Mapping Landscapes in Transformation

Multidisciplinary Methods for Historical Analysis

Edited by
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ISBN 978 94 5867 173 1 (Paperback)
ISBN 978 94 6166 283 5 (ePDF)
https://doi.org/10.11116/9789461662835

Leuven University Press

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Pixels or Parcels?

Parcel-Based Historical GIS and Digital Thematic Deconstruction as Tools for Studying Urban Development

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Very often, scholars aiming at mapping spatial arrangements and developments of the urban past choose nineteenth-century cadastral maps as the starting point for their analysis. These maps were for instance the main sources for the so-called regressive town plan analysis, a research method developed by the geographer Michael R.G. Conzen in his seminal study on the growth of Alnwick, Northumberland (Conzen 1960). The method has its origins in the structuralist approach that affected the historical and geographical sciences in the 1960s and 1970s, was refined afterwards by scholars of the Urban Morphology Research Group at the University of Birmingham, and influenced the still ongoing European Historical Towns Atlases project (Simms 2015). From the 1990s onwards, town plan analysis got a digital afterlife with the emerging of geographical information systems and their implementation in historical geography, urban morphology, landscape studies, building history, and archaeology. Today, various urban historical GIS projects still start from the parcel-based approach, as they also use the nineteenth-century cadastral maps as base layers. The French *Alpage* project is built up from the digitisation, geo-referencing, and vectorisation of the so-called *plans d'îlots Vasserot*, drawn in the period 1810-1836 (Noizet 2008-2009; Chareille et al. 2013; Raveaux et al. 2013). In the Low Countries, the Dutch *Hisgis.nl* website is built upon the cadastral maps from 1832, while the Bruges *Kaartenhuisbrugge* project uses the initial cadastral maps (*primitieve plans*) made in 1811, 1831, and 1835 as base layers (D'Hondt 2009) [**Map 1**].

For the creation of historical GIS applications these nineteenth-century cadastral maps have three important strengths: (1) they are geometrically accurate; (2) they

provide an account of the topographical objects and spatial patterns that existed before nineteenth- and twentieth-century urbanisation and industrialisation hugely transformed the cityscapes; and (3) they can quite easily be geo-referenced and warped on present-day cadastral and topographical maps. Yet, one might ask if both these nineteenth-century cadastral maps and the historical GIS applications that are built upon them are also relevant and useful when it comes to visualise and understand landscape transformation. In order to answer this question, I have assessed some of the renowned historical GIS platforms for Paris, Bruges, Antwerp, and some Dutch cities and towns: Alpage *AnaLyse diachronique de l'espace Parisien* (http://mapd.sig.huma-num.fr/alpage_public/flash/) [**Map 2**], the *Kaartenhuisbrugge* and *MAGIS Brugge* projects (http://www.kaartenhuisbrugge.be/Huis/ and http://magis.kaartenhuisbrugge.be/), the *GIStorical Antwerp* project (https://www.uantwerpen.be/en/projects/gistorical-antwerp/), and the Dutch *Hisgis.nl* website (http://www.hisgis.nl).

In the first section, I will discuss some methodological issues, seen from the perspective of a map and urban historian. It is definitely not my aim to reject the usefulness of these applications or to disregard the huge efforts the project staff has invested in them, but merely to reflect upon their values for studying historical landscape transformation in general and urban development in particular. In the second and third sections I will plead for the integration of this 'traditional' parcel-based historical GIS with the digital analysis of older maps and provide a small example of work in progress.

Parcel-based historical GIS applications: some major methodological issues

It goes without saying that the creation of online historical GIS systems and applications requires a lot of time, energy and funding and that project leaders and map developers face various technological issues during the developing process (e.g. Gregory and Ell 2007; Antrop et al. 2015). In addition to these technological challenges several heuristic issues emerge. Some of them have been discussed intensely before, e.g. the integration of imprecise, incomplete and/or fuzzy historical data in the rigid GIS data model (Bodenhamer et al. 2010; Bodenhamer 2015: 10 and 18). The protection and accessibility of the mass of data are other issues: most historical GIS platforms do not give direct access to the underlying databases and metadata and only offer the opportunity to explore edited map products and search engines for specific enquiries. By contrast, the objectiveness and accuracy of historical GIS systems are less distrusted. One of the reasons

might be that both the producers and users too often reduce map accuracy to geometric accuracy solely. Yet, already in 1980 M.J. Blakemore and J.B. Harley urged scholars also to take topographic and chronometric accuracy into account when it comes to study, interpret and use old maps. While chronometric accuracy concerns 'the methods by which early maps are dated and related to accepted time scales within different map cultures', topographic accuracy deals with 'the quantity and quality of the information in a map about landscape objects' (Blakemore and Harley 1980: 55 and 68).

Just like any other cartographic product, nineteenth-century cadastral maps resulted from a selection process, including both intentional and unintentional choices, and from the conscious or unconscious visions on landscape, territory, and society adopted by commissioning parties and map-makers of the time. The cadastral maps have been produced for fiscal and administrative purposes, which undoubtedly impacted on the map-making practices and the shape and lay-out of the final products. According to Katalin Szende (2013: 189), 'the more relevance a feature had for the primary aims of cadastral mapping, that is, for fiscal and administrative ends, the more attention it would have received from the cartographers'. Since the primary purpose of the surveys was to collect data for taxation assessments, the areas of the taxable units were measured and mapped precisely, while other topographic features such as watercourses, public buildings, and the (remains of) defence systems were less important. In some countries the cadastral maps — which initially were purely institutional products — have been commercialised afterwards, e.g. the so-called 'Popp maps' in nineteenth-century Belgium (Vrielinck 2018). Commercial editors sold reduced copies of the maps, which means that their chronometric and topographic accuracy were reduced compared to the original material.

It seems that scholars using nineteenth-century cadastral maps and historical GIS applications that are built upon them generally do not pay much attention to these issues, and just take advantage of the maps' high geometric accuracy for reconstructing the layout of building plots, parcel limits, and landscape patterns. Anne Kelly Knowles (2008: 2) considers historical GIS systems to be superb tools 'for mapping and geographically analysing census data, social surveys, and other kinds of systematically collected information linked to known geographical units and locations'. Although she also pointed to the use of GIS 'to visualize past landscapes and the changing morphologies of built environments over time', the question remains whether parcel-based historical GIS really is a suitable tool for studying, reconstructing, and visualising landscape transformation, which

inherently starts from and depends on incomplete and heterogenic sets of data. Actually, several historical GISs are temporal-historical systems: they take the nineteenth-century cadastral maps as their starting point, but also tend to visualise older landscape features and spatial patterns and/or link historical data to the base maps (Heere 2008: 115). In other words, these temporal-historical GIS applications add time-depth to the nineteenth-century maps. Georectified Popp-maps of Bruges are for instance used to visualise, analyse, and explain social change in the city between 1300 and 1700, to cite just this very recent example (Deneweth et al. 2017).

It was certainly not the intention of the nineteenth-century mapmakers, commercial editors and governmental institutions that commissioned the cadastral maps to produce 'historical maps', i.e. maps that portray facts derived from the critical interpretation of source materials concerning cultural and physical elements which did not exist when the map was made' (Wallis and Robinson 1987: 107). The maps were not produced as sources for academic research or educational purposes. They simply provide an account of older landscape features and morphological patterns because 'the plan and fabric of the town, representing as they do the static investment of past labour and capital, offer great resistance to change' (Conzen 1980: 6), a phenomenon commonly known as 'spatial inertia'. Notably field and parcel limits and street plans often resist landscape transformation through the times. Although not always visible to the naked eye, these relics structurally remain present in orthogonal (cadastral, topographical) maps and aerial views too. But how do we measure the time-depth of these inert landscape features? This can be achieved only by studying object per object, pattern per pattern: 'it requires special attention to ascertain to which period exactly these features date back, and to place them consistently in a context of their own time', to quote Katalin Szende (2013: 189) again. Hence, the time-depth of a mapped landscape object should certainly not be extrapolated to the whole map.

Finally, most historical GIS applications focus too much, or even solely, on parcels and buildings. The nineteenth-century cadastral maps particularly represent real estate property, while streets, roads, waterways, and other topographic features were just mapped in order to provide spatial context. In contrast to older urban maps, the representation of small landscape features, temporary items, or movables is completely lacking. Hence, the cadastral maps offer a very still and almost sterile representation of the urban landscape, consisting of empty roads and streets, which omits the representation of street furniture, means of transport, waste, animals, people, movables, the hinterland, etc. The same applies to

the historical GIS applications that are built upon them: the main focus is on properties, parcels, and private houses, while public spaces are often neglected [Map 3]. Neither the maps nor the historical GIS applications give an impression of perspectives, skylines and altitudes, hot spots and places of desolation, openness and closures, etc. Yet, when it comes to reconstructing and mapping landscape transformation, these aspects should be taken into account too.

Digital thematic deconstruction: an alternative application with complementary perspectives

The heuristic issues mentioned above should of course not restrain us from building and using historical GIS applications, on the contrary. It is however necessary to keep on reflecting about the strengths and weaknesses of the applications and trying to approve them, preferably by matching the desires from producers and consumers as far as possible. Most publications (books, articles, manuals, reports, etc.) on the subject are written by the producers of these systems (e.g. Noizet et al. 2013), so it might be a good idea that users also publically share their comments. From the producers' perspective, a very simple step might be to provide users with a short note on the accuracy levels and various degrees of time-depth of the base maps used for the applications.

A more advanced yet technologically challenging and time-consuming suggestion would be to evolve from the present-day static historical GIS applications to digital motion maps, showing evolutions of landscape and building patterns through time. In anticipation of this step, scholars are currently experimenting with so-called deep maps, i.e. maps that are 'not confined to the tangible or material, but include the discursive and ideological dimensions of place, the dreams, hopes, and fears of residents'. Being a platform, process, and product at the same time, deep mapping implies the creation of multimedia environments 'embedded with tools to bring data into an explicit and direct relationship with space and time' or, in in short, of 'a new creative space that is visual, structurally open, genuinely multimedia and multi-layered' (Bodenhamer et al. 2015: 3-4). But except for some recent small steps in the GIStorical Antwerp project (Janssens and Jongepier 2015), deep mapping has not yet been introduced in the urban historical GIS systems of the Low Countries.

A network of French urban archaeologists and geographers has chosen a radical alternative, the so-called 'chrono-chorématique', which implies a schematic and abstract modelling of 'urban trajectories' through the times, based on 'chorèmes'

or schematic representations of spatial objects. (Boissavit-Camus et al. 2005; Djament-Tran and Grataloup 2010) Unfortunately, it seems that this approach has not yet found its way to the scholars and research networks outside France, and it remains unclear how it can be integrated into historical GIS.

Another innovation might be to extend and link the traditional parcel-based historical GIS applications with the so-called 'digital thematic deconstruction' of pre-nineteenth-century topographical maps and bird's-eye views. To a certain extent, the focus on the nineteenth-century material has restrained scholars — both landscape historians and urban morphologists — and map developers from taking advantage of the qualities of older maps. These maps often tend to have a figurative nature and are therefore considered less precise, highly symbolic or quite imaginative. It is not surprising, then, that they are merely used as 'nice pictures', visualising or illustrating verbal arguments (Burke 2001: 9-10). But despite their geometric imperfections and sometimes imaginative nature, old maps have important qualities too: many of them show spatial objects, (parts of) landscapes, and territories which are not or only partly visible in the nineteenth-century parcel maps.

Especially the old topographical maps, which mostly have a figurative and pictorial nature, set out 'to convey the shape and pattern of landscape, showing a tiny portion of the earth's surface as it lies within one's own direct experience' (Harvey, 1980: 9). Despite their — sometimes very striking — subjectivity, most early modern urban maps are stuffed with landscape elements represented with quite a high level of topographic accuracy. See for instance Jacopo de' Barbari's impressive bird's-eye perspective of Venice from 1500 which combines a high degree of topographic accuracy with a symbolic and moralising perspective on city and society (Schulz 1978; Howard 1997). Moreover, old topographical maps have been produced in earlier periods, closer to the landscapes and landscape change scholars aim to reconstruct and map. Compared to the nineteenth-century cadastral maps, their chronometric accuracy is much higher.

Digital thematic deconstruction is a method of digital map analysis which is particularly suitable for studying, analysing, and unlocking such pre-nineteenth-century, figurative cartographic and iconographic documents (Vannieuwenhuyze and Vernackt 2014). Briefly speaking, it requires the systematic digital redrawing of an old map which is subsequently saved as vector data through a GIS. A rasterised high resolution scan of the old map serves as the base layer for creating a whole new set of adjoining polygons ('tiling'), which are categorised as clearly

defined topographic typologies and sub-typologies (e.g. 'street', 'house', 'moat', 'gate', 'bridge', 'tree', etc.). As such, a thematic categorisation of all map objects is realised and stored in the accompanying topological database [**Map 4**]. It is a golden rule not to add extra cartographic content, for instance by duplicating parts of the image or correcting mistakes. In the first place the map 'speaks for itself'; secondly, the cartographic elements are categorised (the basic level of interpretation), while subsequently a whole range of supplementary attributes can be added to the database (the second level of interpretation).

Digital thematic deconstruction thus offers the opportunity to convert a static image (the 'nice picture') into a dynamic file and research tool, which can subsequently be used for different inquiries and applications on the web, tablet, or smartphone (Vernackt et al. 2014) [**Map 5**]. One of the main benefits is that it becomes possible to digitally re-edit old maps following everyone's own desires, in other words to turn an early modern figurative map into a historical thematic map [**Map 6**]. In particular, it helps to visualise those landscape objects and patterns which are not necessarily visible with the naked eye. These and other relevant data help archaeologists, landscape scientists, building historians, and urban morphologists to study and explain the morphology and evolution of past landscapes and spatial arrangements.

The future: integrated approaches and systems

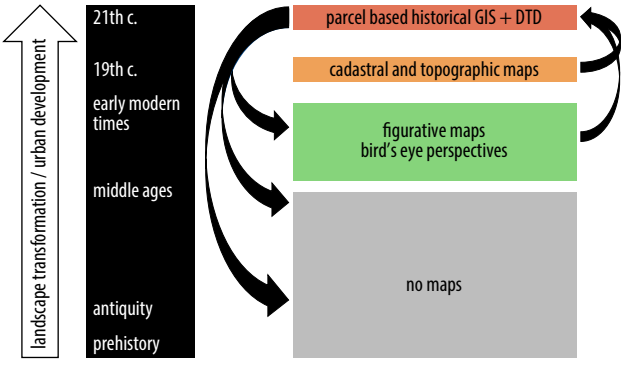
Digital thematic deconstruction using GIS is not that different from regressive town plan analysis and parcel-based historical GIS applications. Both approaches indeed imply the digitisation and vectorisation of a specific type of old maps through the creation of a set of thematically defined layers and storing attributes in a linked topological database. Yet, there are some important differences too. Digital thematic deconstruction does not need a geo-referenced map as base layer: while the geometrically accurate nineteenth-century cadastral maps can easily be warped on present-day parcel and topographical maps, it is mostly futile to geo-reference early modern figurative maps and bird's-eye views, since they witness too many spatial distortions. Geo-referencing hugely deforms the original map/image, which would mean that it becomes 'unreadable' and thus unusable for digital analysis of its topographic and figurative content. The power of these maps actually lies in the three-dimensional representation of the landscape, which most nineteenth-century (and more recent) orthogonal cadastral maps lack.

Another big difference is the extent of the digitisation: while parcel-based historical GIS applications primarily focus on buildings, parcels, and real estate, digital thematic deconstruction takes the entire map into account, including the public spaces, various types of small landscape elements, and 'useless data', such as people, animals, mythological creations, and movables, natural phenomena like shadows and smoke, decorative motifs, legends, cartouches or even 'distortion' (missing parts, damage, blank spaces). In addition, dismantling the map not only means dismantling the mapped landscape, but also questioning the use of the landscape and the map-maker's (and/or commissioner's) visions and perspectives on it. In other words, the method not only allows the isolation of every single cartographic or iconographic detail from the map, but also provides insight into the production process and its complex composition. Both the map and the mapped landscape are analytically and critically approached, which in turn warns users not to take the representation for granted.

It is not my intention to call for a replacement of parcel-based historical GIS by digital thematic deconstruction applications. Admittedly, digital thematic deconstruction has some disadvantages too. First, it is an even more intensive and time-consuming operation to digitise an entire pre-nineteenth-century map manually. Due to their figurative, three-dimensional nature, most of the map elements have complex and irregular shapes, which contrasts with the rather regular and 'simple' shapes of parcels and building plots on the cadastral maps. For the moment it is not yet possible to do the digitisation automatically, e.g. by some kind of image recognition algorithm, but it is expected that technological advances will allow one to do this in future. A second disadvantage concerns the scale and extent of figurative maps: in general, highly detailed figurative maps have a large scale and size (e.g. 109 x 107,5 cm for Cornelis Anthonisz' bird's-eye perspective of Amsterdam from 1544; 177 x 100 cm for Marcus Gerards' copper engraving of Bruges from 1562). A complete digitisation and vectorisation leads to the creation of very large datasets, which are not always easy to handle and use. Finally, just like parcel-based historical GIS applications, the digital thematic deconstruction itself does not allow one to visualise landscape transformation, since it also offers a static representation of the mapped landscape.

Visualising and studying landscape change can, however, be realised by combining both approaches, since they are quite complementary. Therefore, I would like to plead for an integration and juxtaposition of traditional parcel-based historical GIS with the digital thematic deconstruction of one or more maps of the same city, town, or area. Such an integrated system and approach offers the opportunity to combine

the strengths of both applications: the geometric accuracy of the cadastral maps and the figurative power and reduced time-depth of the early modern topographical maps (Table 1). At the University of Amsterdam, students are currently digitising and linking historical data to some of the old bird's-eye perspectives of the city (e.g. Cornelis Anthonisz' woodcut from 1544 and Balthasar Florisz van Berckenrode's engraving from 1625) and to the nineteenth-century cadastral maps, with the aim of studying the socio-economic transformation and the spatial layout and development of the city more thoroughly. In the near future, it will be tested whether it is possible to build and to bring online an integrated digital system which juxtaposes the data and allows the cross-fertilisation of the results of the different inquiries.



	geometric accuracy	chronometric accuracy	topographic accuracy	figurative value	time-depth
19th century cadastral maps	high	good	good	low	good
parcel based historical GIS	high	low	good	low	good
early modern figurative maps	low	good	very good	high	very good
DTD	low	low	very good	high	very good

Tables 1a and 1b: Schematic overviews of an integrated system combining parcel-based historical GIS based on nineteenth-century cadastral maps and digital thematic deconstruction of pre-nineteenth-century topographical and figurative maps, with the strengths of both applications (© Bram Vannieuwenhuyze).

Such an endeavour costs a lot of time and energy. For the moment, the work is still in progress, so it is not yet possible to show and discuss real results. I confine myself to one small case, based on the fourfold digital map analysis of a single

building block in Amsterdam (Prins Hendrikkade, Damrak, Haringpakkerssteeg and Hasselaerssteeg): the digital thematic deconstruction of Cornelis Antonisz's bird's-eye view from 1544, a heat map showing the variation in rental prices in 1562 plotted on the nineteenth-century cadastral map, the digital thematic deconstruction of Balthasar Floris van Berckenrode's bird's-eye view from 1625, and a screenshot from the HisGIS.nl website which offers data on buildings, parcels, occupants or owners, professions, and taxes with the cadastral map from 1832 as base layer (http://www.hisgis.nl/hisgis/gewesten/amsterdam/kaart1830/amsterdam1832; accessed 13 April 2018) [**Map 7a-d**]. Comparing the results of the digital analyses allows one to draw conclusions or to make hypotheses about the evolution of this particular part of the urban landscape, notably the change of parcel limits, building density, and the urban skyline, evolutions in occupations and socio-economic functions, social segregation, etc.

Let us for instance briefly examine if there was a correlation between rental values, presented on the heat map, the occupational data of 1832 stored in the HisGIS.nl database and the architectural characteristics of the urban sixteenth- and seventeenth-century fabric. Both bird's-eye views show large and tall houses inside the building block and alongside the Hasselaerssteeg (on the right side of both images), which seems to contrast with the relatively average rental values and with the small rectangular parcels on the nineteenth-century cadastral map. It is likely that the parcels have been split up at a given time, while the large buildings must have been destroyed and replaced by smaller housing units. The high rental prices alongside the Prins Hendrikkade, highlighted in red on the heat map, can be explained by the presence of wood storing facilities, as is suggested by Cornelis Anthonisz's map. There is no trace of the wood trade in the cadastral data for 1832, since only two ironmongers, a tobacco trader, and a *procureur* are registered in the HisGIS.nl database. The wood trade had probably left the area, leaving space for new activities and building projects. Some of the former open spaces no longer existed in the nineteenth century. At the Damrak, the red spot on the heat map seems to correspond with the large house with the bell gable drawn by Cornelis Anthonisz, which was probably inhabited by a wealthy family. In 1832 this house was occupied by a fruiterer.

Of course, figurative and cadastral maps never tell the whole story, especially if they originate from different periods and were created for different purposes. Additional historical, cartographical, iconographical, and archaeological data must be added in order to check the tentative hypotheses stated above and complete the analysis. What matters here, however, is to stress that juxtaposing the old

maps and integrating the various HisGIS data will open the path for approaching the evolution of the cityscape and socio-economic trends in a new way, especially if larger areas (entire neighbourhoods or whole cities) are taken into consideration. Nevertheless, it will be a huge challenge to design such an integrated system so that users can visualise, interpret, and use the results of their inquiries properly. Among other things, the distinct orientation, the various scales, and the connectivity of the maps need special attention. In a very ideal situation, such a system shall also be supplemented with other visual schemes like the 'chrono-chorématique' or deep mapping applications. The future will tell if such integrated systems will be achievable, viable, and relevant.

Bibliography

Antrop M., De Maeyer Ph., Van de Weghe N. and Neutens T. (2015). *Geografische informatiesystemen*. Ghent: Academia Press.

Blakemore M.J. and Harley J.B. (1980). *Concepts in the History of Cartography. A Review and Perspective*. Toronto: University of Toronto Press.

Bodemhamer D.J. (2015). Narrating Space and Place. In: Bodenhamer D.J., Corrigan J. and Harris T.M. (2015), Deep Maps and Spatial Narratives. Bloomington – Indianapolis: Indiana University Press, p. 7–27.

Bodenhamer D.J., Corrigan J. and Harris T.M. (2010). The Spatial Humanities. GIS and the Future of Humanities Scholarship. Bloomington – Indianapolis: Indiana University Press.

Bodenhamer D.J., Corrigan J. and Harris T.M. (2015). Deep Maps and Spatial Narratives. Bloomington – Indianapolis: Indiana University Press.

Boissavit-Camus B., Djament G., Dufaÿ B., Galinié H., Grataloup C., Guilloteau C. and Rodier X. (2005) Chrono-chorématique urbaine: figurer l'espace/temps des villes. In: Berger J.-F., Bertoncello F., Braemer F., Davtian G. and Gazenbeek M. (eds), Temps et espaces de l'homme en société, analyses et modèles spatiaux en archéologie. Actes des XXV^{e} rencontres internationales d'archéologie et d'histoire d'Antibes. Antibes: APDCA, p. 67–80.

Burke P. (2001). Eyewitnessing. The Uses of Images as Historical Evidence. Ithaca, NY: Cornell University Press.

Chareille P., Bouju A., Bethe A.-L. and Noizet H. (2013). Le géoréférencement des plans Vasserot: méthodes, déformations, interprétations. In: Noizet H., Bove B. and Costa L. (eds), Paris de parcelles en pixels. Analyse géomatique de l'espace parisien médiéval et moderne. Paris-Vincennes: Presses Universitaires de Vincennes & Comité d'histoire de la Ville de Paris, p. 37–52.

Conzen M.R.G. (1960). Alnwick, Northumberland. A Study in Town-Plan Analysis. London: The Institute of British Geographers.

Deneweth H., Leloup W. and Speecke M. (2017). Visualising Urban Social Change, Bruges 1300-1700. In: Plosnić Škarić A. (ed.), *Mapping Urban Changes/Mapiranje urbanih promjena* (Conference Mapping urban changes, Dubrovnik, 20-22 September 2017). Zagreb: Institute of Art History, p. 336–363.

D'Hondt J. (2009). De website huizenonderzoekbrugge.be: stand van zaken en toekomstplannen. In: D'Hondt J. (ed.), *Huizenonderzoek & Stadsgeschiedenis. Handelingen van het colloquium 'Huizenonderzoek & Stadsgeschiedenis' georganiseerd door Levend Archief vzw i.s.m. Bouwhistorie vzw op 28 november 2008 in Brugge*. Bruges: Levend Archief vzw, p. 13–24.

Djament-Tran G. and Grataloup C. (2010). *E pluribus urbibus una*: Modéliser les trajectoires de villes. *M@appemonde*. [online] 100. Available at: https://mappemonde-archive.mgm.fr/num28/articles/art10401.html [accessed 15 March 2018].

Gregory I.N. and Ell P.S. (2007). *Historical GIS. Technologies, Methodologies and Scholarship*. Cambridge: Cambridge University Press.

Harvey, P.D.A. (1980). *The History of Topographical Maps. Symbols, Pictures and Surveys*. London: Thames and Hudson.

Heere, E. (2008). *GIS voor historisch landschapsonderzoek. Opzet en gebruik van een historisch GIS voor prekadastrale kaarten*. Utrecht: Koninklijk Nederlands Aardrijkskundig Genootschap – Faculteit Geowetenschappen Universiteit Utrecht.

Howard, D. (1997). Venice as a Dolphin: Further Investigations into Jacopo de' Barbari's View. *Artibus et Historiae* 18 (35), p. 101–111.

Janssens, E. and Jongepier, I. (2015). GIStorical Antwerp: historisch GIS als laboratorium voor de stadsgeschiedenis. *Stadsgeschiedenis* 10 (1), p. 49–62.

Knowles, A.K. (2008). GIS and History. In: Knowles, A.K. (ed.) *Placing History. How maps, spatial data, and GIS are changing historical scholarship*. Redlands CA: ESRI Press, pp. 1–25.

Noizet, H. (2008-2009). Les plans d'îlots Vasserot, support d'un système de l'information géographique historique de Paris. *EAV. La revue de l'École nationale supérieure d'Architecture de Versailles* 14, p. 86–95.

Noizet, H., Bove, B. and Costa, L. (eds) (2013). *Paris de parcelles en pixels. Analyse géomatique de l'espace parisien médiéval et moderne*. Paris: Presses Universitaires de Vincennes – Comité d'Histoire de la Ville de Paris.

Raveaux R., Burie J.-C. and Ogier J.-M. (2013). La vectorisation automatisée des plans Vasserot. In: Noizet H., Bove B. and Costa L. (eds), Paris de parcelles en pixels. Analyse géomatique de l'espace parisien médiéval et moderne. Paris: Presses Universitaires de Vincennes – Comité d'Histoire de la Ville de Paris, p. 53–65.

Schulz J. (1978). Jacopo de' Barbari's View of Venice: Map Making, City Views, and Moralized Geography Before the Year 1500. Art Bulletin 60, p. 425–474.

Simms A. (2015) The European Historic Towns Atlas Project: Origin and Potential. In: Simms, A. and Clarke H.B. (eds), Lords and Towns in Medieval Europe. The European Historic Towns Atlas Project. Farnham-Burlington: Ashgate, p. 13–32.

Szende K. (2013). How far Back? Challenges and Limitations of Cadastral Maps for the Study of Urban Form in Hungarian Towns. In: Ehbrecht W. (ed.), Städteatlanten. Vier Jahrzehnte Atlasarbeit in Europa. Cologne-Vienna-Weimar: Böhlau Verlag, p. 153–190.

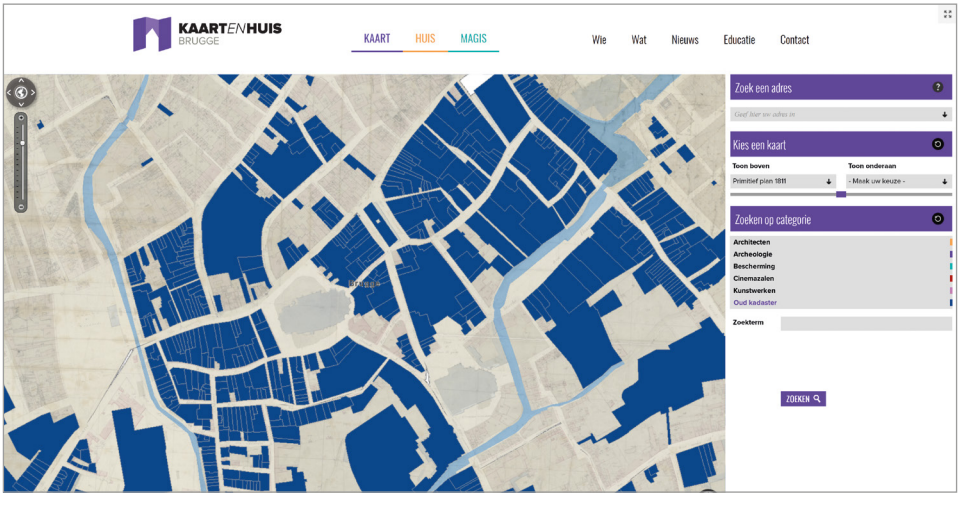
Vannieuwenhuyze B. and Vernackt E. (2014). The Digital Thematic Deconstruction of Historic Town Views and Maps. In: Lichtert K., Dumolyn J. and Martens M.P.J. (eds), Portraits of the City. Representing Urban Space in Later Medieval and Early Modern Europe. Turnhout: Brepols, p. 9–31.

Vernackt E., Heirman A. & Vannieuwenhuyze B. (2014). MAGIS Brugge. Van zestiende-eeuws vogelvluchtplan tot stadshistorische databank. Caert-Thresoor 33 (2), pp. 56–61.

Vrielinck S. (2018) Grootse plannen. De kadastrale Atlas van België van P.C. Popp: genese en datering (1840-1880). Amsterdam: Amsterdam University Press.

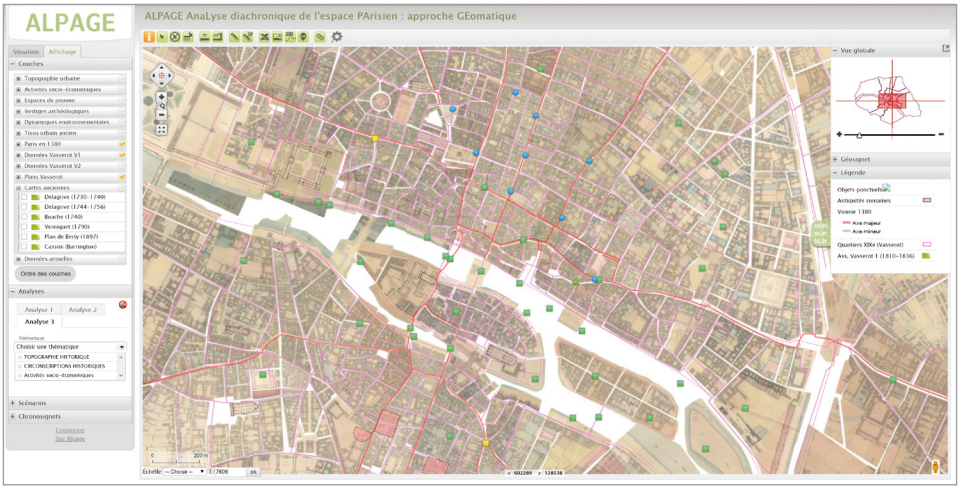
Wallis H.M. and Robinson A.H. (eds) (1987). Cartographical Innovations. An International Handbook of Mapping Terms to 1900. S.l.: Map Collector Publications – International Cartographic Association.

Maps



Map 1: *Primitieve Plan Bruges 1811* [Oud Kadaster], in *KaartenHuisBrugge* [online], available from <http://www.kaartenhuisbrugge.be/Huis> [13 April 2018].

Screenshot of the *KaartenHuisBrugge* website for Bruges, with a zoom on the area around the Saint-Salvator cathedral. The initial cadastral map (*primitieve plan*) from 1811 serves as the base and background layer, on top of which layers presenting data on architects, archaeological findings, protected sites and buildings, cinemas, pieces of art, and property histories can be visualised. By clicking on one of the dark blue polygons, a new window with the property history (*Oud kadaster*) of the parcel pops up. It is also possible to use the search engine on the right side.



Map 2: *Plans d'Îlots Vasserot & Landscape Objects Paris 1380*, in ALPAGE AnaLyse diachronique de l'espace PArisien [online], available from <http://mapd.sig.huma-num.fr/alpage_public/flash/> [13 April 2018].

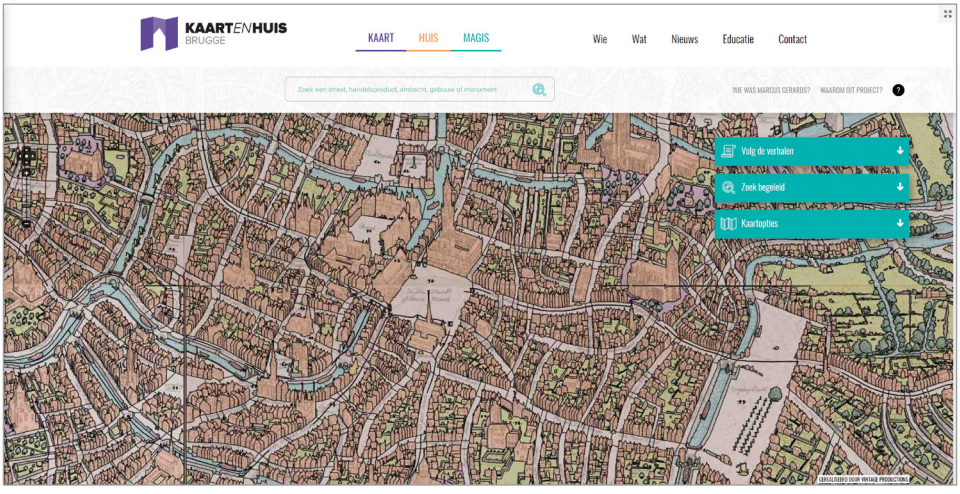
The Paris Alpage website offers the opportunity to export edited maps and diagram legends of the city's old topography, plotted on one of the geo-referenced old or new maps of the city. In the example above, the nineteenth-century *plans d'îlots Vasserot* with the different *quartiers* serve as the background layer for the visualisation of a range of linear and punctual landscape objects that existed in Paris in 1380, e.g. major and secondary roads and streets (red and pink lines), fountains (small blue dots), sites or *lieux* (small green squares), street crosses (small yellow squares), and some Roman antiquities (pink polygons).

Map 3: *Antwerp Vectorized 1834 Cadastre*, in *Gistorical Antwerp* [online], available from <http://www.hisgis.nl/hisgis/gewesten/antwerp/antwerpenkaarten> [13 April 2018].

Screenshot of the *GIStorical Antwerp* project website presenting the results of the digitisation and vectorisation of all parcels in the city-centre of Antwerp based on the cadastral map of 1834. The diagram legend on the right side explains which colour is used for which type of building. The first tab in the menu left above (*Ga naar*) offers the opportunity to search for and navigate to particular streets, while the second and third tabs (*Kaartlagen* and *Achtergrond*) allow one to add layers with additional data (e.g. distribution of professions, former house numbering, other old maps, actual aerial view).

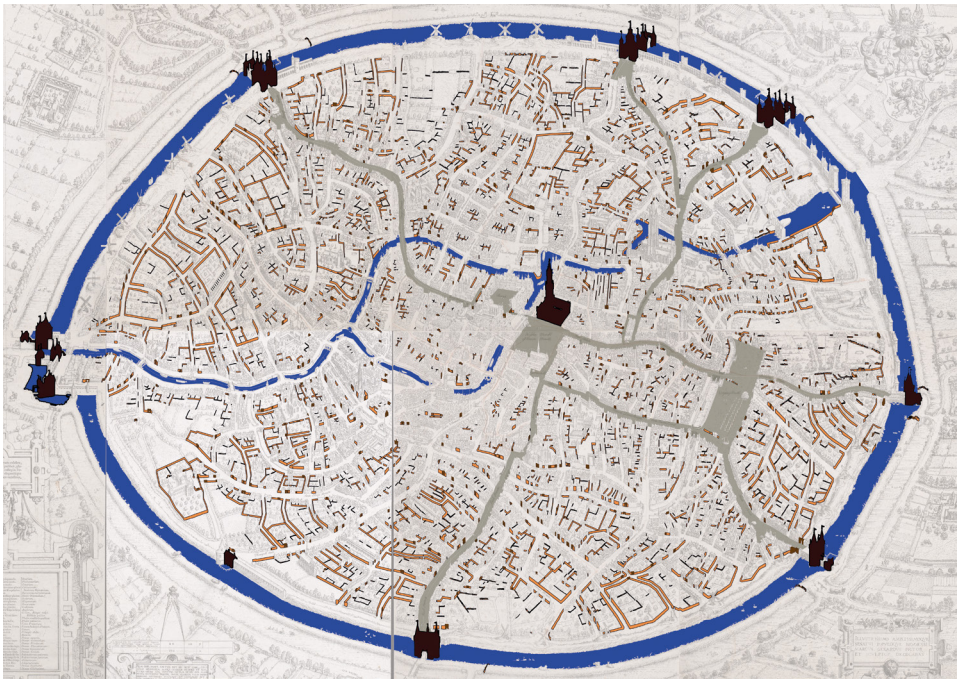
Map 4: Elien Vernackt, *Digital Thematic Deconstruction of Marcus Gerards' Engraved Map of Bruges from 1562*.

Digital thematic deconstruction of Marcus Gerards' engraved map of Bruges from 1562 using QGIS (Bruges Museum). The map objects of the bird's-eye view are redrawn as polygons, saved as vector data, and attributed a particular typology (e.g. house, church, street, bridge, tree, fence, etc.).



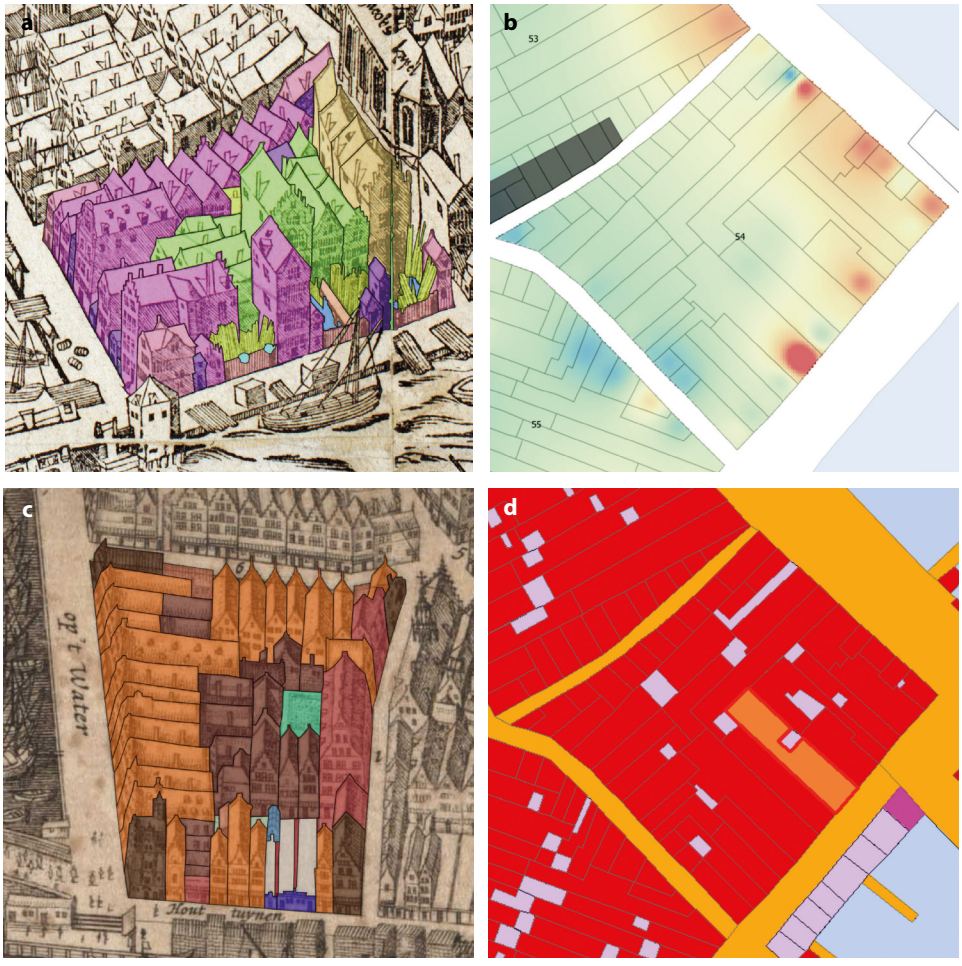
Map 5: *Marcus Gerard (1562) Map of Bruges*, in: MAGIS Brugge, *Kaartenhuisbrugge* [online], available from <http://magis.kaartenhuisbrugge.be/> [13 April 2018].

Screenshot of the *MAGIS Brugge* ('Magic Bruges') website, added to the *Kaartenhuisbrugge* platform. Visitors can manually explore the base map, Marcus Gerards' engraved bird's-eye perspective of the city and its surroundings from 1562, by dragging the image and zooming in and out. Colours have been added to distinguish the main different types of landscape objects (buildings, water, street network, open spaces, fauna). By clicking on those objects, a window with historical background and references pops up. Two search engines offer the opportunity to make general inquiries in the database (blank search field above) or to be guided along some of the main themes of Bruges' history (*Volg de verhalen* and *Zoek begeleid*).



Map 6: Ward Leloup and Bram Vannieuwenhuyze, *Historical Thematic Map Based on the Digital Thematic Deconstruction of Marcus Gerards' Bird's-eye Perspective of Bruges from 1562* [Courtesy of Bruges Museum – Caldenberga].

Historical thematic map, based on the digital thematic deconstruction of Marcus Gerards' bird's-eye perspective of Bruges from 1562. On the map the different types of parcel limits (fences, walls, hedgerows) of the Bruges' city-centre are highlighted. It sheds light on the fragmentary nature of early modern urban space and on the enclosure of large fields in the city's periphery.



Map 7: Juxtaposition of the results of the fourfold digital map analysis for a single building block in Amsterdam. a: Bram Vannieuwenhuyze, *Digital Thematic Reconstruction of Cornelis Antonisz' Bird's-eye Perspective of Amsterdam from 1544*. b: Gabri van Tussenbroek, *Heat Map of Rental Prices from 1562 Plotted on the Cadastral Map from 1832*. c: Bram Vannieuwenhuyze, *Digital Thematic Deconstruction of Balthasar Floris van Berckenrode's Bird's-eye Perspective of Amsterdam from 1625*. d: Geo-referenced and Vectorized Cadastral Map from 1832, from: *HisGIS* [online] <http://www.hisgis.nl/hisgis/gewesten/amsterdam/kaart1830/amsterdam1832> [13 April 2018].

a: digital thematic deconstruction of Cornelis Antonisz's bird's-eye perspective of Amsterdam from 1544. b: heat map of rental prices from 1562 plotted on the cadastral map from 1832. c: digital thematic deconstruction of Balthasar Floris van Berckenrode's bird's-eye perspective of Amsterdam from 1625. d: screenshot of the parcel-based HisGIS.nl website, showing the geo-referenced and vectorized cadastral map from 1832 with data on buildings, parcels, occupants or owners, professions, and taxes in the underlying database.