

The Geodesic Base of Piombino: The Measurement of Italy under an Historical Point of View

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Abstract – The cartographic unification of the Italian peninsula with the *Carta Topografica d’Italia* used the important work done during the pre-unification period and the last years of the XIX century. After the territorial unity of 1870 (leaving aside the appendix of the unredeemed lands of the north-east annexed after the Great War), the vision of a wider space for movement and citizenship took shape. For this reason, it is important to guard the memory and safeguard of all trigonometric points, like geodesic base lines, witnessing in the country the long and hard measurement work.

Keywords – Geodesic; base; Piombino.

INTRODUCTION

A little disclosed field is the cartographic production that took place both before the Unification of Italy and immediately after. The considerations on the before and after are important since the cartographic theme must be analysed as an ever-evolving scientific-historical path that collects previous works by incorporating them into new realizations bearing in mind, in parallel, the technical progress of the survey instruments and techniques [1-7].

MAPPING ITALY

A. The Topographic Map of Italy (1875)

After the territorial unity of 1870 (leaving aside the appendix of the unredeemed lands of the north-east annexed after the Great War), the vision of a wider space for movement and citizenship took shape. However, the design of the 278 sheets (so many were necessary) required immense technical efforts both for the heterogeneity of the pre-unification productions and for the vastness and type of territory to be measured. Among the various technical aspects, there was the measurement of the geodesic bases, which are, as the name states, the foundation of the first order triangulation and define the metric of the territory to be represented.

Given this importance, history and places must be re-

evaluated, as well as rediscovered, in order to remember, with the protection of the monuments that determine it in the territory, the continuous work of measurement that with the global vision of the world has linked points that are also immensely distant from each other. More generally, the definition of a geodesic monument for the strongholds of the geodesic bases, must educate to respect these, often, anonymous objects lost in the plains because they are, directly or indirectly, at the service of the knowledge and management of the space transformed into a territory. Therefore, it does not seem risky to conceive the link between the protection of measuring points and the protection of the territory in its broadest meaning.

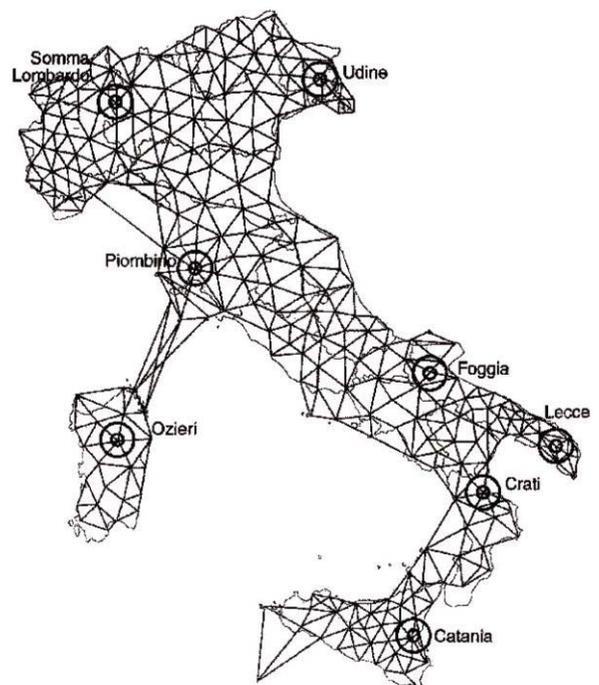


Fig. 1. The National Geodesic Network with the location of the eight historical geodesic bases.

The great geodesic work for the scientific re-

measurement of the peninsula began in 1867 and ended in 1918 with the publication of the first National Geodetic Network. In order to make the long compensation calculation of the network as a whole less laborious, a compensation for partial networks was decided, each of which referred to one of the bases. This made it necessary to introduce a connecting network between those connected to the bases placed in Somma Lombarda, Udine (both in the north of Italy) and Piombino (in the middle of Italy) as shown in Fig.1.

B. The Unification of Maps

With the unification of Italy (March 17, 1861), the various pre-unification cartographic bodies were merged into the Sardinian one, although some continued to operate autonomously in subsequent years such as that of Naples.

To identify an act that marks the beginning of the unitary cartographic representation of Italy, law no. 782/1862 which ordered the completion of operations in southern Italy with the Charter of the Southern Provinces (1862-1876, 1: 50000, 174 sheets). And since this map had to be scientifically accurate, the three geodetic bases of Catania, Crati and Lecce were measured, while that of Foggia had already been measured before the annexation of the Kingdom of the Two Sicilies (October 1860). Following the territorial unification of Italy in 1870, with law no. 2364/1875 the project of the Topographical Map of Italy was launched whose works lasted from 1875 to 1903. The scale of the map, now called by the IGM SERIE 100V, was 1:100,000 and was composed of 277 + 1 sheets (Cantile A., 2007).

Four other bases were measured or remeasured for this undertaking: Udine, Somma Lombarda, Ozieri and Piombino. It is worth mentioning that the unitary geodetic-topographic works were placed within the context of a broader program of studies and measurements on the shape and size of the Earth promoted in 1861 by General J. J. Baeyer (1794-1885). This project had, among other things, the objective of measuring a meridian arc between Palermo and Christiania (now Oslo) (Baeyer J. J., 1861).

Italy joined the international project by establishing the National Geodetic Commission (1864) also to facilitate the availability of funds and personnel for the design of national cartography. The Commission always sought the collaboration of the Papal State, in the figure of Fr. A. Secchi (1818-1878), director of the Astronomical Observatory of the Collegio Romano.

MEASURING THE EARTH

A. The measurement of the territory.

The measurement of a territory made significant progress at the beginning of the seventeenth century when the Dutch W. Snellius (1591-1626) used the triangulation method to measure the meridian arc Alkmaar-Bergen op Zoom in 1617. The triangulation procedure was devised by the cartographer Gemma Frisius (1508-1555) in 1533

(Haasbroek ND, 1968, pp. 12-14) and also used by the astronomer Tycho Brahe (1546-1601) to connect to the continent the astronomical observatory of Uraniborg built in 1576-1580 on the island of Hven located in the arm of the sea between Denmark and Sweden (Haasbroek ND, 1968, pp. 29-47). Triangulation consists in measuring the internal angles of a series of contiguous triangles, as equilateral as possible, which form a network called geodesic.

The vertices from which the angles are measured must be intervisible at least with the closest ones, possibly not too far away to overcome the problems of atmospheric refraction and, at the same time, not too close so as not to perform an excessive number of observations with the possible increase of the errors.

Obviously, the accuracy of a measurement of this kind also depends significantly on the construction of the instruments used. Furthermore, it should not be forgotten that in the eighteenth and early nineteenth centuries the numerical calculation of trigonometric functions was done by hand with the help of special tables and therefore was very long and laborious and a source of further errors.

The mathematical theory underlying triangulation is spherical trigonometry, which, with the help of some theorems (e.g. Legendre's of spherical excess), can be traced back, for limited areas, to plane trigonometry. To measure the distances between the vertices using the angles measured (the real purpose of the geodetic operation) the direct measurement of the length of at least one of the sides is required. This operation is called the *geodetic base*.

B. The geodetic base

The geodetic basis is the distance, measured with very high accuracy (error less than 1 mm), between two arbitrarily chosen points on the ground, possibly in a flat area to facilitate the subsequent mathematical operation of carrying over to sea level.

Table 1. Main data of historical geodetic bases

Base	Year	Length (m)
Somma Lombardo	1788, 1878 - 1879	9999.54
Udine	1874	3248.58
Piombino	1895 1959	4621.51 11643.11
Foggia	1859 - 1860	3930.42
Ozieri	1879	3402.23
Lecce	1872	3044.23
del Crati	1871	2919.55
Catania	1865	3692.18

High accuracy is required because measurement errors could propagate in an uncontrolled manner, invalidating

the entire operation, that is, as they say, they would not allow the network to be closed with an incorrect assessment of the distances. Given the importance of a geodesic base, some historical-technical information of the eight historical geodetic bases used for the map are reported below in order of decreasing latitude. The tab. 1 shows the main data of the bases.

THE GEODESIC BASE OF PIOMBINO (LIVORNO, TUSCANY)

A. The Location

The extent of the old base developed along a country road between Piombino and Vignale Riotorto. Today, the road is called “via della Base Geodetica” (street of the Geodetic Base) and connects the hamlet of Vignale Riotorto to the hamlet of Fiorentina of Piombino. The new layout of the base runs almost parallel to the old one. Length: 4621.51 m (1895) which was mistakenly increased to 4621.57 m.

The measurement of a new base in Piombino, more than double that of 1895, was decided following the directives dictated by the II International Cartographic Conference of the UN (Tokyo, October 1958) to calibrate the new instruments for measuring distances with electromagnetic waves (electro-optical distance meters) (Salvioni, 1960a)[8].



Fig. 2. The Geodesic Base of Piombino, East edge: general view of the pillar: the Author's bicycle has been placed as a dimensional reference.

The new base, which was to be at least 10 km long, was measured with 7 invar wires.

Details and drawings of the extremes of the base from 1959 can be deduced from (Salvioni, 1960)[9]. The measurement of 1959 (length 11643.11 m) made it possible to highlight the error that was made in the measurement of 1895 since the side of I order *Monte Massoncello - Poggio Montieri* (see Fig. 2 and Fig. 3) was shorter by approx. 0.80 m of that measured then (Pericoli A., 1997).

The error was inexplicably kept secret even if, among the various clues, two were macroscopic: the anomalous introduction of a connection network between the 'areas' affected by the Ticino, Udine and Piombino bases and the equal closure error at approx. 10 m between the triangles of the Gargano peninsula with those coming from the Dalmatian coast. The error arose from the incorrect sampling of the Bessel beam compared to that of Peru, an error of 0.00026 m!

The error of the beam was immediately corrected on the measurements of the previous geodetic bases, but it was also on the basis of 1895 where there was no error because the new coefficient was already applied! Therefore, from these considerations the length of the base of 1895 was erroneously increased to 4621.57 m [10-12].



Fig. 3. The Geodesic Base of Piombino, East edge: detail of the plaque.

B. The West Edge

It should be noted that due to the very marshy terrain, the west side was placed on a pile of pine trunks levelled to a depth of 2.50 m.

The bronze doily remained permanently buried under the thick ballast of the new road (depth approx. 1.50 m). The monumental pillar, already 0.65 m off the centre to the south, was moved to a new base, demolishing the old one, in a nearby vineyard and is located 9.64 m from the bronze centre, always towards the south.

A new plaque was affixed to the new monument (July 1982), below the ancient one, with the following text: “*A seguito dell’ampliamento della strada attigua - nel giugno 1981 questo monumento fu spostato dalla sede antica - e ricostruito nell’attuale posizione: metri 9,64 a sud dall’estremo della base geodetica*” (Traslation: “Following the enlargement of the adjacent road - in June 1981 this monument was moved from its ancient site - and rebuilt in its current position: 9.64 meters south from the end of the geodesic base”).

At the moment, it can be visited with great difficulty.

C. East Edge

Due to the more compact soil than that of the west edge, the east side was placed on an underground basement without piles at a depth of only 1.80 m.

It had the shape of a monument with an articulated and tapering shape similar to that of the west edge (see Fig. 2 and 3). On one face, the emblem of the “Regno d’Italia” and the inscription:

“Istituto Geografico Militare - Base di Piombino - misurata nell’anno 1895 - Lunghezza m. 4621,51 - Estremo Est.”

Following the reconnaissance in 1959, it was found that the pillar is not aligned with the centrepiece (see Fig. 2 and 3).

D. Ancillary references

There are a series of ancillary references, which, in the past, were used to measure the distance of the Island of Elba, as they are orographically troubled regions. They are generally placed on hills in such positions that, as the authors have verified, they have excellent visibility at both ends of the geodetic base and, at the same time, enjoy the visibility of *Monte Capanne*, the highest mountain on the island. Our reference in particular is located on *Monte Massoncello* (see Fig. 4), one of the hills overlooking Piombino. Although their history has been lost historically and although very little has remained in the technical archives, their function has been recognized again. This research was a sort of spinoff of our laboratory's measurement program.



Fig. 4. The ancillary geodetic reference of Monte Massoncello.

CONCLUSIONS

In this work, we have historically recovered one of the many terrestrial references that have served to mingle and make known the newly reunited Italy of a century and a half ago. The loss of historical memory and the correct introduction of much more accurate and less cumbersome measurement systems [13,14] (telemetry lasers, differential GPS, etc.) has made not useful and not necessary the enormous efforts that in the past were made

to collect measurements of distance.

We wanted to recover and highlight the very noble and difficult work of topography that has been so useful for the growth of our nation.

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