So where are you? – Mapping Ireland

SCIENCE AND TECHNOLOGY IN ACTION EIGHTH EDITION

Accurate mapping was never as important or feasible as it is today. This lesson explores some of the underlying issues, assumptions, developments and uses of maps today. It covers elements of *cartography, mapping instruments, surveying, projection, grid reference system, the geoid, map scales and map products.*

Cartography

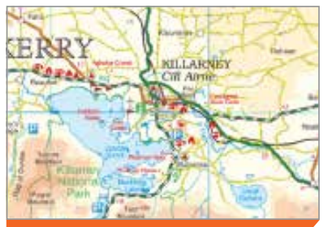
Cartography is the study and practice of mapmaking. As early as 3800 B.C. the Babylonians conducted land surveys for taxation purposes, followed by the Egyptians in order to site, level, and erect the pyramids. Egyptians used measuring ropes, *plumb bobs* (pointed weights on a string that establishes a vertical line), *sighting instruments* (in their case a palm branch with a sight-slit in the broader end) and levelling instruments. The Greeks used *triangulation* techniques and developed the *astrolabe* (by incorporating a star chart and used by sighting on a star) and the *quadrant* (which, by means of a plumb bob and a sighting of the North Star, was used to find latitude). Today's sighting instrument is called a *theodolite*.

Mapping Ireland

In 1846 the Ordnance Survey Office surveyed the entire island of Ireland for land valuation and taxation purposes. Ireland was the first country in the world to be entirely mapped at a scale as detailed as 6 inches to 1 mile, i.e. 1:10,560. It was completed using triangulation, which is the process of determining the location of a point by measuring angles to it, from each end of a fixed *baseline*. The surveyors, Colby and Drummond, introduced their own inventions. They made sightings over 67 miles, longer than previously possible, using *limelight*, and a *heliostat* (a mirror that turns in time with the Sun so as to keep reflecting sunlight toward a fixed point). They used a 10,372 m baseline on the eastern shore of Lough Foyle and used brass-iron *compensation bars* to allow for temperature changes. In 1960 the Ordnance Survey of Northern Ireland re-measured the base line using electronic equipment; the difference was approximately 2.5 cm.

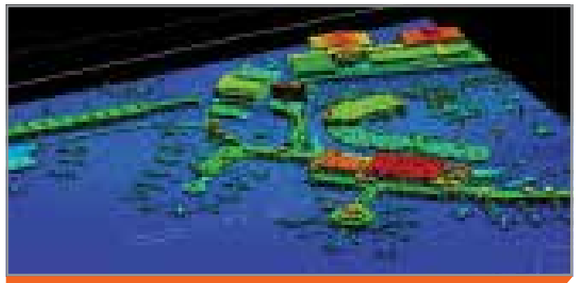
Mapping Today

OSi gathers all its map data by direct measurement. *Elevation* and three dimensional data are captured through *LiDAR* (Light Detection and Ranging) and *Orthophotography*—techniques to geometrically correct photographs so that the effects of perspective and camera tilt are eliminated.



A small-scale map of part of Ireland

OSi hosts two aeroplanes in Shannon. One carries LiDAR equipment, which reflects laser beams off the ground at a rate of 150,000 points per second and with a vertical accuracy of ±25 cm. The final outputs from this *point cloud* are either a *Digital Terrain Model* (DTM) or a *Digital Surface Model* (DSM); the terrain model reflects the bare ground only, the surface model includes vegetation and structures. The other aeroplane carries a Leica ADS800 camera and takes overlapping forward, *nadir* (vertically below), and backward views, which are subsequently combined at a *Digital Photometric Works Station* to produce the maps. The LiDAR outputs are *vector graphic images*, i.e. images made by lines connecting known points (as above); the orthophotographic outputs are *raster graphic images* (pixels or dots) that are similar to digital photographs.

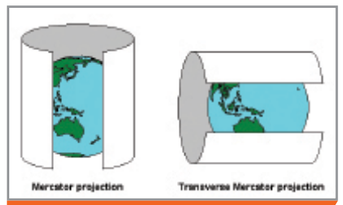

A LiDAR image of Dublin airport

Map Content

Topographic maps reflect the world as accurately as possible and generally encompass an *orientation* (indicates which direction is North), *scale* (e.g. 1:25,000 means 1 unit of distance on the map is equivalent to 25,000 units in reality), *contours* (lines that indicate land of equal height), and a *coordinate grid* consisting of squares that facilitate accurate location of features within them. A *topological* map may have few of these features; it is simplified for a specific purpose such as a schematic map for a transport system.

A challenge

The earth is spherical but not a perfect sphere; Newton had calculated (ca. 1687) that rotation would cause it to bulge at the centre, making a *spheroid*. A two dimensional map cannot fully represent the surface of the Earth. Any *projection* of the curved surface onto a flat map inevitably distorts the shape; imagine the difficulty of taking the peel off of an orange and then laying the orange peel flat on the table.



Mercator and Transverse Mercator projections

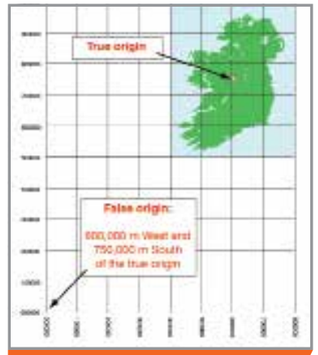
The OSi uses the *Irish Transverse Mercator (ITM)* geographic coordinate system for Ireland. The *Mercator* projection is a cylindrical map projection. It represents the world as if it were a north/south cylinder, unwrapped so that the equator (the *line of tangency*) is unchanged but the north and south poles become infinitely stretched; the distortion increases progressively as one moves from the equator to the poles. Consequently on standard world maps North America and Europe are shown larger than they should be relative to Africa and South America.

To minimise the distortion in a regional map a *Transverse Mercator* adapts the projection; the unwrapped cylinder is east-west with an appropriate line of tangency as the *central meridian* (8° West in the Irish system).

The Irish Grid

The *Irish grid reference system* is used in Ireland (in both Northern Ireland and the Republic) and is based on a modified Transverse Mercator Projection. It overlaps the British grid. The *true origin* (x,y coordinates = 0,0 or 53° 30' N, 8° W in longitude and latitude terms), a point in Lough Ree, Co. Roscommon. A *false origin* is also chosen to the west and south of all points in Ireland; this gives positive coordinates for all parts of the Ireland. The false origin is 200 km West and 250 km South of the true origin. Points to the east and north of that are referred to as *eastings* and *northings*. The co-ordinates of the true origin (in Lough Ree) become Easting 200,000 m, Northing 250,000 m and other points are adjusted accordingly.

A location may be indicated by an Easting and Northing as above, or by reference to a *grid*. Ireland is divided into 25 squares, measuring 100 km by 100 km, each identified by a single letter. The squares are numbered A to Z with I being omitted. Within each square, eastings and northings from the origin (south west corner) of the square are given numerically. For example, G0305 means 'square G, 3 km east, 5 km north'. G003005 indicates greater resolution – 'square G, 300 m east, 500 m north'.



The position of the true and false origins for Ireland

Sea Level

Height above sea level is given by the vertical *datum* which is a standard position or level from which measurements are taken. For Ireland it references the Mean Sea Level of the tide gauge at Malin Head, County Donegal. This was adopted in 1970, before which the datum had been Poolbeg Lighthouse, Dublin, which was 2.7 m lower.

Scales

Maps are produced to numerous scale sizes. An overall country map of Ireland (small scale) is 1:600,000. A large scale map such as those in use by the Land Registry might have a scale of 1:1000. Medium scale maps include city maps at 1:10,000 or typical maps for walkers at 1:50,000 or 1:30,000.

Map Products

Apart from maps used by travellers, accurate maps, as produced by the OSi, are required by architects, archaeologists, geologists and agriculturalists; for town, building and transport planning, environmental reporting, wind and flood mapping, land registration, historical mapping, aeronautical charts and boundary data (county, electoral, townland). The OSi Environmental Reports include information on land use, historic sites, land stability, water history and statutory licences.

OSi maps are increasingly being supplied via online services such as MapGenie, enabling fast and efficient access to maps from web browsers and internet connected mobile devices.

Ordnance Survey Ireland (OSi) is the national mapping agency of the Republic of Ireland. It produces and sells a very comprehensive range of urban, rural, tourist and leisure maps at a variety of scales in digital and printed form. OSi also produces aerial photographs and digital terrain models.

Customers include:

- Individual members of the public
- Tourists
- Schools
- The construction industry
- Architects
- Engineers
- Property and legal firms
- Government Departments and local authorities.

Annual sales are currently about €24 million.

OSi also licences data for a wide range of computer based applications such as Computer Aided Design (CAD) and Geographic Information Systems (GIS).

OSi products are state of the art produced by the most up to date technology and consequently the company is a leader in the Irish geographic information market.

OSi owns a network of 16 GPS stations around Ireland continuously recording and streaming data from GPS satellites back to the agency's centre in the Phoenix Park in Dublin. That information is then processed in real time. In all, OSi stores a total of some 220 terabytes in 30 separate databases. This is delivered to users by 160 servers making OSi one of the largest database managers in the country.

All products are available directly from the OSi shop (+353 (1) 802 5300) at the OSi headquarters in the Phoenix Park (near Castleknock Gate) through the website and through a national network of retail outlets.

Find out more about the work of OSi on www.osi.ie

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OSi Ordnance Survey Ireland
National Mapping Agency

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Syllabus References

The appropriate syllabus references are:

Leaving Certificate Geography

Core unit 3 (the geographical investigation and skills unit)

Students should be able to understand and use

- co-ordinate systems (latitude and longitude)
- grid references
- scale, distance and direction
- altitude and slope
- sketch maps
- symbol recognition
- pattern recognition

Learning Outcomes

On completion of this lesson, students should be able to:

- Outline a brief background to cartography
- Distinguish between topographic and topological maps
- Explain some of the traditional instruments used in mapping
- Explain the concept of projection and how it is used in OSi maps of Ireland
- Describe the Irish grid system
- Explain the concept of easting and northing
- Describe how sea level is defined for OSi maps
- Explain scales and distinguish Large, Medium and Small scale maps.
- List map users and map products
- Distinguish between vector and raster images.

General Learning Points

The following points can be used to enhance the lesson content and to inform discussion.

Spheroid and Ellipsoid

An ellipsoid is the surface of a three-dimensional shape produced by rotating an ellipse around one of its main axes. Mathematically an ellipse satisfies the equation: $(x/a)^2 + (y/b)^2 = 1$.
An ellipsoid satisfies the equation:

$$(x/a)^2 + (y/b)^2 + (z/c)^2 = 1.$$

A spheroid is a special case of an ellipsoid found by making $a=b$ in the above equation.

Magnetic declination

A compass needle points to the magnetic north which (for Dublin) is 4º 6´ to the West of the true north. The size of the variation changes from place to place and over time. When *taking a bearing* (using a compass to point in a desired direction of travel) this factor must be added (in Ireland) to the magnetic compass reading.

Total Station

A total station is an electronic/optical instrument used in modern surveying. The total station is an electronic theodolite integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

Some Terms used in Mapping:

Azimuth: This is an angular measurement in a spherical coordinate system in mapping. The azimuth of a point is the angle on the horizon between it and the North. (This is also known as a bearing).

Alidade: A device which allows one to sight a distant object and use the line of sight to perform a task (e.g. theodolite, sextant)

Turlough: A seasonal lake.

Karst: Landform that develops on rock types that are readily dissolved by rain water, e.g. limestone.

Dyke: An intrusive igneous (volcanic) body.

Fault: A fracture in a large body of rock.

Weir: A small overflow type dam.

Sluice: A water channel controlled by a gate.

Swallow hole: Point where a surface stream disappears underground.

Student Activities

1. Describe how to take a bearing using a compass and 1:50,000 OSi map. Detailed descriptions may be found online.
2. Take an area in a map showing contours and directly below the area draw an elevation showing the rises and falls. Preferably take a mountainous terrain and show the higher mountains behind the lower hills.
3. Measure the school yard (or similar area) by pacing it and taking each pace to equal 1 m. Then write the dimensions in cm as they would be represented on a 1:500 Land Registry map.
4. Go to **www.osi.ie** and with the free map viewer, find your school on the map. Describe the changes (new roads, buildings?) that took place in the area from the original 6 inch map, to the 25 inch map and right up to modern day.

True/False Questions

1. A "plumb bob" is a spherical weight suspended on a line. **T** **F**
2. A topological map accurately reflects geographic details. T F
3. The orientation of a map will tell you which side is North. **T** **F**
4. A quadrant is a four sided figure. **T** **F**
5. A baseline is a fixed line from which other measurements are derived. **T** **F**
6. Drummond's compensation bars were made of brass and iron. **T** **F**
7. The earth is a perfect sphere. **T** **F**
8. Projection is the representation of a spherical body on a flat surface. **T** **F**
9. Transverse projection uses an East-West axis. **T** **F**
10. Transverse projection uses a North-South central meridian. **T** **F**
11. The origin of the Irish grid is Poolbeg in Dublin. **T** **F**
12. LiDAR scanning produces a point cloud. **T** **F**
13. Ireland uses its own grid system to demonstrate independence from Britain. **T** **F**
14. G0305 means 'square G, 3 km east, 5 km north'. **T** **F**
15. Mean sea level is the same all around Ireland. **T** **F**
16. An ellipsoid is an exact local representation of the geoid. **T** **F**
17. A map of scale 1:600,000 is a small scale map. **T** **F**

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Geography OL 2011

11. Ordnance Survey Map

Examine the 1:50000 Ordnance Survey map and legend accompanying this paper. The map may be downloaded from:
http://examinations.ie/archive/exampapers/2011/LC005CLP003EV.pdf

(i) Name the feature/symbol which can be found at each of the following grid references:
Q 442 010
Q 441 005

(ii) Name the feature formed by coastal deposition in grid square V 48 98.

(iii) (Calculate the total area of the map in square kilometres.

(iv) State one reason why there is no evidence of settlement in the area at Q 50 04.

Did You Know?

- **Compensation Bar:** The Colby-Drummond compensation bar system adapted the compensation method used in pendulums where the different expansions of different metals can be used to make a compensating adjustment for the effects of heat on metal. The apparatus incorporated spirit level, and six 308.6 cm brass/iron bars each with a compensating microscope.
- **Conversion of eastings/northings to latitude and longitude:** The OSi website has a conversion tool to interactively convert co-ordinate points between difference reference systems.
- **Location-Based Service (LBS):** LBS is a service that uses information on the geographical position of a mobile device. A LBS may identify the nearest ATM or the whereabouts of a friend or employee. LBSs include parcel tracking, vehicle tracking, personalised weather forecasting, personalised advertising based on a customer's location.
- **Other uses of LiDAR:** Laser technology can provide very accurate measurements over very long distances. A worldwide network of observatories uses LiDAR to measure the distance to reflectors placed on the moon, allowing the moon's position to be measured with mm precision. LiDARs are also used to scan solid objects to make a 3D digital model.
- **Land Registry:** The Land Registry (which records the ownership of land throughout the Republic) is currently digitising its maps under a five-year project begun in 2005 based on satellite photography visually inspected by analytical teams based in India.

Biographical Notes

George Stokes (1819–1903)

George Stokes was the son of the Reverend Gabriel Stokes, rector of Skreen, County Sligo. He was professor of mathematics in Cambridge from 1849 until he died aged 83. He was a first class mathematician and experimentalist making significant contributions to the fields of fluid dynamics and light. He derived *Stokes' Law* giving the terminal velocity for a sphere falling in a viscous medium. He introduced the concept of the *Reynold's Number* relating inertial to viscous forces (a low number indicates laminar flow, a high number turbulent flow). The *Stokes' Shift* honours his description of fluorescence (the emission of light by a substance which has absorbed light or other electromagnetic radiation). Stokes' relevance to this lesson is through *Stokes' Theorem* which is used in calculations for the geoid.

Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

astrolabe, baseline , cartography, central meridian, compensation bar, datum, digital mapping, eastings and northings, ellipsoid, false origin, geoid, grid, heliostat , Irish grid reference system, land register, limelight, Mercator projection, orientation, orthophotography, oxyhydrogen, plumb bob, projection, quadrant, quicklime, spheroid, sighting instrument, theodolite, topographic map, topological map, Transverse Mercator, triangulation, (true) origin

Check the Glossary of terms for this lesson on www.sta