BEREF and Lambert 2008
New geodetic and cartographical standards applied in Belgium

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BD72 and Belgian Lambert 1972

At the end of the Second World War, Belgium adopted a new geodetic system based on the Hayford ellipsoid (International 1924, see table 1), the initial point of which is situated at the Brussels Observatory. The projection chosen for creating the cartographic grid for Belgium is the Lambert conformal conic projection with two standard parallels. It is on this basis that new cartographic series were established, at a basic scale of 1:25,000.

Semi-major axis (a)	6,378,388 m
Semi-minor axis (b)	6,356,911.946 m
Flattening coefficient f = (a-b)/a	1/297

Table 1. General parameters of the 1909 Hayford ellipsoid (or International 1924).

In use since the early 1950s, the geodetic datum has nevertheless been considerably improved and a new global compensation resulted in the 1972 version, which was called the *Belgium Datum 72* or BD72. This datum still uses the Hayford ellipsoid, but the initial point had shifted since 1950 (Uccle Royal Observatory). It therefore proved necessary to define new projection parameters, constituting the system of rectangular coordinates Belgian Lambert 72 (table 2). The vast majority of current topographical maps rely on BD72 and the Belgian Lambert 72 coordinates, especially the new cartographic series created, since 1989, starting from the base scale of 1:10,000.

Geodetic system	Belgium Datum 1972
Ellipsoid	International 1924
Latitude origin	90° N
Longitude of initial point (of the central meridian)	4° 22' 02.952" E
1st standard parallel	49° 50' 00,00204" N
2nd standard parallel	51° 10' 00,00204" N
False origin – Easting translation	-150,000.013 m
False origin – Northing translation	-5,400,088.438 m

Table 2. Parameters of the Belgian Lambert projection 1972.

The BD72 datum, and the Belgian Lambert 72 coordinates associated with it, apply strictly locally. In other words, a point situated on the border between Belgium and one of the neighbouring countries presents geodetic coordinates (longitude et latitude) and rectangular plane coordinates (x, y) which are different in each country, depending, respectively, on the geodetic datum and the projection system selected by each country.

Geodetic spatial systems

In the second half of the 20th century, spatial geodesy made it possible to determine and track over time the shape of the geoid and the position of the Earth's centre of mass (which are constantly changing, notably in function of plate tectonics). By choosing the centre of mass as the common origin, a system can be composed of three mutually perpendicular axes, two of the axes forming part of the plane of the equator, whilst the third corresponds to the direction of the poles. A point may therefore be localised by any triplet of Cartesian coordinates (X, Y, Z), regardless of whether it is below, above, or on the surface of the Earth. It is on this principle that the international terrestrial reference systems have been created (for example the ITRS or *International Terrestrial Reference System* and WGS or *World Geodetic System*). Measurements are regularly carried out by combining satellite instruments and observations on the ground to determine the coordinates (X, Y, Z) of several hundred points on the surface of the Earth. The framework thus constructed (called the *Frame*) is identified by the letters of the reference system followed by the year of the observations (after the example of the ITRF2008, the last realization).

Ellipsoids globally adjusted to the shape of the geoid and centred on the same centre of mass are also established in order to allow the determination of the longitude and latitude of points on the surface of the Earth (such as the GRS80 for *Geodetic Reference System* 1980, see table 3).

	GRS80	WGS84
Semi-major axis (a)	6,378,137 m	6,378,137 m
Flattening coefficient (f)	1/298.257222101	1/298.257223563

Table 3. General parameters of two global ellipsoids.

For the sake of avoiding problems caused by separate geodetic systems per country, there is an incentive to apply a single spatial geodetic system and global ellipsoid. This is what the American Department of Defense has done by selecting the geodetic system and the ellipsoid WGS84 (the geodetic datum and ellipsoid bear the same name) as references for the GPS satellite positioning programme.

To meet the current needs, particularly those of cartography, having a reference system whose coordinates are constantly changing is anything but convenient. However, the points situated on a single tectonic plate undergo the same displacement, so that, with the exception of local accidents, one can regard them as maintaining the same relative positions. It is on these considerations that the subcommittee of the International Association of Geodesy responsible for determining the reference system for Europe (EUREF) envisioned the definition of a stable terrestrial reference system applicable in all the countries on the Eurasian tectonic plate. This was attached to the realization of the ITRS in 1989. The system, called ETRS89 (with E for *European*), is now the system recommended by the European Union for all cartographic and topographical activities, for example within the framework of the INSPIRE directive.

BEREF *(Belgian Reference Frame)*

As soon as 1989, the Belgian National Geographic Institute (*Institut Géographique National/ Nationaal Geografisch Instituut* or IGN/NGI) began participating in the EUREF programme. The first GPS campaign conducted in Belgium and in neighbouring countries has established a homogeneous network of tens of points located in precise ETRS89 coordinates. This network now relies on permanent stations of the European Permanent Network (EPN), both located in Belgium (5 stations now) than in neighbouring countries. A second GPS campaign was used to determine the ETRS89 coordinates of some 4200 geodetic points which form the Belgian geodetic frame, so called BEREF.This has now become the reference system for all national cartographic and topographic works . The GRS80 ellipsoid is associated with BEREF and together they serve as a basis for the new 2008 Belgian Lambert projection.

Lambert 2008

Once the EUREF programme allowed for the construction of the international geodetic network ETRS89, which was accurate and above all compatible with the WGS84 satellite positioning system, it was only natural to take this into account in the framework of national and European cartographical projections.

In Belgium, once the BEREF was completed, the NGI proposed a new version of the Belgian Lambert in which the coordinates of the central meridian (Royal Observatory) and standard parallels (49° 50' N and 51°10' N) have been defined this time on the global ellipsoid GRS80, linked with ETRS89 (table 4). In order to avoid any confusion with the 1972 version in reading the rectangular plane coordinates, approximately 500 km are added to the two translations of the false origin in the 2008 version of the Belgian Lambert. As this range exceeds the dimensions of the country both in Easting and Northing, there is no longer any potential confusion between the two systems of cartographic coordinates. The new projection is now applied to the NGI's topographical information infrastructure as well as to the production and updating of topographical maps.

Geodetic system	BEREF
Ellipsoid	GRS80
Latitude origin	50° 47' 52.134" N
Longitude origin (central meridian)	4° 21' 33.177" E
1er standard parallel	49° 50' N
2e standard parallel	51° 10' N
False origin – Easting translation	-649,328 m
False origin – Northing translation	-665,262 m

Table 4. Parameters of the 2008 Belgian Lambert projection.