Commercial exploitation of Great Britain's permanent GNSS network infrastructure

Authors: *Neil Ackroyd, Paul Cruddace, Tom Satterthwaite*
Ordnance Survey, Survey, Romsey Road, SOUTHAMPTON, SO16 4GU.

Biographies:

Neil Ackroyd is the Executive Director responsible for Data Collection and Management at Ordnance Survey. He has board level responsibility for the capture and maintenance of the data supporting the National Geospatial Database. Before joining Ordnance Survey, Neil worked for Racal Survey Ltd and then within the senior management team at Trimble® Navigation (Europe) Ltd. Neil holds a BA in Geography, is a Fellow of the Royal Institution of Chartered Surveyors (RICS®), is a member of the British National Space Centre Technical Advisory Board and is on the departmental advisory boards of a number of universities.

Paul Cruddace is Geodetic Adviser and OS Net® product manager at Ordnance Survey, where he has worked for eight years. Before Ordnance Survey, Paul was a product manager at Ashtech Europe Ltd and then a Research Fellow at University College London®. Paul holds a BSc in Surveying Science and a PhD in the use of GPS and geophysics for the study of the earthquake cycle in Greece. Paul is a Member of RICS and is on the RICS Geomatics Faculty Board, Fellow of the Royal Society for the encouragement of Arts, Manufactures & Commerce (RSA) and an Associate Fellow of the Royal Institute of Navigation (RIN).

Tom Satterthwaite is Senior Product Manager at Ordnance Survey with responsibility for OS Net, OS MasterMap Integrated Transport Network™ Layer and Points of Interest. He has a background in commercial product management and marketing communications gained in companies including Sharp Electronics™ (UK) Ltd and Pace® Micro Technology. Tom joined Ordnance Survey in 2004, holds a Professional Post Graduate Diploma in Marketing from the Chartered Institute of Marketing and is an Associate Fellow of the RIN.

Abstract:

Ordnance Survey benefits Great Britain as both the national mapping agency and a self-funding government department, which aims to satisfy the national interest and customer need for accurate and readily available geospatial information and mapping. Ordnance Survey collects, maintains, manages and distributes the definitive record of the features of the natural, built and planned environment, the definitive record of official boundaries and the record of such other national geographic datasets as required by government and the private sector. Both Ordnance Survey and our partners produce and market a wide range of geographic information (GI), digital map data and paper maps for business, leisure, educational and administrative use.

Central to Ordnance Survey, and the wider GI community, is the establishment and development of the core underpinning geodetic framework and associated positioning services. It is crucial that this framework is accurate, appropriate and accessible and defines the national standard. The geodetic framework is intrinsically linked to the increasing prominence of positioning, especially through Global Navigation Satellite Systems (GNSS) and in particular our permanent GNSS network infrastructure for Great Britain (OS Net). The two primary geodetic objectives of Ordnance Survey are:

- to define, maintain and provide access to Great Britain's spatial reference system to meet national and international requirements; and

- to be a leader of world class standing in the development of positioning services and specifications and the provision of associated advice.

As the national mapping agency, Ordnance Survey provides coordinate reference frameworks for all geospatial data in Great Britain. Referencing to a single reference framework (OSGB36®) supports interoperability and also reflects the principles of the Digital National Framework (DNF), which describes methodologies for integrating and sharing geographic information from multiple sources. In support, OS Net provides the national underpinning infrastructure for GNSS positioning.

The OS Net service is now commercially established and Ordnance Survey is interested to extend the use of the service into new applications and market sectors. We expect to work with key partners to establish these new markets including a range of positioning and GNSS monitoring applications.

Ordnance Survey's role will remain in the maintenance and development of a highly accurate, resilient and available network. During 2008−09 we will upgrade our base-station network with new receivers and antennas that are not only capable of receiving GPS and GLONASS signals, but that will also be capable of receiving Galileo signals when that constellation becomes available.

The paper will provide delegates with details of the improved infrastructure supporting our geodetic frameworks and OS Net. It will also provide information on our commercial model, our near future plans for further commercial exploitation in the context of Ordnance Survey's role as national mapping agency and provider of key geospatial infrastructure.

Keywords: GPS, GNSS, OS Net

Introduction:

Ordnance Survey is Great Britain's national mapping agency, providing the most accurate and up-to-date geographic data, relied on by government, business and individuals. An enabling cornerstone is the definitive three-dimensional satellite-based geodetic reference framework for Great Britain that both underpins the national datasets and facilitates the integration and analysis of location-based information from many sources. Part of the job of OS Net is to define the reference frame and to provide access to it.

This paper describes the wide user community for the data and services from OS Net. The community for this resource is however still small and it is this further exploitation that Ordnance Survey looks to develop.

The development of geodesy and positioning within Ordnance Survey is laid out in its four year strategy (http://www.ordnancesurvey.co.uk/oswebsite/gps/docs/geodesy_and_positioning.pdf).

Overview of OS Net

Since 2003, Ordnance Survey has been developing a network of permanent Global Navigation Satellite System (GNSS) receiver base stations across Great Britain – OS Net. The network currently (October 2008) consists of 106 geodetic quality base stations, 102 of which are GPS only and four track both GPS and GLONASS satellites (a full description of the technology behind OS Net is given in Cruddace et al 2005). Base stations are located with a wide variety of site owners, from the RNLI® to the Met Office and from various utility providers to a mountain rescue station. The network (figure 1) has an inter-station density of 50 km–80 km and the raw data received is sent in real-time through a dedicated managed communications network to Ordnance Survey's head office in Southampton. The raw data is then distributed to the internal and external OS Net stakeholder community.

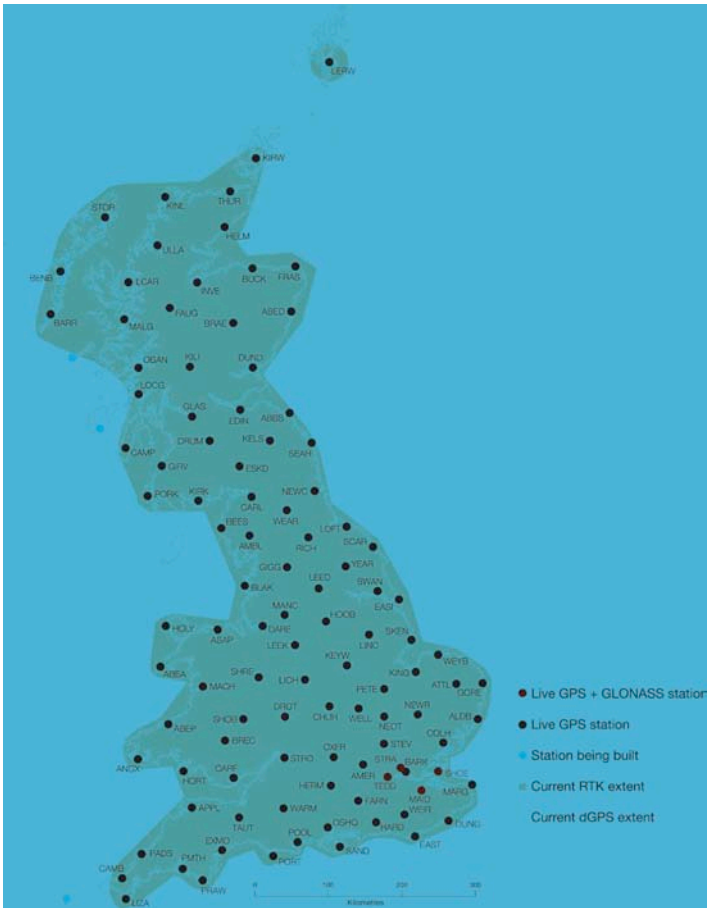

Figure 1: The OS Net base station network

OS Net applications

OS Net is a facility that was set up as an enabler for a number of different user communities. Its main purpose is to provide:

1. A stable reference frame, based on ETRS89, for Great Britain. Prior to 2002, the mapping coordinate system of Great Britain was still defined by the National Grid® coordinates of more than 2 000 triangulation stations. The locations of the OS Net stations now define the national geodetic coordinate reference frame. The coordinates of the stations are monitored daily to ensure stability and are precisely tied in to both European and Global geocentric coordinate systems. The definition of ETRS89 was officially recognised in 2002 by EUREF – the IAG Reference Frame Sub-Commission for Europe. Ordnance Survey is an active member of EUREF and contributes OS Net data to the community for projects and studies.

2. Ordnance Survey has a field survey workforce of 270, 150 of which use Real-Time Kinematic (RTK) GPS positioning. Ordnance Survey runs its own GNSS software that delivers Networked RTK corrections, derived from the OS Net data stream, via mobile phone to the surveyors. This yields faster and more flexible geographic information data capture and end user positions at the few centimetre level – enabling over 45% more efficient data capture. Ordnance Survey also operates two aircraft, where OS Net is used to help position the planes in the air.

3. Raw OS Net GNSS data, at no charge, in the Receiver Independent Exchange Format (RINEX), is available for post process applications from www.ordnancesurvey.co.uk/OSNet. This service provides an access mechanism for all who want to link to the national coordinate reference frame, helping to ensure data compatibility.

4. A data resource to the scientific community, the Met Office and academia.

   All historical GPS data from OS Net, plus data from at least ten other organisations, can be accessed via the British Isles GPS archive Facility (BIGF) (www.bigf.ac.uk). BIGF is funded by the Natural Environment Research Council (NERC) and the data is used for a huge variety of products, including; atmospheric water vapour studies, long-term regional vertical land movement, weather prediction and Wildlife tracking .

   OS Net has also either been used or will be used in the future, for:

   - Department for Trade and Industry funded VISTA project: investigating the use of global navigation satellite technology linked to existing asset records to produce 3-D images of utilities' underground assets;
   - Technology Strategy Board funded ViewNet project: ViewNet will develop the next generation of distributed localisation and user-assisted mapping systems, based on the fusion of multiple positioning and communication technologies; and
   - Technology Strategy Board funded GAARDIAN project: GAARDIAN will commence in late 2008 and will create a web enabled data gathering system which can be used in the vicinity of mission or safety critical activities to certify the integrity, accuracy and reliability of Positioning, Navigation and Timing (PNT) systems.

Case study 1 – The UK Met Office

Ordnance Survey and the Met office has a close tie-up through OS Net. The Met Office provides access to, and use of, a number of key locations around the country for OS Net receiver station sites. In return the Met Office gets access to the OS Net data stream.

After a number of years of testing, in May 2007 the UK Met Office included GPS data from the OS Net network into its live forecasting system. The GPS signal is sensitive to water vapour, where the delay in the signal is proportional to the water vapour present (a case where one community's error source is another's measurement!)

The Met Office takes data in near real-time from 250 GPS base stations around Europe, including the 106 OS Net receivers. The assimilation of GPS delay parameters into numerical models shows improvements in humidity fields, cloud cover and surface temperatures and is starting to play a part in longer term climate modelling due to its' high level of stability. Biases in other meteorological instruments can also be identified by using long term GPS derived water vapour measurements.

GPS data is now providing a rich data source of new information invaluable to weather prediction.

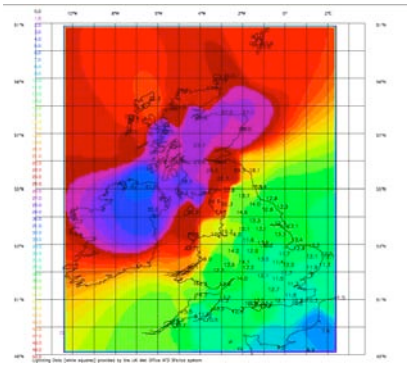

Image: GPS derived integrated water vapour map: www.knmi.nl/samenw/egvap/products/uk.html

5. A data source for commercial applications, accessed through the OS Net partner community. Real-time network RTK and L1 differential GPS (dGPS) commercial services are currently licensed for survey, construction and utility uses and agriculture and forestry is planned. New uses for the OS Net data stream are actively being sort; these could be in near-shore operations, transport, integrity monitoring or telematics, for example.

Ordnance Survey works through partners with OS Net, because it believes that there is a natural split between the skills and services that Ordnance Survey can provide, and those that a partner can. Ordnance Survey's skill set is to set up and run a leading edge network of GNSS base stations and to ensure that the data stream from them is robust and has a high degree of availability. Our partner's however, have the expertise and reach to support an end-user customer base that often works 24 x 7 and in harsh environments.

Case study 2 – The Olympic Delivery Authority

The Olympic Delivery Authority (ODA) is the public body responsible for developing and building the new venues and infrastructure for the Games as well as their use post 2012. The ODA have procured a GPS correction service based on OS Net through an Ordnance Survey partner. The correction service will be available to all contractors on the main Olympic site. It will also help to ensure that all GPS users carry out their work in the same coordinate reference frame as the correction service is broadcast in the site-wide Olympic Grid coordinate system.

Once an organisation has become an Ordnance Survey OS Net partner, they can then take up one, or more, Specific Use Contracts (SUCs). These enable them to sell services into different usage areas. Ordnance Survey will then work with the partners to help then develop the new market areas.

The accuracy of an OS Net partner's GPS correction service will mostly be dependant on the equipment level being used by the end user. Figure 2 looks to express what accuracy levels are attainable, from raw GPS, to L1 code dGPS, to phase smoothed L1 dGPS through to RTK.

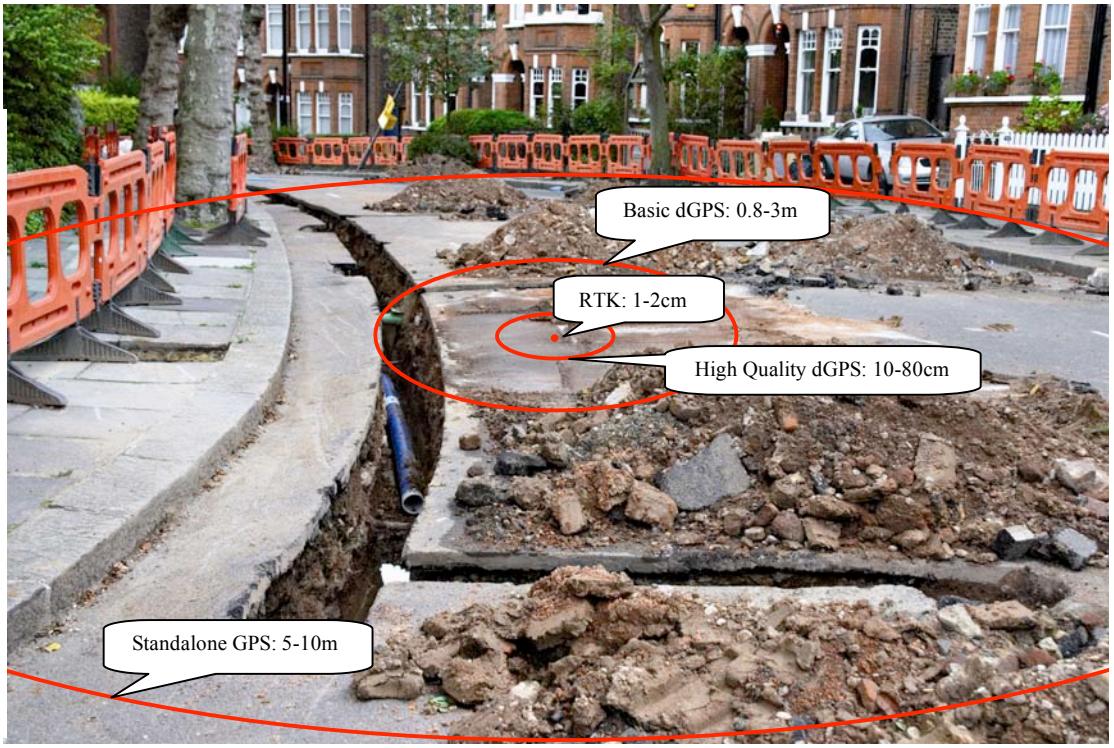

Figure 2: Attainable accuracy by receiver type from an OS Net based partner correction source.

Network RTK provides almost ubiquitous positioning around a network of base stations (an excellent introduction is given in the RICS MAPPP 2007 guidance). It has several advantages over traditional RTK:

i. extended operating range over single base station RTK: users can operate anywhere within the boundary of the base station network and at significant distances from it;
ii. cost savings due to reduced staff, hardware and security requirements;
iii. improved initialisation time and accuracy;
iv. simplified operating procedures; and
v. increased integrity and robustness of RTK solution.

Case study 3 – The Highways Agency

The primary aim of the Highways Agency is to manage, maintain and improve England's 4 500 mile motorway and trunk road network. There are however, 100 000 accidents on this network every year. 5 000 of these require thorough police investigation, where the incident results in fatal, potentially fatal or serious (life changing) injuries, to ascertain the full facts and cause of the incident.

The Highways Agency work closely with the 38 police forces in England to give them the tools to carry out accurate investigations. As part of this, the Transport Research Laboratories found that GPS based collision investigation equipment reduced the investigation time by an average of 40 minutes (www.highways.gov.uk/business/18040.aspx)

The result is that since mid-2008, 37 of the 38 English police forces, now routinely use GPS equipment and an OS Net partner's RTK correction service.

'The Highways Agency is really demonstrating how it is committed to working with the police across the country, in a bid to make the roads safer for drivers, as well as making journey times more reliable. This is a sound investment in a new technology that can really make a difference for everyone involved.' − Tom Harris, Road Minister.

Future for OS Net:

The future for GNSS is promising to be very exciting over the next five years where 100+ positioning satellites could be available to users. OS Net is being developed to meet the demands of both this new environment and a more diverse use-base. All of the GPS only base stations will be upgraded by spring 2009 to be dual GPS+GLONASS constellation enabled. They will also have an upgrade path to both Galileo and Compass when those systems start to be deployed.

OS Net is also developing a sub-network of 12 rock-anchored base stations. These will be stable in terms of both geology and longevity, and will become the core of the network.

Summary:

OS Net is a national GNSS network that was set up to fulfil the needs of a wide and diverse user community. Its' core function is to define the reference frame across Great Britain and to provide positioning services to internal customers and an increasing external customer community through a strong partner network. The network is however, also being exploited by a varied academic and scientific community, who have access to the raw data through the BIGF archive. As GNSS develops over the next few years, OS Nets capacity will increase too, to meet the needs of the diverse user base who take advantage of it.

Ordnance Survey is actively seeking new opportunities for where OS Net could be applied in the future.

References:

(1) P Cruddace; C Fane; M Greaves; *Enabling Application Development through a Supporting National GPS Infrastructure.* Proceedings of Nav05 (2005)

(2) RICS Mapping and Positioning Practice Panel (RICS MAPPP); *Virtually Right? – Networked GPS - A useful guide from RICS on aspects of cost effective networked GPS correction services.* RICS Publications (2007)