- 250 staff are trained to capture data using GPS;
- new equipment purchased as part of the project has included 278 Leica 530 GPS recievers, 62 Leica TPS total stations and 300 Leica DISTO Pro distance measurers;
- there has been a 43% increase in productivity;
- there has been a 26% improvement in currency.

GPS is typically used by surveyors with a combination of two receivers; one is set up as a base receiver providing the DGPS corrections for the other "roving" receiver. The roll out of a Wide-Area RTK network Infrastructure in 2004 will mean that the 30 or so active GPS stations will be increased to over 130 and it will be possible to use single receivers, in conjunction with the fixed permanent stations, to provide real time detail data capture.

Key Points from this section:

- The PAI programme, coinciding with the release of a major Rural Revision and the release of OS MasterMap, is an important and difficult issue for Ordnance Survey and its customers, including RoS. The programme tackles a problems built up over decades and is undoubtedly necessary to improve the quality of Ordnance Survey data. Users will have to develop strategies that best suit their data and businesses, but it will be disruptive and costly for many;
- Ordnance Survey is sensitive to the problems caused by PAI and has put considerable resources into helping customers;
- CODES is a means by which Ordnance Survey gathers an increasingly large percentage of newly built features – including over 60% of new built houses. The data provides the Land-Line Pre-Build data but will eventually be incorporated as a layer of OS MAsterMap;
- GPS has become an indispensable tool for Ordnance Survey. It provides a consistently accurate data capture method which has provided 43% productivity gains. Densification of the Wide-Area RTK GPS network Infrastructure in 2004 will mean that single receiver data capture will be possible in all parts of Great Britain.

References:

www.ordnancesurvey.co.uk/positional
www.ordnancesurvey.co.uk/mastermap
www.apic-eads.com/shrft
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