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Mediterranean Archaeology and Archaeometry
Vol. 22, No 2, (2022), pp. 189-207
Open Access. Online & Print.

DOI: 10.5281/zenodo.6886485

THE DATE OF FOUNDATION OF AUGUSTA TAURINORUM (TORINO) BY CROSS-CHECKING ASTRONOMY, ARCHAEOLOGY AND GROMATICS

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Received: 09/05/2022
Accepted: 21/07/2022
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ABSTRACT

The paper dates the foundation of the city *Augusta Turinorum* (Turin) by applying an interdisciplinary and cross-checking method that relies on astronomy, archaeology and philology. The foundation procedure employed in the Hellenistic/Roman time has been reconsidered after a careful reading of the texts of the gromatic treatises of *Sextus Iulius Frontinus* and *Hyginus Gromaticus* who inform us that, at some point, the *decumanus* was oriented following the Sun position at its rising and at its falling by means of a gnomon. Then, an accurate reconstruction of the sun motion and the local measurement conditions by computing algorithms for the True Sun and applying the gnomon theorem, so far never introduced for such studies, provide a range of reliable years in which the alignment of the *decumanus* (the urban axis of the city) and the course of the Sun occurred. Finally, with the help of historical criticism and of professional astronomical tools, and according to some peculiar historical and archaeological condition of *Augusta* Taurinorum, the foundation day results the 30th of January, with good chances for 9/8 BC, in concomitance with the celebration of the festival at the *Ara Pacis* in Rome, instituted by the Senate of Rome in honor of *Pax* and in order to celebrate the reditus of *Augustus* from Gaul and Spain.

KEYWORDS: Ara Pacis, Augusta Taurinorum, Augusta Praetoria, Astronomy, Capricorn, Corpus Gromaticus, Decumanus, gromatics, Hyginus Gromaticus, Hyginus Minor, Kardus, Roman Town, Sextus Iulius Frontinus, Torino, True Sun.

1. INTRODUCTION

Since XIX century, archaeology and astronomy studies highlighted the existence of recurrent alignments between the road axis of several Roman *castra* and colonies with the Sun position on specific days of the year (Niessen, 1869; Erdmann, 1883; Valeton, 1893; Brown, 1980; Hawkins, 1985; Aveni, Romano, 1994; Torelli, 1966; Audin, 1949; Decramer, 2011; Lanciano, Virgili, 2016). Recently, a study conducted over 38 Roman cities (Magli, 2008) demonstrated how their alignments span a relatively narrow range related to the sun positions at its rising, while other researches established a connection between the orientation of some Roman cities to specific days of the year (González-García et al., 2019). A further analysis of 92 cities founded or rebuilt during Augustus' time shows «a major concentration of orientations towards the winter solstice sunrise, with also significant orientation towards the cardinal points and summer solstice» (González-García, Garcìa Quintela, Rodríguez-Antón and Espinosa-Espinosa, 2022).

As a matter of fact, the date of the foundation of many ancient towns was linked to religious calendars. The ancient writers (Plut. *Romulus* 11, 1-12; Zonara *Epith.* VII, 3) mention the foundation of Rome at the "pastoral New Year" of the *Parilie* on 21th April, 753-4 BC (Carandini, 2007) recorded as *Natalis Urbis Romæ* and celebrated by Hadrian with the *Romaia*, while Constantinople was founded in honor of Saint Mocius on 11th May, 330 AD (Barnes, 1981) and *Brindisium* on 5th August in coincidence with the festival of *Salus* (Miano 2015).

The importance of the ritual orientation of ancient buildings, cities and fields in antiquity is highlighted by many evidences spanning from pagan temples (Richardson 2005, Liritzi, Vassiliou, 2002, 2006a and 2006b) to the christian churches in Late Antiquity and Middle Age (Neri, 2015, Dallas, 2015 and 2016; Spinazzò, 2016).

In respect to the Augustan age, connections between the local topography and the course of the Sun have been suggested for: *Lugdunum*/Lyon, oriented with the rising sun on 1st August (day of the Celtic *Lughnasadh* and first day of Augustus' month) (González-García and García Quintela, 2016); *Ara Ubiorum*/Cologne oriented with the sunrise on 23th September, Augustus' birthday (Espinosa-Espinosa, González-García and García Quintela, 2016); *Augusta Prætoria Salassorum*/Aosta, a colony founded in 25 BC, oriented with respect to the winter solstice sunrise, *i.e.* to the Augustus conceiving (Bertarione, Magli 2014); the *Ara Pacis Augustae* in *Campus Martius*, oriented to the rising Sun on 21th of April, coinciding with the foundation of Rome (Vence Tiede, 2016).

The present work examines the case of *Augusta Taurinorum* (Turin), nowadays an industrial city of about 1 million inhabitants famous for having been the first capital of Italy, formerly a Roman colony founded in Augustan age in a well-irrigate plain surrounded by the Alps. The study of the inauguration day of Turin can represent a 'case model' to investigate the foundation criteria of the Roman colonies. Our novel findings have been obtained by interfacing archaeology, astronomy along with a careful reading of the gromatics' texts concerning the *limitatio* (the art to trace the fields boundaries), and the orientation of *cardines* and *decumani.* As it will be clarified in the following sections, an important role was played by the *ars gnomonica*.

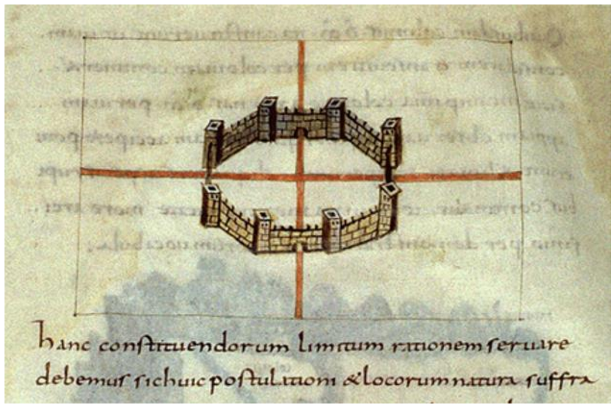

Figure 1. An image from the Corpus Agrimensorum shows the ideal city where the decumanus and the kardo originate in the middle of the castrum end extend to the country through the city gates (from Dilke 1971)

2. HISTORICAL BACKGROUND

2.1. The gromatic texts

The *gromatici* or *agrimensores* were the Roman technicians who had in charge the division and the measurement of the lands. Among the most significant treatises preserved we must consider *de limitibus* of *Sextus Iulius Frontinus* - who lived at the age of Trajanus and was also author of *De aquis urbis Romae*- and *de limitibus constituendis* of *Hyginus Gromaticus* - whose activity is framed between the II and the III c. AC - also called Minor to be distinguished from *Hyginus Maior* active in the previous century.

The gromatics, who worked in close relationship with the *augures* during the foundation of Roman cities, clearly state the existence of a strict connection between the centuriation and the urban city grid. In particular, *Hyginus Gromaticus* expressly declares as "ideal" the colony where the city grid overlaps the centuriation (Hyg. Grom. *Const. lim.* L. 180, 10-15).

Furthermore, the *gromatici* point out how the centuriation ideally should originate from the center of the town and spread towards the country through the main city gates (Hyg. Grom. *Const. lim*. L. 178, 1-9), (See Fig. 1).

The act of *condere* ("founding") and track the centuriation were both necessarily coordinated and synchronic (Migliario, 2011).

During the imperial age the foundation procedure revitalized the ritual 'of the origins', according to *Sextus Pompeius Festus*, *Sextus Iulius Frontinus*, *Hyginus Gromaticus*, and *Gaius Iulius Solinus*. Namely it comprises three subsequent steps: i) the auspices, ii) the inaugurate rite, iii) and the *solcus primigenius* of Romulean tradition.

Sextus Iulius Frontinus clarifies how the *decumanus,* traced from east to west, settles the orientation of the city axes (Front. *de lim.* L.10-11, 20-8). As a matter of fact, in order to deduce the Roman town orientation, the prevalence of modern archaeoastronomers hypothesize a line connecting the observation spot with the position of the rising Sun on the horizon.

Noticeably, *Frontinus* states that many cities were founded by orienting them according to the rising of the Sun: «Optimal and rational is the orientation of the fields when the *decumani* are traced from east to west and the *cardines* from south to north. Nevertheless many, following the variable rising and setting of the sun, changed this principle. So, when the measurement was made, they oriented the *decumans* in the direction where the sun was rising» (Front. *de limit.* L. 31, 1-5, translated by the authors).

Afterwords, with the aid of a *groma*, the gromatics would have derived the perpendicular, that is to say the *cardo* south-north axis. It's worth premising that the gromatics indicate the north-south axis with the term «midday» or «sixth hour» with respect to the shadow cast by a gnomon on a dial (Dilke, 1987).

In summary, many late republican and imperial cities were not simply oriented east-west, but frequently pivoted of some degrees clockwise (Magli, 2008).

The Latin sources do not explain carefully the reason, possibly related to the aim to optimize the life quality of their inhabitants and to obtain the best insolation in each season (Incerti, 2010). The final choice was presumably a trade-off between several factors such as: religious and ritual aspects (Gottarelli 2013a, Carandini, 2007), the presence of major traffic routes, the need of an efficient solar exposure, the local winds (Vitr., de *arch.* I, 4 and 6), the local geomorphology and hydrology (Dilke, 1976), the use of Hellenistic science, technology and medicine as stated by Vitruvius (Vitr. *de arch.* I, 10).

Besides, *Hyginus Gromaticus* asserts that some gromatics oriented the *limites* not only taking into account the rising point of the sun but also its falling, and that the interferences due to the natural reliefs at the horizon implies a variation of the *decumanus* azimuth. Then, the presence of a natural obstacle on the horizon delays the rising of the sun while the presence of a relief at the sunset anticipates its setting (Hyg. Grom. *Const. lim.* L.108, 9-10).

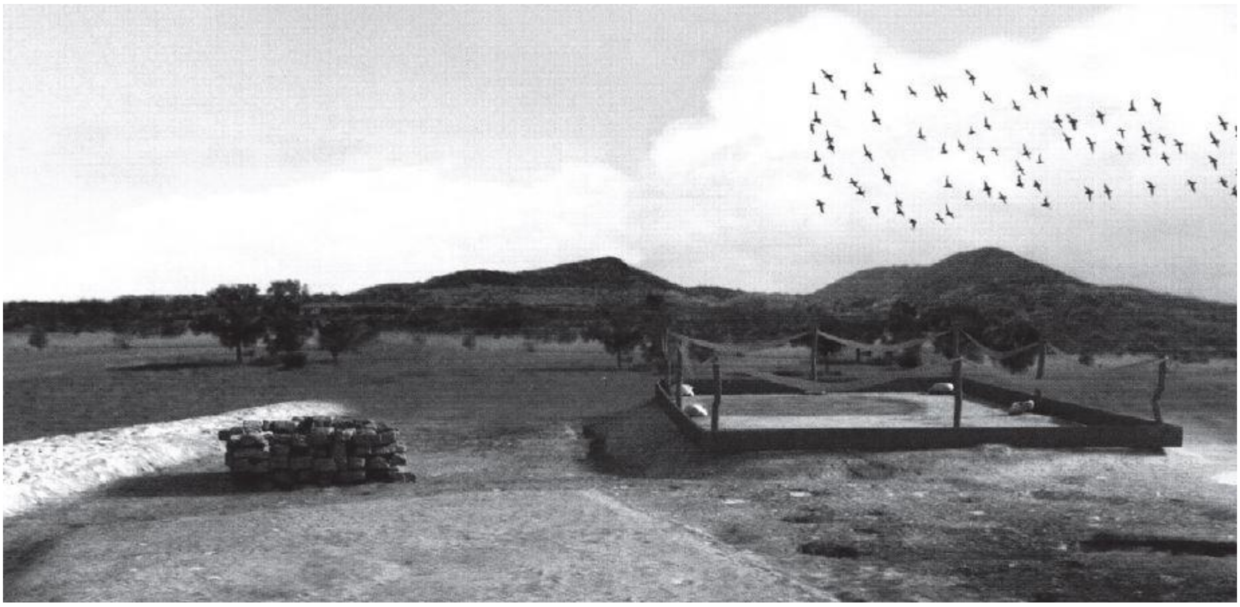

Figure 2. Visual reconstruction of the auguraculum of Meggiaro d'Este. On the right the 'templum in terris' describing, in a smaller scale, the 'squared' shape of the forthcoming city. The templum is the place where augures obtained the auspices just before the foundation act and the 'Romulean' ritual ploughing (Ruta Serafini and Seinati, 2002)

2.2 The inauguration and foundation criteria

An attentive reading of the *Corpus Gromaticus Agrimensorum* (Blume and Lachmann, 1952; Thulin, 1971) shows that a complex procedure was involved. Noteworthy, the most recent papers concerning the foundation criteria suggest an inaugural activity focused on the movement through different points in order to accomplish some progressive and autoptic observations aimed at balancing the city axis with the real course of the sun at its rising and setting (Gottarelli, 2010).

The concept finds archaeological support thanks to the discovery of several cippi and *auguracula* at *Bantia* (Torelli, 1966), Meggiaro di Este (Ruta Serafini and Sainati, 2002, see Fig. 2), and Marzabotto (Sassatelli and Govi, 2003).

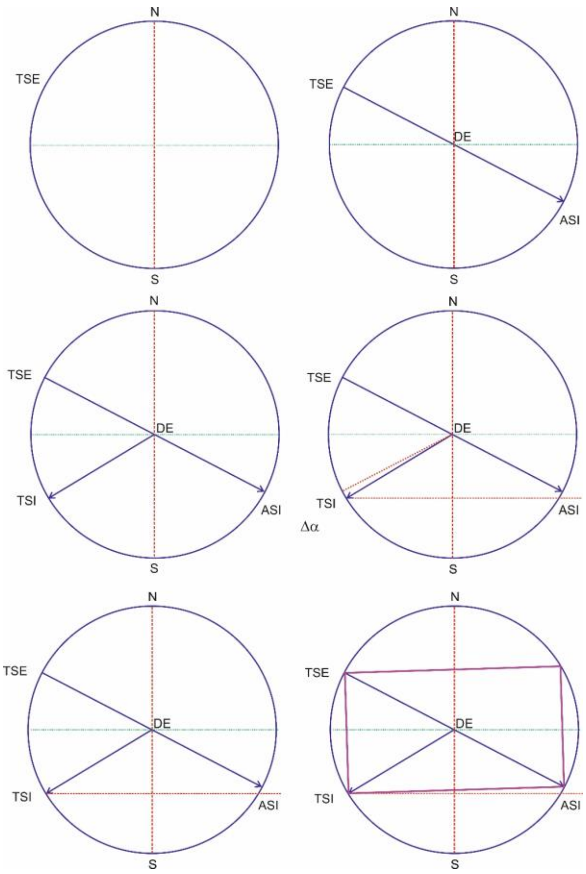

Figure 3. Sequel of operations according to Gottarelli (2013) in order to orient the decumanus following the course of the Sun from its rising to its falling on the foundation day (A. Gottarelli). TSE stands for the sunset point at the summer solstice, TSI for the sunset point at the winter solstice, ASI the rising sun on winter solstice, DE for decussis. A detailed description is in section 2.2

The model concerning the foundation of archaic Etruscan cities (like Marzabotto) implies the tracking of the city *decumanus* along the E-W direction by exploiting the diagonal lines inscribed in the gromatic circle.

In the present work we introduce a modified scheme that merges the theorical fundaments of the *inauguratio* criteria and those applied by the gromatics.

In the model proposed by Gottarelli (Gottarelli 2013 a and b) (Fig. 3) the *auguraculum* is arranged at the western end of the forthcoming city whence it would have be possible to capture at a glance the space to inaugurate.

In the ideal procedure, the first observation occurs at winter solstice from the sunset point at the summer solstice (TSE) in order to contemplate the SE quadrant, this is to say to the rising sun on winter solstice (ASI). In order to complete the operations an *auguratorium/decussis* (DE) is placed at the midway of the *decumanus* at the intersection with the *kardo*.

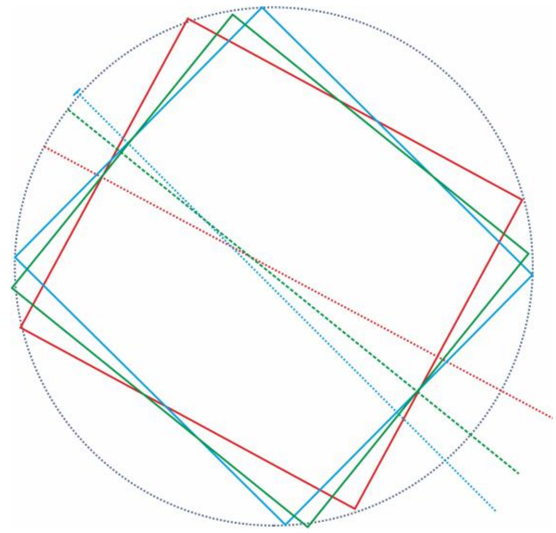

Figure 4. Orientation of a Roman town according to the presence of obstacles to the horizon. Green: no obstacle to the horizon. Red: presence of reliefs to the sunrise horizon (anticlockwise rotation). Blue: presence of reliefs to the sunset horizon (clockwise rotation)

Later, a second line is traced from the *decussis* (DE) to the setting sun (TSI stands for the sunset point at the winter solstice). By tracing a further segment from ASI to TSI the *decumanus* is determined.

The angular deviation of the TSI-TSE axis thus obtained is then used to correct the original TSE-ASI line axis via a practical adjustment.

The orientation of the decuman results perfectly East-West in presence of a flat skyline, but slightly revolved of some degrees clockwise or anticlockwise according to the presence of natural reliefs at the horizon that delay the rise of the Sun or anticipate its setting (Fig. 4).

Noteworthy, the model has been conceived for Marzabotto, i.e. a town founded in archaic age where the decumans lays on the E-W orientation determined by the diagonals TSE-ASI and TSI-DE.

Our adaptation to the above model (preliminary introduced in Crosta, Caranzano, Massone, 2020 and references therein) relies on the practical application of the gnomon theorem, widely quoted by gromatics (Boeth. *Eucl.* L. 385.20). We assume the following procedure (see Fig. 5).

At first, a line joining the *auguraculum* (TSE) with the appearance point of the sun (AS) is traced, taking into account (if the case) the effects due to the obstacles represented by hills or mountains.

Applying the Marzabotto model, the *auguratorium* station (DE) is fixed at the midpoint of the forthcoming *decumanus* (line TSE-AS).

Very likely the gromatics accomplished their task with the help of a gnomon, as indeed recalled in their treatises. *Hyginus Gromaticus* clarifies the context: "We must call for help the supreme and divine art of the *gnomonica*. Indeed, our wish to obtain the 'true' can not be satisfied if not with the movement of a shadow" (Hyg. Grom. *Const. lim.* L. 184.1, translated by the authors).

The gromatics could have in practice compared three shadows due to a gnomon: the first appearance at dawn (hA), the shorter length corresponding to midday (hM), and the last glow of the sunset (hT).

Having identified the N-S axis (i.e the meridian) and a perpendicular to it, the correction is dictated by the difference between the lengths at rising and setting due to the presence of hills and mountains.

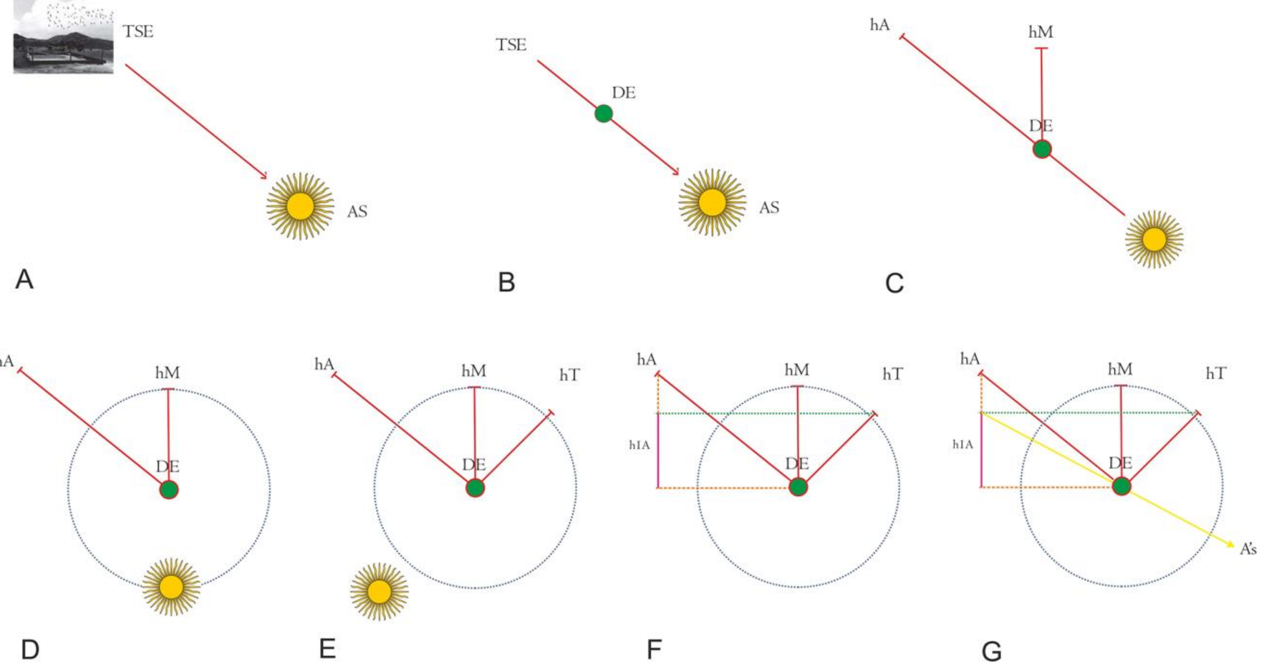

Figure 5. In this figure we adapt the basic Gottarelli' s schema to the Hyginus Gromaticus recommendations for city foundations during the imperial time in case of obstacles intervening along the sunrise/sunset direction. The whole procedure is composed by the following steps.

A. The sunrise is observed from the auguraculum TSE position and then a sign along such a direction is placed in hA (corresponding to the end point of the sun shadow at sunrise).

B. An auguratorium station DE is chosen along the direction TSE-AS. At noon, the shortest shadow of the Sun of length hM is recorded

C. A circle with center DE and radius hM is drawn (indeed the circumference with the shortest radius). With 2 or 3 shadows proceeding and following the Sun culmination on the meridian, the N-S axis perpendicularly to the E-W axis is thus obtained.

E. The sunrise is observed from the DE position and then a sign along such a direction is placed in hT (corresponding to the endpoint of the sun shadow at sunset).

F. Given the (possible) difference of the shadow heights projected at sunrise and sunset onto the W-E axis (equinox line), from hT a parallel to such axis is outlined to intercept the segment starting from hA.

G. The line hT -DE traces the final direction of the decuman with azimuth AS'.

The intersection thus obtained is joined to DE determining the "balanced" axis of the decumanus. Estimating the *proximum true ortum* point - which in itself does not produce a significant shadow in the immediate rising - involves such an adjustment in order to inscribe the "foundation" rectangle in the reference circle on the ground.

The correction on the rising point can be easily obtained by considering the theorem of gnomon for the geometrical computation, namely from Euclidean equivalences, corresponding to the azimuth correction of $\Delta A = 2\pi - (AT + AS)$, where AT and AS are, respectively, the azimuths at sunset and sunrise (Fig. 6).

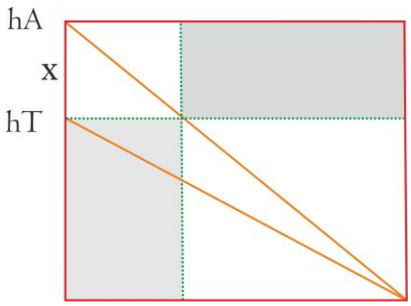

Figure 6. Step F in the procedure depicted in Figure 5 is an application of the gnomon theorem. The grey areas are equivalent and according to the second theorem of Euclid the segment x is the quantity to be subracted to hA in order to obtain the equivalence in defect as explained in section 2.2

Following Pitagora, the number was conceived according to the nature of the gnomon. The Euclidean "algorithm" was used to apply mutual subtractions of iterative processes aimed at finding the common measure between two quantities. The gnomom theorem (*Elements*, I ,43) states that in each parallelogram the complements around the diagonal are the same. Undoubtedly this was well known, the deduction of the golden section relies on such a proposition as application in excess. For the application in defect, as our case, " If a straight line is cut into equal and unequal segments, then the rectangle contained by the unequal segments of the whole together with the square on the straight line between the points of section equals the square on the half."(*Elements*, II, 5). According to this proposition and the notations in Figure 6, the rectangle $hT \cdot x$, is the difference of two squares $(hT + x)^2/4$ and $(hT - x)^2/4$ or, equivalently, $(hA)^2/4 - (hA-2x)^2/4$. In other words, since $hA \cdot x - x^2 = hT \cdot x$, the area of the rectangle with segments hA and x minus the square of x is equal to the rectangle with segments hT and x that in terms of angles translates into applying the azimuth correction at hT.

While the *groma* was the essential instrument for tracing right angles with the due precision on the ground and for establishing the centuriation, the gnomon shadow represented the complementary basic tool for every theoretical consideration on the movement of the Sun (Hyg. Grom. *Const. lim.* L 189, 1-15).

2.3 The astronomical toolkit

The *decumanus* of Turin coincides with the present via Garibaldi as indicated in the archaeology city map published by C. Promis in 1868 and later revised by A. D'Andrade, where the ruins of the Roman walls, roads and sewers revealed through occasional excavations and public works, are superimposed to the modern city layout (see Figs. 7-8).

The measurement of the astronomical azimuth by means of a theodolite, *i.e.* with respect to the astronomical north, provided a value of 26°40′ E-S-E, *i.e.* 116.379°±0.002° respect to north (see Appendix B, in Crosta, Caranzano, Massone, 2020).

In our investigation, we use two approaches: the evaluation of the Sun motion both at its rising and setting with the confrontation of the True Sun motion, and the simple visual alignment with the rising point on the horizon.

The related literary fragments show a certain degree of indefiniteness concerning the exact location chosen for the astronomical observation (*i.e.* the *auguraculum*). No detailed information is provided on the instrumental error introduced during the observation and the operations carried out on the ground, as well as no records of the possible disturbances generated by occasional atmospheric or climatic anomalies.

Another problem regards the moment in which the position of the Sun was measured, *i.e.*, when the first glare of the Sun or a portion of the its disc was beginning to be barely visible (Gottarelli, 2003A).

Fortunately, once again the gromatics come into our help. They are pretty explicit in considering both the first and the last glow of the Sun. *Hyginus Gromaticus* states that the observation must be conducted *unde primum sol appareat, occasum, ubi novissime desinat: hactenus dirigere mensuram laboraverunt* (Hyg. Grom. *Const. lim.* L. 183.1).

The opposition between *primus* and *novissime* (the first and the last) validate such a hypothesis. Moreover, the use of gnomon suggests that, in case of not optimal visibility conditions, the first record could be corrected at dawn with the second measurement at sunset.

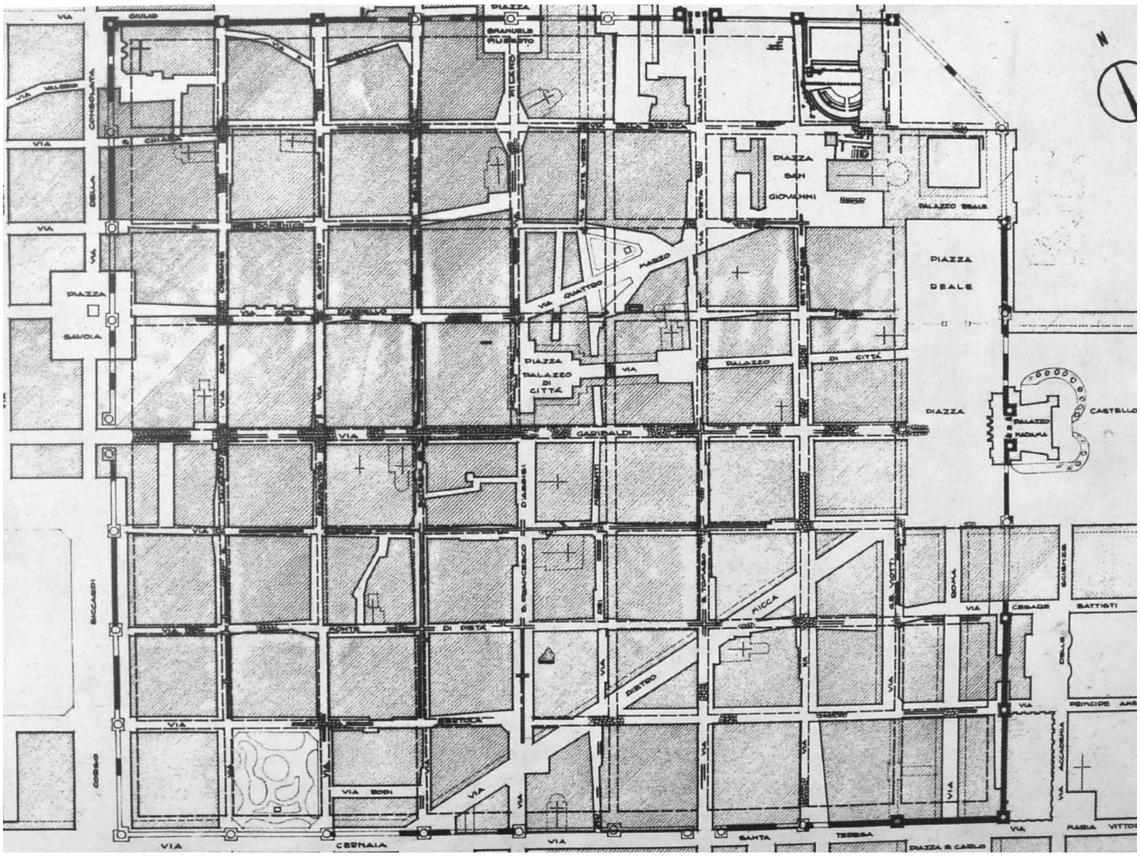

Figure 7. Map published by C. Promis in 1868, where the ruins of the Roman walls, roads and sewers revealed through occasional excavations and public works are superimposed to the modern city layout. It is an historical document testifying that via Garibaldi follows exactly the orientation of the Roman decumanus

Figure 8. The Roman decumanus unearthed at the interception of via Garibaldi with piazza Castello (source: https://www.museotorino.it/images/1f/5e/22/78/1f5e2278f2514d2e8864e264c9bb3a03-1.jpg?VSCL=100)

Some kind of cultural implication concerning the relations elapsing with the ancient naturalistic beliefs and *kosmos* could also be evoked (Gottarelli, 2010).

To obtain reliable data we used the astronomical algorithms for a True Sun (Laskar, 1998; Bretagnon, Simon 1986; Lattanzi and Pannunzio, 2006; Meus 1999) implemented in a IDL program (Interactive Data Language version 8.7.3) specifically developed for this study. The purpose of such an elaboration is also to frame a coherent mathematical and astronomical set-up to analyze and reconstruct back the measurement operations made by the gromatics.

In addition to the true motion several factors could invalidate the observation of the first appearance of the Sun limb, in particular: i) the atmospheric refraction that anticipates the onset of dawn (a very uncertain value, since does not exist an analytical function which links the heights with the atmospheric parameters); ii) the human error in the detection of the solar edge (about 3 arc minutes, as the human eye can perceive with the naked eye a separation of about one arcminute); iii) finally, in the case of Turin, the elevation of the hill, with a highly variable profile, which alters the astronomical horizon.

Furthermore, daily variations of the weather or other causes influence the times of the Sun rising (for example a different arboreal population). The local geographic conformation was considered (the elevation and distance of the mountainous or hills were determined with Google Earth). Curiously, the extension of the orientation of Via Garibaldi over the hill locates very close to the Turin Astrophysical Observatory (INAF-OATo, see Fig. 9).

Figure 9. Map of the geographical context where the direction of the sunrise et sunset are traced. Source: Google

In summary, to the angular height at the rising point we need to subtract the refraction angle (estimated by the program considering standard atmospheric pressure and temperature values) and the angular radius of the sun (again computed by the program according to the ephemerides at that epoch). Given the latitude of Turin (λ = 45.07°), the formula for the azimuth (A) computation is obtained by the first fundamental formula of spherical trigonometry, namely:

$$A = \left(\frac{180}{\pi}\right) \arccos\left(\frac{\sin\delta}{\cos\lambda\cos h} - \tan\lambda\,\tan h\right), (1)$$

where h is the Sun height and δ its declination. The corresponding hour angle (H) results:

$$H = \left(\frac{180}{\pi}\right) \arcsin\left(\frac{\cos h}{\cos\delta}\sin A\right)\ (2).$$

Formulas (1) and (2) depend on the Sun declination calculated as

$$\delta = \arcsin(\sin E \sin L), (3)$$

where E represents the average obliquity of the ecliptic (*i.e.* its average inclination with respect to the celestial equator) and L the apparent geocentric ecliptic longitude (corrected for the aberration) of the Sun, both calculated according to the algorithms that provide the true Sun positions (Lattanzi and Pannunzio, 2006; Meus, 1999).

Finally, the above spherical trigonometric formulae depend on time, in astronomy computed by means of the Julian date that uniquely identifies the moment in which a certain astronomical phenomenon occurred regardless of the calendar in use.

As regards the assessment of the visual obstacle to the rising and setting of the Sun, the reconstruction of the diagonals on the local horizon between the TSE-DE points has been carried out on a cartographic basis.

Since the line of sight, at the hypothetical DE point, could also be tangent to the second hilly peak, a range in height between 268 m and 314 m over an estimated distance of about 4500 m (first peak) and 8120/8500 m (second peak), has to be considered, it corresponds to an overall elevation in degree between 1.8° and 3.4° (Fig. 10).

Figure 10. Reconstruction on a cartographic basis of the line of sights over the local horizon between the TSE and E-S direction at the rising of the Sun (Turin hills). Source Google Earth

The horizon at the sunset (near Col Giulian) presents an altitude interval of about 2555 m on average over an estimated distance of 54.3 km, equal to an elevation of 2.69 ° (Fig. 11).

The data generated by the IDL program were then restricted around the measured value of the azimuth of via Garibaldi within an interval of approximately 2° (therefore also including the road width, *i.e.*, a parallactic angular value of about 0.07°).

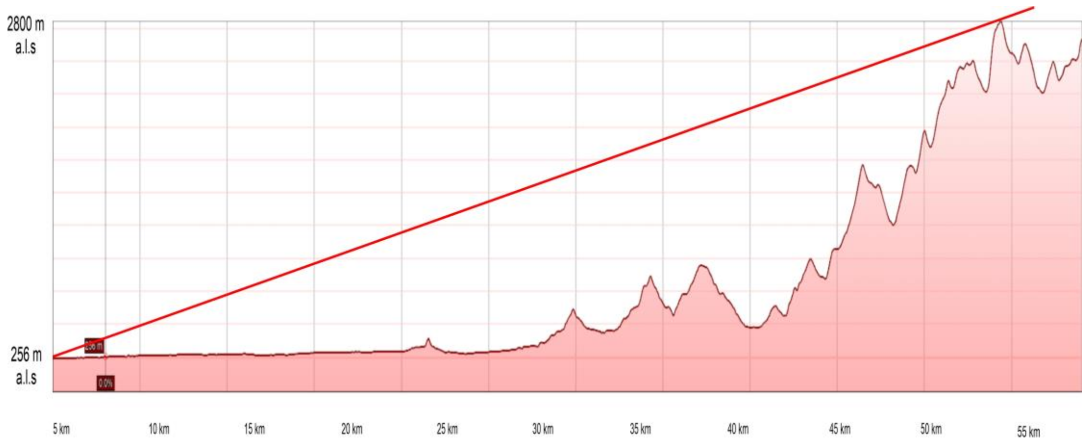

Figure 11. Reconstruction on a cartographic basis of the line of sights over the local horizon between the TSE and S-W direction at its sunset (Col Giulian, Cottian Alps). Source Google Earth

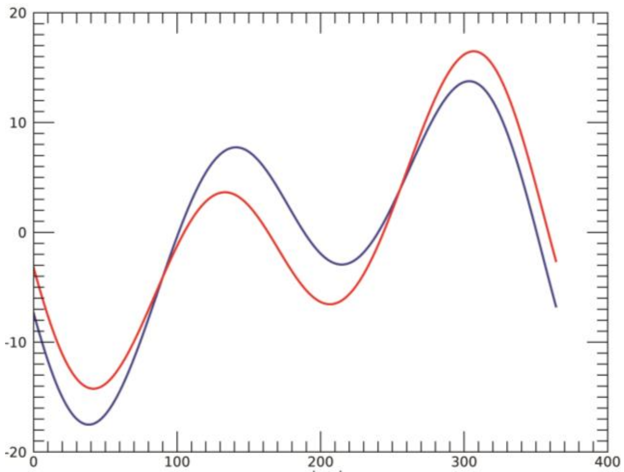

Figure 12. The figure shows the difference in minutes (Y-axis) along one year (X-axis) of the Sun passage at the local meridian in Turin. As an example, the years 9 BC (blue line) and 2019 (red line, corresponding to the epoch of our measurement) have been chosen. Since the lines do not coincide and the difference in some cases amounts around 10 or 17 minutes, this explains why astronomers need to compute the True Sun to correctly recover past Sun positions

The results represent the whole measurement made by the gromatics, therefore including all the possible errors and measurement conditions. In addition, the effective height has been varied by applying a progressive step of 0.01° (below this range the values generated by the program do not vary significantly). In this way we can include 3′ (about 0.05°), corresponding to the perception of the first appearance of the Sun edge on the hill profile, and an occasional poor atmospheric visibility or phenomena that could have altered significantly the refraction value. The same has been adopted for the calculation of the azimuth and the hour angle (*i.e.* the time) at sunset.

Finally, using specific IDL astronomical libraries, a numerical inversion of the trigonometric formula for the azimuth coordinate around the unique available data (the orientation of via Garibaldi) was computed, thus selecting a range of corresponding dates to be considered. Such an inversion allows to convert the Julian date to civil day according to the calendar of the time, for all the relevant years. It should be noted that the true Sun gives some variability, although cyclic, of the years associated with the presumed date for the foundation of the city, while the day can also be inferred with the mere application of the so-called mean Sun.

The latter case needs, however, the necessary consideration of the equation of time, which gives the anticipations or delays of the sun passage to the local meridian. Since the range of possible foundation dates for *Augusta Taurinorum* occurs under a narrow historical period, *i.e.* the Augustan age from 27 BC to 14 AD, it has been possible to make a screening of the dates that match with the geographical, epigraphic, historical, and archaeological contexts.

3. RESULTS

3.1 Evidences from the astronomical data

The Sun runs gradually higher and higher starting from the winter solstice and proceeds in the opposite direction in the six months following the summer solstice. Hence, given the motion of the Sun and the latitude of Turin, every year there are two dates compatible with the Eastern orientation of the city *decumanus*: in autumn around 11-16th November and in winter between the end of January and the beginning of February (see the examples in Table A).

Having carried out a numerical calculation, a certain variability and repetition of the dates occur from year to year within the contextual errors.

Note that we consider all of the possible moments of the measurements from the first glow of the Sun until its complete appearance. We stress also that in the inverse procedure of formula (1) and (2) we let vary the altitude in the range of values provided by the geographic context. Namely, the program lists the altitudes most suitable to the measured azimuth and to all the uncertainties/constraints reported in the section 2.3 (see Table B).

Following the basic principles of the inaugural tradition (Carandini, 2007), we choose to neglect the date of November (see section 3.2 for further comments).

If we adopt solely a rising Sun as a foundation criterion, the distribution around the value of the measured azimuth indicates the day of foundation on 3rd and 4th February and for heights between 2.2° and 2.5° (see Fig. 13). This presupposes the observation of a large part of the solar disk (corresponding to about 0.5°) as the altitude of the obstacle at sunrise (the hill in Fig. 8) is around 2 degrees.

The two dates on February, therefore, are possible only by postulating that the Sun was observed when it had already risen above the hill. However, this could have made the observation more difficult, because the increased brightness of the Sun, while its disk was more and more evident, it would have prevented to define a precise direction.

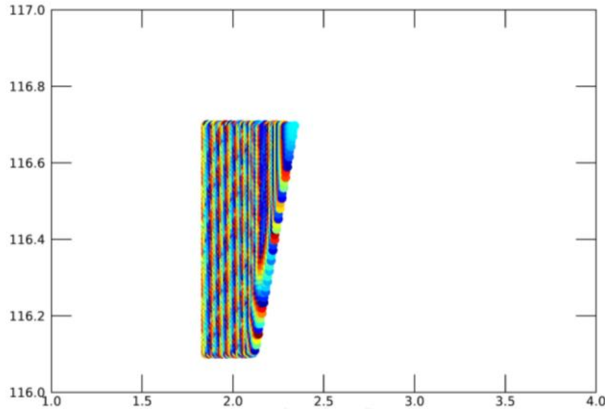

Figure 13. Distribution of the azimuth values (Y-axis) corrected with respect to the various heights of the hill (X- axis) in January. All the azimuths correspond to altitude values not exceeding 2.3° that presuppose the observation of the first glow of the solar limb (3′).

Moreover, if we adopt the operational procedure proposed for Marzabotto to balance the rising and setting sun, the date of 3rd February (azimuth = 242.3°) appears sporadic and only for heights from 2.3° to 2.6°, which again presupposes the observation of a part of the solar disk, while on 4th February it is practically absent.

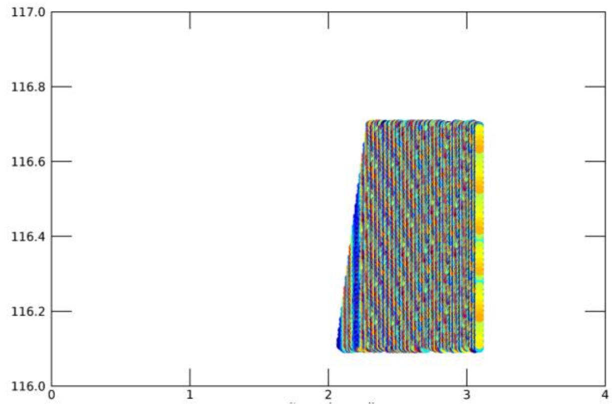

Figure 14. Distribution of the azimuth values (Y-axis) corrected with respect to the various heights of the hill (X- axis) in February. All the azimuths correspond to altitude values over 2.2° that presuppose the observation at least of half of the solar disk (about 0.26 °).

On the other hand, the azimuth of the rising sun on 30th January for heights close to 2° matches the hypothesis that the very first glow of the Sun upper edge was observed.

In fact, by applying the correction to balance the not-equal obstacles, the plausible days are evenly distributed (approximately 30,323 generated values) from 30th January to 1st February. Then, filtering the data around the punctual value of 116.379° (about 600 data for each year) and for a height equal to 2.69° at the sunset (azimuth of 240.653° on average), the average rising azimuth that generates the correction results equal to 117.867°. This automatically narrows the day to 30th January (and even 29th in some years), with some fluctuations to 31st. The occurrence of 30th January is confirmed for hill values close to 1.9° and 2° (first glow) while that 31st for slightly higher heights (Table A).

As for the hour angle, it oscillates between 7.41h - 7.48h (on average about 7h 26m 35s), and indicates the sunrise time of the edge of the true Sun, while it is about 16.55h for sunset. For the calculation of the local mean hour angle, it is necessary to take into account the correction for the equation of time which amounts approximately to -17 minutes (calculated by the IDL program), which would result in about 7h 43m.

Once obtained consistent scientific outputs, in order to define which date has to be considered valid, one must necessarily rely on the historical and archaeological criticism, that is to say, on an interpretative process.

Nevertheless, the analysis of the numerical results allows us to make important deductions. First of all, the dates towards the beginning of February should be excluded if the observation criteria of the first glare is adopted. Instead, it clearly emerges that 30th January matches with the motion of the True Sun, regardless of possible errors of calculation related to the civil calendar adopted, along with the observation of a *proximum true ortum* point, confirming the hypothesis that the city was founded according to the course of the Sun.

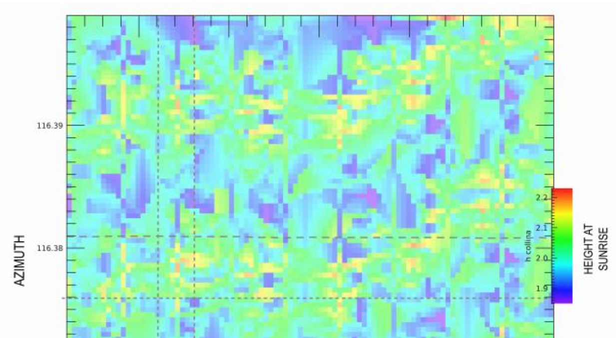

Figure 15. The figure shows the density distribution of the computed azimuths (Y-axis) around the measured value (between the horizontal lines) according to the variations of the altitudes at sunrise (color code on the right) over the years (X-axis) from 14 BD to 14 AD. The dotted rectangle contains the values we explored for our analysis (i.e., the years -9 and -8).

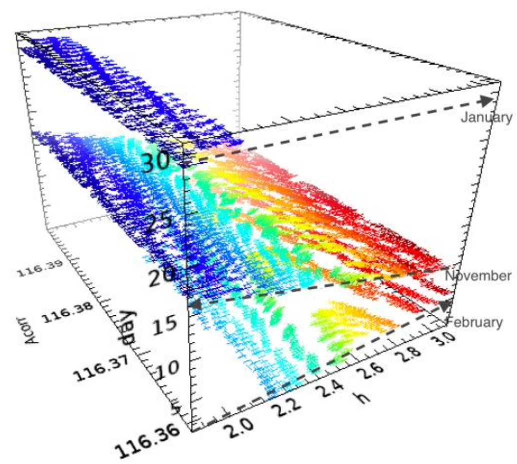

Figure 16. The figure plots the distribution of the days (Z-axis) over the heights (X-axis, same color code of fig.15) at sunrise around the measured value of the azimuth (Y-axis) from -14 BC to 14 AD. It is evident that dates around 30th January match with the hypothesis of the first glare and the heights of the natural obstacle at sunrise, while days from 1st February onward correspond to higher altitudes. The dates of November (from 11th to 16th) are also reported.

3.2. *Evidences from the historical context*

Table C lists the main events related to Augustus life. Once discarded those related to inauspicious events (such as military defeats or relatives' death), the remanent ones reflect the nature of the Augustan propaganda.

As far as the foundation of *Augusta Taurinorum* concerns, the 30th January is particularly convincing since it coincides with the celebration of the *Ara Pacis Augustæ* festivity, established in 13 BC (Fer. Cum.; Moretti, 1947; Rossini, 2006; Centanni, Ciani, 2017).

The latter was designated by the Senate of Rome in honor of Augustus and celebrated in *Campus Martius* from 30th January 9 BC onward at the presence of the magistrates, the priests, the Vestals and the citizen of Rome. The date is recorded in the *Fasti Prænestini*.

The institution of the festivity was the consequence of a long period of conflicts that began with the murdering of *Iulius Caesar* and ended with *reditus* of Augustus to Rome following a long campaign of war in Gaul and Spain and the 'pacification' of the Alps.

The operations began in 27 BC when Augustus obtained by the Senate the direct control of the provinces of Spain (*Tarraconensis* and *Lusitania*), *Gallia Narbonensis, Lugdunensis, Aquitania,* and *Belgica*, towards which large military forces were moved (Cass. Dion. 53, 12; Vota, 2000).

In 20 BC *Marcus Vipsanius Agrippa* resided in *Lugdunum*/Lyon in order to supervise the construction of a road network directed towards the *Aquitania*, the

Rhine, the northern *Belgica* and the mouths of the Rhone (Strabo IV, 611).

Between 16 and 13 BC, Augustus dwelt in Lyon to reorder the administration of the Gallic territories, to plan some military operations in the Alps against 46 Alpine Tribes. Finally, he entrusted the territory to his stepchildren, *Tiberius* and *Drusus*.

In 13 BC, the military actions extended to the Maritime Alps and further north (Cass. Dion., 54, 24.).

The Celtic king *Cotius*, commander of a coalition of tribes, after an initial attempt of insurgency (however reported only by *Ammianus Marcellinus*) stipulated a *foedus* (13 BC) and, consequently, a Roman *præfectura* was established. For gratitude, the son of the old king *Donnus* (*Cotius*) was adopted by Augustus and aggregated to the equestrian order, assuming the title of *præfectus* (Cresci Marrone, 1994, pp. 185-196; Fogliato, 1992).

The same year Augustus, after his returning from Gaul and Spain, instituted the festival of the *Ara Pacis Augustae* and began the construction of the altar in *Campus Martius* after a decree by the Senate (Fer. Cum. T. 6), even though the first official celebration took place on January 30th of 9 BC.

Significantly, in the same year (9-8 BC) an honorary arch dedicated to the emperor was inaugurated in *Segusium*/Susa, a Roman town laying approximately 30 miles from Turin (Caranzano, 2019).

Shortly after (around 7 BC) an administrative division of Italy in the canonical *XI Regiones* was carried out and the present Piedmont territory north of the river Po was ascribed to the *XI Regio Transpadana.*

The victory over the Alpine tribes found its definitive celebration (between 7 and 6 BC) in the famous *Tropæum Alpium* at La Turbie, close to *Monoikos* (France).

It is worth noting that the frieze of the Susa Arch shows a scene of sacrifice (*suovetaurilia*) at the presence of Roman magistrates and of a veiled priest (*velato capite*) in close similarity with the subject of the *Ara Pacis* frieze in Rome. According to the Augustan propaganda, both the monuments are purged from every mention of war and the related bloody events in order to remove them from the collective memory.

As widely documented, the Augustan guidelines encouraged the subjects connected with Peace, the celebration of the ancient origins of Rome and the religious tradition (on 12 BC Augustus obtained the maximum priesthood magistracy of the ancient Rome, becoming *pontifex maximus*).

The hypothesis that *Augusta Taurinorum* was founded in the last decade of the first century BC relies also on archaeological and historical clues.

The name *Augusta Taurinorum* is mentioned in the fourth Vicarello Cup, adorned with a roman *itinerarium* that should have been drawn up after 13 BC (since it quotes the *Provincia Alpias Cottiae*), while it lacks in the last three cups reporting an itinerary drafted between 24 and 19 BC (France, 2001; Masci 2012).

Even the ancient writers lack of references to the city: Pliny the Elder in his Geography quotes *Augusta Praetoria Salassorum* (founded in 25 BC) but seems to neglect Turin; oddly enough, he must have consulted the Map of Agrippa, namely the legitimate plan of the roman imperium commissioned by Augustus and displayed in *Campus Martius* in Rome after 12 BC (Strabo. *Geo.* 4).

Moreover, the frequent archaeological investigations carried out in the old town lack of findings of the early Augustan time (Filippi, 1982; Brecciaroli Taborelli and Gabucci, 2006), whereas the city walls and gates (reckoned as Augustan until some years ago) appear to be a later addition of Julio-Claudian era (Brecciaroli Taborelli and Pejrani Baricco, 2000).

Located in a territory crossed by an important commercial and military road directed to the Alpine passes and founded in the middle of a fertile plain nearby the access to the Susa Valley where the *Quadragesima Galliarum* was exacted - *i.e.,* a 2,5% tax on trades from and to the Gauls (France, 2001; Betori, Mennella, 2012) - the Roman city provided an essential logistic stop along the road leading to the lands of Gauls.

In the meanwhile, Turin could have represented an economic resource for the citizen (most of them veterans dismissed by Augustus) benefiting of a fruitful territory drained by the rivers Po and Dora Riparia.

The *post quem* data on the 30th January 9 BC not only is compatible with the epigraphic, archaeological, and literary sources (Bendinelli, 1929; Brecciaroli Taborelli and Pejrani Baricco, 2000; France, 2001; Brecciaroli Taborelli and Gabucci, 2006), but matches perfectly with the historical context and with the opinion expressed by the prevalence of the critics (Cresci Marrone, 1997; Paci, 1998; Culasso Gastaldi, 1988; Cimarosti, 2006-2007; Masci, 2012).

A possible syncretism between Augustan festivities and pre-existing Celtic festival could also be questioned. To our knowledge, the ancient *oppidum* of the Taurini was drastically destroyed by the army of Hannibal in the end of III century AD (App. *Hannib. 5*; Tit. Liv. *Ab Urbe Cond*, XXI, 39.4). After such a dramatic event, probably, the indigenous scattered in the surrounding area, living in minor villages (Culasso Gastaldi 1997, Paci 1998).

As regards the hypothesis of a continuity between a pre-existing Celtic *oppidum* and the Roman town, no significant evidence of a substantial Late Iron Age settlement (La Tène C and D) has been detected under the Roman town (Fedele 1997; Gambari 2008).

Moreover, it is worth mentioning that *Augusta Taurinorum* was founded as a *Roman colonia* as part of the *XI Regio* of the Augustan *Italia* with the relocation of roman citizens, while the Roman epigraphy lacks of indigenous and epicoric names (Cresci Marrone, 1996). Nevertheless, despite their position of strenght, Romans conceived the name of the colony in terms of integration between new settlers and indigenous (Cresci Marrone, 1996).

3.3 Evidences from other foundations

The hypothesis of a solar orientation of *Augusta Taurinorum* finds affinity with a study conducted on the nearby *Augusta Praetoria Salassorum*, a colony founded in 25 BC after the military campaigns of the consul *Aulus Terentius Varro Murena* in the territory of the *Salassi*, at the starting point of the alpine roads directed toward the passes of *Alpis Graia* (Little S. Bernardo) and *Alpis Poenina* (Gran S. Bernardo).

Excavations carried out at the basis of the Torre dei Balivi in the Roman colony of *Augusta Prætoria* brought to light an unsuspected sculptural relief depicting the sign of Capricorn flanked by a plow and by two apotropaic phalluses, symbols interpreted as auspicious 'seals' contextual to the deduction of the colony. *Augusta Prætoria Salassorum* was oriented with respect to the course of the Sun (considering the elevation of the surrounding mountains) in order to obtain the alignment of the *cardo maximus* with the rising sun on the day of the winter solstice (Bertarione, Magli, 2014). The anomaly of the inverted position of the *decumanus* (from E-W to S-N) given the very high mountain profile is explicitly listed by *Hyginus Gromaticus* as one of the variants of the canonical centuriation scheme (Hyg. Grom. *Const. lim.* L. 170, 10-16; Front. *Const. lim.*10, 1-5).

We are informed on the importance assumed by astrology/astronomy under Augustus thanks to a series of studies undertaken on the recurrence of the bimillennial of Augustus death (2014) that enriched our knowledge on the political propaganda as well as on the emperor's personal trends and cultural interests.

According to *Svetonius*, while in 45-44 BC *Gaius Ottavius* resided in *Apollonia* (today Albania) attending his grammar and rhetoric studies, he consulted the astrologer *Theogenes* in his observatory; on that occasion, the auspices were so favorable as to induce the astrologer to prostrate himself on the ground. The experience made on the future prince a great impression and, according to the Roman historian, Augustus gained faith in his own destiny and «disclosed publicly his horoscope and minted a silver coin with the sign of Capricorn, under which he was born».

Especially after the battle of *Actium* (31 BC), the zodiacal theme of Capricorn appeared more and more frequently in the official iconography. Augustus was born on the ninth day before the calends of October (23st of September) just before the sunrise under the sign of Lybra.

Indeed, the astrologers distinguished between the 'day of conception' and the 'birth' day. Augustus was conceived in December when the sun was hosted by the sign of Capricorn (the so-called 'point of luck' in the compilation of the horoscope) while perhaps the Moon entered in the same sign on the day of his birth (Zanker, 2000; La Rocca, 2007; Borbone, 2013).

Confident that the stars were custodians of human destiny, he assumed the date of his conception as fortunate (as coinciding with the shortest day of the year announcing the beginning of a new course and, symbolically, of a new age).

A separate aspect concerns the attention paid to the days following the winter solstice (under the sign of Capricorn) for the cities founded according to the Etruscan-Italic *inauguratio*. As of 30th January, part of the Capricorn constellation is in a 'heliacal rising'. In December, in fact, giving the precession of the equinoxes, the Sun was in the constellation of Capricorn, but the following month it moved to the Aquarius.

Table A. Some relevant dates picked from the marked rectangle of figure 15 (in the hypothesis of first glare, values generated by the IDL program around the measured azimuth of the decumanus). Sun_dec stands for the Sun declination, Acorr for the corrected azimuth, Aort for the azimuth at sunrise, Aocc for the azimuth at sunset, Hort for the hour angle at sunrise, Hocc for the hour angle at sunset, and finally h for the altitude of the geographic obstacle. A few examples with h>2.2° are also given.

Julian date	Month	Day	Year	Sun_dec(°)	Acorr(°)	Aort(°)	Hort(°)	Hocc(°)	h@ort(°)	h@occ(°)
1718164.500000	1	30	-9	-18.532	116.378	118.103	7.436	16.555	1.95	2.75
1718165.500000	1	31	-9	-18.268	116.374	117.844	7.428	16.564	2.05	2.67
1718166.500000	2	1	-9	-18.000	116.377	117.685	7.429	16.563	2.23	2.74
1718168.500000	2	3	-9	-17.448	116.375	117.247	7.422	16.572	2.53	2.72
1718451.500000	11	12	-9	-17.437	116.372	117.256	7.424	16.570	2.55	2.75
1718452.500000	11	13	-9	-17.721	116.375	117.476	7.427	16.566	2.39	2.75
1718453.500000	11	14	-9	-17.999	116.375	117.683	7.428	16.563	2.23	2.74
1718454.500000	11	15	-9	-18.271	116.377	117.849	7.428	16.564	2.05	2.67
1718529.500000	1	29	-8	-18.594	116.370	118.141	7.435	16.555	1.91	2.74
1718530.500000	1	30	-8	-18.333	116.377	117.942	7.433	16.558	2.05	2.74
1718531.500000	1	31	-8	-18.065	116.379	117.730	7.429	16.562	2.19	2.73
1718532.500000	2	1	-8	-17.793	116.377	117.532	7.428	16.565	2.35	2.75
1718534.500000	2	3	-8	-17.234	116.378	117.0384	7.416	16.579	2.62	2.65
1718816.500000	11	12	-8	-17.368	116.372	117.138	7.417	16.577	2.54	2.65
1718817.500000	11	13	-8	-17.653	116.379	117.412	7.425	16.568	2.42	2.73
1718819.500000	11	15	-8	-18.206	116.379	117.805	7.428	16.564	2.09	2.68
1718820.500000	11	16	-8	-18.474	116.378	118.058	7.435	16.556	1.98	2.75

Table B. List of uncertainties and values assumed in the program.

List of uncertainties and values assumed in the program		
Measured azimuth	116.379°±0.002°	By a theodolite Hilger-Watts Microptic N.2, w.r.t. to the astronomical north
Refraction	$\frac{P}{273+T} \cdot \frac{(0.1594 + 0.0196 \cdot h + 0.00002 \cdot h^2)}{(1 + 0.505 \cdot h + 0.0845 \cdot h^2)}$	Computed by the program and by varying pression P and temperature T
Parallatic Shift	~ 0.07°	Width of the decumano/Via Garibaldi
Solar radius	~ 0.267 °	Computed by the program according to the True Sun
Perception of the solar limb	0.05°	Corresponding to 3' (a naked eye can perceive approximately 1')
Range of the obstacle, sunrise	1.8° - 3.4°	The range considers a variable peak profile, from the closest to the farthest
Range of the obstacle, sunset	2.4° - 2.8°	Range related to peak along the azimuth direction at sunset
Interval for the computed azimuths in the inversion of formula (1) and (2)	± 2°	Corresponding approximately to an uncertainty of 2-3 days

Table C. Chronology of the main events related to the Octavianus Augustus life:

753 BC (21th April): Foundation of Rome.
63 BC (23th September): Birth of *Gaius Octavius*.
58 BC (30th January): Birth of *Livia Drusilla*.
43 BC (7th January): First *imperium* of *Octavianus*.
43 BC (9th January): First consulate of *Octavianus*
42 BC (23th October): Military victory at Alesia.
38 BC (17th January): Marriage of *Octavianus* with *Livia Drusilla*.
36 BC (3rd September): Military victory at *Naulochus.* A feast day is proclaimed by the Senate of Rome.
31 BC (2nd September): Military victory against *Gneus Pompeius* and *Claeopatra* at *Actium*.
30 BC (1st August): Conquest of *Alexandria* and suicide of *Cleopatra.*
29 BC (13 -15th August): Triple triumph of *Octavianus*.
29 BC (18th August): Dedication of the Temple of *Divus Iulius* in the Roman Forum.
28 BC (17th January): Dedication of an altar to *Octavianus*.
28 BC (9th October): Dedication of the Temple of Apollo on the Palatine hill.
27 BC (13th January): *Octavianus* returns to the Senate of all the special powers received. The Senate confers to him an oak-crown for having put an end to the Civil wars.
27 BC (16th January): *Octavianus* is appointed *Augustus* by the Senate of Rome.
19 BC (21th September): Death of *Publius Virgilius Maro* and publication of the Aeneid.
15 BC (24th May): Birth of *Iulius Caesar Germnicus*.
14 BC (21 September): Celebration of the *Ludi Augustales* for the return of Augustus from Asia Minor in 19 BC; A feast day (*feria*) is added to the calendar.
13 BC (4th July): The Senatus of Rome vote the construction of an altar dedicated to *Pax* in *Campus Martius* for the return of Augustus to Rome after three years in Hispania and Gaul.
12 BC (6th March): Augustus is appointed *pontifex maximus*. The Senatus of Rome establishes an annual festivity.
12 BC (28th April): The *Signum Vestae* is dedicated on the Palatine hill.
12 BC (12th May): Dedication of the Temple of M*ars Ultor* on the Palatine hill.
12 BC (1st August): *Nero Claudius Drusus* establishes the cult of Augustus in Gaul. Triple triumph of Augustus.
9 BC (30th January): Dedication of the Ara Pacis in Rome in honor of *Pax*. Established in coincidence with the *Livia Drusilla* birthday, the Ara became the background of a public ceremony hold yearly in Rome at the presence of the magistrates, the priests and the Roman people.
9 BC (9-11th September); Defeat of *Publius Quintilius Varo* at Teutobourg.
7 BC (1st January): Dedication of the *Porticus* of Livia and of the Temple of *Concordia Augusta*.
4 BC (26th June): Adoption of *Tiberius Iulius Caesar Augustus* and institution of a yearly festivity by the Senate of Rome.
2 BC (5th February): Augustus is appointed *Pater Patriae*.
14 BC (19th Augustus): Augustus dies in Nola.

4. CONCLUDING REMARKS

Sextus Iulius Frontinus, whose treatise is chronologically framed between 70 and 90 AD, quotes *Marcus Terentius Varro* to underline the connection between the city orientation and the celestial vault: "The origin of the *limites* – as explained by Varro – derives from the Etruscan *disciplina*" (Front. *de lim.*10-11, 20-8, translated by the authors).

It is worth underlining that under Augustus a renewed interest in the tradition of the early Rome took place and the act of *condere* (founding) was evaluated of peculiar and symbolic importance in propagandistic. Literature and art abound of explicit references to the myths linked to *Romulus* and *Remus*, *Enea* and *Ascanius*, and the same *Octavianus Augustus* considered himself the «new Romulus» (Bianchi, 2008). Furthermore, he paid particular attention to the Roman *disciplina* and to the old rituals. *Svetonius* refers: *Nonnulla etiam ex antiquis cærimoniis paulatim abolita restituit* (Svet. *Aug.* 31; Schütz, 1991).

In the encyclopedic dictionary of *Sestus Pompeus Festus*, under the name of *Roma Quadrata*, it is referred that Augustus built an altar in front of the Temple of Apollo on the Palatine (close to his *domus*) where was put «what is auspicious for the foundation of a city» (Fest., *de verb. sign.* 310); we must presume a *lituus*, a *groma* and other similar instruments.

Gaius Svetonius Tranquillus reports that the prince «repopulated Italy with 28 colonies that he himself had established, endowing them with many public works and incomes, and guaranteeing to each one the same dignity and honor of the *Urbs* itself». The vast majority of the scholars include among them *Augusta Taurinorum* (Folcando, 1996).

In summary, the historical, archaeological and literary sources show a close relation between augural 'science', astrology/astronomy and the political propaganda, while *augures* and *gromatici* would have shared common knowledges, coordinating their activities during the foundation.

Thanks to the astronomical validation and the coincidence of the inauguration date with an important Roman festival, we had the opportunity to trace back the chronology of the foundation as a *post quem*, since the city could not be founded before the feast of Pax at the Ara Pacis was established.

From a methodological point of view, it is worth mentioning that foundation date of the Etruscan-roman city would not have been affected by the incorrect intercalation occurred in the Roman official calendars on account of the errors made by the priests and emended by Augustus after 8 BC (the matter was recently rediscussed by Jones, 2000 and Skeat, 2000).

The inaugural 'science' must be intended first and foremost related with religion and astronomy (Gottarelli, 2003b, 2010 and, implicitly, in Magli 2008; González-García A.C. and García Quintela M.V., 2014). The gromatics state clearly that the orientation of the city is obtained following the course of the Sun by the use of a gnomon (Hyg. Grom. *Const. lim.* L. 170 and 184.1) and not according to the civil calendar.

Moreover, given the fact that the calendar reform of Augustus was in progress in 9/8 BC and that the *augures* and the *gromatici* were surely aware of it, to found a city following the *Fasti* instead of the course of the Sun would have turn out in an on-going misalignment of the *decumanus* with the real course of the Sun in the subsequent years.

The connections between Etruscan *disciplina* and *cosmos* as well as the relation between the recurrence and festivities and the influence exerted by the stars on Earth as described by *Marcus Manilius* in his *Astronomica*, appear to be the pivot around which revolves the inaugural rites of the Augustan age.

According with the premises, the sacrality of the inauguration is intrinsic in the relation between the city axes (*kardo* and *decumanus*) and the position of the Sun, so that the Roman religious authority aimed to harmonize the civil calendar to the cosmic order, and not the opposite (Crosta, Caranzano, Massone, 2020; Caranzano and Crosta, 2020).

Obviously, that did not prevent the celebration of public events and festivities.

Finally, the IDL program, based on professional astronomical tools, takes into account any variations of the civil calendars when it converts julian date to julian calendar.

Augusta Taurinorum - undoubtedly an Augustan foundation - was inaugurated in accordance with the solar orientation related to an imperial occurrence; the astronomical result results do not discard the date of 30th January or the days immediately following it. That constitutes a credible day for the colony inauguration that would have been founded under the auspices of *Pax* and in correspondence to the heliacal rising of the sign of Capricorn.

Our study of *Augusta Taurinorum* underlines the role played by the gnomon in the foundation of the roman cities and give us the opportunity to contextualize the innovation introduced by the hellenistic science. To date, no previous studies have considered the application of the gnomon theorem to establish the day of foundation. Aware that in Roman times different founding criteria coexisted, the novelty of the model we proposed, based on an interdisciplinary approach, pushes further investigations and comparisons on Augustan colonies that we will accomplish in subsequent works. *Hyginus Gromaticus* warns us: «Many, to prevent the fields of the city to have the same orientation of the adjacent colonies, gave them a different direction» (Hyg. Grom. *Const. lim.* 5-10, translated by the authors). It explains what the practical experience shows, namely that «throughout the world there is an individual configuration of limits»: this is to say: there are several *criteria* for the orientation of the towns (Front. *de. limit.* 10, 1-5).

Further diachronic and historical investigation should deal with the variability of the choices occurred on the basis of the local topography, of the sensitivity of the urban planner-architect in charge of the foundation, and on the central or peripheral position of the colony with respect to Rome.

If the gnomonic theory was fundamental in the gromatics measurements, interesting scenarios could emerge in which ancient astronomy and computational geometry played a key role.

AUTHOR CONTRIBUTIONS

Conceptualization, Sandro Caranzano and Mariateresa Crosta; methodology, Sandro Caranzano and Mariateresa Crosta; software, Mariateresa Crosta; validation, Sandro Caranzano and Mariateresa Crosta; formal analysis, Mariateresa Crosta; investigation, Sandro Caranzano and Mariateresa Crosta; resources, Sandro Caranzano e Mariateresa Crosta; data curation, Mariateresa Crosta; writing—original draft preparation, Sandro Caranzano e Mariateresa Crosta; writing—review and editing, Sandro Caranzano e Mariateresa Crosta; visualization, Sandro Caranzano e Mariateresa Crosta; supervision, Sandro Caranzano e Mariateresa Crosta; project administration, Sandro Caranzano e Mariateresa Crosta; funding acquisition, Sandro Caranzano (Centro studi Archeologici Herakles). All authors have read and agreed to the published version of the manuscript.

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