ORDNANCE SURVEY GB

POLICIES FOR GEODESY AND POSITIONING SERVICES

Ordnance Survey

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Version History

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1.0	07/05/2019	Final draft	Mark Greaves
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Summary

This document sets out Ordnance Survey's Geodetic & Positioning Services policies and activity plans for the near future. The text has been updated (April 2022) to provide an update on some of the activities.

It describes OS's current core policies for services in the field of national geodesy and positioning. It also sets out a number of strategic aims for future work and consultations.

The intended audience is both current and future users of the OS's geodetic and positioning infrastructure and services.

This strategy aligns with and provides mutual support to the OS Position, Navigation and Timing Strategy.

Introduction

Ordnance Survey (OS) is Great Britain's mapping service for government, business and citizens. Our geospatial data serves the national interest by enabling a safe, healthy and prosperous society. Everything happens somewhere, and every day we support the delivery of efficient public services, support land management & planning, help protect our environment and underpin national security, infrastructure and emergency services. With our partners, we provide expertise and accurate location data and services to help create a resilient nation, ready for next-generation technology. We're driven to ensure Britain can build a world-leading digital and connected economy of the future.

OS operates as a Government owned limited company and, as such, has a "Public Task" under the Public Sector Geospatial Agreement (PSGA) (*https://www.ordnancesurvey.co.uk/about/governance/public-task.html*). One of the Public Task items relates to national geodesy:

> *Maintain and develop the underlying physical infrastructure which is needed to support the capture and maintenance of the NGD.*

"NGD" in the above statement refers to "National Geographic Database".

Geodesy, and the supported infrastructure, underpins all OS data. This is achieved through the realisation of a nationally consistent and accurate coordinate referencing system. A robust geodetic framework enabling accurate and reliable positioning is vital for high quality, nationally consistent GI data. The positioning infrastructure also supports a great number of stakeholder user groups, and this will continue to develop and evolve.

This document sets out Ordnance Survey's core policies regarding the provision of Geodetic & Positioning services and activity plans related to these policies.

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Strategic aims of geodesy and positioning at Ordnance Survey

There are four broad objectives related to current geodesy and positioning activities at OS.

Fulfilling the Public Task through ownership and maintenance of the physical infrastructure and delivery of associated data outputs and resources, namely:

- The national GNSS Network OS Net® realising a frame of the European Terrestrial Reference System 1989 (ETRS89) coordinate reference system.
- OS Net data and products to provide user access to ETRS89.
- The national transformation OSTN15™ to define and provide user access to the OSGB36® mapping coordinate reference system via ETRS89.
- The Fundamental Bench Mark (FBM) network to define Ordnance Datum Newlyn (ODN) on mainland GB.
- The national height corrector surface ("geoid model") OSGM15™ to realise and provide user access to ODN and other height datums (e.g. on some Scottish islands) via ETRS89.

To be a leader of world class standing in the development of positioning services and specifications and the provision of associated data and services.

To provide expertise and support to Ordnance Survey and to contribute to the efficient operation of Ordnance Survey's data collection activities.

To advise on and promote the science of geodesy and positioning and its value to policy makers, the scientific community and wider society.

Policy statements

The following statements set out current OS policies for geodesy and positioning activities.

OS Net

Figure 1. OS Net station locations

OS Net is a network of over 110 permanent, geodetic quality, GNSS stations. GNSS observation data is streamed in real time to a central hub. Access to the national standard realisation of ETRS89 is enabled via the following services:

- Real-time GNSS correction services available to customers of OS Net commercial partners.
- Real-time GNSS correction services for OS surveyors.
- High rate (i.e. 1Hz) RINEX data (available from OS Net commercial partners) for use in commercial GNSS positioning operations, e.g. airborne remote sensing.
- Publicly available, free of charge, OS Net station 30 sec rate RINEX data via an OS website (*https://www.ordnancesurvey.co.uk/gps/os-net-rinex-data/*).
- Long term archive of OS Net GNSS data at the UK Research and Innovation (UKRI) funded British Isles continuous GNSS Facility (BIGF, *www.bigf.ac.uk*) hosted at the University of Nottingham.
- Contribution of OS Net data to European GNSS initiatives such as the EPN (EUREF Permanent GNSS Network, *http://www.epncb.oma.be/*) and the EPOS (European Plate Observing System, *https://www.epos-eu.org/*).

OS Net policies seek to benefit users by supporting the provision of as comprehensive and openly available, stable, and well defined realisation of ETRS89 as possible. This enables all OS Net users to access the same reference frame no matter where they are or what their positioning activity is.

OS Net policies:

A1. Maintain national coverage at suitable density to enable real time, nationwide, GNSS correction services at the few cm level.

A2. Maintain GeoNet - a sub-network of "zero order" OS Net stations - to provide the core realisation of ETRS89. GeoNet is the network ratified (Resolution #1, EUREF 2010 Symposium, *http://www.euref.eu/symposia/2010Gavle/08-02-ResolutionsEUREF2010.pdf*) by the International Association

of Geodesy (IAG) sub-commission 1.3a "Regional Reference Frames - Europe" (*https://com1.iag-aig.org/sub-commission-13*) as the official realisation of ETRS89 in GB.

A3. Support open formats for access to GNSS data streams (RTCM) and recorded GNSS data (RINEX).

A4. Support all currently viable satellite signals and support newer signals when viable.

A5. Continue to give free access to recorded 30 second rate OS Net RINEX data. This data, along with high rate data (at 1Hz epoch rate), will be archived long term (currently at the BIGF).

A6. Enable GNSS correction services and supply of high rate RINEX data through commercial partners.

A7. Offer access to OS Net data (streamed and stored) as widely as possible for commercial, scientific and research purposes. This includes contributing data to EPN and EPOS where possible.

A8. Monitor OS Net stations for position and data stability.

Coordinate reference system definition and realisation

Having a national, well defined, accurately realised, and easily accessed coordinate reference system (CRS) is a crucial resource for the nation. Users can be confident of working within a consistent reference system no matter where they are located in GB.

The national geodetic, 3D coordinate reference system is ETRS89. ETRS89 is directly linked to the global ITRS coordinate reference system and its realisations through the ITRF frames. ETRS89 in GB is realised through the coordinates of the OS Net stations. OS Net has a sub-network of 12 stations, GeoNet, which is the fundamental, "zero order" ETRS89 realisation and whose coordinates have been ratified (see A2 above) as the official realisation of ETRS89 in Great Britain.

The national mapping coordinate reference system is OSGB36 National Grid. OSGB36 is realised from ETRS89 via the national transformation OSTN15.

The national height system, based on mean sea level, consists of a variety of datums. On mainland GB the datum is Ordnance Datum Newlyn (ODN). Larger islands have their own, similar, mean sea level based datums – Scilly Isles, Isle of Man, Outer Hebrides, Orkney and Shetland. ODN is physically realised through the heights of approximately 190 Fundamental Bench Marks (FBMs). Access to ODN and the other datums is from ETRS89 in combination with the national height corrector surface ("geoid model") OSGM15.

CRS definition and realisation policies:

B1. Maintain realisation of ETRS89 at the cm level through OS Net coordinates.

B2. Offer free and open access to OSTN15 and OSGM15 through a variety of tools and data sets.

B3. Full info and technical support documentation on the national CRS and transformations freely available.

B4. Monitor the impact on users of the changing relationship between ETRS89 and the more dynamic, global coordinate systems such as WGS84.

B5. Where possible seek a "protected status" for FBM monuments.

Collaboration

Collaboration with outside parties is an essential component of the Objective – 'To advise on and promote the science of geodesy and positioning and its value to policy makers, the scientific community and wider society'. Collaboration will benefit third parties by enabling them to realise the full potential of the geodesy and positioning components of their activities.

Examples of current collaborations include:

- With the UK Met Office to site OS Net stations at Met Office compounds in return for access to OS Net data files and streams. A similar collocation type of collaboration could be extended to the wider scientific community by offering OS Net sites to host other sensors.

- With BIGF on long term archiving of OS Net data and making it freely available to the academic community.

It is not possible to have detailed policies covering types of collaboration, or on who collaborating partners may be since opportunities change all the time. The overall collaboration "ethos" will always be to have free and open collaboration where possible.

C1. Collaborate, where possible, with Government, academia, and business on aspects of positioning and geodesy to the mutual benefit of all parties.

Legacy monuments

Great Britain has several sets of legacy geodetic monuments. These include triangulation pillars, benchmarks (not FBMs) and so called "Passive" GPS stations. Although these markers are no longer used for national mapping or actively maintained by OS they remain useful markers for some users and some are considered to be of historical significance.

Legacy monuments policies:

D1. Endeavour to retain triangulation pillars and passive stations where possible. Priority being given to "navigationally significant" markers, e.g. pillars in isolated locations with no other easily identifiable "hard detail" close by. Where it is not possible retain a navigationally significant pillar an attempt will be made to replace with a cairn or similar.

D2. Free access to databases and lists of legacy monuments will be given through the OS website.

Planned and completed activities

The proposed activities are intended to improve a service or product, in line with the above polices and to the benefit of users. Some of the activities, proposed in the previous version of this document, have been completed. Other activities are ongoing and have been updated.

Where an activity has been completed or updated the original version is given first (in grey text).

OS Net

Completed activities

OS Net - 2. (Original)

Further to improving the resilience of OS Net data – the recently upgraded OS Net receivers can potentially enable a national framework for the monitoring of interference to GNSS at OS Net stations. Over a period of time this will allow the interference "noise floor" to be baselined. Monitoring will be a continuous activity and will commence once a study is completed by end of 2019.

OS Net - 2. (Also see updated "*Collab - 3*")

OS has now developed a capability to detect, monitor and analyse spectrum interference data from across OS Net and is analysing the radio spectrum noise floor with regards to impact on our own network, services, partners and customers. Our current datasets are providing unique insights gained during periods of national lockdown and are continually being updated.

OS Net - 3. (Original)

A cost benefit analysis of densifying OS Net in urban areas to provide users with even better positioning and height accuracy and integrity will be carried out. This will be completed by mid 2020.

OS Net - 3.

Whilst studies have shown that increasing station density can result in small increases in GNSS plan positioning but proportionally better improvements in GNSS height accuracy there is currently no cost benefit from densifying OS Net further.

More benefit is likely to be gained from focused densification to support increased integrity for large infrastructure projects (e.g. as was done for HS2) or adding additional stations in isolated areas (e.g. Shetland) to support full network RTK and better quality GNSS spectrum analysis.

Ongoing activities

OS Net - 1. (Original)

It is a benefit to users that the OS Net data is as resilient as possible and to also have the highest possible levels of data availability. To this end, ways of increasing resilience of OS Net, e.g. through back up communications, RINEX integrity (aiming for 100% complete RINEX files where possible) will be investigated. A "roadmap" of potential improvements will be completed by end of 2019.

OS Net - 1.

The OS Net server infrastructure has been updated to improve resilience of the data flows. This includes a new dedicated data archiving server and a live clustered pair of production servers. The data archive server automatically chooses the best file from the production server pair every hour. Trials of back up 4G and 5G communications links, to automatically take over from a failed land line, continue.

Trials of the RINEX integrity function built into the OS Net software are planned. Following a communications break this function, for compatible receivers, auto recovers the missing files directly from the receiver. This functionality will first be assessed against the impact on the bandwidth available for the real time data stream.

OS Net - 4. (Original)

Expand the usability of OS Net signals to users by upgrading the OS Net RINEX data service to support the increased number of signals (including Galileo and BeiDou) that are now available from the upgraded OS Net receivers. This will be achieved by adopting RINEX 3 format (and using associated IGS naming convention) in parallel to RINEX 2 for an appropriate amount of time. The upgrade is anticipated to be complete by mid 2020.

OS Net - 4.

The "end to end" OS Net data flow is now RINEX 3 format containing all possible (as allowed by receiver configurations and capabilities) observables of the 4 major GNSS constellations (GPS, GLONASS, Galileo and BeiDou). This is the data now archived at the BIGF. This data is also available from the EPOS project data gateway (*http://gnssdata-epos.oca.eu/#/site*).

The OS Net public RINEX web site (*https://www.ordnancesurvey.co.uk/gps/os-net-rinex-data/*) has been upgraded to deliver both RINEX 2 format data (GPS and GLONASS, basic observables) and RINEX 3 format data (4 constellations, all possible observables).

OS Net - 5.

Explore the benefits of OS Net data and services for other applications including unmanned aerial vehicles, location-based services and autonomous vehicles use. This will be an ongoing activity based upon identified opportunities.

Coordinate reference system definition and realisation

CRS - 1. (Original)

With the almost ubiquitous use of satellite-based positioning methods, there is a certain amount of appeal in having a mapping coordinate system that is directly compatible with ETRS89 and other global systems i.e. one that no longer requires the OSTN15 transformation to link OS Net positioning with mapping. In addition, the integration of Building Information Models (BIM), GNSS, national mapping and engineering works for example is creating issues around compatibility. To this end a consultation will start, on the benefits and disadvantages to users of a possible OSGB36 National Grid replacement. Following internal consultation we aim to invite the initial public consultation by the end of 2020.

CRS - 1.

With the almost ubiquitous use of satellite-based positioning methods, there is a certain amount of appeal in having a mapping coordinate system that is directly compatible with ETRS89 and other global systems i.e. one that no longer requires the OSTN15 transformation to link OS Net derived

positioning with national mapping. In addition, the integration of Building Information Models (BIM), GNSS, national mapping and engineering works for example is creating issues around compatibility when OSTN15 is always required to link back mapping coordinates. To this end a public consultation is planned to start in 2022 on the benefits and disadvantages to users of an updated national map projection as an alternative to the legacy OSGB36 National Grid. It is likely this consultation will be combined with one on the national height system (CRS - 2).

CRS - 2. (Original)

There is a trend for national height systems to move away from "traditional" sea level / levelling based networks to ones based on GNSS measurements in conjunction with an accurate geoid model and with a "W0" datum value that best approximates mean sea level and also aligns to regional and global height systems. The advantages of such a system to users in GB would be a single, consistent height datum available across the entire country, including on islands that currently have their own datum. Also, heights in this system would be compatible with others in Europe and maybe globally. A consultation will be carried out on the full benefits and disadvantages to users of implementing such a system. We aim to begin the initial consultation by the end of 2020.

CRS - 2.

Similar to CRS - 1 which addresses the needs of GNSS based horizontal positioning, there is a need to consult on an alternative national height system (GNSS / geoid model based) to the current legacy mean sea level / levelling based networks. A height system based on GNSS measurements, in conjunction with an accurate gravimetric geoid model and with a "W0" datum value that best approximates current mean sea level, will also align to regional and global height systems. The advantages of such a system to users in GB would be a single, consistent height datum available across the entire country, including on islands that currently have their own datum. Also, heights in this system would be compatible with others in Europe and potentially globally. A public consultation (likely combined with the CRS - 1 consultation, planned to start in 2022) will be carried out on the full benefits and disadvantages to users of implementing such a system as an alternative to the current height datums in use in Great Britain.

CRS - 3. (Original)

To assist users in the "metre / few decimetre" positioning arena a clear policy and action plan will be produced to deal with the effects of the increasing WGS84/ETRS89 separation. The plan will be published by the end of 2020.

CRS - 3.

To assist users in the "metre / few decimetre" positioning arena clear guidance will be produced on how to deal with the effects of the increasing WGS84/ETRS89 separation (~0.8m at time of writing). Clarification on the long term future of ETRS89, especially the fixing to epoch 1989.0, will be pursued at the EUREF level.

CRS - 4.

Provide increased information to users on the quality of the ETRS89 realisation through time series, deformation analysis, etc.

CRS - 5.

Refresh OS Net website to include a repository of technical/geodetic information including historic documents.

CRS - 6.

Improve user access to transformation through, for example, an RTCM broadcast version of OSTN15.

Collaboration

Collab - 1.

Seek to establish a "GB Geodesy Forum" to include representatives from science and academia, industry, space agencies, national facilities providers and government geodesy providers. The aim would be to own a "joined up" geodetic vision for the whole of GB and to look for opportunities to deliver collaborative ventures for the benefit of the wider PNT user community.

Collab - 2. (Original)

Work with Met Office to enable them to make best possible use of OS Net data for national weather and space weather forecasting.

Collab - 2.

Work with Met Office to enable them to make best possible use of OS Net data for national weather and space weather forecasting. This includes the possibility of sharing resources to add additional stations to OS Net in areas where the data would be of advantage to Met Office.

Collab - 3. (Original)

OS, as a large GNSS infrastructure provider and user, has a strong interest in the characteristics and impact of natural and manmade interference on GNSS. OS will therefore continue to seek collaboration opportunities that help to understand the effects and sources of interference to GNSS.

Collab - 3.

Aligned with the updated "*OS Net - 2*" activity OS is collaborating with several external bodies on a system to detect, monitor and quantify GNSS interference.

Collab - 4.

Seek opportunity to work with others to further utilise the benefits of the OS Net infrastructure beyond geodesy and "survey" positioning and into the wider PNT community.

Glossary of acronyms

Acronym	Explanation
BIGF	**B**ritish **I**sles **G**NSS Archive **F**acility. National, long term archive for all permanent GNSS station data in Great Britain. Hosted at the University of Nottingham. www.bigf.ac.uk
EPN	**E**UREF **P**ermanent GNSS **N**etwork. A network of continuously operating GNSS reference stations covering the whole of Europe. http://www.epncb.oma.be/
EPOS	**E**uropean **P**late **O**bserving **S**ystem. Collects and makes available a wide range of "Earth science data" including GNSS data from permanent networks. https://www.epos-eu.org/
ETRS89	**E**uropean **T**errestrial **R**eference **S**ystem 19**89**. A geodetic quality reference system for use across the whole of Europe and fixed in time at 01/01/1989.
EUREF	EUREF is the IAG Reference Frame Sub-Commission for Europe, integrated in the Sub-Commission 1.3, Regional Reference Frames, under Commission 1 – Reference Frames. EUREF deals with the definition, realisation and maintenance of the European Reference Frame. http://www.euref.eu/
FBM	**F**undamental **B**ench **M**ark. Zero order, physical height marker in mainland GB. Physical realisation of the Ordnance Datum Newlyn (ODN) mean sea level based height datum.
GNSS	**G**lobal **N**avigation **S**atellite **S**ystem. A term encompassing ALL the current navigation systems including American GPS, Russian GLONASS, European Galileo and Chinese Beidou.
IAG	The **I**nternational **A**ssociation of **G**eodesy. http://www.iag-aig.org/
ITRS (and ITRF)	**I**nternational **T**errestrial **R**eference **S**ystem. Global, high accuracy coordinate reference system compatible for use with GNSS positioning. Realised by successive ITRFs (International Terrestrial Reference Frame). I.e. ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008 and ITRF2014
National Grid	The national map projection of Great Britain. A modified, transverse Mercator projection linked to the OSGB36 datum.
OS Net	Ordnance Survey's national network of permanent, geodetic quality GNSS receivers.
OSGB36	The national mapping datum of Great Britain. First designed in 1936.
OSGM15	National height correction model for Great Britain. Relates ETRS89 heights to mean sea level based heights.
OSTN15	National coordinate transformation of Great Britain. Relates ETRS89 coordinates to OSGB36 coordinates.
PNT	**P**ositioning, **N**avigation, and **T**iming. Umbrella term for all the various services provided by GNSS.

Acronym	Explanation
RINEX	**R**eceiver **In**dependent **Ex**change Format. Globally accepted, open format for the recording of GNSS observation data.
RTCM	**R**adio **T**echnical **C**ommission for **M**aritime Services. Publishes data format standards used in the transmission of GNSS observations and corrections. RTCM version 3 is widely used for GNSS data. *http://www.rtcm.org*
RTK	**R**eal **T**ime **K**inematic. A GNSS correction technique that enables real time surveying quality (i.e. a few cm) positioning. OS Net enables *Network* RTK where the corrections are based on a positioning solution from the whole network rather than just a single station.
WGS84	**W**orld **G**eodetic **S**ystem 19**84**. Coordinate reference system for GPS and realised through GPS satellite orbit data. Current version of WGS84 is known as "WGS84(G1762)" and is aligned to ITRF2008