The Geometry of the Roman Torino, that is to say the Varatio of Augusta Taurinorum

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Abstract This work is proposing the use of the geometry based on rectangular triangles, the varatio, in the study of the planning of Roman Torino, that is, of Augusta Taurinorum. It is known that the planning of Roman towns was based on the centuriation, a grid of parallel and perpendicular streets, where the two main axes were the Decumanus and the Cardo. By means of the varatio, the angle the Decumanus was forming with the east-west direction was given by the ratio of the catheti of a rectangular triangle. In the case of Torino, the town planning seems based on the ratio of catheti 1:2, which is giving an azimuth of the decumanus (Via Garibaldi) of 116,565° from true north. This value is in good agreement with the measurement of the direction of this street.

Keywords: Centuriation, Orientation of Roman colonies, Varare, Varatio

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The planning of the Roman colonies was mainly realized, by the ancient land surveyors, by means of a method which is known as *limitation* or *centuriation*. This planning is characterized by a layout in the form of square or rectangular grids, created by parallel and perpendicular roads or canals, which were subdividing the settlement into *insulae*. These parcels of land were the house-blocks in the towns or the agricultural plots in the countryside. In some cases these plots were allocated to Roman army veterans [1]. The main axes of the grids were the *decumanus maximus* and the *cardo maximus*. The parallel roads to them were the *decumani* and the *cardines*. Of course, the choice of the place of a town or colony was mainly dictated by the local environment and the presence of rivers and roads.

To subdivide and label the plots of the land, the surveyor (*gromaticus*) identified a central viewpoint, known as the *umbilicus agri* or *umbilicus soli*. Taking position there and assuming the same orientation of the decumanus, the gromaticus defined the territory with the following names: *ultra*, the land he saw in front of him; *citra*, the land behind him; *dextera*, the land to his right; *sinistra*, the land to his left [2,3]. According to the Latin writer Frontinus [3], who was referring Varro, the Romans inherited this manner of subdividing the land from Etruscans.

We read in [3] that the *decumanus* runs from *oriens* to *occasus*, that is from the sunrise to the sunset. Of course, this is a natural manner to identify the plots of the land by a simple orientation from east to west and from north to south, in order to have a conventional method to label them. Actually, this happens because the centuriation was a process at the end of which the land was parcelled out and assigned (ager "divisus et adsignatus") [4].

After Frontinus' words, some scholars, such as Walter Barthel for instance [2], argued for an orientation of the decumanus towards the point of the horizon where the sun was rising, *secundum coelum.* Other scholars maintained that the orientation was just dictated by the local environment or by the main roads of the area, as stressed by Le Gall and Castagnoli [5,6]. In any case, to have the regular grids of the limitation matching the local environments, *secundum naturam*, the Roman surveyors, the Gromatici, had to rotate the grids. Actually, these surveyors possessed some methods to adapt the grid to the land, methods that we can include under the term of *varatio.* The literature of the Gromatici shows that the varatio was based of the geometry of triangles [7,8].

Several articles are discussing the link between geometry and Roman land surveying. In [9], we find a detailed discussion of the centuriation, applied in particular to the analysis of the Roman Tunisia. In [10], we find explained - with several illustrations - the methods used by the Romans and the Euclidean geometry involved in them. Let us stress that in [10] the author, Roth-Congès, uses the verb *varare*, from which *varatio* is coming. This verb can be translated in the action of measuring by means of triangulation [11]. In [12], it is told that the term *varatio*, also written *uaratio*, refers in general to the process of oblique surveying. It has two approaches: the v*aratio fluminis*, by means of which the distance of an inaccessible point could be calculated by the construction of right angled triangles, and the v*aratio in agris divisis*, that the surveyors made by means of lines "along the hypotenuse of right angled triangles defined in a rectangular coordinate system" [12]. This second v*aratio* is the one which is statistically analyzed in [12]. As stressed by John Peterson, when introducing his analysis, the variety of observed oblique relationships, that is (1:1, 1:2, 2:3, 3:4 …), is limited.

Besides the study of *varatio* concerning the Hadrian's Wall and the Wetterau Limes [12], we can find the *varatio* considered for the orientation of the Roman towns in Spain [13,14]. In [15,16], we have analyzed some Roman towns in Italy, Como, Verona, Pavia, and others. In [16], Torino was shortly discussed. Here we consider this town specifically.

In the discussion here proposed, let us assume that the *insulae* of the centuriation are squares. Then the town planning is essentially a chessboard of insulae. The towns of Como and Verona, as shown in [15], are examples of a chessboard rotated to form, with the east-west axis, a rectangular triangle with sides 3,4 and 5 (the fundamental Pythagorean triple). In the Figure 1, the rotated chessboard is shown.

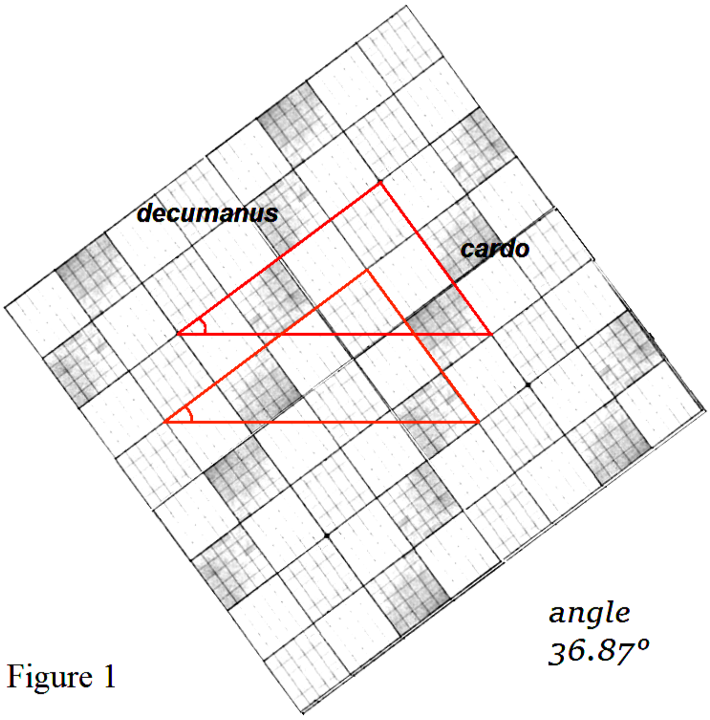

Figure 1

In the Figure 1 we can see the rectangular triangles (Pythagorean triple 3,4,5) which could have been used in the *varatio* of Como and Verona [15]. The hypotenuses are coincident to the east-west direction. The catheti have to correspond to 3 and 4 *insulae* respectively. The two catheti give the directions of the *decumanus* and the *cardo* (in this case 4 and 3). The angle between the decumanus and the hypotenuse is $\alpha = \arctan(3/4) = 36.87°$. Then, the azimuth from true north of the *decumanus* is 53,13°.

Let us now analyse the case of the Roman Torino, that is, Augusta Taurinorum**.** About the foundation and the orientation of Torino, we discussed in [17-19]. Torino was probably founded in 28/27 a.C. as the *colonia Julia Augusta Taurinorum*. The Roman town was placed close to the confluence of Dora and Po rivers, at the foot of the hills (see Figure 2).

In 69 AD, the colony suffered a great fire as reported by Tacitus [20]. It was probably after this fire that the colony was subjected to some restructuring works. The colony received a sewage system and an aqueduct, and some streets were paved. The network of the Roman sewage system was running under the decumani and cardi of the town [21]. Under Via Garibaldi, the decumanus maximus of the Roman colony, it was running the greatest sewer. Actually, we can easily appreciate that Via Garibaldi slightly slopes down from Piazza Statuto to Piazza Castello, that is, approximately from the west gate to the east gate of the Roman town. It means that, in the first century AD, the decumanus of Augusta Taurinorum was rebuilt above the greatest sewer, which was gently sloping down to help the drainage of waters.

The Roman town, its perimeter and the position of the gates are given in the Figure 3.

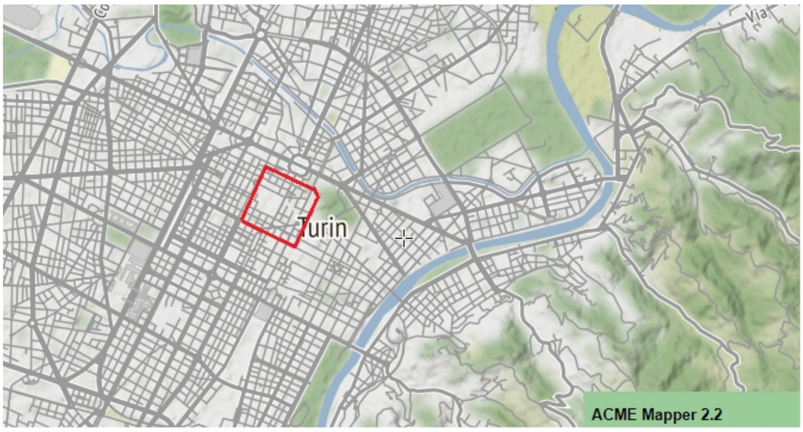

Figure 2: Thanks to Acme Mapper, https://mapper.acme.com, we can appreciate the position of Augusta Taurinorum, the red square, and the terrain surrounding it.

Figure 3: This is the Roman Torino from Acme Mapper. The places of the four gates are marked (two of them are still existing). The Decumanus Maximus, the modern Via Garibaldi, is the inclined east-west line. Note the blocks coincident with the roman insulae. The "umbilicus", the centre of the town, is at the crossing of the decumanus and the cardo. The perimeter of the Roman town is running from Porta Palatina to Via della Consolata. Then the perimeter turns south on Via della Consolata and Corso Siccardi. On this side, there was the gate Porta Segusina, of which nothing remains. At the corner of Via Cernaia, the perimeter turns toward Porta Marmorea, completely dismantles. Today, on this path there are Via Cernaia, Santa Teresa, Maria Vittoria, Piazza San Carlo. At the corner of the Academy of Sciences, where we find the Egyptian Museum, the perimeter is running due north, crossing Piazza Castello, where there is the Porta Decumana. Then the perimeter crosses the area of the Royal Palace, returning to the Porte Palatine.

Now, according to the varatio, what was the geometry of Torino, or better, of Augusta Taurinorum? More precisely, of the town as it was after the fire of 69 AD.

The geometry of Torino was probably based on the rectangular triangles 1:2. This geometry had been suggested by Gaetano Barbella in 2008 [22]. Triangles are shown in the Figure 4. In the image, the *Decumanus* and the *Cardo* are also shown such as the position of the four gates.

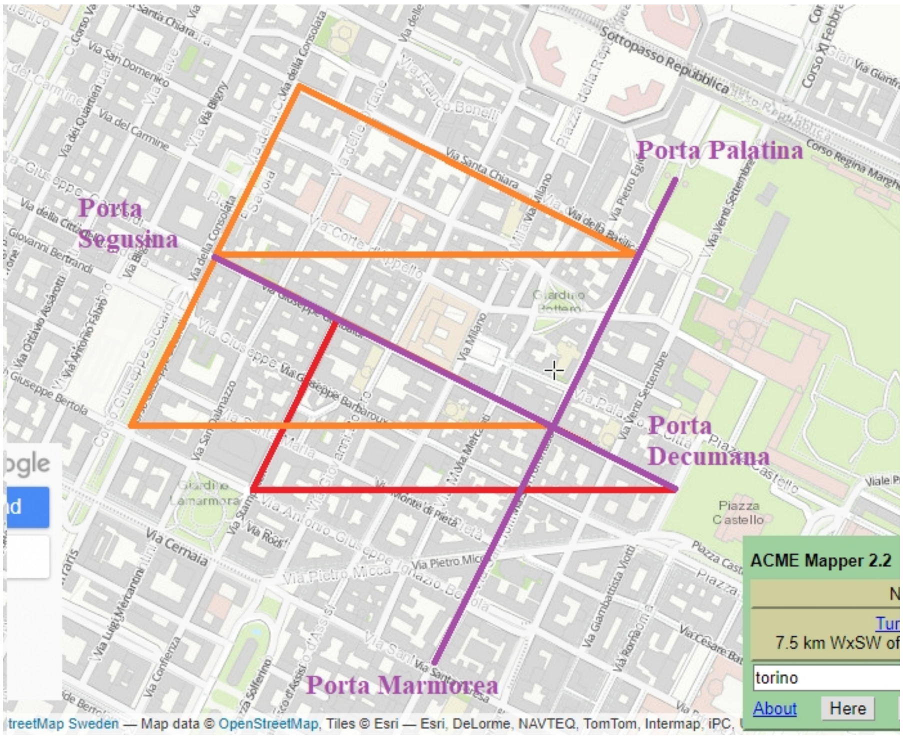

Figure 4. By means of Acme Mapper and © OpenStreetMap contributors, we can see the layout of Torino. OpenStreetMap (CC BY-SA). In the image, the *Decumanus* and the *Cardo* are also given.

The angle between the decumanus and the hypotenuse is $\alpha = \arctan(1/2) = 26{,}565°$. The azimuth from true north of the *decumanus* is 116,565°. In [23], we find a value of the measured azimuth of Via Garibaldi of 116,379° +/– 0,002. The difference 0,186°, that is 11' of degree, is a very small difference indeed. So it seems that the geometry proposed by Gaetano Barbella could have been the varatio used for Torino, to have the best agreement between the planning of the colony and the local environment.

To conclude, let me quote an important sentence. As told in [24], the author of [25], Alan Kaiser, is telling that the “Roman Empire used standardized street grids to efficiently lay out new towns and colonies during rapid imperial expansion”. Then, also Torino had its planning determined by a standardized urban layout, based on the ratio 1:2.

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[3] In the Corpus Agrimensorum Romanorum, which is the Roman book on land surveying collecting works by Siculus Flaccus, Frontinus, Aggenus Urbicus, Hyginus Gromaticus and other writers, we find the following (ex libro Frontini secundo): Limitum prima origo, sicut Varro descripsit, a disciplina Etrusca; quod aruspices orbem terrarum in duas partes diuiserunt, dextram appellauerunt quae septentrioni subiaceret, sinistram quae ad meridianum terrae esset, ab oriente ad occasum, quod eo sol et luna spectaret, sicut quidam architecti delubra in occidentem recte spectare scripserunt. Aruspices altera linea ad septentrionem a meridiano diuiserunt terram, et a media ultra antica, citra postica nominauerunt.

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[11] For "varo", see the link https://www.dizionario-latino.com/dizionario-latino-italiano.php?lemma=VARO200 ; vara, https://www.merriam-webster.com/dictionary/vara . "varo" is related to "vara", a sort of pertica. This noun indicates in general "any of various branched structures or implements". It is a term derived from feminine of vārus, "bent outwards with converging extremities, bow-legged," of uncertain origin.

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