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## Remote archaeoastronomical analysis of the town-planning of the Roman Aosta

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### Abstract

For what concerns the astronomical orientations of architectural complexes, a preliminary analysis can be made by considering the local astronomical horizon, to evidence the possible existence of alignments along the rise or setting of the sun, the moon or some bright stars. This analysis can be easily performed using satellite imagery and software for the simulation of astronomical events. In the case of a positive result, that is, that an astronomical alignment is possible, a further analysis can be made by means of the local natural horizon. Actually, also this further analysis can be obtained by means of software. Here we show that using Google Earth, a remote archaeoastronomical analysis is possible. The case study considered is that of the Roman Aosta.

Keywords: Archaeoastronomy, Simulation software, SunCalc.org

In astronomy, and therefore in archaeoastronomy, we have to consider two horizons. One is the astronomical horizon, which is the horizon that would be seen if the earth's surface were perfectly smooth. It is given by the intersection with the celestial sphere of the local horizontal plane which is passing through the observer. The second horizon is the natural or sensible horizon, that is, the line at which the sky and Earth appear to meet. If we use a software simulating azimuth and altitude of the sun or the moon, such as SunCalc.org, MoonCalc.org or the Stellarium for the stars, we have to remember that the lines representing their azimuths are given on an astronomical horizon. However, the true visibility of sun and moon and the stars too, is depending on the local natural horizon.

Therefore, for what is concerning the astronomical orientations of architectural complexes, we can perform a preliminary analysis, by considering the local astronomical horizon, to evidence the possible existence of alignments along the rise or setting of celestial bodies. This analysis can be easily made by means of the satellite imagery and software for the simulation of astronomical events. In the case of a positive result, that is, that an astronomical alignment is possible, a further analysis can be made by means of the local natural horizon. Actually, this further analysis can be obtained by means of software too. We can apply Google Earth, and its tool giving the elevation profile for such a remote archaeoastronomical analysis.

Before discussing a case study, concerning the town-planning of the Roman Aosta, let us observe the following. We could have an ideal orientation or a natural orientation of the considered site. In the first case, the orientation would be just symbolical, not referring to the actual point of the natural horizon where sun, moon or stars are rising, but referring to an ideal horizon. In the second case, it is the natural point of the horizon which is prevailing, because related to some landmarks such as peaks or hills of the local landscape. Then, let us start considering Aosta for our remote archaeoastronomical analysis.

In proto-historic times, Aosta was a center of the Salassi, probably a Celtic or Ligurian population. Many of the Salassi were killed or sold into slavery by the Romans [1,2]. It was in 25 BC, when Augustus ordered a campaign, led by Terentius Varro, against them. After this campaign, Varro founded the colony of Augusta Praetoria Salassorum for the retired veterans. The layout of Augusta Praetoria is therefore the typical one of the Roman colonies, which is the same of that of the military camps (castra) [3].

The roman walls of the town are still partially preserved, such as the streets; they were enclosing a rectangle 724 by 572 metres [2], partitioned by the regular scheme of parallel and perpendicular streets (Figure 1). Two of them are the main streets, the Decumanus and the Kardo, which are crossing at right angles near the center of the settlement. In his book on the ancient town-planning of Romans, Haverfield wrote about these main streets, that probably they "were laid out under definite augural and semi-religious provision" [3].



Figure 1: Augusta Praetoria in Wikimapia. The "Torre di Bramafam" is occupying the area of the Gate Principalis Dexter of the Roman town.

When Haverfield discussed the town of Timgad [4], he referred to what Walter Barthelemy wrote, about the orientation of the Decumanus. In [5], Barthelemy told that the orientation of Roman planning was based on the 'Disciplina Etrusca', a set of rules for conducting all sorts of divination. In the Disciplina [6], Heavens and Earth, supernatural and natural world, or, if we prefer, macrocosm and microcosm, appear echoing each other in a doctrine based on the orientation and division of space. The two intersecting straight lines, Kardo and Decumanus, give the orientation of the space. Let us note that Kardo is the word used to indicate the pivot about which something turns, and then it is used also for the axis of the sky, about which we see it rotating.

In the Etruscan Doctrine, if an observer is at the cross-point of the two lines, and he is facing South, he sees two half-spaces delimited by the Decumanus. The southern half-space is the 'pars antica', 'the anterior part'. The northern half-space is the 'pars postica', 'the posterior part'. A similar partition of space occurs along the Kardo. To the left of the observer, there is the eastern sector, that of good omen, the 'pars sinistra' or 'familiaris'; to the right, he has the western sector, of ill omen, the 'pars dextra' or 'hostilis'[6]. The sky is further subdivided in sixteen sectors, each having its divinity.

In Haverfield [3], we find also that the Decumani could have been determined to have their direction aligned along the azimuth of the rising sun. The Decumanus points, "where the sun rises above the horizon on the dawn of some day important in the history of the town" [3], or, let us add, important for symbolic reasons. Since the sunrise azimuth changes during the year, the Decumani have different orientations. By means of satellite maps and sunrise azimuths, it is possible to check if a Roman town or castrum had a possible solar orientation (it is remarkable the presence of towns aligned along the sunrise/sunset solstices, as discussed in [7]). Of course, this analysis is not limited to Roman locations; it is easy to find several examples of places around the world, which have a solar orientation in their planning (see for instance [8-10]), in a layout symbolically linking Earth and Heavens.

In [11], Giulio Magli investigated the orientation of the Decumani of several Roman towns in Italy, to determine if an orientation of them along sunrise azimuths is possible. In the article, we can read that: "We are interested here in the yearly movement of the rising sun at the eastern horizon during the course of the year. I will completely avoid any consideration which would actually alter the "idealized" view I am going to adopt, thus, in particular, I will not take into account atmospheric refraction, and the possible existence of a local non-flat horizon. The reason is that this paper of course does not aim to a complete archaeoastronomical evaluation of each site, ... . My aim here is rather to investigate on the existence or not of an 'archaeoastronomical phenomenon' which, once proved, would certainly show the need for a more complete analysis" [11]. This is interesting. Actually, we can make two investigations; the first is concerning a possible astronomical orientation, which is involving the local astronomical horizon; the second is an analysis of alignments, by means of the local natural horizon (Adriano Gaspari, Osservatorio Astronomico di Brera, is illustrating the difference of the two horizons in [12]).

In [11], among the towns considered for the analysis of the astronomical orientation according to the sunrise azimuth, we find Augusta Praetoria, the town that we are using here as a case study for illustrating our remote archaeoastronomical analysis. In 2013, the same town had received a further investigation by Stella Bertarione and Magli, with an approach based, this time, on the natural horizon [13]. The archaeoastronomical analysis of the Roman layout was made in [13], "taking into account the complex natural horizon of the Alps in which Aosta valley is nested". As told in [13], the "results show that the town was very likely oriented in such a way as to pinpoint Augustus associations with the cosmic signs of renewal: the winter solstice and the Capricorn". Actually, as we will show in the following discussion, it is the Kardo having the main role in the astronomical orientation allowed by the local environment. In [13], we find that it has a natural orientation according to the winter solstice. For Aosta, the orientation of the Kardo is more relevant than that of the Decumanus.



Figure 2: A Kardo of Aosta, seen by means of Google Earth in the Street View mode, in the direction looking at the 'anterior part' of the town.

Is it necessary to visit Aosta on the winter solstice, to evidence the alignment of the Kardo? The answer is negative. Of course, Aosta, the Rome of the Alps, is beautiful and deserve a visit for sure, but it is not necessary for testing the above mentioned archaeoastronomical alignment. We can use a remote archaeoastronomical analysis.

Here in the following we show the method. It is based on software SunCalc.org, already used in [14-18], and on Google Earth. To have an idea of the natural horizon, let us consider a Kardo, like the street in the Figure 2, seen by means of Google Earth in the Street View mode, in the direction looking at the 'anterior part' of the town. We see the Monte Emilius ridge, that, as told in [13], "raises as much as 3000 meters at less than 9 Kms from the center" of Aosta.

Now, let us consider software SunCalc.org, which is giving azimuth and altitude of the sun for any moment of the day, on any day of the year. In the Figure 3, we can see that, on the winter solstice, the Kardines are oriented towards the sun, when it has an altitude of 17.60 degrees. Let us consider again article [13]; in it, we read what happens in Aosta on the winter solstice: "the sun rises with a theoretical azimuth of 125 degrees but remains behind the mountain ridge to the south-east until it has an altitude of 17 degrees. The azimuth of the sun at this altitude is very close to that of the Aosta Kardo". In [13], it is also mentioned that the altitude of the sun, at Augustus' time was greater of 0.42 degrees, due to the precessional effect. Of course, in the Figure 3, we are using the astronomical horizon.

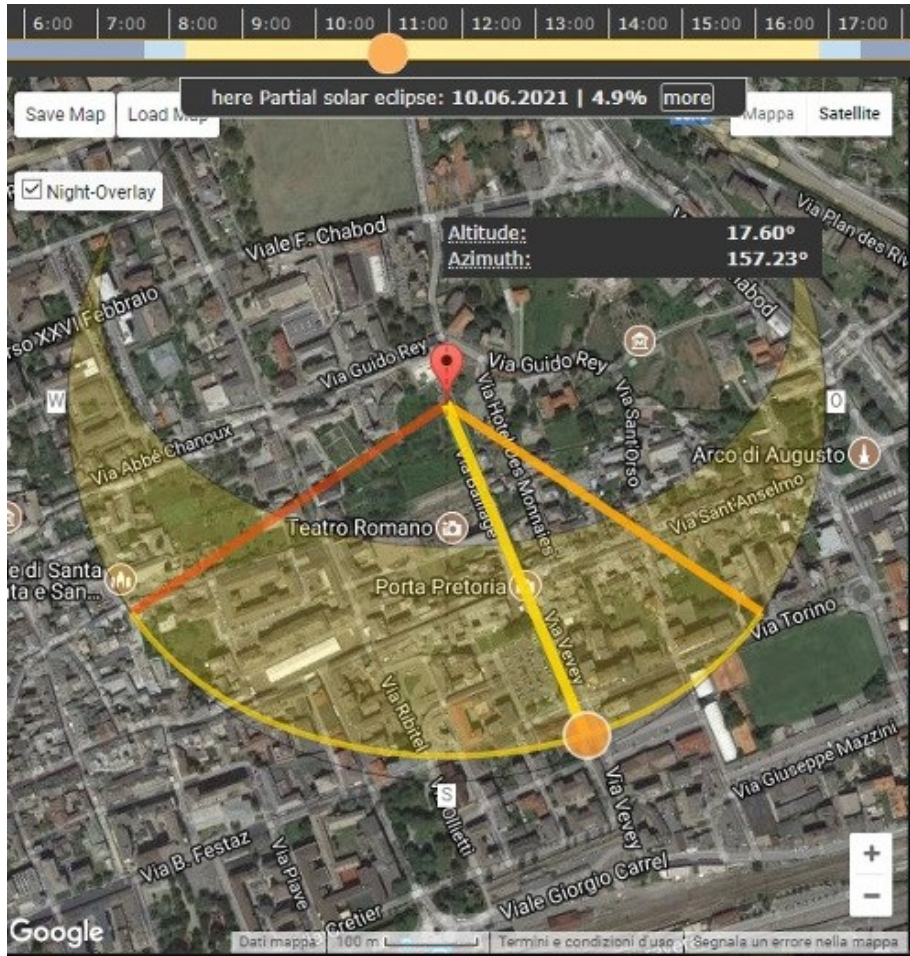


Figure 3: SunCalc.org screenshot, for Aosta, on December 21. The Kardines are aligned along the solar azimuth when the sun has an altitude of 17.60 degrees.

How can we obtain information about the natural horizon, and evidence the sun altitude mentioned in [13]? Here in the following the solution.

Let us consider Google Earth. It has a tool for showing the elevation profile. So, let us consider a straight line passing through Aosta, as in the Figure 4, parallel to the Kardines. The sun, for being seen by an observed in Aosta, must have an altitude greater than the angle between the yellow line, shown in the low part of the Figure 4, and a horizontal line. This angle is easily calculated. It is given by:  $\arctan [(2110-563)/4930] = 17.42$  degrees. Compared to the altitude given in [13], the difference is of 0.42 degrees, the same value of the precessional variation, that we can consider as the uncertainty of the altitude given in [13].



Figure 4: We can use Google Earth and its tool for showing the elevation profile. So, let us consider a straight line passing through Aosta. The sun, for being seen by an observed in Aosta, must have an altitude greater than the angle between the yellow line and a horizontal line. This angle is given by:  $\arctan [(2110-563)/4930] = 17.42$  degrees.

As a conclusion, we can tell that the Kardo of Aosta is aligned along the azimuth of the appearance of the sun on the natural horizon, on the day of the winter solstice. To obtain this result, we have used SunCalc.org software (Figure 3) and the Google Earth elevation profile (Figure 4). By means of this case study, we have seen that a remote archaeoastronomical analysis of a site is possible, when we have to consider the role of the natural horizon as relevant (another example of this approach was given in [18]). For what is concerning Aosta, other evidences are furthermore supporting the astronomical orientation of the Roman town, as given in [13].

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