Taking measures across the medieval landscape: aspects of urban design before the Renaissance

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Abstract. *This paper considers the significance of geometrical knowledge and the role of surveying as influences on medieval town plans in Europe. Analyses of selected plans show signs that improvements in methods of measurement made it possible to lay out towns with greater accuracy from the mid-twelfth century onwards, and that surveying techniques based on practical and theoretical geometry were used to produce towns with orthogonal plans. It is suggested that orthogonal town plans had symbolic importance in the Middle Ages.*

Key Words: town plans, urban design, orthogonality, surveying, medieval Europe

James Corner, an American landscape architect, has demonstrated the importance of 'measure' in the spatial ordering of cultural landscapes in North America. However, in the preface to his book *Taking measures across the American landscape* (Corner, 1996), he repeats the widely-accepted view that the Renaissance marked a change in the use of measurement in the design of landscapes in Europe, and that in the fifteenth and sixteenth centuries there was a transition from 'traditional' methods of measurement to more scientific and abstract forms of measurement, guided by geometry (see also Cosgrove, 1988; Soderstrom, 1996). It is possible to question this view by carefully studying the forms of towns before the Renaissance.

In this paper, it is suggested that certain towns in medieval Europe were devised and laid out according to geometrical principles. Although there have been a number of studies of medieval town planning, the significance of medieval learning and techniques of surveying have largely been overlooked as potential influences on the form of medieval towns. The study of medieval town plans, however, has a long lineage in modern European scholarship. Early in this century, the work of German-speaking scholars prepared the ground for the analysis of medieval town plans and town planning (Whitehand, 1981, p. 6). This research informed the approach of M.R.G. Conzen (1960, 1968), especially his technique of town-plan analysis. The approach in this paper draws on the work of Conzen, beginning with a problem that he confronted when he looked at the plan of Conwy in north Wales.

There is an expectation that medieval towns with planned origins will have regular

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plans (Beresford, 1967). Although Conzen (1968) rejected the distinction between 'organic' and 'planned' towns as artificial and unhelpful, he found it necessary to explain why a town could have quite clear planned origins yet possess a plan that showed few signs of regularity in its form. He wrote: 'Conwy owes its medieval town plan to a simple act of foundation in 1284 ... yet the plan is far from uniform' (Conzen, 1968, p. 127). In attempting to explain this, Conzen noted two factors which seemed to have influenced the form of Conwy. One was its site, the peculiarities of local relief and topography; the other was the presence of residual landscape features, a 'morphological frame' which, in the case of Conwy, included a Cistercian abbey. As explanations for the often quite 'irregular' form of planned towns, the factors offered by Conzen have been accepted, namely that although the plan of a town may have been conceived as a regular 'ideal', it was somehow adapted to fit into the 'real' landscape. The distinction between ideal and reality was also adopted by Slater (1987) in explaining why it was that the twelfth-century planted episcopal towns of Stratford-upon-Avon and Lichfield have regular but not strictly orthogonal forms. But are there other factors which could influence urban form? One explanation that has not had the attention it deserves is the role that surveyors played in the laying out of medieval towns, as well as their potential role in devising designs for new urban landscapes.

In examining more closely the role of surveying in medieval town design, it is necessary to consider the use of and importance attached to geometrical knowledge in the Middle Ages. The discussion is divided into three main parts. In the first a distinction is drawn between towns that have strictly orthogonal plans and those that are quasi-rectilinear in plan.[1] In the second, this distinction is explained in terms of differences in surveying technique and expertise in the Middle Ages. In the last part it is suggested that geometry was not only of practical importance for the surveying of medieval towns, but that towns with geometrical forms had a symbolic importance too.

Quasi-rectilinearity and orthogonality in medieval urban form

When looking at the form of medieval towns it becomes apparent that in certain cases streets and plot boundaries have absolutely straight alignments, and that the plan is configured using right angles. However, such orthogonality is not always present in medieval town plans, for it is also possible to identify streets and plots that have curving alignments, and form a plan that is quasi-rectilinear in form. This simple morphological distinction provides a basis for establishing a firmer understanding of why some town plans had orthogonality whilst others did not. The distinction between quasi-rectilinearity and orthogonality is clearly revealed in the plans of two rather well-studied towns, Ludlow in Shropshire (England) and Drogheda in County Meath (Ireland) (Lilley, 1997). Both towns were held by the de Lacy family in the later-twelfth century and both have plans that show evidence of town planning.

At Ludlow, probably at some time in the 1160s, perhaps under the eye of Walter de Lacy, a new area of streets and plots was laid out on the south side of an existing market place, on a sloping site (Lilley, 1997, p. 198). The form of this area, comprising Mill Street and Broad Street, is very regular, with streets intersecting at right angles and configured in a grid-iron pattern (Conzen, 1988; Slater, 1988). Fronting the streets are plots that have, on the whole, straight boundary lines (Figure 1). In morphological terms, this area, defined in an analysis of Ludlow's plan as plan-unit 'V', may be described as orthogonal in form, that is having straight-sided streets and plots, with a predominance of right angles. At Drogheda, on the north side of the River Boyne, again on a sloping site, an area of streets and plots was laid out, most probably in the 1180s or 1190s under the initiative of Hugh de Lacy (Bradley, 1990;

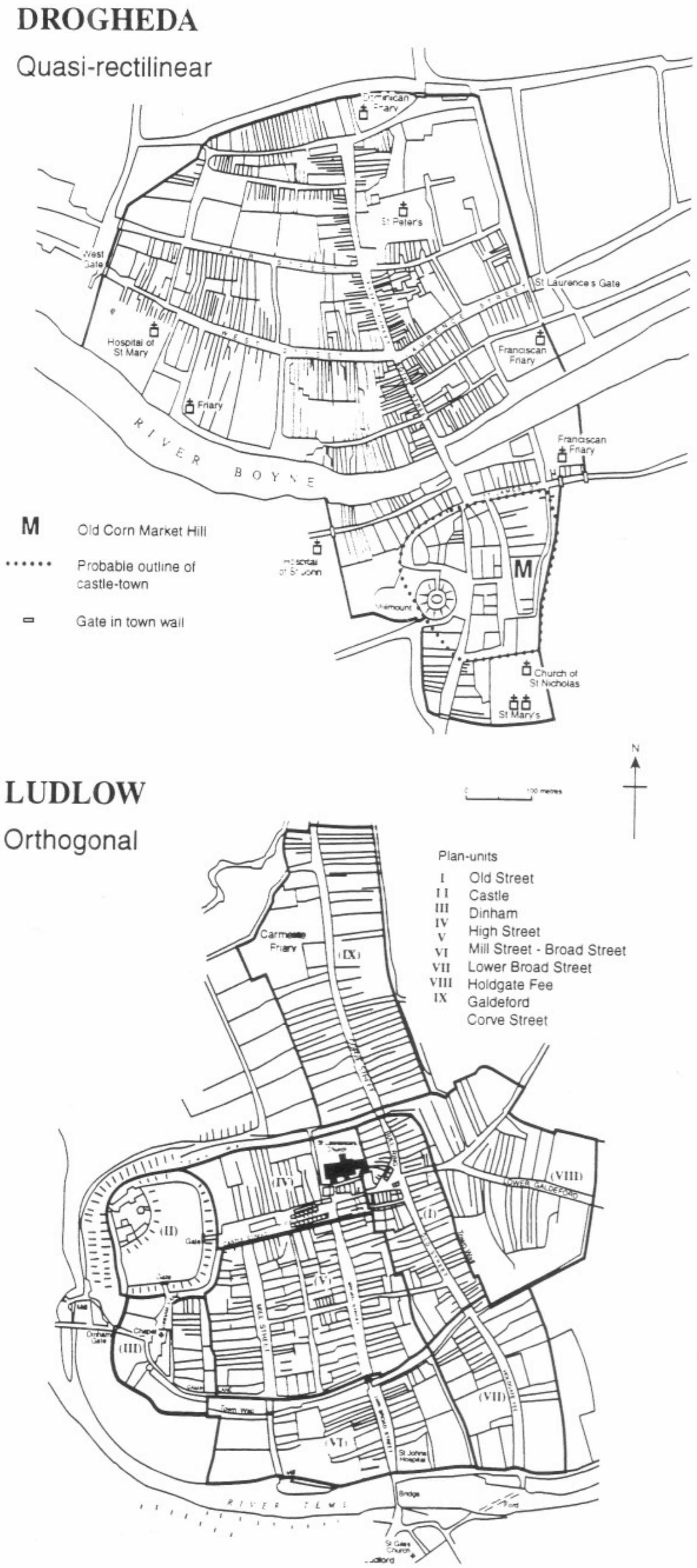

Figure 1. Medieval towns with orthogonal and quasi-rectilinear plans, Ludlow (UK) and Drogheda (Eire) (the plan of Drogheda is adapted from Bradley, 1990).

Dargan, 1996). In this case, though, the streets and plots are far from orthogonal in form. The main axial street, and those leading from it, are slightly sinuous, and the plots too lack orthogonality. In essence, Drogheda's plan is regular, but quasi-rectilinear in form, rather than orthogonal.

Here, then, are examples of two towns that were developed in stages of planned growth by the same magnate family within a few decades of each other, but with differing plans. The usual explanation would be to attribute the differences to the particulars of local relief and antecedent features, as Conzen did for Conwy, and as Slater did for Stratford and Lichfield. But Ludlow and Drogheda share similar physiographical and historical characteristics. The morphological difference between the two towns raises a question - could the area of Broad Street and Mill Street at Ludlow, with its highly regular form, have been planned and designed professionally, using a knowledge of geometry, whilst Drogheda's plan was laid out using simply measurement without any specific application of geometrical knowledge? Before pursuing this question it is worth examining more closely the distinction between orthogonal and quasi-rectilinear plans. Analysis of medieval town layouts from across Europe suggests that the distinction has certain temporal and spatial characteristics.

Of course, in antiquity, in Roman and Greek civilisations for example, urban layouts were frequently orthogonal in form, but in the Middle Ages, the strict orthogonality evident in the Mill Street and Broad Street area of Ludlow only begins to appear in towns established from the mid-twelfth century onwards. This is evident in Gascony in south-west France, in Tuscany in Italy, and in parts of Eastern Europe such as Bohemia, Moravia and Poland (Table 1). In these regions, towns with orthogonal plans (such as Grenade sur Garonne, Terranuova, and Ceska Budejovice) date from the later-twelfth and, more particularly, the later-thirteenth centuries (Lauret, Malebranche and Seraphin, 1988; Friedman, 1988; Gutkind, 1972). Meanwhile, towns with quasi-rectilinear plans, which lack orthogonality in their form, are evident throughout the Middle Ages, from at least the ninth century onwards, including some well-known examples, such as Winchester, Bury St Edmunds and New Salisbury in England (Biddle and Hill, 1971; Crummy, 1979). This temporal pattern provides a clue which might help to account for the morphological differences between towns with orthogonal and quasi-rectilinear plans. It would appear that after *c.* 1150 geometry became an important determinant not only in the actual shape of certain towns but in the process of their design. To examine this further, the role of surveying in the laying out of medieval towns will be considered, in particular the importance of geometry in enabling abstract geometrical figures to be accurately realized in the actual ground-plans of towns.

Surveying, geometry and urban design

Little is known of medieval surveyors in comparison with their later counterparts, yet it is clear that there were individuals specifically engaged in surveying in the Middle Ages (Schulz, 1978, pp. 432-5). The knowledge and practices of these surveyors can be examined by studying the many 'practical geometries' that appeared in the thirteenth and fourteenth centuries, which were intended to be used as guides on how to accomplish certain surveying and engineering problems, such as measuring the height of a building, or laying out the quadrangle of a monastic cloister (Bucher, 1979). A late example of such a textbook is the *Geometria Culmensis*, of *c.* 1400. The significance of this particular 'practical geometry' is its account of two different types of surveyor: those who were called *mensores layci*, or 'lay measurers', and those known as *mensores literati*, or literate, learned measurers (Zientara, 1976, pp. 73-4). The distinction suggests that there were surveyors who had a knowledge of how to survey using 'learned' methods and those who did not.

Table 1. Dates of planning (or foundation) and present location of selected medieval towns with orthogonal and quasi-rectilinear plans

Period	Quasi-rectilinear	Orthogonal
850-1050	**Winchester** (890s), UK **Rouen** (925-50), France	None known
1050-1150	**Bury St Edmunds** (1080s), UK **Villengen** (1120s), Germany	None known
1150-1250	**Stratford-upon-Avon** (1196), UK **Drogheda** (1190s), Eire **New Salisbury** (1219), UK	**Ludlow** (plan-unit V, ?1160s), UK **Chelmno** (1233), Poland **Villeneuve-sur-Lot** (1253), France
1250-1350	**Villareal** (1274), Spain **Aberystwyth** (1277), UK	**Ceska Budejovice** (1265), Czechoslovakia **Moravska Trebova** (late-13th century), Czechoslovakia **Flint** (1277), UK **Monpazier** (1284), France **Grenade-sur-Garonne** (1290), France **Nowe Miasto Lubawski** (1325), Poland **Terranuova** (1337), Italy

Information from: Beresford (1967); Lauret, Malebranche and Seraphin (1988); Friedman (1988); Gutkind (1972); Biddle and Hill (1971).

This is supported by an earlier text, the *Practica Geometria* written by an Italian merchant, Leonardo Fibonacci, in *c.* 1220. As in the *Geometria Culmensis*, Fibonacci draws a distinction between 'two audiences - those who "would work following geometric demonstrations and those who would proceed following common usage, or, as it were, lay custom"' (Friedman, 1988, p. 125). The reference to lay custom is significant. It suggests that the *mensores layci* of the *Geometria Culmensis* were those surveyors who did not use theoretical geometry to set out buildings and, perhaps, towns, either through lack of learning or lack of care. Certainly the table of chords that Fibonacci derived in the early-thirteenth century has been shown to have been used in the early-fourteenth century as the basis for setting out the orthogonal plans of Terranuova and San Giovanni in Tuscany (Friedman, 1988, p. 129).

During the thirteenth century other practical geometries were composed, most likely for the purpose of showing to a wider audience the usefulness of geometrical theorems in the practical work of surveying and engineering. One well-known example is Villard de Honnecourt's *Sketchbook*, which includes many illustrations and demonstrations of design, surveying and building based on the principles of theoretical geometry (Bucher, 1979, pp. 98-124). The principles of geometry were taught in medieval universities across Europe as part of the *quadrivium*, along with arithmetic, astronomy and music (Haskins, 1927). Without theoretical geometry, in particular a

knowledge of Euclid, demonstrations of the practical uses of geometric principles would not have been possible. For this reason it is important that the practical geometries of Villard and Fibonacci are placed within a broader intellectual tradition of medieval learning and scholarship that taught the principles of geometry from a theoretical basis.

Perhaps the most significant contribution to geometrical knowledge in the Middle Ages was made by Adelard of Bath, a scholar who travelled extensively across Mediterranean Europe in the early decades of the twelfth century, and who is credited with translating Euclid's *Elements* from Arabic into Latin, probably in *c.* 1140. Adelard was already well acquainted with geometry. In his *De Eodem et Diverso*, written after 1105, he explained the relationship between geometry and astronomy: 'both are concerned with the magnitude of bodies', he wrote, 'geometry with immobile bodies and astronomy with heavenly bodies. Geometry is thus the lesser of the two and serves astronomy' (Drew, 1987, p. 22). As Drew put it, 'geometry as presented by Adelard ... is an entirely practical subject ... deriving from the manuals of the Roman *agrimensores*'. In the first half of the twelfth century, contemporaries of Adelard, such as Hugh de St Victor in his *Didascalicon*, also saw geometry as a practical subject which divided geometry into altimetry, planimetry and cosmimetry. In his *Practica Geometria*, however, Hugh drew a distinction between theoretical geometry, which he says investigates dimensions through reason alone, and practical geometry, which uses instruments and reaches its conclusions by the study of proportions (Drew, 1987, pp. 22-3).

At the time he wrote *de Eodem*, Adelard 'seems not to have been aware of theoretical geometry' and was far more 'impressed by the methods for measuring set out in the practical geometries' (Drew, 1987, p. 23). However, in one of the translations of *Elements* attributed to Adelard, a distinction is drawn between two types of geometer: the *demonstrator*, who explains theorems, and the practitioner (*exercitator*) who is 'concerned simply with measurement' (Drew, 1987, p. 23). Once again, this distinction is significant for it suggests that Adelard, along with others such as Hugh de St Victor, recognized that they had two audiences, one learned in geometry, and the other skilled in measuring. What they were trying to do, it seems, is enlighten the latter with the knowledge of the former.

Thus, in the middle of the twelfth century, well before the Renaissance of the fifteenth and sixteenth centuries, a distinction was beginning to be made between theoretical and practical geometry. Furthermore, theoretical geometry appears to have started to inform problems in practical geometry at the time when a number of towns were laid out using strict orthogonal plans and geometrical designs. As a tentative hypothesis, then, it might be suggested that Adelard's translation of Euclid's *Elements* became incorporated into the practice of a certain type of learned surveyor, the *mensores literati*, who 'proceeded by geometric demonstrations' rather than 'lay custom'. The possible impact of this development in the knowledge and application of theoretical geometry has not gone entirely unnoticed by some modern architectural and art historians (Gimpel, 1983; Wittkower, 1988). For example, it has been suggested that the use of Euclidean geometry had an influence on the ground plan of churches in twelfth and thirteenth century England (Bulmer-Thomas, 1979) and, recently, Randolph (1995) has suggested that geometry was a factor behind the plans of bastides in thirteenth-century Gascony. But neither suggested why it was that greater geometric exactitude was desirable, and generally there has been a tendency to neglect how Euclidean geometry, coupled with practical geometry, enabled more accurate measurement of ground-plans after *c.* 1150. Moreover, surprisingly few modern scholars have looked to geometry as the means by which medieval towns could be and were laid out with greater precision.

If the translation of Euclid's *Elements* did have an impact on the development of more

precise measuring techniques, as seems likely, then it is reasonable to ask why it was that greater emphasis was placed on making abstract geometrical figures into designs for urban landscapes in the twelfth century and onwards. To answer this it is necessary to consider the symbolic importance that was attached to geometry in the Middle Ages. The connections between geometry, cosmology and astronomy seem particularly significant in this respect.

Symbolic form and urban design

From a German psalter of the thirteenth century there is a now well-known image depicting God, with dividers in hand, as 'architect of the universe' (*artifex principalis*) (Frayling, 1995). This image serves to show how, in the thirteenth century at least, geometry and Christian cosmology were closely intertwined. This connection is more commonly discussed in the context of medieval architectural form rather than urban design (Bucher, 1972), yet it may be argued that geometry was used for the same purpose in the design of towns as it was in Gothic architecture. Geometry mediated between heaven and earth, between God above and the world below. Geometry acted as a mirror of the divine order, something that art and architectural historians have long accepted (Panofsky, 1951; Morris, 1950). Although the geometrical order of medieval towns with orthogonal plans has not generally been viewed in this way, there is no evidence to suggest it should not.

What has been noted in the design of certain orthogonal-form towns is their carefully regulated geometrical proportions. In particular, Grenade sur Garonne, a bastide founded in 1290-1 by Eustache de Beaumarchais, has a plan which was apparently conceived and laid out according to the proportion of 1:$\sqrt{2}$ (Bucher, 1972; Friedman, 1988; Randolph, 1995) (Figure 2).

Figure 2. Plan of Grenade-sur-Garonne (founded in 1290-1), showing the proportional relationship between streets.

Mathematically this equates to the ratio of 1:1.414, but using geometry it is based on a system in which 'the right rectangle or diagon is produced by a square whose diagonal determines the side of a rectangle' (Bucher, 1972, p. 43). At Grenade, the diagonal distance across the street blocks within the two central parallel streets was used to determine the length of street blocks immediately to the north and south. The diagonal across these street blocks was then used to fix the line of the next parallel street, and so on. The use of ratios such as 2:1 and $1{:}\sqrt{2}$ seems relatively commonplace in medieval architectural design (Guidoni, 1970; Fernie, 1976).

The use of proportion and geometric exactitude in the layout of orthogonal towns such as Grenade may be further understood in the context of attitudes to aesthetics and cosmology in the twelfth and thirteenth centuries, both of which relied on the notion that form equated with beauty. For example, in the 1240s, Robert Grosseteste 'regarded Good and Beauty as names for God', and Alexander of Hales, in his *Summa* of 1245, proposed that good and beauty 'were grounded primarily in the concrete form of things' (quoted in Eco, 1986, p. 24). As Umberto Eco put it, 'truth and beauty were both defined in terms of form' (Eco, 1986, p. 23). Likewise, Hugh de St Victor, in his commentary on the Celestial Hierarchy (*In Hierarchiam Coelestem*), wrote that 'all things visible, when they obviously speak to us symbolically, that is when they are interpreted figuratively, are referable to invisible significators and statements ... for since their beauty consists in the visible forms of things ... visible beauty is an image of invisible beauty' (quoted in Eco, 1986, p. 58). It does not seem too unlikely, then, that the strict geometrical forms of towns with orthogonal plans were devised to please God, for through their physical form 'visible beauty' became 'an image of invisible beauty'.

It can thus be argued that symbolic form found an expression not only in architecture but in the design of towns. On a practical level, too, there seems to have been a connection between town design and architecture. According to Jean Gimpel (1983, p. 121), 'life's vagaries sometimes led architects to become town planners', and in *c.* 1200 we hear of Master Simon, 'learned in the art of geometry', 'pacing with rod in hand', laying out the walls of Ardres (Frayling, 1995, p. 64). It seems that his occupation, perhaps like many others, involved surveying and designing. There is, however, a significant difference between using geometry to build a cathedral and using geometry to devise and lay out a town, a difference not simply of scale. The cathedral was visible to all, in all its glory, as a three-dimensional enclosed structure, an allegory of Christian teaching and discipline; yet the plan of a town, designed according to geometrical principles and laid out using a practical knowledge of geometry, could really only be appreciated when viewed from above. On the ground, the straight streets would have given a sense of linear order, but the overall plan could only have been fully seen by the designer (presumably as a drawn plan), and of course by God. Perhaps in this context the designer of an orthogonal-shaped town, learned in geometry as a theoretical and practical geometry, established a geometrical layout of streets and plots on the ground in order to make the 'invisible' visible.

There are other aspects to geometry that ought to be considered, not least its use in medieval astrology. Adelard was himself interested in astrology and astronomy. By 1150 he knew of the astrolabe as an instrument for measuring the movements of constellations, and in 1126 he 'translated the astronomical tables of al-Khwarizmi, an early-ninth century astronomer from Central Asia working in Baghdad' (Gibson, 1987, pp. 7, 13). Adelard is also known to have drawn up horoscopes in the 1140s, during the civil war of Stephen's reign in England (North, 1987). These horoscopes take the form of geometrical figures, and in some ways show similarities with the orthogonal plan-forms of certain thirteenth-century towns in Bohemia and Moravia, such as Moravśka Trebova

(Figure 3). The idea that astrology may have been behind the use of geometrically arranged town plans is not as far-fetched as it first appears. For example, it is known from Giovanni Villani, writing in Italy in the fourteenth century, that the foundation date of the town of Firenzuola was set according to astrology (Friedman, 1988, pp. 139, 228-9).

All in all, the symbolic value of geometry in itself may explain why certain towns were laid out with strict orthogonal forms, for it could simply be a reflection of a town founder's desire to invoke the protection of God, and in the physical shape of his town realize the truth and beauty of geometry to reflect his devotion. The mechanism by which such towns were laid out also relied on geometry. Measuring the land with precision required knowledge of theoretical geometry, and through the *practica geometria* of Villard and others, even those lay surveyors whom Fibonacci disdainfully called 'vulgar' could learn to make use of geometry to design and lay out new urban landscapes of orthogonal form (Friedman, 1988, p. 129). Those that did not make this transition, however, presumably continued using 'lay custom', and set out their towns using only measurement, or metrology, fixing lines with ropes and stakes.

Conclusion

This paper started by questioning the view that, before the Renaissance, land measurement was undertaken by only 'traditional' means. Of course, traditional, or lay, methods of measuring did exist throughout the Middle Ages in Europe, and they seem to have been used to lay out towns or parts of towns, to fix the lines of streets and plots, at least since the ninth century (see Crummy, 1979). In such cases the results are evident in the plans of those towns that have quasi-rectilinear (but not orthogonal) plans, such as Drogheda, Winchester and Salisbury. However, more advanced methods of measurement were also used to design towns in the Middle Ages. These relied on a knowledge of how to use principles of theoretical geometry to solve practical problems in surveying. In this respect, the acquisition of Euclid's *Elements* was instrumental, along with other scholarship on the theory and practice of geometry, since it provided the means of implementing more precise geometrical designs. After *c.* 1150, the dissemination of theoretical geometry, in its own right and in the guise of 'practical geometries' written by learned men such as Fibonacci, helped those who wished to

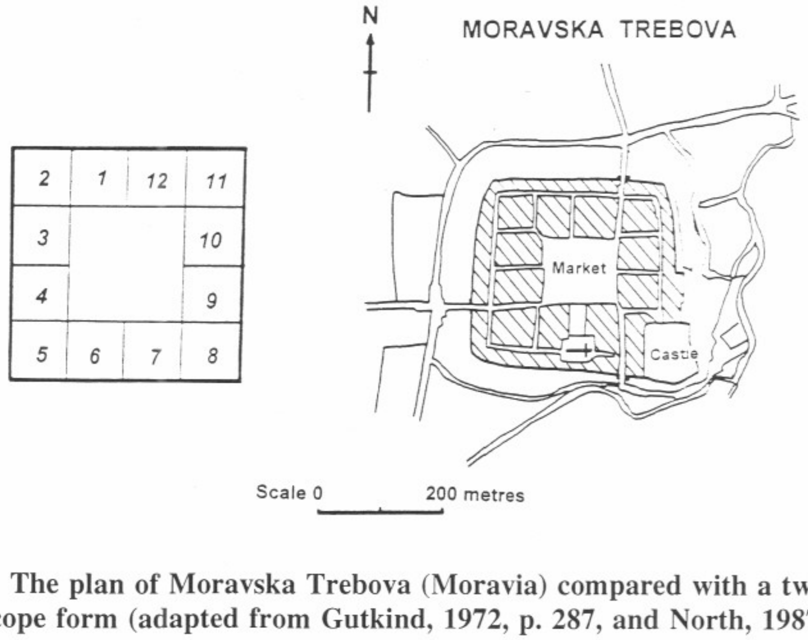

Figure 3. The plan of Moravska Trebova (Moravia) compared with a twelfth-century horoscope form (adapted from Gutkind, 1972, p. 287, and North, 1987, p. 148).

measure the land more precisely, according to the principles of geometry, rather than measuring it according to 'lay custom'.

The two types of medieval surveyor, the lay measurer and the literate measurer, thus appear to find an expression in the physical form of medieval towns, the latter contributing to the creation of urban landscapes with orthogonal plans, and the former creating towns with quasi-rectilinear plans. It remains for this relationship to be shown with certainty, either by new documentary research or by the careful morphological analysis of orthogonal urban forms in relation to Euclidean geometry. Friedman (1988) has already demonstrated that newly-founded towns in fourteenth-century Tuscany were set out using the methods contained in Leonardo Fibonacci's *Practica Geometria*.

It is not just greater accuracy in surveying that is reflected in the orthogonality of town plans after *c.* 1150, but an associated reverence for geometry as a signifier of God, beauty and truth. Whether geometry was used to reflect the divine order of things or as an astrological device, it seems that orthogonality was seen as a means of making the 'invisible' visible. This, too, is an avenue for further research, connecting the writing of medieval theologians and philosophers with the changing form of urban landscapes in the Middle Ages. In this context, the methods of town-plan analysis provide a suitable means by which to study subtle variations in medieval urban form, and make it possible to explore why it was that towns were designed in one way but not another. There is thus great potential for linking the morphology of medieval towns with contemporary ideas about cosmology and symbolic form, and connecting ourselves with the minds of those individuals who were responsible for taking measures across the medieval landscape.

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Note

1. The term 'quasi-rectilinear', though rather cumbersome, is perhaps the most appropriate for it covers those towns that have plans (or parts of their plans) made up of either straight streets or curving streets, but which lack orthogonality.

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