Geodetic policy for Ireland and Northern Ireland

Background

Ordnance Survey Ireland (OSi) is the National Mapping Agency (NMA) of the Republic of Ireland. The Ordnance Survey of Northern Ireland (OSNI) was the mapping agency of Northern Ireland, which is now included as part of a larger government organisation, Land and Property Services (LPS).

The two organisations are jointly responsible for the development and maintenance of the geodetic infrastructure in Ireland. This is the survey control network, or skeleton, on which the mapping hangs, ensuring that mapping on the island "fits together". It is vital that this framework is accurate, suitable, and readily available to users both in the public and the private sector.

In the past the survey control network consisted of two separate parts. Horizontal control was provided by the trigonometric network which was computed using angular measurements observed in the 1950s and 60s. Vertical control was provided by the height network of benchmarks observed by spirit levelling. Both of these traditional survey networks had three orders of accuracy, primary, secondary, and tertiary.

Global Navigation Satellite Systems (GNSS) now enable precise three dimensional positioning anywhere on earth with a precision of up to a few millimetres, if an appropriate reference frame and positioning infrastructure is in place.

Current status

To support precise positioning within Ireland, the NMAs have developed networks of active and passive GNSS stations which realise the European Terrestrial Reference System (ETRS89) in Ireland. ETRS89 is date stamped as being coincident with the International Terrestrial Reference System (ITRS) at 1989.0. This is in order to negate the effects of tectonic movement, the Eurasian plate is moving across the globe at approximately 2.5 cm per year. These reference networks comply with international standards and provide high precision, distortion free control for GNSS surveys. Both

LPS and OSi supply data from active stations to be included in the European Permanent Network (EPN).

A passive GNSS network was established in 1995/6 as part of the IRENET project. This consists of a series of survey markers or passive stations for which precise coordinates have been determined. This network was designed to allow users to set up equipment at these sites to establish survey control or to use as a base station. Now this passive network while still available to users, has largely been superseded by an active GNSS network.

This active GNSS network consists of a series of permanently recording Geodetic GNSS tracking receivers (sometimes known as CORS). The data recorded at these stations is streamed live to the control centres within the two Ordnance Surveys where it is used to compute real time kinematic (RTK) corrections for rover users. These corrections mitigate atmospheric errors in the GNSS signals and correctly used can provide relative accuracies at the few centimetre level. Observations from both the United States GPS and the Russian GLONASS systems are used to compute the RTK corrections. Internally in order to supplement the data from our own network stations, the two NMAs include data from each other's stations around the border areas and LPS also stream data from stations in Great Britain and the Isle of Man.

Surveyors access these RTK corrections via mobile internet, using the network either to survey detail directly or to supply survey control from which detail is captured using total station or graphic survey.

Whilst LPS and OSi surveyors access networks operated by the NMAs, commercial users can access the reference frame through our commercial partners who make available network RTK corrections derived from the live data from our active permanent GNSS stations. Applications for network RTK in Ireland include building and construction, machine automation in agriculture and construction, asset management by utilities, emergency services, etc.

For more precise applications or when post processing is required, the streams are converted into hourly RINEX files for use in post processing GNSS applications. LPS

and OSi post process GNSS observations to provide ground control points and precise aircraft photo centres for aerial surveys.

This data from the active GNSS stations is not only important to the survey community but is also used extensively by the scientific community. GNSS data is supplied to the Met Office where it is used for research and analysis in weather forecasting and in European Meteorology research (The EUMETNET E-GVAP project). The data is archived for use by the scientific community at the BIGF archive facility in Nottingham.

The EUREF Permanent Network (EPN) is a science-driven network of Over 200 permanent GNSS tracking stations whose weekly computed positions are used by EUREF to realize the European Terrestrial Reference System (ETRS89).

Stations Enniskillen (ENIS), Foyle (FOYL), Castlebar (CASB), and Tallaght (TLLG) are included in the EPN while station Belfast (BELF) had contributed to the European Real Time project EUREF-IP when the site was operational. OSi and LPS are planning to include more stations in the EPN in the future.

The coordinates of the permanently recording GNSS stations determined in the EUREF IE/UK 2009 campaign comply with International standards, having been approved by the International Association of Geodesy (IAG) through their sub-committee EUREF as the current realisation of ETRS89 in the UK and Ireland. These coordinates were implemented as official by both OSi and LPS on the 26th August 2016, when the Geoid Model OSGM15 was launched.

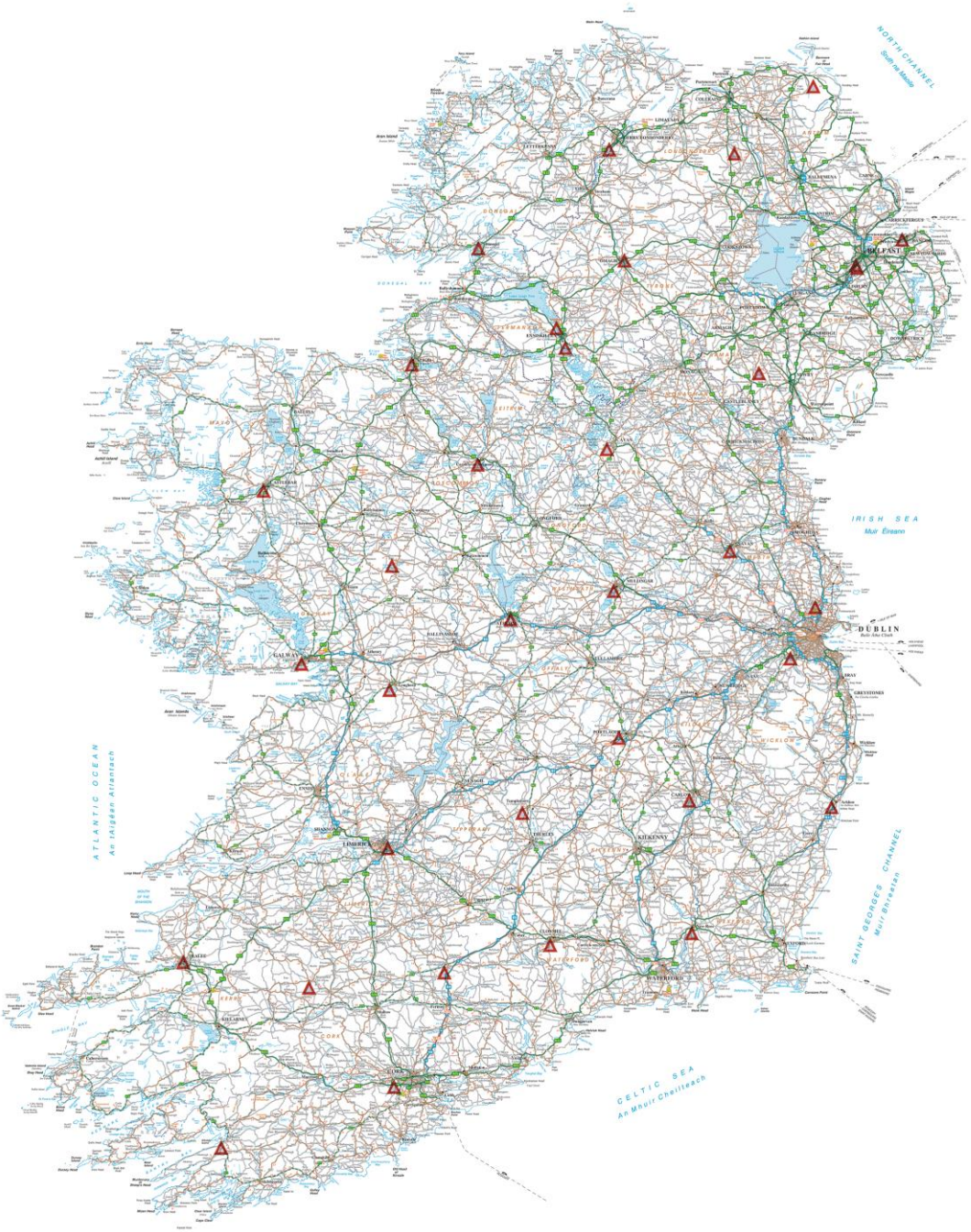

Figure 1 GNSS Network Stations location diagram

Coordinate Reference Systems (CRS)

OSi and OSNI large scale mapping is made available in two coordinate reference systems; Irish Grid (IG) and Irish Transverse Mercator (ITM).

Introduced in the 1950s and 60s to replace county series mapping and further adjusted in 1975, the Irish Grid is a two dimensional coordinate system providing Easting and Northing coordinates from a Transverse Mercator projection of detail on the Airy Modified ellipsoid. For parameters and further detail see The Irish Grid
A Description of the Co-ordinate Reference System

Irish Grid is a local CRS which is not compatible with the modern global systems. In order to realise IG positions from GNSS observations the coordinates must be transformed to Ireland65 datum before applying the Transverse Mercator projection.

ETRS89 is a three dimensional GNSS compatible reference system using the GRS80 ellipsoid which provides the Datum for the ITM projection.

To provide a GPS compatible mapping system Irish Transverse Mercator (ITM) was designed as a two dimensional coordinate system based on the ETRS89. This consists of a Transverse Mercator projection which provides Easting and Northing coordinates from detail on the GRS80 ellipsoid. For parameters and further detail see New Map Projections for Ireland Consultation Paper (OSi/OSNI)

Two height Datums are used in Ireland. Mean Sea Level (MSL) Belfast Lough is used on all OSNI large scale mapping. MSL Belfast Lough was derived from a series of tidal observations, covering the six-year period from 1st January 1951 to 31st December 1956. Mean Sea Level Malin Head is used on all OSi mapping and on OSNI small scale mapping. MSL Malin Head was derived from observations between January 1960 and December 1969, and adopted as the Ordnance Datum in 1970.

Height above datum was realised through a network of Bench Marks established through spirit levelling in the 1960s and 1970s. The NMAs no longer have any spirit levelling program, the levelling networks are no longer maintained, other than the

Fundamental Bench Marks and their substitutes which continue to provide the link to the height datum.

GNSS surveys determine positions in a three dimensional coordinate system, the height component of which is not related to gravity or the Geoid but is in fact a height above a mathematical surface, the GRS80 ellipsoid. In conjunction with OSGB, OSi and OSNI developed a model or corrector surface of the differences between GNSS derived ETRS89 ellipsoidal heights and Orthometric heights above the relevant local Ordnance Datum. This Geoid model or more correctly Vertical Reference Frame, OSGM15 allows surveyors to use modern GNSS equipment to realise height in Ireland. It is now recommended that determination of height above MSL is best achieved by use of GNSS survey and the current OSGM15 model. The current model is made freely available in the current version of the OS translator.

In order to help establish the European Vertical Reference System (EVRS) four stations in Ireland were observed using GNSS as part of the European Vertical reference Network (EUVN) project. EI01 Kenmare, EI02 Slane, EI03 Malin Head, GB02 Belfast.

Transformations

OSi and OSNI have developed a polynomial transformation which allows users wishing to determine positions in the Irish Grid reference system to derive these from GNSS positions.

This transformation is made freely available in the current version of the OS GridInquest translator which can be downloaded from the OSi website.

The OSGM02 geoid model has been developed to allow levels to be transferred between GNSS derived ellipsoidal heights and Malin Head Datum or Belfast Datum. This model was replaced by the OSGM15. It is recommended that determination of height above MSL is best achieved by use of GNSS survey and the current OSGMyy geoid model.

OSi and LPS updated the OSGM02 geoid model, in 2016, by taking advantage of new data from satellite gravity missions, improved ellipsoidal heights determined in the EUREF IE/UK 2009 campaign, and modern local GNSS observations.

Historic and legacy data

The network of triangulation stations used to realise the Irish Grid coordinate system were observed mainly in the 1950s and 1960s as part of the re-triangulation of Ireland. Irish Grid coordinates were determined using this triangulation network as control. It is now recommended that coordinates in the Irish Grid system are best determined by use of GNSS survey and the application of the polynomial transformation. The triangulation network is no longer maintained by LPS or OSi.

The initial realisation of the GNSS compatible ETRS89 coordinate reference system in Ireland was through the results of the Zero order network of the 1995 GPS campaign IRENET95. This campaign was ratified by EUREF at the 1996 symposium in Ankara, Turkey. The Zero order Network of 11 points was densified by around 200 lower order control points to allow users access to the ETRS89 coordinate system.

The IRENET95 Zero order network is no longer considered to be the official realisation of ETRS89 in Ireland. The coordinates of these 11 points (3 in NI) were never made available to the public. It has been considered that this policy will remain in the interests of protecting the monuments. The coordinates of the IRENET95 densification points are now available free of charge from both LPS and OSi.

The values of the Bench Marks will be made available free of charge as an archive.
In cases where research is required to provide further details of survey marks there will be a search fee charged.

Professional bodies

The NMAs work closely with the International Geodetic community including EUREF, the sub-committee of the International Association of Geodesy (IAG) which has responsibility for reference frames in Europe.

OSi and LPS maintain close links with the relevant survey institutions in Ireland including the Chartered Institute of Civil Engineering Surveyors (CInstCES), Royal Institute of Chartered Surveyors (RICS) and the Society of Chartered Surveyors Ireland (SCSI). These professional bodies produce a number of Client Guides over a wide range of surveying and positioning topics which are of relevance to NMA customers in Ireland.

The OSGM02 and OSGM15 height models have been developed to allow levels to be transferred between GNSS derived ellipsoidal heights and Belfast or Malin Head Datum. The use of these formulae and models are promoted by the professional surveying bodies as "current best practice" for surveys.

Availability and Access

Software/Applications which allow users to convert/transform coordinates between the different relevant Coordinate Reference Systems (CRSs) will continue to be made available.

Access to the mapping framework infrastructure is freely available in a number of ways. GNSS data from the active station network in the form of RINEX files is made available for 30 days to users. The coordinates of the passive network densification stations are published. Access to real time corrections computed from data streamed by the active station network is available at a cost through our commercial partners.

Dependent upon the accuracy level required, although it is recommended that orthometric height values are realised by the application of the current OSGM15 to convert ellipsoidal height coordinates obtained by post processing the RINEX files above, the values for the obsolete Benchmarks (BMs) from the levelling network are

published as an archive. However, it must be emphasised that these values are taken from an obsolete, unmaintained archive.

Planned development and maintenance

OSi and LPS intend to maintain and develop the Geodetic infrastructure by;

1 A continuous campaign to improve the network of continuously recording GNSS stations through the installation of a number of new stations for densification and by repositioning of some existing stations. This is in order to improve inter station spacing and to provide added redundancy. It is intended that when practical the monumentation of at least one of these new stations should be of "rock-anchored" Geodetic quality to provide maximum stability and longevity.

2 To maintain and upgrade the active GNSS stations, it is intended to upgrade the station receivers to receive signals from the new European Galileo GNSS when the planned constellation is fully available and to include other signals as appropriate should other GNSS become available.

3 OSi and LPS will continue to improve and update any geoid model when significant new data becomes available, typically from improved satellite altimetry and gravity observations.

4 The feasibility of establishing a number of Absolute Gravity Points in Ireland is currently being considered. This may provide a framework leading to the possibility of a terrestrial relative gravity survey being carried out.

5 Continuing to work closely with the International Geodetic community to maintain and comply with policy and developments such as EPN, ETRS89, EVRS, and INSPIRE.

6 Continuing to work closely with the industry professional bodies, the scientific and academic communities to educate and promote Geodesy where appropriate. This will include support for research into an attempt to develop a method of linking local height Datums to the European Datum.

7 LPS and OSi will comply with the terms of any International, UN resolutions on Geodesy.

Reference Guides

Guidelines for the use of GNSS in Surveying and Mapping 2nd edition (RICS 2010)

The Irish Grid A Description of the Co-ordinate Reference System (OSi/OSNI 2000)

New Map Projections for Ireland Consultation Paper (OSi/OSNI 2001)

Making Maps Compatible with GPS (OSi/OSNI 1999)

Useful Websites

http://www.dfpni.gov.uk/lps/

http://www.osi.ie/Home.aspx

Acronyms

BIGF	British Isles GNSS Facility
CInstCES	Chartered Institution of Civil Engineering Surveyors
CORS	Continuous Operating Reference Station
CRS	Coordinate Reference System
E-GVAP	EUMETNET GNSS water vapour program
EPN	EUREF Permanent Network
ETRF2000	European Terrestrial Reference Frame 2000, the current approved realisation of ETRS89 in Europe
ETRS89	European Terrestrial Reference System 1989
EUMETNET	Grouping of European Met Offices
EUREF	The sub-committee of the IAG with responsibility for Geodetic reference systems in Europe
EUREF-IP	EUREF real time data streaming project
EUVN	European Vertical reference Network

EVRS	European Vertical Reference System
Galileo	The proposed European civilian GNSS
GLONASS	Russian military GNSS
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System, the US military satellite navigation system
GRS80	Global Reference System
IAG	International Association of Geodesy
IGS	International GNSS Service
INSPIRE	Infrastructure for Spatial Information in the European Community, an EU directive
ITRS	International Terrestrial Reference System, a global spatial reference system, Earth centred and co-rotating with the Earth
LPS	Land and Property Services, the Government body including OSNI
NMA	National Mapping Agency
OSGB	Ordnance Survey Great Britain
OSGM02	Ordnance Survey Geoid Model 02, geoid model and corrector surface used to determine Orthometric height from GNSS observations
OSGM15	The 2015 update to OSGM02
OSGMyy	Any update of an OSGM model
OSi	Ordnance Survey Ireland, the national mapping agency of the Republic of Ireland
OSNI	Ordnance Survey Northern Ireland, the national mapping agency of Northern Ireland
RICS	Royal Institution of Chartered Surveyors
RINEX	Receiver Independent Exchange
RTK	Real Time Kinematic
SCSI	Society of Chartered Surveyors Ireland