

HERSCHEL SOCIETY MEETING

Convener: Richard Phillips FRAS, The Herschel Society.

THE FRENCH CONNEXION – BETWEEN ENGLISH AND FRENCH MAP SURVEYS

Michael Knowles, BRLSI Member, on 3 January 2003

Mankind's concept of the Earth has progressed from the flat to the spherical form through Pythagoras, Aristotle, Eratosthenes (who measured its diameter) and Hipparchus up to the 17th Century.

Our knowledge of the Earth has progressed with exploration. The western limit of the ancient world was the island of Ferro in the Canaries and from the time of Ptolemy (AD150) its most western point was the basis of navigation with a longitude of 0° up to the late 15th century. In 1634 Louis XIII ratified the Ferro prime meridian as passing 20° west of Paris though this was inaccurate.

The ellipsoidal era began with Newton and Huygens. Triangulation conceived by Tycho Brahe in the 16th century was developed into a science and used to measure arcs by Willebrord van Roijen Snell in the 17th century.

In 1669 the French astronomer Jean Picard measured an arc of 1.2° north of Paris. Results suggested that the Earth was a prolate spheroid. In 1670 a decimal metric system based on the virga (1 virga = 1/1000th part of one minute of arc along a meridian = 1.852 m. = 1/1000th of a nautical mile)(1) was published by Gabriel Mouton, just after Picard published a similar idea.

The Paris Observatory was built between 1668-73 and Jean-Dominique Cassini (Gian Domenico) was appointed its first director by Louis XIV. A French expedition to Guyane in 1672 found that a clock lost 2½ minutes per day near Equator which supported the ellipsoidal Earth theory. Isaac Newton published his Principia in 1687 which predicted an oblate spheroid with the poles flattened by 1/230 of the equatorial diameter (modern value = 1/297). Around 1700 Cassini I and Cassini II extended Picard's arc to Dunkerque and Spain. This was used later for the 'Metre Survey'.

In 1724 the French Royal Academy of Sciences sent the astronomer Louis Feuillée to Ferro to determine the difference in longitude between Orchilla and the Paris Observatory.

Dedicated to resolving the question of the form of the Earth, the Academy of Sciences sent Pierre Bouguer and Charles-Marie de La Condamine to Peru in 1735 to measure a degree on the prime meridian at the Equator and in 1736 a second expedition went to Lapland, led by Pierre- Louis Moreau de Maupertuis, to measure one degree on the meridian near the North Pole.

In 1745 Cassini III published the first surveyed map of France, revealing that the land area was about 10 per cent greater than had been thought previously. The Jacobite rebellion of 1745 showed the need for a military map of the United Kingdom and by order of George III an initial survey covered SE England to Hastings and Dover.

The Cross-Channel Connexion, commenced in 1784 under Major-General Roy. Triangulation began from Windsor Castle, via Hanger Hill Tower and St Ann's Hill (Chertsey) across Surrey, Sussex and Kent to Hastings, Dymchurch and Dover Castle by 1787. The project was recorded by Roy in the Philosophical Transactions of the Royal Society Vol XX (1790) with diagrams of a Ramsden three-foot theodolite that was used for angular measurements.

The original base-line across Hounslow Heath was chosen in April 1784 between King's Arbour and Hampton Poor House. In July-August it was measured with deal rods and iron bars to be 27,404 ft. When it was re-measured with 1,370 placements of glass tubes as 27,406 ft. When this was corrected for temperature and mean sea-level, the value after re-measurement by Mudge was 27,404.2 ft (i.e. 8.352800 km). This accuracy of 1 inch in 27,404 ft is 3 parts per million.

Sightings from the ends of the baseline to St Ann's Hill (Chertsey) and Hanger Hill Tower gave another calculated baseline for the triangulations to Severndroog Castle (near Greenwich) and Hundred Acre (Banstead), then quadrilaterals through Frant to Hastings (Fairlight Down), and Hollingbourne Hill (Maidstone) to Allington Knoll and Dover Castle.

Before taking measurements to France, a check-base was set up on Romney Marsh, West of Dymchurch, of approximately 30,000 feet. The error of the value calculated by triangulation from Hounslow Heath baseline was alleged to be 1 foot (33 p.p.m.).

The cross-channel observations were made in September 1787 after the French party (Arago and Mathieu) had crossed to Dover by boat. Both parties enjoyed the cordial encounter, where a scientific common interest transcended national and political issues. A baseline was set up on the French coast East of Dunkirk but measured with deal rods. The English measurements connected with French stations of the Cassini survey at Montlambert, Calais (Notre Dame) and Dunkerque (Tower). Point M is between the latter stations. The French Revolutionary Assembly adopted the new unit of length, the provisional metre, in 1791.

A new survey, ordered and signed by Louis XVI on 19th June 1792, was completed in 1798. Astronomers Jean-Baptiste Delambre and Pierre Mechain left Paris to survey France north and south of Rodez on the basis of the triangulations of Cassini II and III - a century earlier.

The diagram of the northern triangulation from Paris to Dunkirk, surveyed by J-B Delambre, was principally in flat country and shows the baseline near Amiens. Note that the unit of measurement was the Toise (fathom) of Peru.

The diagram of the southern triangulation by P F Mechain through the Pyrenees was in arduous country. The baseline was measured from Salces to Vernet near Perpignan. The Paris meridian intersects the Spanish coast at Premià del Mar, east of Barcelona. In December 1798 there was a grand convention in Paris of the six original signatory nations to the Metric System. Mechain was plagued by realisation that one of his surveys contained an error.

The typical instrument for observing two heavenly bodies or objects was the 1805 'Repeating Circle' by Lenoir, with two telescopes. Instruments used for surveying were heavier.

While the metre survey was in progress, the first triangulation of Great Britain was undertaken from 1791 to 1822, using the new Ramsden theodolite and chains in lieu of deal rods or glass tubes. Baselines were at Hounslow Heath, Salisbury Plain, Sedgemoor, Misterton Carr, Clifton (Yorks), Belhevie Sands (North of Aberdeen) and Rhuddlan Marsh, North Wales. The Irish Survey was also undertaken by Colby, from his HQ in Phoenix Park, Dublin. Ireland was connected with the British Island across St George's Channel and Irish Sea using limelight introduced by Major Drummond and which was visible by night at 67 miles.

The Greenwich-Paris connexion was re-measured in 1821-23 by Colby and Captain Henry Kater, who ignored the work of Roy and Mudge of 1784-87. The surveys in France were supervised by Arago and Mathieu. The Cross-Channel sightings were made over distances up to 48 miles (77 km) with 3-ft limelights.

As calculations were based on the Bouguer spheroid, the 1821-23 re-measurement was technically better than that of Roy and Mudge. Kater wrote his report before the French published their results. The difference of longitude between Greenwich and Paris was calculated via Calais (Notre Dame) as $2^{\circ} 20' 10''$. The Greenwich physical meridians of Bradley, Pond and Airy were superseded by a virtual meridian following satellite measurements in the 1970s.. The IGN value is $2^{\circ} 20' 14.25''$.

No historical account of the Cross-Channel Connexion would be complete without a mention of Alexander Ross Clarke. He attended the Royal Military Academy at Woolwich, joined HM Ordnance Survey in 1850, and was appointed Head of Dept of Trigonometry and Levelling in 1856. In 1863, he led a new triangulation between England, France and Belgium and made determinations of the form of the Earth in 1858, 1866 and 1880, leading to publication of his book Geodesy in 1880.

Clarke's spheroid of 1866 was used as the basis of geodesy by triangulation in the United States, a gargantuan task of the early 20th century, undertaken by General Gordon Meade. Meade's Ranch contains a stone marker, which was used as the datum for triangulation. In 1927, it was adopted by Mexico & Canada and thus became the geodetic centre of North America.

Baseline measurements and national surveys proliferated in the 19th century.

In 1824, Austria based its cadastral longitudes on the Ferro meridian. In 1832, the German mathematician F. W. Bessel measured a baseline and set up the observatory at Königsberg. The Federal German survey is based on a national reference point at Rauenberg near Berlin (in Bavaria at Munich Marienkirche) and international reference points introduced with effect from 1991.

The French meridian and the Metre Survey were celebrated in France at the Millennium, by the creation of "La Meridienne Verte" - a line of trees planted along the historic axis. This was especially celebrated at the town of Clermont de l'Oise, which is very near the meridian. A statue also commemorates Cassini III, i.e. Cesar Francois Cassini de Thury. The Cassini family tree shows a complete dynasty of French astronomers. It extends over a century from the opening of the Paris Observatory in 1672 and appointment of Cassini I.

The churches at Clermont, Noyers St Martin and Coivrel used as triangulation points now have new towers, new roofs and repairs of damage in WW2 which mask traces of the astronomers' visits, if any remained.

The Orchilla lighthouse now stands on Ferro at Ptolemy's meridian, an historic juxtaposition of two great contributions to the sciences of navigation and geodesy in the seventeenth century, which one may still inspect today.

A selection of documents was received from the Orchilla Lighthouse including photocopies from "El Hierro – La Isla de la Longitud"

Copyright Michael Knowles & Richard Phillips © 2003

Following photograph of Hanger Hill Tower in 1880 from a published work: by courtesy of Hanger Hill East Residents Association.



48. Photographed in 1880 shortly before its demolition this tower, known as Mount Castle, was on the site of Fox's Reservoir. It is said to have been an Elizabethan watch tower but during the nineteenth century it was the resort of local people who, on clear days, could see as far as Windsor Castle from its summit and have refreshments in its tea-garden.