# OS Net - Preparations for Future GNSS

Ordnance Survey (OS) has just updated its geodetic infrastructure. Mark Greaves, Lead Consultant at Geodesy, describes these developments and takes a look at shorter and longer-term geodetic issues for surveyors.

OS Net is Ordnance Survey's national network of over 110 permanent, geodetic quality, GNSS stations. GNSS observation data is streamed in real-time to a central hub and access to the national standard realisation of ETRS89 is enabled through 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 for use in commercial GNSS positioning operations (e.g. airborne remote sensing).
- Publicly available, free of charge OS Net station RINEX data via the OS website.
- Long term archive of OS Net GNSS data at the Natural Environment Research Council (NERC) funded British Isles continuous GNSS Facility (BIGF) hosted at the University of Nottingham.

## New OS Net Receivers

Like all national GNSS networks it is important that OS Net keeps pace with developments in GNSS systems and signals. To this end, the entire OS Net receiver stock has recently been updated with brand new receivers.

The previous receivers were nine years old and after a long period of constant (remember this equipment runs 24x7x365) and reliable service they were starting to reach the end of their life. Additionally, despite the old receivers (and antennas, which are not changing) being multi-constellation capable, different upgrade paths and timescales of receiver firmware and OS Net control software meant that it was only possible to stream and supply data from GPS and GLONASS.

The advent of the RTCM MSM (Multiple Signal Messages) data transfer format has meant it is now a lot easier to handle the greatly increased number of observations available. This includes data from the European Galileo and Chinese BeiDou systems.

## Ready for New Signals

The upgraded OS Net is not only ready for Galileo and Beidou but also the newer GPS signals L2C and L5. Although not being tracked at the moment, the network is also ready for GLONASS L3. The L3 GLONASS signal is the start of a move away from the FDMA (Frequency-division multiple access) technique to the CDMA (Code-division multiple access) technique used by all the other GNSS systems. The original FDMA signals will continue for the foreseeable future but will be augmented by new CDMA signals.

## 50/50 Hardware Split

The old OS Net receivers were almost all of a single make and model. For the refresh, the network is split approximately 50/50 across two different makes of receiver which will be located evenly across the country. Additionally, there are a small number of a third make of receiver. The reason behind the mix of receiver manufacturers is to mitigate against the very rare situation where an undiagnosed firmware problem can cause all the receivers of a particular make/model to fail at the same time. Whilst these events are thankfully very rare, the impact across an entire national GNSS network can be very serious indeed since the potential is for the whole network to be non-functional until the problem is fixed.

Previous problems that unexpectedly triggered a failure of all receivers have been caused by such things as a GPS week number roll over not being handled correctly in the firmware. See ‘GPS Rollover Week’ box out.

## Accessing New Signals

OS Net users will access the new signals either through the RTK correction service they are subscribed to or via the free OS Net RINEX data from the OS website - [www.ordnancesurvey.co.uk/gps/os-net-rinex-data/](www.ordnancesurvey.co.uk/gps/os-net-rinex-data/). The current web site delivers GPS+GLONASS data files in RINEX v2 format. This will not change. New data files in RINEX v3 format containing GPS+GLONASS+GALILEO+BEIDOU data will be made available, initially, via manual download. The current manual download directory is www.ordnancesurvey.co.uk/gps/rinex. Longer term, the RINEX ordering process will be modified to allow users to select data delivery in RINEX v2 (GPS+GLO) or RINEX v3 (GPS+GLO+GAL+BDS) formats.

All these new signals can only mean better and more robust positioning for users, especially in harsh 'urban canyons'. Outside of the surveying world, the convergence of new signals and services and improved user devices means accurate (sub metre) and low cost positioning for a much larger group of users. For example the Galileo Commercial Service, which now looks like it will be free of charge (http://insidegnss.com/fundamental-rethink-for-galileo-commercial-service/), could offer decimetre positioning on low cost devices without the need for an additional correction signal. The future is not just about new signals.

## Dealing with Drift

The improvements to positioning from new signals and constellations, along with devices getting better, means this "future GNSS" has other impacts outside of the need to update national GNSS CORS networks. One of these impacts is a greater number of users becoming aware of the drift between the fixed reference frames used for mapping and positioning, such as ETRS89 in Europe, and the 4D WGS84 reference frame used by their positioning device.

It's a fact that the world is constantly shifting on tectonic plates, but maps (and their users) like fixed coordinates that don't change. Before GNSS, this was simple to achieve as most positioning and mapping was created from fixed ground points in a coordinate reference system tuned to a particular country. For example, in Great Britain our fixed points used to include the very familiar trig pillars and we have a mapping coordinate reference system called OSGB36 National Grid which is fitted closely to our little bit of the Earth. Tectonic plate movements had little or no impact on the mapping coordinates or fixed points because they all moved 'as one' and the network generally stayed the same shape.

GNSS require a coordinate reference system that has a good average fit to the whole Earth and also has to change to keep up with the shifting of tectonic plates – it is effectively 4D (3D + time). The GPS coordinate reference system is WGS84 and it is perfect for GPS but perhaps not ideal for large- or mid-scale mapping because it moves, albeit slowly and in a predictable way.

Europe's GNSS compatible datum, ETRS89, is fixed to the European tectonic plate. It was aligned to WGS84 on 1 January 1989 and moves by around 2.5cm each year. In theory, coordinates derived directly from GNSS without additional correction from, for example, OS Net, are now about 72cm away from where they should be in the ETRS89 system. However, for most consumer users the 72cm difference is swamped by the accuracy limits of their receiver (phone, satnav etc) which are only accurate to within a few metres. So, the difference is not noticeable if you're out walking, or driving around the country. Professional users, such as surveyors making use of an OS Net derived RTK correction service, are automatically positioned in ETRS89 so the drift is accounted for.

The drift happens at a constant rate but with GNSS and receivers at the 'prosumer' and consumer level becoming more accurate over the next few years, the drift is likely to become more noticeable to a large number of users.

## Future Options

There are a number of options to deal with this in the future:

- Mapping in each country could stay on a local system such as OSGB36, then an additional transformation could be employed to first go from WGS84 to ETRS89 and then on to OSGB36.
- All mapping could be based on ETRS89 and simply keep the time evolving WGS84/ETRS89 transformation.
- Adopt a version of ETRS89 with a more current time stamp (e.g. ETRS2030) and have coordinate jumps every few decades to keep up with dynamic GNSS reference frames (i.e. if the ETRSyyyy / WGS84 difference were to be kept at less than 1m, a coordinate jump would be required approximately every 40 years.)
- Alternatively have a dynamic "4D" coordinate system that constantly evolves like WGS84 and users become used to all coordinates and map data having a time stamp plus the availability of a transformation to bring coordinates into a common time frame if so desired.

Ordnance Survey, and other mapping agencies in Europe, are planning for the future when this becomes an issue and will be considering, in consultation with users, the best way to deal with it.

## OS Geodetic Strategy

Regarding not just the future of OS Net and coordinate reference frames but OS's wider geodetic future for Great Britain – a new strategy will be published soon for consultation with users. It will set out Ordnance Survey's Geodetic & Positioning Services policy and activity plans through the next few years. It will describe OS's current core policies for services in the field of national geodesy and positioning and a number of strategic aims for future work and consultations.

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## GPS Rollover Week

The data field in the GPS signal that holds the current GPS week number is a 10-bit binary number. This limits the range of the week number to between 0 and 1023, or 1024 weeks in total. The next time the counter will reach week 1023 and rollover to zero is on 6 April 2019.

Receivers must use the week number to give the correct date and not one that's 19.7 years (1024 weeks) adrift. There are various methods of doing this and they commonly involve referencing another date embedded in the receiver firmware. This is the second week number rollover in the life of GPS so receiver manufacturers are better prepared for it this time. So, as long as the receiver firmware is up to date, the week number roll over should not be a problem.

Source: [https://spectracom.com/resources/blog/lisa-perdue/2018/gps-2019-week-rollover-what-you-need-know](https://spectracom.com/resources/blog/lisa-perdue/2018/gps-2019-week-rollover-what-you-need-know)

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## GNSS Constellation Summary

Surveyors can now collect data from four constellations of GNSS satellites, GPS, Glonass, Galileo and Beidou, with a combined total of over 100 satellites. This article summarises the state of each constellation.

### GPS

GPS has been upgrading, with additional signals and improvements with each new generation of satellite. Developments with the upcoming Block III satellites include longer design life, better clocks and the installation of laser reflectors. The current state of play is shown in Table 1.

| Block | No of operational satellites | C/A code L1 | P code L1/L2 | L2C | L5 | L1C | Launch span | Design Life (yr) |
|---|---|---|---|---|---|---|---|---|
| **IIA** | 1 | Y | Y | N | N | N | | 7.5 |
| **IIR** | 11 | Y | Y | N | N | N | 1997-2014 | 7.5 |
| **IIR-M** | 7 | Y | Y | Y | N | N | 2005-2009 | 7.5 |
| **IIF** | 12 | Y | Y | Y | Y | N | 2010-2016 | 12 |
| **III / IIIF** | 0 | Y | Y | Y | Y | Y | from Sep 2018 | 15 |
| **Total** | 31 | | | | | | | |

*GPS constellation status.*

### Glonass

The Glonass constellation currently comprises of 24 'M' class and 1 K1 class satellites. In 2019, there are plans to launch four further K1 satellites and a K2 satellite. These will all broadcast FDMA signals and CDMA signals on L1, L2 and L3 frequencies. The K2 satellite will use 'radiation hardened' components and have a 10 year design life.

### Galileo

The Galileo constellation has 18 operational satellites and a further four are due to be launched on 25 July 2018. Galileo broadcasts four signals using CDMA.

### Beidou

When complete in 2020, the Beidou constellation will comprise of 27 medium earth orbit (MEO), 5 geostationary and 3 inclined orbit satellites. The system has been providing regional coverage in SE Asia since 2012 and is now expanding to provide a global service.

Currently, all geostationary, 8 inclined orbit and 14 MEO satellites, are in operation. A further 1 geostationary and 6 MEO satellites are programmed to be launched this year and possibly four more.

Beidou broadcasts using CDMA in four bands – E1, E2, E5B and E6 which overlaps with Galileo.

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https://www.gim-international.com/content/article/os-net-preparations-for-future-gnss